American Gas Foundation

Research and Development in Natural Gas Transmission and Distribution

March 2007

American Gas Foundation
400 North Capitol St., NW
Washington, DC 20001
202-824-7270
www.gasfoundation.org

Research and Development in Natural Gas Transmission and Distribution

March 2007

Prepared for the American Gas Foundation, with sponsorship by the INGAA Foundation, Inc., by:

**Nicholas Biederman, Jim Fay,
Marlon McClinton, Michael Whelan**

**Gas Operations Innovation Alliance
203 North LaSalle Street – Suite 2100
Chicago, IL 60601**

DISCLAIMER

Legal Notice: This report was prepared for the American Gas Foundation, with co-sponsorship of the INGAA Foundation, Inc., by the Gas Operations Innovation Alliance, LLC to provide an independent study to assess the status of R&D programs in the gas transmission and distribution industries. Neither the American Gas Foundation, the Gas Operations Innovation Alliance, nor any person acting on their behalf:

a. Makes any warranty or representation, express or implied with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately-owned rights,
b. Assumes any liability, with respect to the use of, damages resulting from the use of, any information, method, or process disclosed in this report, or
c. Recommends or endorses any of the conclusions, methods or processes analyzed herein. Use of this publication is voluntary and should be taken after an independent review of the applicable facts and circumstances.

American Gas Foundation

Founded in 1989, the American Gas Foundation is a 501(c)(3) organization that focuses on being an independent source of information research and programs on energy and environmental issues that affect public policy, with a particular emphasis on natural gas. For more information, please visit the website at www.gasfoundation.org or contact Gary Gardner, Executive Director, at 202-824-7270 or ggardner@gasfoundation.org.

INGAA Foundation, Inc.

The INGAA Foundation's primary activity is to sponsor research aimed at promoting natural gas use and safe, efficient pipeline construction and operation. Projects focus on key industry issues such as environmental impacts of energy use, improved pipeline construction practices, pipeline safety procedures, new technologies and market opportunities for natural gas. For more information, please visit the website at www.ingaa.org or contact Mark Shaffer, Executive Director, at 202-216-5909 or mshaffer@ingaa.org.

The Gas Operations Innovation Alliance

The Gas Operations Innovation Alliance, LLC provides a unique set of information products and consulting services to natural gas companies, R&D organizations, gas distribution operations technology suppliers, and other companies. The Alliance produces the ***Gas Operations Innovation Monitor***, a subscription service monitoring new technology distributions operations technology developments. The Alliance also provides custom consulting services in new product development, new product development process management, market and competitive analysis, business case analysis, and strategic planning. For more information, please visit the website at www.gasopsalliance.com.

Acknowledgements

The American Gas Foundation wishes to acknowledge the following organizations and individuals for their assistance and contributions in carrying out this study.

Study Review Team	
Consolidated Edison of New York	*David Davidowitz*
GE Energy	*Michael Brooks*
Pacific Gas and Electric	*Paul Brooks, Robert Howard*
Panhandle Energy	*Jeryl Mohn*
Public Service Electric & Gas	*George Ragula*
Questar Gas	*Ron Jorgensen*
Southwest Gas	*Paul Gustilo*
American Gas Association	*Christina Sames*
American Gas Foundation	*Gary Gardner*
INGAA Foundation, Inc.	*Mark Shaffer*
Industry Contributors	
American Petroleum Institute	*David Miller*
APGA RF	*Bob Beauregard*
AwwaRF	*Frank Blaha*
Alberta Energy Research Institute	*Catherine Laureshen*
Battelle	*Bruce Nestleroth*
CA Gas PIER	*Phillip Misemer*
CERI	*George Eyon*
Canadian Gas Assoc.	*Shahrzad Rahbar*
DOC/NIST/Advanced Technology Prgm	*Stephanie Shipp*
DOE/NETL	*Dan Driscoll*
DOI/MMS TA&R Program	*Sharon Buffington*
DOT/PHMSA	*Robert Smith*
EPA Infrastructure	*Michael Royer, Dan Murray*
EPA Climate Change	*Lisa Handle*
GSTC	*Joel Morrison*
GTI	*Paul Beckendorf*
GERG	*David Pinchbeck*
Gaz de France	*Jean-Pierre Capdevielle*
Inline Inspection Association	*Bryce Brown*
KeySpan	*Jack Haran*
NACE International	*Linda Goldberg*
Nat. Assoc of Pipe Coating Applicators	*Merritt B. Chastain, Jr.*
NARUC	*Grace Soderberg*
Nat Gas Tech Centre	*Caroline DuPhily*
NRRI	*Ken Costello*
NYSEARCH	*Daphne D'Zurko*
Office of Energy Research and Develop.	*Winston Revie*
OTD	*Maureen Droessler*
Osaka Gas	*Yasuhiro Fujii*
Petroleum Technology Alliance Canada	*Eric Lloyd*
PRCI	*Gil Sperling*
Southern California Gas Co.	*Gilbert Ching*
So Gas Assoc / GMRC	*Marsha Short*
SwRI	*Narasi Sridhar*
Toho Gas	*Hirofumi Sumi*
Tokyo Gas	*Koji Yoshizaki, Dr. Eng.*

TABLE OF CONTENTS

Page

1 EXECUTIVE SUMMARY

The U.S. natural gas transmission and distribution industry has undergone profound and fundamental changes over the past 30 years. Historically, the U. S. natural gas industry has funded research and development (R&D) to address the important industry challenges of maintaining the safety and integrity of the gas transmission and distribution systems, controlling costs and enhancing productivity, and maintaining environmental stewardship. The industry has a solid record of accomplishment in applying the results of R&D to address these challenges.

The purpose of this study is to assess the historical trends and current status of R&D in the gas transmission and distribution (T&D) industry, to examine how that research funding aligns with current industry objectives, to compare gas industry R&D funding to similar industries, and to characterize current R&D organizational structures and strategies. An analysis of general business and gas industry literature and publications, contacts with key individuals and organizations in the gas industry, and independent analysis were used by the research team to complete the work described in this report.

SUMMARY OF FINDINGS

- While R&D spending in U.S. industry as a whole has been increasing, R&D spending in the energy industry, which includes gas transmission and distribution, has been declining and is below comparable industries. In addition, natural gas R&D has also been declining in other countries that have traditionally supported R&D.

- Less than five years ago, the Department of Energy (DOE) and Gas Technology Institute (GTI) managed two significant R&D programs. Today, these programs are gone and collaborative industry funding for R&D has only partially offset the loss of these programs. The resulting decline in industry and government funding has raised concerns about the future impact on the industry and its customers. R&D funding in the transmission and distribution sector has declined about $25 million and is roughly half of what it was three years ago.

- Funding increases for collaborative industry programs through Pipeline Research Council International for gas transmission, through Operations Technology Development and NYSEARCH for gas distribution, and through the Department of Transportation, Pipeline and Hazardous Materials Safety Administration (PHMSA) for both transmission and distribution have only partially offset these declines.

- An important outcome of the recent funding reductions has been the elimination of formal industry avenues for long-term basic research. With the exception of GTI's SMP program, a small $2 million program which focuses investments on "mid-term" R&D, the gas industry's R&D funds are focused on near-term developments. In contrast, the electric and water industries each maintain basic research programs oriented at longer-term industry goals through their primary industry R&D collaboratives and their government funding agencies.

- Key non-manufacturing transportation industries (air, rail and trucking transportation) all have federal government R&D programs targeting safety and reliability improvements. These programs are analogous to the DOT PHMSA R&D program for gas pipeline safety and reliability. There is $8 million of government funding currently available for gas pipeline R&D ($4 million from DOT PHMSA; $4 million from the Department of Interior's Minerals Management Service (MMS) for offshore pipelines R&D). The R&D intensity[1] of this combined U.S. government gas pipeline R&D funding is 0.05% compared to 0.10% for air transportation, 0.07% for trucking transportation, and 0.15% for rail transportation.

- Comparable industries (electric utilities, potable water, propane, and heating oil) all have significant collaborative industry programs administered through a surcharge or fee-based mechanism. As of December 2006, the natural gas distribution industry had surcharge mechanisms in 21 states.

- The current gas industry R&D environment places a premium on coordination and communications to assure high priority issues are addressed and to minimize duplication. The former GRI and DOE programs were planned and implemented with public funds. The R&D priority-setting and budget planning processes were open and the resulting plans and "roadmaps" were public documents. Therefore, all interested stakeholders had the ability to know what research was being conducted and to gauge progress. Today, gas distribution R&D programs are conducted in a more decentralized environment that creates a greater demand for the industry to coordinate R&D activities and it creates a greater need for communications. The natural gas transmission (pipeline) sector is less fragmented by its focus on PRCI and the close coupling of the PRCI and PHMSA programs.

- Further investigation is needed to determine what actions may be necessary to address the impact of this downward trend in R&D funding on the development of new and innovative products to meet the future needs of the natural gas industry. The trend should be a concern for all sectors of the industry and should lead to use of collaborative models and long-term planning to ensure that products and services come to the market that address the priorities of the industry and expectations of all stakeholders (including government and customers).

[1] R&D intensity = research funds divided by net revenues

2 INTRODUCTION

The natural gas transmission and distribution industry has been through a period of significant change in the past two decades, which has included regulatory restructuring, significant cost-reduction and improvements in operational efficiency and productivity. The results of research and development (R&D) programs have played an important role in the financial, safety and environmental achievements of the industry. At the same time, the cost cutting has reduced traditional industry R&D spending levels and changed the approaches to R&D management.

For the purpose of this study, research is defined as expenditures incurred in pursuing R&D including experiment, design, installation, construction, or operation. This definition is discussed in more detail in Section 5.

Due to the current private and government approach to R&D in the industry, the reduced R&D budget within the U.S. Department of Energy (DOE), and the pressure to cut costs in a strongly competitive market, concern exists regarding the future of R&D in the natural gas industry. R&D needs remain in such areas as addressing the industry's aging infrastructure, aging workforce, enhancing environmental quality, and improving pipeline safety and integrity through new technology. There is a concern in the gas industry that there is a possible risk of underinvestment in R&D that could negatively impact customers and the safe, reliable, and cost-effective delivery of natural gas to residential and business consumers.

Important elements of past R&D efforts have been discontinued. The phase-out of funding for the cross-industry Gas Research Institute (GRI)—now Gas Technology Institute (GTI)—R&D program through a surcharge approved by the Federal Energy Regulatory Commission (FERC) was completed in 2004. Department of Energy R&D funding through the National Energy Technology Laboratory (NETL) directed at increasing the reliability of U.S. gas T&D infrastructure was eliminated in 2005.

Currently, R&D is being performed and funded by other government agencies (federal and state), manufacturers, research consortiums, foundations, and individual energy companies. Government grants and co-funded projects, state commission trackers, or individual company investments help to fund these programs. The natural gas transmission and distribution sectors have responded by using organizations such as NYSEARCH, Operations Technology Development (OTD), Pipeline Research Council International, Inc. (PRCI), American Gas Association (AGA), American Petroleum Institute (API), American Gas Foundation (AGF), and INGAA Foundation, Inc., to focus what funds are available on issues that are urgent to their respective groups and members.

Focusing on the natural gas transmission and distribution sector, the objective of this study is to independently review past and current processes used to coordinate gas industry R&D needs & priorities, identify and assess the current level of funding, examine trends and drivers, and measure investment in comparison with similar type of industries. In order to compare R&D investments across different industries, the project examined the R&D management professional literature and considered the natural gas industry's unique characteristics to identify the most appropriate measures to be used. The most common measure used is R&D intensity, or expenses as a percent of total industry revenue. However, the total industry revenue for only the natural gas transmission and distribution sectors must be broken out from reported total gas industry revenues. Therefore, in developing a measure of R&D investment, an adjusted R&D intensity measure will be used for the natural gas industry and where possible, for the industries to which it is to be compared. The comparison in the study also evaluates the organizational structures and strategies for managing R&D activities in the industry.

To fully characterize all of the on-going R&D activities directed at gas transmission and distribution applications requires not only information about the more public components of R&D (R&D within industry consortia, government projects and public benefit programs), but also information about R&D activities going on within individual pipeline and distribution companies, industry manufacturers and private contractors. The current non-public research activities are largely proprietary and can never be fully known, either in the gas industry or in industries best for comparison. Therefore, this study focused on the public components of R&D. The fact that the true measure of this private R&D can never be known challenges the ability of the gas industry (or any industry) to determine if the level of R&D funding is adequate for industry needs.

It is important to use a common basis to compare R&D spending in the gas industry with other industries. R&D funding can be through industry collaboratives, from government sources or within individual companies – either in an industry or from manufacturers and other suppliers to the industry. Since collaborative and government is known, these components are compared.

Differences in the funding numbers found in this report are due to:

1) Some funding numbers may be included as stated by a funding organization (such as cofunding), but are not verified or not included to avoid double-counting, and
2) Aggregated totals may only include some funding sources.

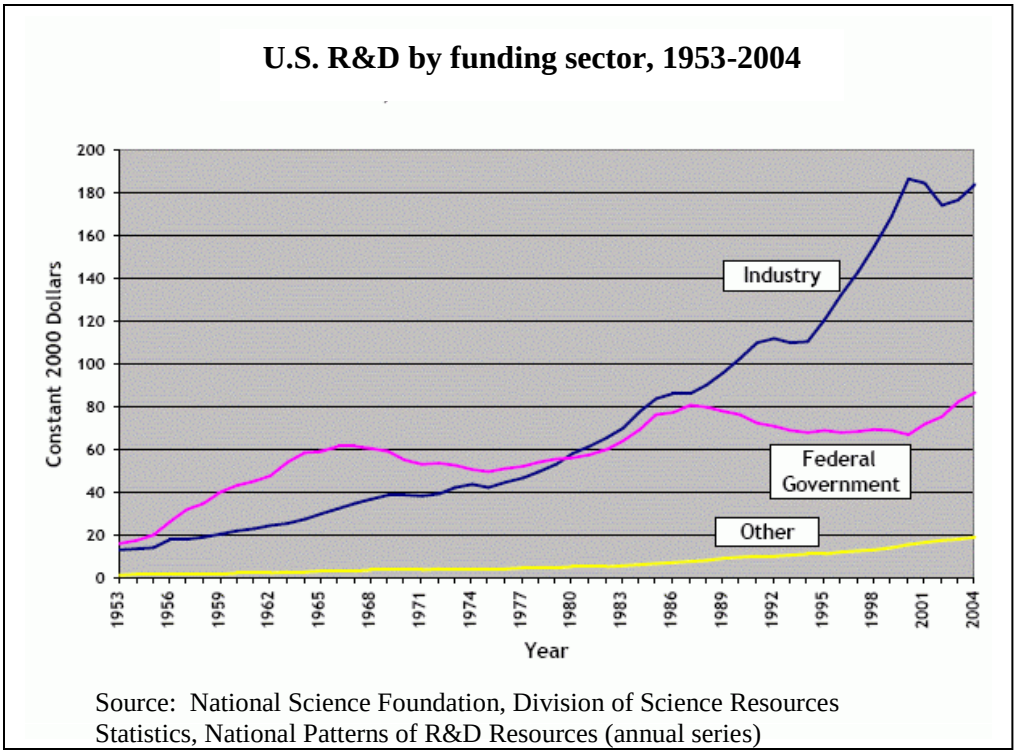
Where differences occur, an explanation is provided.

3 OVERVIEW OF U.S. AND GLOBAL R&D (ALL INDUSTRIES)

In 2005, the U.S. spent a total of approximately $320 billion on R&D[2]. This is roughly one-third of the world's R&D budget, which totaled $978 billion. R&D in European countries made up 24% of the total, with Germany (6%), France (4%), and the U.K. (4%) accounting for the largest shares. Asia accounted for another 35% of total R&D spending, with both Japan and China accounting for 13% each.

Figure 3.1 shows the growth of U.S. R&D over the past 50 years, by source of funds. Overall funding for R&D has exhibited strong growth with funds from industry sources surpassing government sources around 1980. The graph below also shows steady growth in the "other" sector (primarily universities).

Figure 3.1 R&D in the U.S.



Source: National Science Foundation, Division of Science Resources Statistics, National Patterns of R&D Resources (annual series)

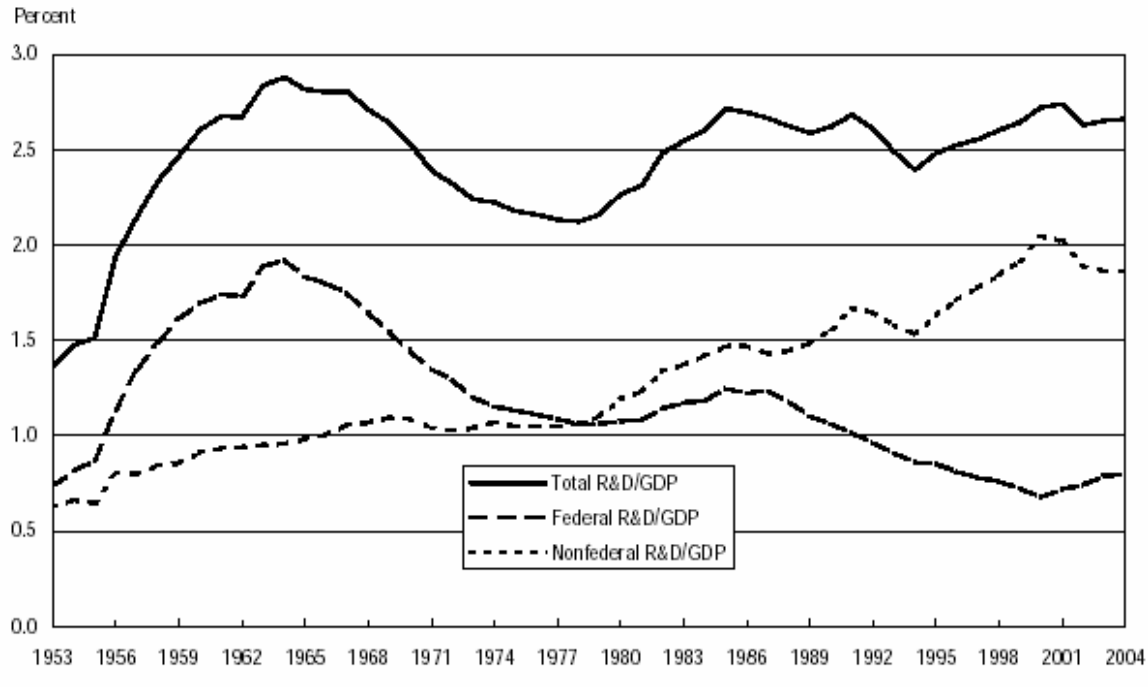
The U.S. R&D intensity (R&D spending as a percent of GDP) was 2.6% in 2005. Only a handful of countries had a higher percentage: Israel (4.5%), Sweden (3.9%), Finland (3.5%), and Japan (3.2%). Worldwide R&D has exhibited strong growth, nearly doubling over the past 10 years. The strongest growth rates in 2005 occurred in China, India, Russia and Singapore.

In all of the countries with major R&D programs, most of the funds come from industry (as opposed to government sources). An important trend in R&D is the outsourcing of selected product development activities to lower-cost countries.

[2] The data and trends reported in this section are drawn from annual publications of R&D Magazine: the *Global R&D Report (Years 2005-2007)*, R&D Magazine, September, 2004 – 2006; and the 2005-2006 *R&D Funding Forecast*, R&D Magazine, January, 2005-2006.

Figure 3.2 shows U.S. R&D intensity across all industries for the years 1953 to 2004[3]. While overall R&D spending has increased as a percentage of GDP, it has been between 2 - 3% since the late 1950s. An important trend to note is that the private sector share of R&D spending has exceeded the federal government share since the late 1970s.

Figure 3.2 R&D Share of U.S. GDP (1953-2004)



GDP = gross domestic product

NOTE: R&D data for 2004 are projections.

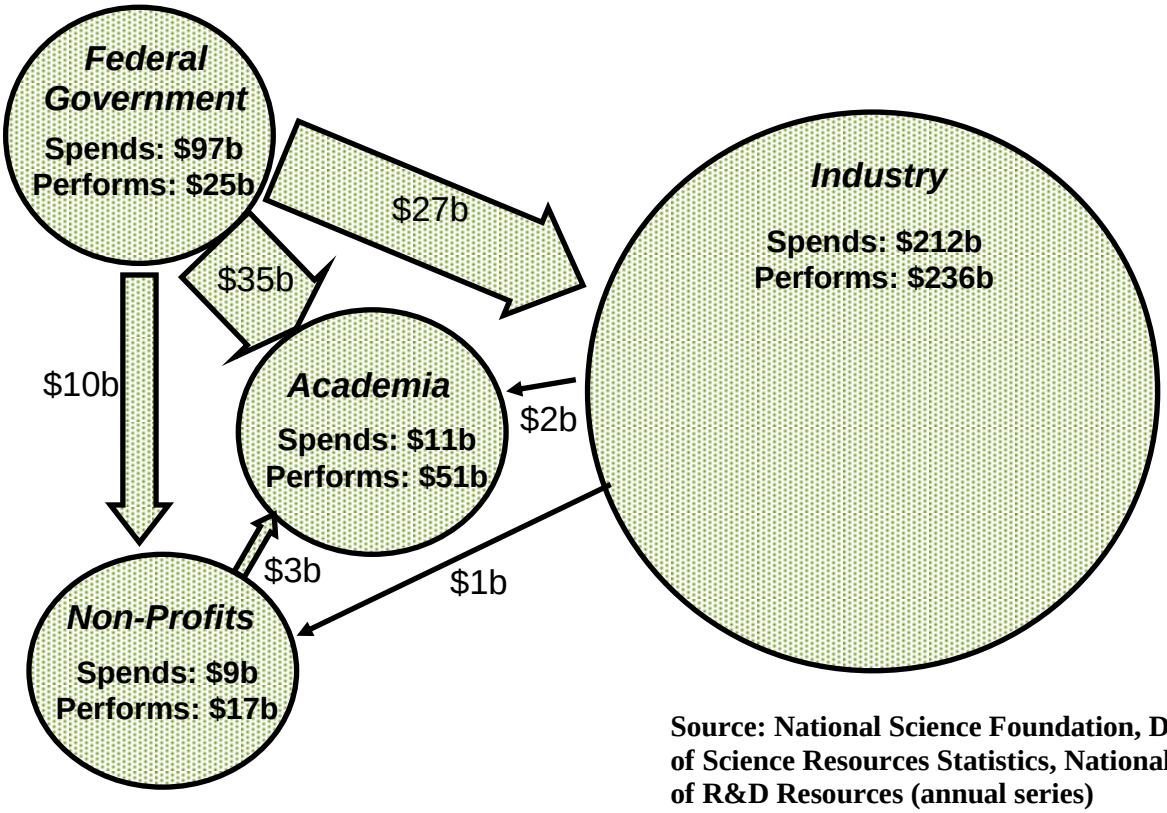
SOURCE: National Science Foundation, Division of Science Resources Statistics, National Patterns of R&D Resources (annual series).

Most of the R&D spending estimated for 2006 is expected to come from private industry (64%), with 30% from the federal government, and 3% each from academia and independent contract laboratories.

Figure 3.3 provides the sources of R&D funds for the U.S. economy as a whole, along with the types of organizations that perform the R&D.

[3] National Science Foundation annual survey of industry R&D, latest data are from 2003.

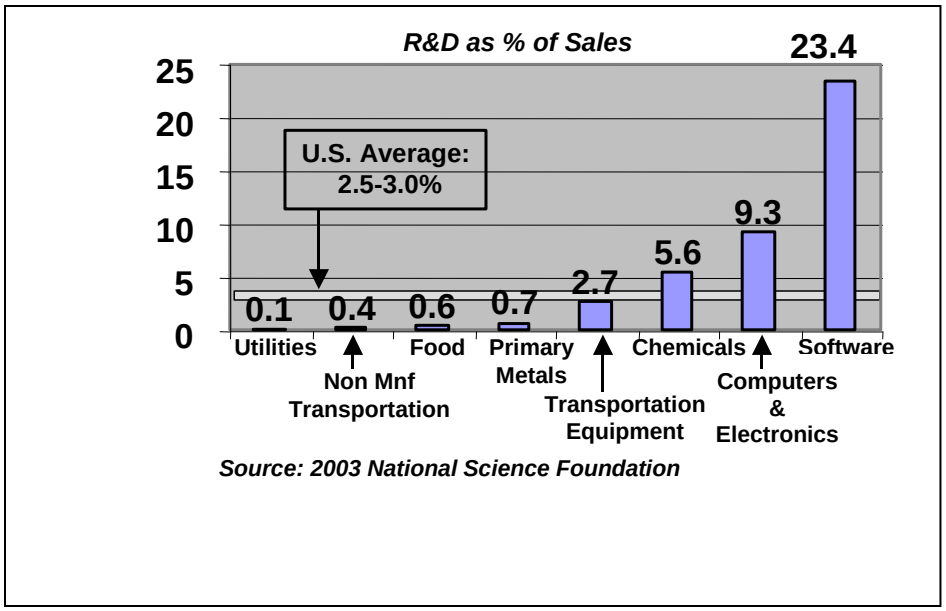
Figure 3.3 R&D Funding Sources and Performers: U.S. Economy



Source: National Science Foundation, Division of Science Resources Statistics, National Patterns of R&D Resources (annual series)

A comparison of selected U.S. industries and their R&D intensities is shown in Figure 3.4. Utilities, which include power generation, transmission, and distribution, natural gas distribution, water supply and sewage treatment, spends 0.1% of revenues on R&D. Non-manufacturing transportation, which includes natural gas transmission spends 0.4% of its revenues on R&D. These R&D intensities are well below the U.S. average of 2.5-3.0% and the average for non-manufacturing industries of 3.3%. Food and primary metals are examples of two mature industries with below average R&D intensities. Transportation equipment, which includes motor vehicles and airplanes, is around the average at 2.7%. Faster growing industries, such as chemicals (which includes the R&D-intensive pharmaceutical sector), computers & electronics, and software have higher R&D intensities.

Figure 3.4 R&D Intensities of Selected U.S. Industries



While data is not available at the gas utility or gas transmission level, overall utility R&D spending (the category that includes gas distribution companies) and transportation (the category that includes gas transmission companies) are low (at 0.1% and 0.4%, respectively) compared to other industries.

The energy industry provides another perspective on R&D spending. In contrast to research and development spending for the economy as a whole, R&D spending in the energy industry has declined from a high point in the late 1970s (when DOE was established, in response to the energy crisis of the same era). Overall R&D spending in the energy industry has declined since the early 1990s, due primarily to a drop in private industry funding.

4 NATURAL GAS R&D – HISTORICAL BACKGROUND

Natural gas transmission and distribution management priorities have always included: 1) safety, reliability and system integrity; 2) cost control and productivity enhancement; and 3) environmental stewardship. This section describes the history and evolution of industry R&D efforts directed at these objectives, the impact of those programs, the business and regulatory pressures that have affected funding mechanisms and levels, recent trends in funding, and the current conditions in the gas industry.

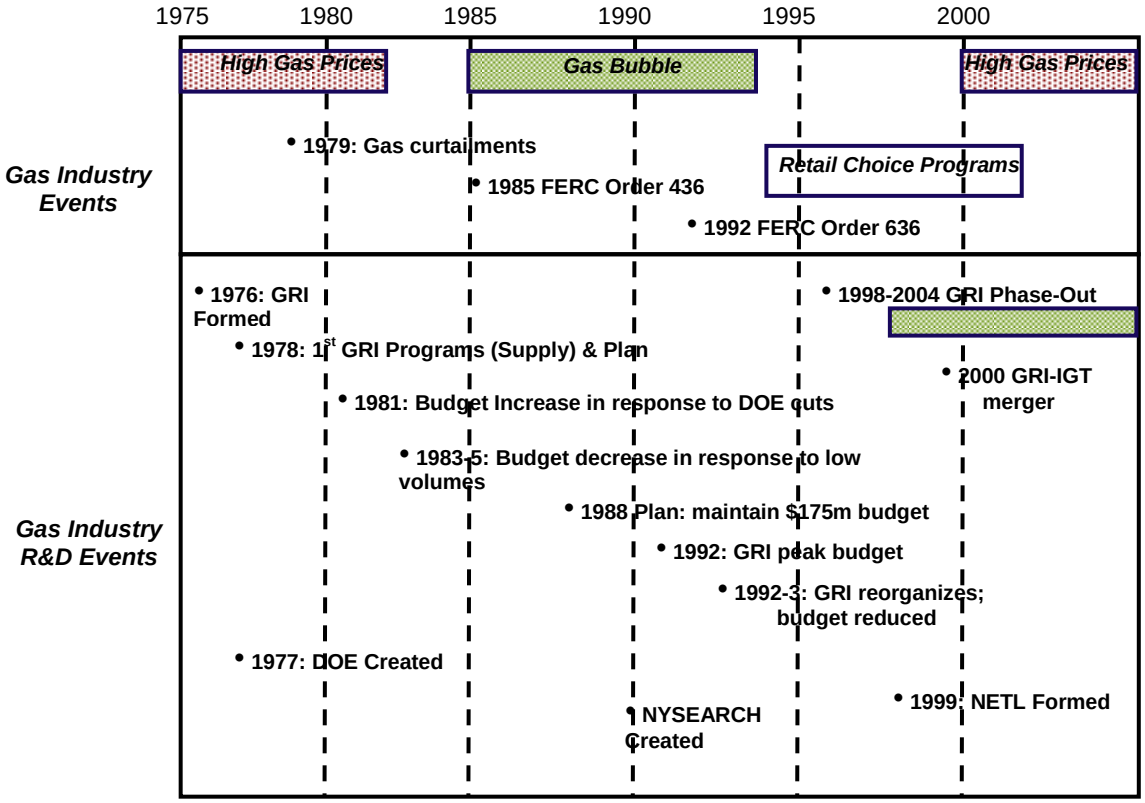
4.1 Transmission and Distribution R&D Initiatives

R&D in the natural gas industry has been funded through regulatory-approved industry collaborative organizations, voluntary dues-based collaborative pools, government programs and individual industry projects. The largest component of gas industry R&D spending has historically been through collaborative R&D programs. Collaborative R&D funding offers the ability to leverage investments to address common R&D needs.

Collaborative R&D has undergone significant change over the past 30 years. As highlighted in the timeline in Figure 4.1, collaborative industry R&D organizations have been created and funded in response to important industry needs. The Pipeline Research Committee (later PRCI) was formed in the 1950s to pursue needed research for pipelines. GRI was formed in the late 1970s in response to industry needs to develop new sources of supply. The Electric Power Research Institute (EPRI) and GRI were providing central organizations to manage the public research programs that were funded via mechanisms designed to pass R&D costs through to the end-customer.[4] A few years later, DOE was established and funding for energy R&D, in general, and in particular, supplemental gas supplies, were substantially increased.

[4] Historical Review of Gas Research Institute Research and Development, Gas Research Institute, May, 1987.

Figure 4.1 Gas Industry R&D Timeline



During the 1980s and early 1990s, GRI was expanded to include R&D programs addressing supply, transmission, distribution and end-use. Funding was reduced in the early 1990s due to pipeline competitive concerns (the funding unit was adjusted for discounted throughput). GRI was reorganized to accommodate the lower funding levels and to emphasize near-term industry impact.

Also in the early 1990s, NYGAS (now NYSEARCH) programs were initiated in New York and were later expanded to include gas companies in other states. In 1997, perceived funding inequities were such that the gas industry agreed to phase out funding (over a seven-year period) for research through the GRI funding mechanism. In 2000, GRI and the Institute of Gas Technology (IGT), which had been the R&D performing laboratory for the gas distribution industry, merged to form the Gas Technology Institute (GTI). By the end of 2004, funding for the GRI the program was completely phased out. GTI continues to maintain technical staff and facilities to manage and perform research funded by others such as the OTD and Utilization Technology Development (UTD) programs as well as NYSEARCH, CEC, DOT, and others.

In the late 1990s, The National Energy Technology Laboratory (NETL) was established and all DOE natural gas R&D programs were consolidated into this program. A consolidated research program was initiated aimed primarily at preventing pipeline damage of "the U.S.'s aging natural gas infrastructure."[5] DOE funding in 2006 for these programs was eliminated.

[5] "National Labs to Strengthen Natural Gas Pipelines' Integrity, Reliability", NETL News Release, October 3, 2001.

4.2 The Impact of Past Natural Gas Transmission and Distribution R&D Initiatives

The gas transmission and distribution industry has worked with all of the funding and management options available to respond to a changing set of industry R&D needs. Following is a brief sampling of examples of some successful impacts of this research:

- The gas distribution industry has responded through collaborative R&D to a need to better understand the material performance over time of plastic pipe.

- The gas transmission industry has improved system integrity by developing innovative pipe inspection methods. The Pipeline Safety Improvement Act of 2002 incorporated industry research results to allow greater flexibility in demonstrating system integrity.

- The gas transmission industry has, through the development of innovative compressor emissions control technologies, created a significantly more reliable and cost-effective set of options to comply with nitrogen oxides (NO_x) emissions limits.

- Installation, inspection and repair technologies (trenchless) have improved through the results of R&D.

- New leak-detection systems have been introduced through industry research that have increased safety and improved industry productivity.

The role of new technology in meeting industry objectives was highlighted in a recent Peoples Energy Annual Report:

> *"Through new technologies and efficiency and productivity improvements over the past 10 years, we have reduced the utility work force by approximately one third and invested approximately $900 million in maintaining and enhancing the distribution system to ensure the safe and reliable delivery of natural gas service. We have replaced many of our information technology systems, and expanded our automated meter reading system to include most of our one million customers."*
>
> - Peoples Energy 2005 Annual Report to Shareholders

Between 1996 and 2001, Peoples Energy has reduced operations and maintenance (O&M) expenses by 30%, headcount by 25% (without the use of outsourcing), and decreased lost time and recordable injury rates by 75%. The technology applications to accomplish these results include keyhole technology advancements, anaerobic sealants, horizontal directional drilling, optical methane detectors, and Clock Spring repairs[6].

[6] Remarks from Donald M. Field, Pipeline Research & Development Forum, December 11-13, 2003, Washington, D.C.

A report published in May, 2006, based on input from the Steering Committee on Energy Pipelines and Research (containing representatives of gas, oil and oil products pipelines), reviews the pipeline industry, its stakeholders, its market, business and regulatory drivers and how cross-cutting R&D is organized to respond to industry needs in safety, reliability, and environmental and cost management[7]. The report concluded that Pipeline R&D has paid dividends and summarizes R&D programs that have produced results.

Studies conducted by PRCI member companies have indicated that typical returns from long-term participation in the PRCI research program range from four to seven times the total dollars invested. Three domestic pipelines and one European member sponsored these reviews of the impact of PRCI research on their internal operations.

GRI routinely conducted cost/benefit studies as required by FERC to determine net benefit to gas consumers and if the GRI program was in the national interest. These studies consistently showed large, positive total financial returns.

4.3 The Influence of Market and Business Drivers on R&D Levels

The gas transmission and distribution industries have undergone profound changes over the past 30 years. These changes have impacted both the overall level of R&D funding, and the R&D organizational structures the industry has adopted.

R&D investments, with their uncertainty and longer lead-times to deliver productivity improvement results, are considered along with other investment alternatives, often in a fixed or declining budget environment. In many cases, individual pipeline or LDC operators are often owned by a larger holding company. The business investment philosophies of these companies can vary dramatically in terms of their treatment of the operating subsidiaries.

The general industry environment for R&D investments has been determined by the pressures on discretionary corporate budgets due to these three concurrent forces:

1. ***Business Conditions***: Increased pressure to cut costs, improve productivity and increase operating efficiency created a greater challenge for the business case for R&D investments.

2. ***Market Conditions***: A shifting gas supply, demand and price situation has altered industry priorities for R&D strategies.

3. ***Market Regulation***: Regulatory restructuring and increased competition have caused companies to re-examine the costs and benefits of R&D.

[7] *The Role of Energy Pipelines and Research in the United States,* by Cheryl J. Trench and Thomas O. Meisner, The Steering Committee on Energy Pipelines and Research, Published by Pipeline Research Council, International, Inc. May, 2006.

In addition to these factors, the process of rate regulation and the treatment of R&D expenses also play an important role in determining the overall level of R&D spending. Pipeline or LDC rate regulation determines whether any of the cost savings, improved performance and reduced capital requirements benefits only the pipeline or distribution company, if all benefits flow through to consumers, or some combination. The regulatory treatment of R&D expenditures as investments in performance, environmental & safety enhancement is an important determinant of industry R&D spending.

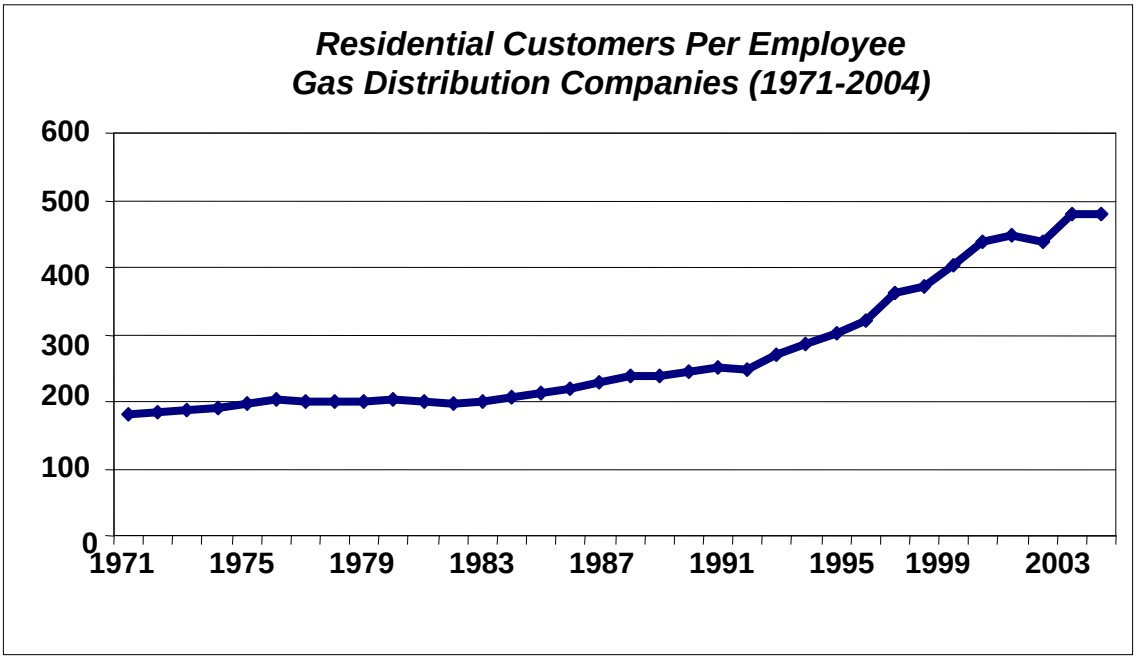
4.3.1 Business Conditions: Pressure to Cut Costs and Improve Productivity

> *"Since 1990, the productivity of distribution companies has steadily improved. This improvement resulted from: changes in the work practices resulting from continuous-improvement type programs; reductions in the workforce with judicious use of contracted labor; and the implementation of new technologies affecting all aspects of construction, maintenance and operations of gas distribution systems."*
>
> - Balancing Natural Gas Policy, National Petroleum Council
> September, 2003 Vol. 5, p. t-45

An important objective of gas transmission and distribution companies is to manage costs and improve productivity. The overall global business environment, combined with structural changes in the gas industry, intensified pressures to reduce costs and improve productivity in the late 1980s and into the 1990s. Both gas pipelines and LDCs have made significant improvements in productivity during the 1985-2004 time frame. Figure 4.2 shows the number of residential customers per employee for gas distribution companies[8]. The gas distribution industry serves nearly 2.5 times as many customers per employee as they did 20 years ago.

[8] AGA Gas Facts (2004 Data), published in 2006.

Figure 4.2 Gas Distribution Company Productivity Trends
(Source: AGA Gas Facts)



Similar improvements in productivity have been witnessed in the natural gas transmission industry. The collection of data on employment was discontinued in the early 1990s, but throughput per pipeline doubled between 1986 and 1990.

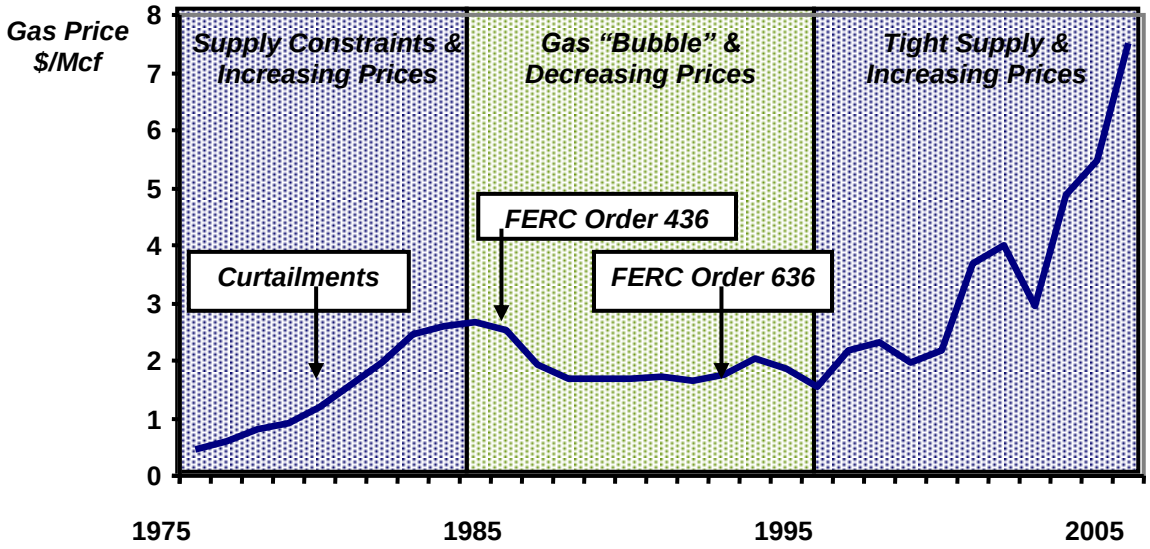
> *"The pipeline and distribution sectors have experienced significant improvements in productivity as well. During the period 1984 to 1993, for example, labor productivity in these sectors improved by 24 percent, and operation and maintenance expenses per unit declined by 18 percent."*
>
> - Costello & Duann (Regulation, 1996, Vol. 19, No. 1)

Despite the contributions to company financial performance (as mentioned in Section 4.2), industry R&D spending levels (and R&D staffs) were reduced during the late 1980s and early 1990s.

4.3.2 Market Conditions: Changing Gas Industry Supply and Demand

In the past, the overall gas supply, demand and price situation has influenced the shape of R&D programs. Figure 4.3 shows three supply and demand periods in the gas industry since 1975. Both GRI and DOE were formed in the late 1970s during a period of supply constraints. The late 1980s and early 1990s were a period of excess supplies. After 2000, higher prices and supply limitations returned.

Figure 4.3 Supply/Demand Periods Affecting R&D Programs



The current and expected future gas supply, demand and price situation affects the priorities of gas companies, their customer and regulators. R&D program spending levels and priorities in the future will continue to be shaped by these market factors.

4.3.3 Market Rules: The Impacts of Regulatory Restructuring

The regulation of several important U.S. industries has been restructured in the last quarter of the 20th century:

- Airlines (Airline Deregulation Act, 1978)
- Long-Distance Telecommunications (AT&T Divestiture, 1984)
- Natural Gas Transmission (FERC Order 436, 1985)
- Railroads (Staggers Act, 1980)
- Trucking (Motor Carrier Act, 1980)

These industries have been studied to assess the impacts of these changes.[9,10,11,12] In each of industry, competition increased, prices decreased, as well as revenues and profitability. Each industry responded by increasing efforts to reduce costs and improve productivity.

In 1985, FERC Order 436 initiated the transformation of natural gas transmission to open access. In addition to the regulatory changes, the gas industry went through an extended period of supply surplus (the "gas bubble") and, in many regions, excess pipeline capacity. These regulatory and market drivers increased the competitive pressures in the gas transmission industry.

---

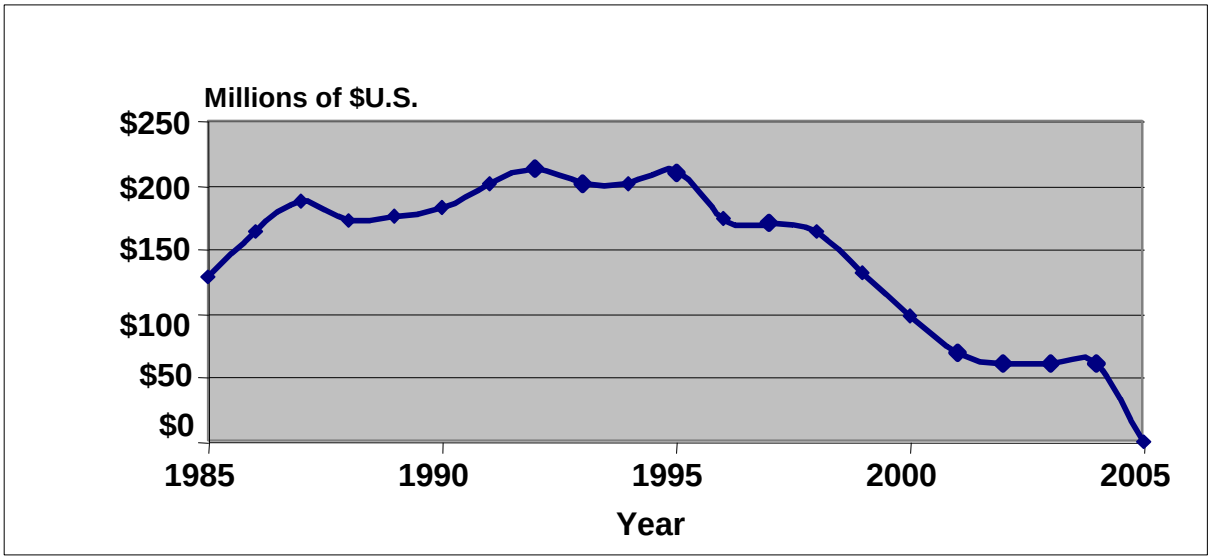
[9] The Impact of Deregulation: An Overview of Five Industries, Edison Electric Institute, February 1995.
[10] Economic Deregulation and Customer Choice: Lessons for the Electric Industry, Robert Crandall and Jerry Ellig, Center for Market Processes, 1997
[11] The Outlook for a Restructured U.S. Electric Power Industry: Lessons from Deregulation, Kenneth W. Costello and Robert J. Graniere, The Electricity Journal, May, 1997.
[12] *Contrived Competition, Regulation and Deregulation in America, Richard H. K. Vietor, Harvard University Press, 1994.*

This transition to a more competitive regulatory environment has changed R&D spending levels and organizational structures, and will continue to affect future industry R&D funding models.

4.4 Recent Trends in R&D Spending

With the phasing out of the GRI funding (Figure 4.4), the gas industry has significantly reduced its level of R&D spending, with GRI funding decreasing from a high of over $200 million to zero over a 10-year period (GRI funds included supply and utilization along with T&D). In addition, support through the GRI collaborative structure discontinued: 1) a centralized organization responsible for planning and coordinating the industry's R&D, and 2) formal industry-sponsored funding for basic research on gas transmission and distribution issues.

Figure 4.4 Gas Research Institute Funding (1985-2005)

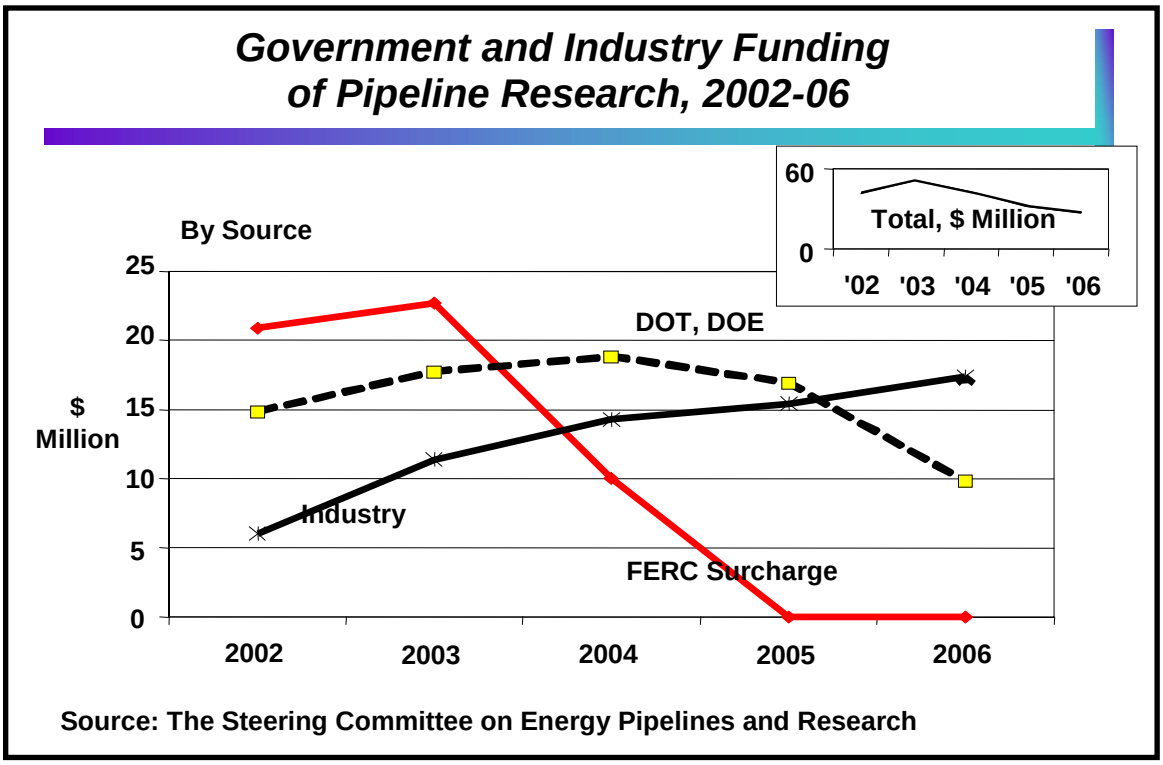


It is important also to note that the discussion of funding levels and trends in this report has not considered adjustments for inflation. For much of the 1990s, the GRI FERC-based annual program budget for transmission R&D was about $14 million. Applying a typical rate of inflation to the GRI reference point of about $14 million/year program implies that, in constant dollar terms, 2006 funding of twice that amount (about $28 million) would be required to match that previous level of R&D effort[13]. The gap between historical funding levels and today's industry R&D budgets is significantly increased when factoring in the effects of inflation.

[13] Adjustments for R&D cost inflation are greater than general inflation. An examination of the increase between 1998 and 2006 in the hourly billing rates of a principal investigator at a representative R&D contractor shows an annual increase of 9.25% over that period.

The elimination of DOE funding through NETL discontinued a large share of government funding for gas T&D, including long-term fundamental research (federal funding for gas T&D continues through the U.S. Department of Transportation—DOT—but this research funding does not include long-term R&D). Figure 4.5 below shows government and industry funding of pipeline research. The combination of eliminating both the GRI and DOE programs results in a significant drop in industry R&D funding (about 50% in three years), even with an increase in other sources of industry funding.

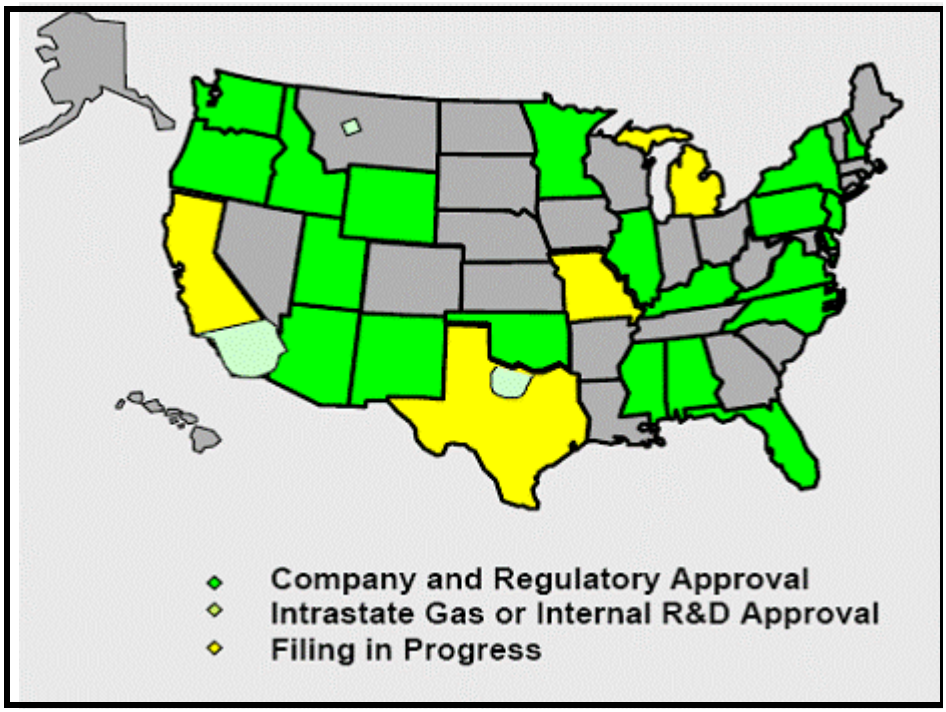
Figure 4.5 Government and Industry Funding of Pipeline Research, 2002-06



In response to these recent trends, the collection of customer funds for distribution R&D through the approval of state regulatory commissions (Delta Funds) has grown in recent years to 16 states in 2005[14] and 21 states in 2006 (see Figure 4.6 on the next page). These funds can be applied to gas distribution R&D programs benefiting the customer. In California, an additional category of "public interest" R&D funding is collected. This research includes end-use efficiency, environmental and climate change research, transportation and advanced electric generation[15]. It includes some liquefied natural gas (LNG) and gas storage economic modeling, but generally gas distribution operations R&D is not funded through the "public interest" surcharge in California.

[14] GTI Gas Operations News, April, 2005 (Vol. 2, No.1)
[15] Public Interest Energy Research Program, Natural Gas, 2006 Program Plan and Budget, California Energy Commission, January, 2006.

Figure 4.6 Status of State Delta Fund Approval
As of 12/1/06, 21 States, Total Funding Available: $22.4 million
(Source: Gas Technology Institute)



4.5 Current Business Conditions in the Natural Gas Industry

> *"Some future levels of reductions in the workforce are likely. However, the ability to continue workforce reductions at these historical rates through the study period (to 2020) without degrading customer service and safety is unlikely."*
>
> - Balancing Natural Gas Policy, National Petroleum Council
> September 2003 Vol. 5, p. t-45.

The business and regulatory environment in the natural gas industry today presents a unique set of challenges. An aging infrastructure and workforce, changing supply and demand, working with stakeholders to create and implement system integrity management practices, and maintaining environmental standards create challenges for innovation.

Business conditions in the gas transmission and distribution industries are different today than in the past. In general, tight supplies and higher prices create pressures to develop new gas supplies. For gas transmission, a high level of capital investment in new infrastructure will be required. The trend toward customer choice in gas distribution has leveled off. Efforts to improve productivity in gas transmission and distribution continue; however, the trend will not likely continue as has been seen historically.

5 STATUS OF NATURAL GAS R&D

5.1 Introduction

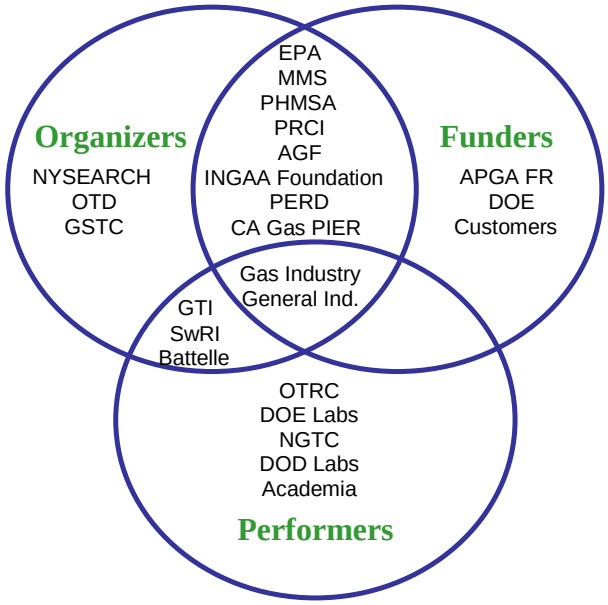
This section summarizes the government and private organizations in the U.S. and Canada that either provide funding or perform R&D activities in the area of natural gas transmission, storage and distribution (T&D). Detailed descriptions provided in Appendix A highlight how these different groups organize the selection and performance of R&D, and the 2006 budgets where available in T&D research. A summary of these organizations is presented in Table 5.1.

The roles played by the significant organizations in natural gas T&D research are shown in Figure 5.1. These organizations are grouped by the roles they play, i.e.:

1) Organizers: Decide what projects are funded
2) Funders: Provide the funds for research
3) Performers: Perform the R&D

As shown in Figure 5.1 there is significant overlap between funders and organizers, but only the gas industry and manufacturers/service companies provide all three activities.

Figure 5.1 Natural Gas Research Organization Roles

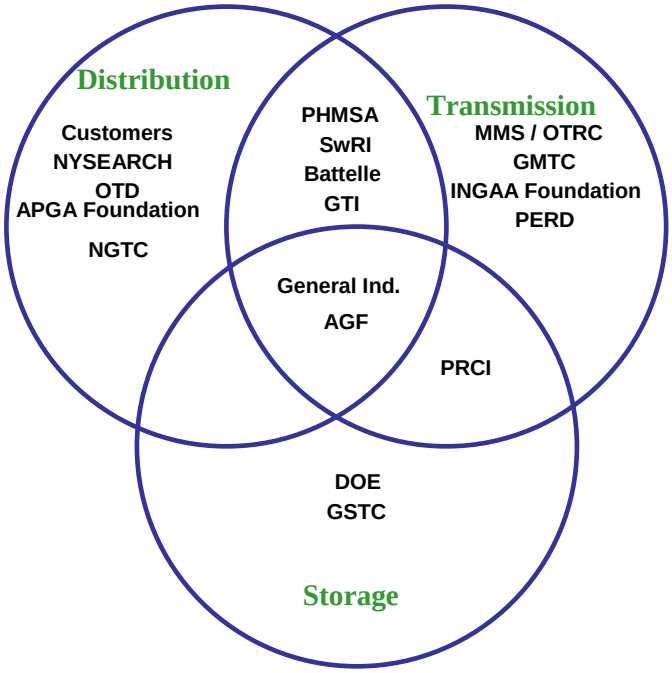


Under Funders in Figure 5.1 is listed Customers. Customers represent the so-called "Delta" funds that are collected as a rider on the cost of gas, and funds that are collected as a direct rider to distribution company tariffs. This category of funding also includes the California public interest funds. Although as described below there is only a small amount of funding used for natural gas T&D research from this source.

Table 5.1 Summary Of U.S. And Canadian Organizations Involved With T&D R&D

ORGANIZATION	2006 SECTORS OF INTEREST DISTR	TRANS	STRG	T&D RELATED FOCUS	FUNDED 2006 T&D R&D	FUNDING SOURCE
U.S. GOVERNMENT						
DOE / NETL			X	Dropped T&D funding in 2005 Still funding GSTC	YES	GOV'T
DOT / PHMSA	X	X		Near-term safety oriented, regulatory dirive on-shore pipeline R&D	YES	GOV'T
DOE / GSTC			X	Underground storage R&D	YES	GOV'T / IND
DOE Laboratories				Basic research -- Some pipeline integrety R&D. Includes: Argonne, BNL, INL, ORNL, PNNL and Sandia	NO	GOV'T
EPA	X	X	X	Air, water and solid environmental issues, including Gas STAR, and a fugitive methane initiative as part of the Global Warming Division	NO	GOV'T
DOD Laboratories				Basic research in related areas, e.g., corrosion, lasers.	NO	GOV'T
DOI / MMS TA&R Program		X		Safety and design of off-shore pipelines and production platforms	YES	GOV'T / IND
NACE International				Codes and standards for corrosion control and prevention.	N/A	MEMBER DUES
DOC / NIST / Advanced Tech. Prgm				Basic R&D for innovative technologies	NO	GOV'T
NSF				Independent federal agency for research and education in science and engineering generally.	NO	GOV'T
NARUC / NRRI				Studies on regulatory and tariff issues	NO	GOV'T
ASSOCIATIONS / NON-PROFITS						
American Petroleum Institute	X	X	X	Develops codes and standards for equipment, e.g., measurement, regulators, valves.	N/A	MEMBER DUES
AGA	X			Policy and issue papers.	NO	MEMBER DUES
American Gas Foundation	X	X		Public policy issue studies.	YES	CONTRIBUTIONS
APGA RF	X			Municipal distribution system R&D.	YES	GAS TARIFF
INGAA		X		Pipeline forum for legislative and business advocacy.	NO	MEMBER DUES
INGAA Foundation		X		Pipeline related technical issue papers, technical workshops.	YES	MEMBER DUES
So Gas Assoc / GMRC		X		Transmission compressor and prime mover R&D	YES	DUES / ROYALTIES / IND COFUNDS
ORGANIZERS						
PRCI		X	X	Pipeline integrety R&D, compressors and storage	YES	DUES / GOV'T / IND COFUNDS
OTD	X			Collaborative program in distribution	YES	Cust. Funds / GAS IND / GOV'T
NYSEARCH	X	X		Colaborative distribution RD&D funding.	YES	Cust. Funds / GAS IND / GOV'T
CONTRACTORS						
GTI	X	X		Technical research institute for full range of RD&D and education in natural gas.	NO	IND / GOV'T / DUES
Battelle	X	X		Applied R&D in distribution, transmission and storage, manages DOE labs.	NO	IND / GOV'T
SwRI	X	X		Applied R&D in distribution, transmission and storage	NO	IND / GOV'T
Nat Gas Tech Centre	X			Contract research company in distribution.	NO	IND / GOV'T
CERI				Public policy and technical issue papers for conservation and environmental issues.	NO	GOV'T / IND
STATE AGENCIES						
CA Gas PIER			X	Only storage modeling and econmic analysis currently.	YES	GAS TARIFF
NYSERDA				None in T&D. Historically some storage R&D.	NO	GAS TARIFF
CANADIAN GOVERNMENT						
Office of Energy Res. and Develop. / PERDA		X		Safety, environmental and design R&D for on- and off-shore pipelines in adverse environments.	YES	GOV'T / IND COFUNDS
Canadian Gas Assoc.	X	X		Legislative policy and business advocacy for distribution and pipelines.	NO	MEMBER DUES
Alberta Energy Research Institute		X	X	Reservoir engineering and some transmission with universities	NO	GOV'T

Figure 5.2 2006 Natural Gas Funding Organizations by Sector



The organizations identified also focus on specific sectors. Figure 5.2 shows the sector(s) in which these organizations primarily focus their efforts. Absent from this group of companies that are apart a part of the group in Figure 5.1 are the DOE and DOD laboratories, and EPA. In the survey of 2006 T&D R&D activities these organizations were found not to be funding or doing any significant research in these sectors.

5.2 Natural Gas R&D Funding for Transmission, Storage and Distribution

A survey of the U.S. and Canadian organizations was done to determine the amount of funding in 2006, and to determine the total value of the R&D program in 2006. Further all the organizations were asked to provide either a project list and/or direct and cofunding amounts for distribution, transmission and storage, in order to further subdivide projects and funding into activity categories. A detailed description of these categories can be found in Appendix B Natural Gas R&D Study Research Categories (page A-19). The categorization of research into these activities was then rolled-up into R&D objectives to determine the focus of overall gas industry R&D.

5.2.1 Definition of Natural Gas Research

Research was defined for this study according to the CFR Title 18 Uniform System of Accounts[16]:

> "…expenditures incurred… in pursuing [R&D] including experiment, design, installation, construction, or operation. This definition includes expenditures for the implementation or development of new and/or existing concepts until technically feasible and commercially feasible operations are verified."

By definition, therefore, economic research and modeling; legislative and regulatory policy analysis; development of codes and standards; fugitive methane emissions mitigation and climate change were excluded from the total funding.

5.2.2 R&D Objectives for Transmission and Distribution

A review of different natural gas organizations and focus groups was done to identify a set of R&D objectives that would represent the natural gas industry priorities. The set of objectives that was developed is:

- Improving monitoring and assessment of system integrity
- Enhancing system flexibility and throughput and reliability
- Reducing incidence and cost of subsurface damage
- Improving capability of cost effective construction, maintenance and repair
- Improving data quality and timeliness for system, operation, planning and regulatory acceptance
- Identifying and mitigating environmental issues.

Details of the project activities incorporated into each of these objectives can be reviewed in Appendix B (page A-19). Note that safety is integral to most all activities undertaken by the natural gas industry; particularly for system integrity, enhancing reliability, reducing subsurface damage, and in all aspects of new construction and maintenance activities. As such "safety" is not a separate objective.

5.2.3 Sources and Level of R&D Funding in 2006

The results of the survey of natural gas funding are shown in Table 5.2 (page 24). Research funding for natural gas totals $54 million:

- Distribution……..$26.1 million
- Transmission……$26.8 million
- Storage…….$1.3 million.

[16] Code of Federal Regulations, Conservation of Power and Water Resources, Title 18, Parts 150 to 279 (Revised as of April 1, 1993), Subchapter F – Accounts, Natural Gas Act, Part 210, USA Prescribed for Nat. Gas Companies Subject to the Provisions of the Nat. Gas Act, Definitions ¶ 29.D.31.B Research, Development and Demonstration, pg 147.

As illustrated in Figure 5.3 (see page 25), 48 % the funding goes to distribution operations with 3% to storage and 49% to pipeline R&D.

Government funds provide a large proportion of these research funds, and together with the natural gas and general industry co funds represent 58% of the T&D research funding. Although all of the T&D research funds are gone from the DOE NETL program, it still provides some funding through the Gas Storage Technology Consortium (GSTC) for underground storage research. The two remaining major U.S. federal funding sources of T&D R&D are DOT PHMSA and DOI MMS. The PHMSA directed research work is coordinated through industry steering committees, with the majority of the pipeline research work done in conjunction with PRCI. MMS is responsible for offshore T&D research through its Technology Assessment and Research (TA&R) Program.

The Office of Energy Research and Development (OERD) is responsible for the Program of Energy Research and Development (PERD) and the Technology and Innovation Research and Development initiative which supports the energy-related R&D activities of federal departments, including Natural Resources Canada. PERD supports transmission research that focuses on how to design safe and environmentally benign pipelines in the adverse conditions of arctic and sub-arctic regions.

The Pipeline Research Council International, Inc. coordinates, and through transmission industry contributions funds, collaborative transmission R&D. As mentioned above, a significant portion of this R&D is done in collaboration with PHMSA and MMS. PRCI also provides the industry co funds for storage R&D done through GSTC.

Gas Manufacturers Research Council (a subsidiary of the Southern Gas Association) provides funding for R&D on compressors and drivers for the transmission industry. Funding through GMRC comes from industry contributions to the Council.

In the distribution sector, the industry funded collaborative programs at NYSEARCH (a subsidiary of Northeast Gas Association) and the Operations Technology Development, Inc. (OTD) (a research consortium organized by the Gas Technology Institute) dominate this sector. Neither of these organizations conducts research.

Other collaborative R&D programs are also funded principally at three contract research organizations: Gas Technology Institute (GTI), Southwest Research Institute (SwRI) and Battelle Memorial Institute. A Canadian contract research firm focusing on distribution and end-use R&D is the Natural Gas Technology Centre. The funding for these organizations come from government, natural gas and general industry sources; and is represented in the Other Industry funding category.

Funds used by natural gas transmission and distribution companies generated through corporate (i.e., stockholder) funds is another matter in that it is not reported anywhere in an aggregated form. Without a comprehensive survey of the industry – which the limitations of this study prohibited – a definitive estimate of this source of R&D funds cannot be made. The research team did perform a cursory survey of some of the larger LDCs and transmission companies to estimate the likely range for this source of R&D funding. While gas in-house distribution

funding could be much higher, only the amount that was identified -- $6 million – is used to represent this source of funds. Gas in-house funds are used to contract for R&D directly for company-only projects, for demonstrating new technology within their own systems, and for purchasing new components or equipment still in the "company proof-of-concept" stage of introduction. It was not possible to identify any similar funds being used by the transmission industry.

Consumer funds ("Delta" funds and other funds collected by LDCs based on tariff riders. See section 4.4 Recent Trends in R&D Spending of this report for more information.) do not appear separately in Table 5.2, but have been allocated to the organizations in which these funds are used: NYSEARCH and OTD, primarily. GTI and NGTC also share some of the Consumer funds.

Table 5.2 2006 Research Budgets

SOURCE	Distribution	Transmission	Storage	%
	$ million for 2006			
DOE/NETL	-	-	1.0	1.8%
PERDA	-	2.2	-	4.0%
Gas In-house	6.0	-	-	11.0%
Government CoFunds*	1.2	7.8	-	16.6%
MMS TA&R	-	4.3	-	7.9%
PHMSA†	4.1	3.9	-	14.7%
PRCI	-	7.8	0.3	14.9%
NYSEARCH	3.8	-	0.0	7.0%
OTD	7.8	-	-	14.3%
SGA/GMRC	-	0.6	-	1.1%
Other Industry‡	3.2	0.2	-	6.2%
TOTAL	26.1	26.8	1.3	100%

* Includes all non-gas industry funding associated with government projects not accounted for in other categories

† DOT's definition of distribution is under 10-in diameter.I thought it was 20% of SMYS? According to Robert Smith, PHMSA, his definition is under 10-in diameter

‡ Includes commercial research not covered in other categories

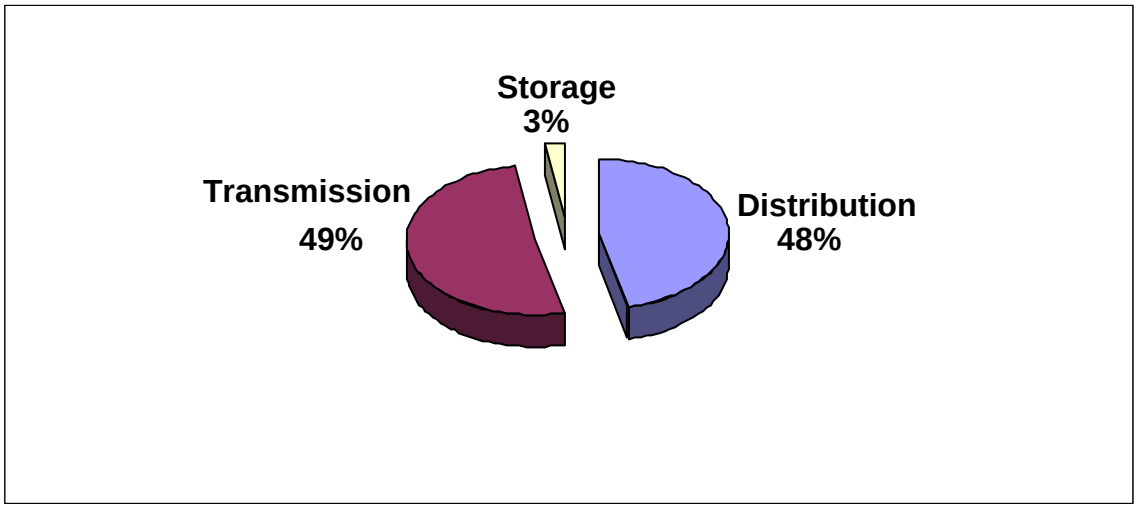
Manufacturers and service providers to the natural gas T&D industry conduct in-house R&D to maintain their competitive position and market share. Some of these manufacturers and service providers deal exclusively with the natural gas industry, but the overwhelming majority service several industries, including potable water distribution, electric distribution and transmission, telecommunications, to name a few. In many cases R&D activities simultaneously benefit several industries.

The gas industry has been successful in identifying and implementing technology developed in other industries. For example, technologies such as computers, plastic pipe joining equipment, mobile phones, lasers, and enterprise management and field workforce management software. This "source" of research, development and implementation funding can be considered "shadow research funding," in that while it benefits the natural gas industry it is not directed specifically at it or by it.

This study did not support a rigorous analysis of this source of shadow R&D funds; therefore, we can address it only anecdotally.

Some of the smaller equipment manufacturers for the distribution industry routinely spend between $100,000 - $500,000 annually on new product development and testing. Larger companies can spend millions of dollars on R&D. For example, Sensus Metering Systems, Inc., has averaged (between 2003 - 2006) over $18 million in research activities that are primarily focused on new product development. R&D activities include meter development for water and electric, as well as natural gas; more specifically, R&D activities for automated meter reading (AMR).

Figure 5.3 Proportion of R&D Funding by Sector



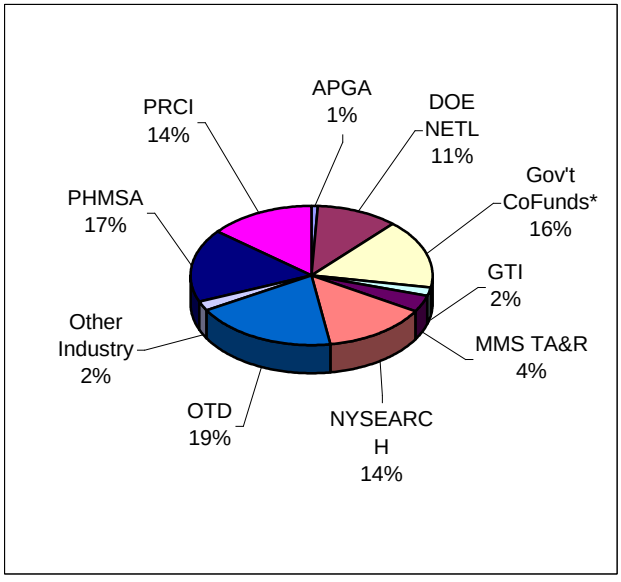
The T&D R&D funding amounts discussed so far represent those funds allocated for project activities initiated in 2006 (i.e., 2006 budgeted amounts). Since funds committed to research projects generally extend across several years the total committed funds are several times higher than the newly budgeted 2006 funds. The value of all active research projects in 2006 including these multi-year projects is shown in Table 5.3.

Table 5.3 Total Value Of Research In 2006		
SOURCE	$ million	%
APGA	0.88	0.8%
DOE/NETL	12.42	11.0%
Gov't Co Funds*	18.17	16.1%
GTI	2.33	2.1%
MMS TA&R	4.28	3.8%
NYSEARCH	15.75	14.0%
OTD	21.83	19.4%
Other Industry*	2.57	2.3%
PHMSA	18.31	16.3%
PRCI	16.00	14.2%
TOTAL	112.53	100%

* Includes all non-gas industry funding associated with government projects not accounted for in other categories

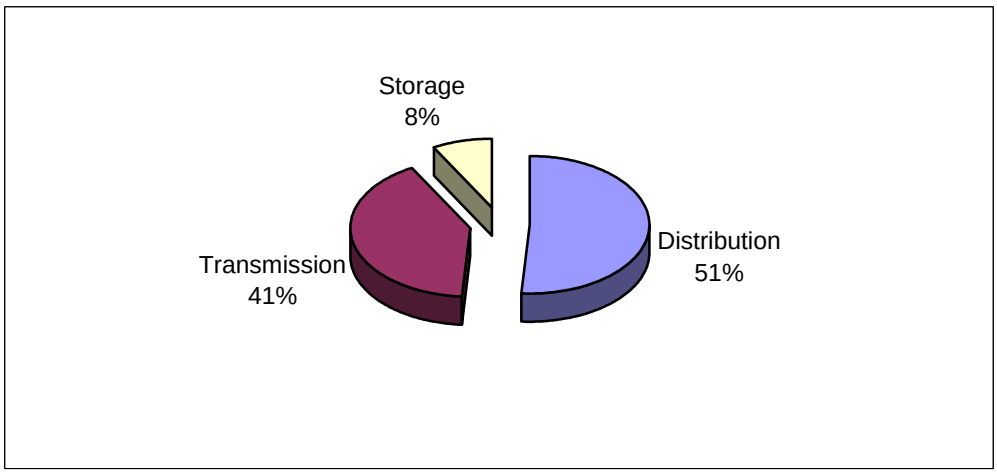
The proportion of these funds by the funding/management organizations is shown in Figure 5.4. While DOE/NETL funding was zeroed out in 2005, there were projects that did not complete until 2006.

Figure 5.4 Value of Active Research by Source of Funds



* Includes all non-gas industry funding associated with government projects not accounted for in other categories

Figure 5.5 Value of Active Research by Gas Industry Sector



The value of active projects in 2006 apportioned to sectors is shown in Figure 5.5. The apportionment is approximately the same as with 2006 budgeted project shown in Figure 5.3.

5.2.4 Focus of Natural Gas R&D for 2006 Projects

The tables 5.4 to 5.7 and charts presented as Figures 5.6-5.8 show how these R&D funds are divided into the second-order research categories that are part of the categories defined in Appendix B. As previously stated, these are funds that were budgeted for projects beginning in 2006 and are, therefore, only a snapshot of these activities.

Table 5.4 and Figure 5.6 show that the focus of distribution R&D funding is in Repair and Construction at 43% of R&D funding. The next highest activity is Inspection activities at 28% and Remote Sensing 14%.

Table 5.4 Distribution Funding Focus

DISTRIBUTION R&D				
			GOV'T	INDUSTRY
TOTALS	%	**$24,174,200**	$4,054,697	$20,119,503
Remote Sensing	14%	$3,325,064	$564,651	$2,760,413
Inspection	28%	$6,807,497	$2,438,827	$4,368,670
Boring/HDD	2%	$400,000	$0	$400,000
Repair / Construction	43%	$10,396,994	$556,381	$9,840,613
Materials / Design	3%	$758,838	$494,838	$264,000
Compressors	0%	$0	$0	$0
Automat / GPS / GIS	1%	$300,000	$0	$300,000
Measurement / Press Control	0%	$0	$0	$0
General Studies	1%	$145,000	$0	$145,000
Modeling	1%	$200,000	$0	$200,000
Environmental	4%	$958,668	$0	$958,668
Knowledge-Base	0%	$0	$0	$0
Quality / Interchangeability	4%	$882,139	$0	$882,139
Codes / Standards	0%	$0	$0	$0
Regulatory Compliance	0%	$0	$0	$0
Basic Research	0%	$0	$0	$0

Figure 5.6 Focus of R&D Funding for Distribution

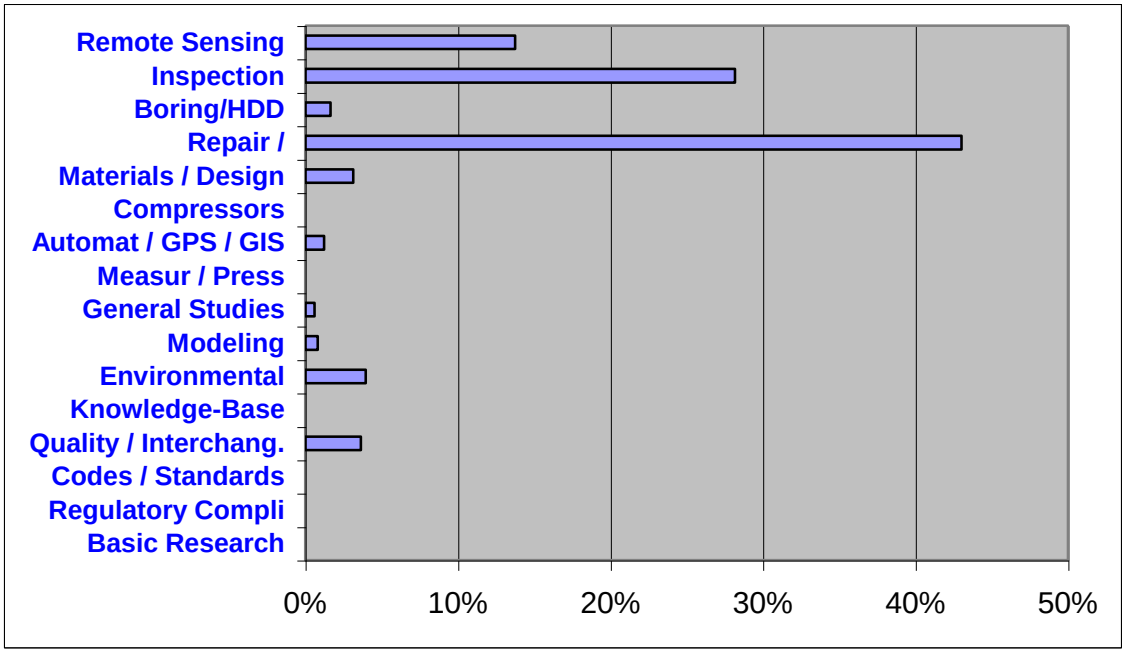


Table 5.5 and Figure 5.7 show that the focus of transmission R&D funding is in Materials and Design at 54%. This activity area is being driven by the R&D from MMS, which is exclusively classified in this area. Inspection technology research represents 20% of the R&D funding and is the area in which PHMSA allocates most of its funding.

Table 5.5 Transmission Funding Focus

TRANSMISSION R&D				
			GOV'T	INDUSTRY
TOTALS	%	**$26,753,133**	$9,688,957	$17,064,176
Remote Sensing	1%	$355,109	$355,109	$0
Inspection	22%	$5,818,960	$1,646,066	$4,172,894
Boring/HDD	2%	$421,424	$171,424	$250,000
Repair / Construction	0%	$0	$0	$0
Materials / Design	54%	$14,322,847	$5,780,000	$8,542,847
Compressors	2%	$655,116	$0	$655,116
Automat / GPS / GIS	1%	$365,000	$0	$365,000
Measurement / Press Control	2%	$468,108	$0	$468,108
General Studies	4%	$1,051,432	$716,984	$334,448
Modeling	0%	$0	$0	$0
Environmental	4%	$1,085,784	$0	$1,085,784
Knowledge-Base	0%	$0	$0	$0
Quality / Interchangeability	0%	$0	$0	$0
Codes / Standards	0%	$0	$0	$0
Regulatory Compliance	0%	$0	$0	$0
Basic Research	8%	$2,209,353	$1,019,374	$1,189,979

Figure 5.7 Focus of R&D Funding for Transmission

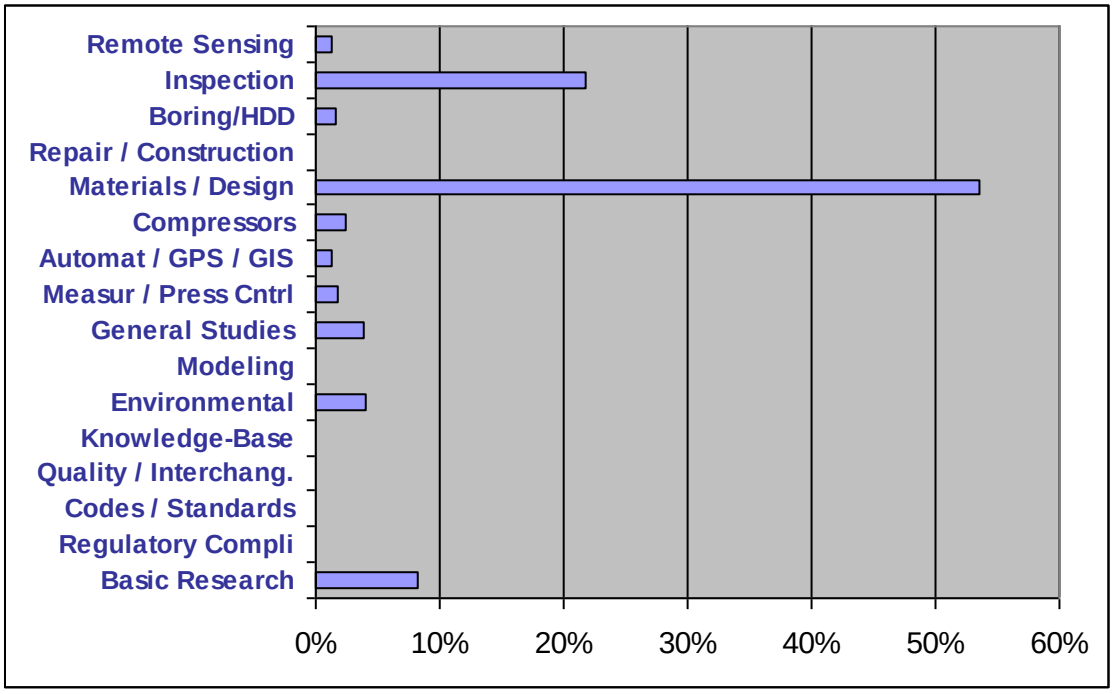
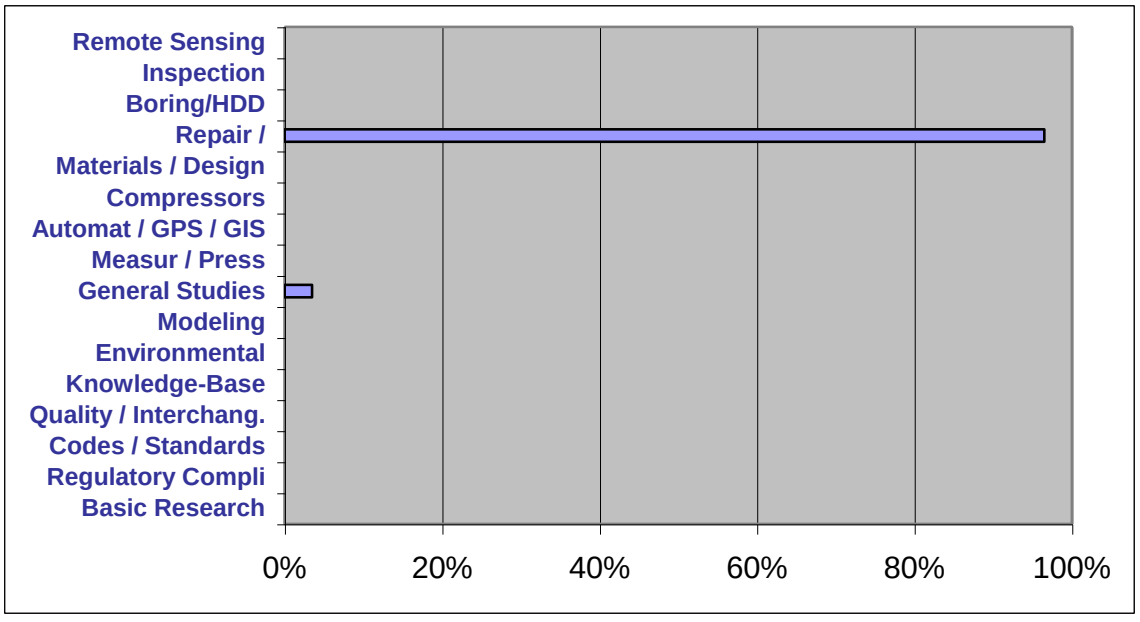


Table 5.6 and Figure 5.8 show that the storage R&D funding is focused almost exclusively on Repair/Construction activities (96%).

Table 5.6 Storage Funding Focus

STORAGE R&D				
			GOV'T	INDUSTRY
TOTALS	%	**$1,339,611**	$976,844	$362,767
Remote Sensing	0%	$0	$0	$0
Inspection	0%	$0	$0	$0
Boring/HDD	0%	$0	$0	$0
Repair / Construction	96%	$1,292,611	$976,844	$315,767
Materials / Design	0%	$0	$0	$0
Compressors	0%	$0	$0	$0
Automat / GPS / GIS	0%	$0	$0	$0
Measurement / Press Control	0%	$0	$0	$0
General Studies	4%	$47,000	$0	$47,000
Modeling	0%	$0	$0	$0
Environmental	0%	$0	$0	$0
Knowledge-Base	0%	$0	$0	$0
Quality / Interchangeability	0%	$0	$0	$0
Codes / Standards	0%	$0	$0	$0
Regulatory Compliance	0%	$0	$0	$0
Basic Research	0%	$0	$0	$0

Figure 5.8. Focus of R&D Funding for Storage

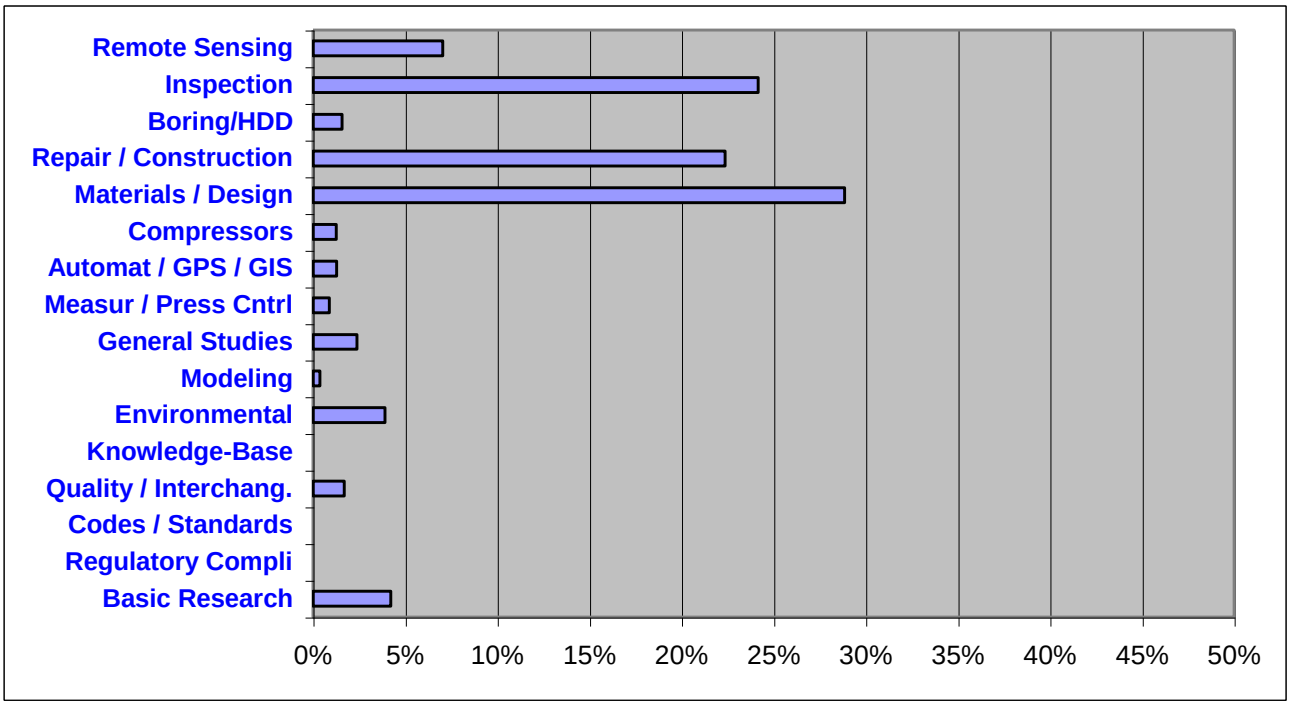


The overall focus of industry funding is shown in Table 5.7 and in Figure 5.9. This shows that overall focus of industry research funding is in Materials and Design (29%), Inspection (24%), and Repair / Construction (22%).

Table 5.7 Focus Of Overall Gas Industry Research Funding

TOTAL GAS INDUSTRY R&D FUNDING				
			GOV'T	INDUSTRY
TOTALS	%	**$52,266,944**	$14,720,498	$37,546,446
Remote Sensing	7.0%	$3,680,173	$919,760	$2,760,413
Inspection	24.2%	$12,626,457	$4,084,893	$8,541,564
Boring/HDD	1.6%	$821,424	$171,424	$650,000
Repair / Construction	22.4%	$11,689,605	$1,533,225	$10,156,380
Materials / Design	28.9%	$15,081,685	$6,274,838	$8,806,847
Compressors	1.3%	$655,116	$0	$655,116
Automat / GPS / GIS	1.3%	$665,000	$0	$665,000
Measurement / Press Control	0.9%	$468,108	$0	$468,108
General Studies	2.4%	$1,243,432	$716,984	$526,448
Modeling	0.4%	$200,000	$0	$200,000
Environmental	3.9%	$2,044,452	$0	$2,044,452
Knowledge-Base	0.0%	$0	$0	$0
Quality / Interchangeability	1.7%	$882,139	$0	$882,139
Codes / Standards	0.0%	$0	$0	$0
Regulatory Compliance	0.0%	$0	$0	$0
Basic Research	4.2%	$2,209,353	$1,019,374	$1,189,979

Figure 5.9 Focus of Overall Natural Gas Industry Research



5.2.5 Addressing the Natural Gas Industry's Objectives

Rolling up the R&D funding presented above into the six overall objectives of the natural gas industry discussed in Section 5.2.2 illustrates how R&D funding is being utilized by the gas industry. As shown in Table 5.8, 34% of funding is addressing the objective "Enhance system flexibility and throughput and reliability;" and 24% is devoted to "Improve monitoring and assessment of system integrity" and 22% to "Improve capability of cost effective construction, maintenance and repair." Just under 10% each is allocated to "Reduce incidence and cost of subsurface damage" and to "Improve data quality and timeliness for system, operation, planning and regulatory acceptance." Activities to exclusively "Identify and mitigate environmental issues" receive 4% of the R&D funds identified.

However, the environmental driver is a dominant factor behind compressor station R&D. While not specifically designated for environmental concerns, upwards of 80% of those funds are integral to fulfilling the objective "Identifying and mitigating environmental issues." This also does not include any of the activities for fugitive methane emissions mitigation, or environmental considerations that are a part of other R&D efforts. As mentioned previously, safety is an integral part of all natural gas activities. Safety is specifically an integral part of R&D directed at "Improving monitoring and assessment of system integrity," "Enhancing system flexibility and throughput and reliability;" "Reducing incidence and cost of subsurface damage" and "Improving capability of cost effective construction, maintenance and repair." These four objectives represent 90% of total R&D funding.

Table 5.8 Natural Gas Industry R&D Objectives

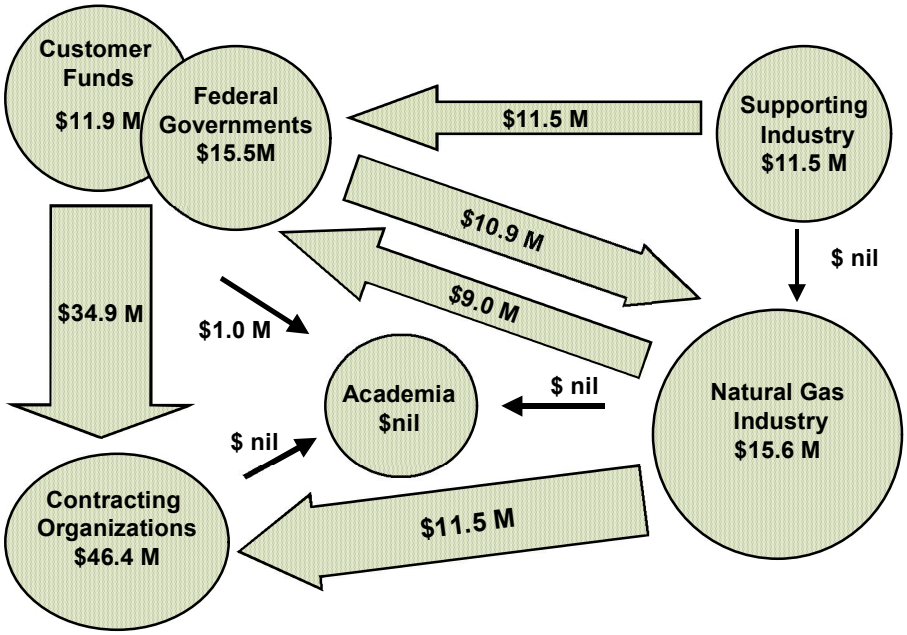
R&D Funding	Percent	Objective
$12.6	**24%**	***Improve monitoring and assessment of system integrity***
$17.8	**34%**	***Enhance system flexibility and throughput and reliability***
$4.5	**9%**	***Reduce incidence and cost of subsurface damage***
$11.7	**22%**	***Improve capability of cost effective construction, maintenance and repair***
$3.7	**7%**	***Improve data quality and timeliness for system, operation, planning and regulatory acceptance***
$2.0	**4%**	***Identify and mitigate environmental issues.***

5.2.6 Origins and Destinations for Natural Gas R&D Funds

To summarize the sources of R&D funding in the U.S. and Canada and where these funds are used the chart shown in Figure 5.10 was constructed. As shown in the chart government sources of funding total approximately $32 million from both direct government programs and from funds collected from consumers less the $11 million that is administered predominantly by gas distribution companies. To government programs cofunding by the gas industry and industrial/service companies that totals approximately $20 million is added back. Therefore,

from government and the gas industry contract research organizations receive approximately $46 million to carry out research activities. The difference between $54 million total and $46 million going to contract research organizations is due primarily to funding at universities and the use of gas industry funds in-house.

Figure 5.10. Origins and Destinations of Natural Gas R&D Funding



Due the confidentiality of the data it was not possible to determine the magnitude of funds going to each of the contracting organizations, or the amount of funds that are counted as cofunding by manufacturers, vendors and service companies.

5.3 European Natural Gas R&D Activities

Collaborative R&D is coordinated by the European Gas Research Group (GERG). Founded in 1961, a full-time Secretariat based in Brussels, manages the activities of GERG and maintains links with outside bodies, particularly the offices of the European Union and worldwide gas industry organizations.

The members of GERG include natural gas companies and research groups. GERG operates at several levels, with a Board and Plenary responsible for strategic direction, operating within a structure designed to maximize high-level networking. GERG relies principally on the interactions within the Programme Committees, where groups of technical experts, drawn from the member organizations, meet on a regular basis.

GERG's Board meets twice a year and the committees at the discretion of the chairmen. Members maintain GERG with dues and support specific R&D projects with contributions of direct and in-kind funding, and funds are also provided through the European Union's 7th R&D Framework Programme.

In 2005 (the latest information publicly available), the GERG research budget was allocated as shown in Table 5.9.

Table 5.9 European Gas Research Group (2005)

	Value $1,000	EC funding $1,000	% of total
General Studies	2,080	0	0
Transmission & Storage	4,606	1,007	21.9
Distribution	1,497	470	31.4
Utilization	26,775	16,315	60.9
Totals	34,958	17,792	50.9

Note: 1 Euro = $1.34

The budget in 2005 for Transmission and Storage was $4.6 million and Distribution $1.5 million**,** and General Studies $2.1 million for a total T&D budget of $8.2 million**;** not including the direct and indirect contribution for project participants. Since 2001, the GERG overall budget has increased 30% due to an increase in Utilization funding. During this same period, the budget for transmission projects has stayed relatively constant, however, the distribution budget is 85% less than in 2001. The GERG combined budget for Distribution and Transmission (excluding Utilization and General Studies) has declined 52% since 2001.

As in North America, European industrial concerns conduct R&D that impacts natural gas operations. There are also several government-sponsored institutions and others (e.g., The Swedish Gas Centre, Danish Gas Technology Centre) supporting some form of natural gas R&D. However, outside of GERG and individual gas companies, the overwhelming amount of funding supports end-use and hydrogen activities.

5.4 Japanese Natural Gas R&D Activities

Japan's three primary natural gas companies were reviewed for their R&D activities and budgets: Tokyo Gas Co., Ltd.; Osaka Gas Co., Ltd.; and Toho Gas Co., Ltd. For 2005, total R&D budgets for each of these companies is shown in Table 5.10.

Table 5.10. Japanese Distribution Companies R&D Budgets (2005)

	2005 R&D Expenses, $ million
Tokyo Gas	70.5
Osaka Gas	90.5
Toho Gas	25.4
TOTAL	186.4

Anecdotal evidence suggests that these funding levels were almost constant in 2006. However, the total R&D funding levels for these companies have declined since 2000 by approximately 35%. Osaka Gas indicates that 12.5% of its R&D expenses are used for cost-reduction, 8.5% for environmental protection, 9.0% for safety, 1.7% for IT and 68.4% for expanding sales of gas. Assuming that cost-reduction refers to operations, applying 12% of the R&D budgets for all three companies would mean an expenditure of $22 million for T&D research.

Research activities for Japanese gas companies include upgrading distributed energy technology (including hydrogen research); promotion of environmental preservation and energy conservation (includes CNG vehicles, advanced appliance concepts, and GHG); and strengthening of city gas infrastructure. This last activity area includes improvements in the supply infrastructure (e.g., storage), enhanced safety (e.g., maintenance of services, mains and pipelines, gas appliances), investigations of unconventional sources of gas, LNG system cost reductions, strategic use of information communication technology (ICT), and development of common applications of technological innovations in support of the regional gas utilities.

Industrial support of natural gas research in Japan must be assumed to be as it is in the rest of the world. However, GOIA was not able within the resources of this project to quantify the extent of this support. Anecdotally, UBE Industries, Ltd., has spent corporate funds for commercializing Polyamide 12 pipe, and developing a laser-welding device for PA 12 fittings.

6 COMPARISON OF NATURAL GAS R&D TO OTHER INDUSTRIES

"Current trends indicate that the "headlight beams" are being lowered in private sector R&D in the United States. That is, corporate R&D expenditures are being refocused to shorter-term, quicker-payback projects, related to near-term business goals, in response to corporate restructuring and financial market pressures."

"A Brewing R&D Crisis", a report on U.S. Energy R&D, Daniel Yergin, Chair, DOE Energy R&D Task Force[17]

A comparison of natural gas transmission and distribution R&D spending to other industries can help place the current situation into context. This section discusses the results of research to determine funding levels and R&D funding intensities in other industries that are relevant to natural gas transmission and distribution. The R&D funding mechanisms and models adopted, and the objectives of R&D programs will not only provide benchmarks for industry funding levels, but may also offer insights regarding how R&D is effectively organized.

6.1 Methodology and Approach for Industry Comparison

6.1.1 Metrics For Comparing R&D Spending Across Industries

To make the comparison to other industries, it is important to: 1) provide a basis for establishing what is important in comparing R&D models in different industries, 2) determine appropriate and comparable measures of R&D investment and success, and 3) develop a set of metrics that are relevant to the natural gas industry. The literature was surveyed to develop appropriate metrics for comparison.

The most common metric used in comparing R&D spending among industries is R&D intensity. To normalize for industry size, this measure divides R&D spending by industry revenues. However, some adjustments are needed to the reported data to capture revenues that only apply to a particular industry (e.g., separating revenue for transporting a commodity from revenue associated with the sale of the commodity).

The R&D intensity comparisons in this report are base on adjusted R&D intensities. For natural gas transmission and distribution, total industry revenue includes wellhead, transmission to the city-gate, and distribution. To obtain gas industry transmission and distribution revenues, the gas commodity (reflecting the gas production cost) component is subtracted. In this way, only the industry revenues for the transmission and distribution functions are captured. The same approach was taken in comparing the gas industry to the transportation and utilities industries

[17] Energy R&D: Shaping Our Nation's Future in a Competitive World; report of the Task Force on Strategic Energy R&D (Yergin Report), June 1995

6.1.2 Criteria for Selecting the Best Industries for Comparison

Important characteristics in comparing R&D spending and models in different industries include:

1) **Industry type:** Natural gas transmission and distribution involves the transportation of a commodity, rather than production
2) **Industry maturity:** The natural gas industry is well over a century old and has grown to serve most homes and businesses in the U.S.
3) **Growth rates:** By several measures (e.g., customers, volumes), the gas industry is growing at a few percent per year
4) **Degree of regulation:** Despite recent efforts at regulatory restructuring, the natural gas industry continues to be highly regulated at the federal and state level.

Comparing R&D investments made in gas T&D to other industries requires careful analysis of the data to ensure a common, "apples-to-apples" comparison. One key characteristic is the difference in each industry's position in the product manufacturing and distribution channel. For example, a durable good, such as a gas furnace, requires raw material mining, equipment manufacturing, product assembly, transportation, and retail distribution. Each of these functions has its own R&D intensity. Natural gas transmission and distribution are similar to the transportation and distribution functions in other areas of the economy. Care must be taken to define revenue only as it applies to the transmission or distribution function and not include revenues for the commodity or product transported.

6.1.3 Selecting the Best Industries for Comparison

An initial point of comparison for the natural gas industry is the U.S. economy as a whole. How does the R&D investment for natural gas transmission and distribution compare to the average for the aggregate U.S. economy?

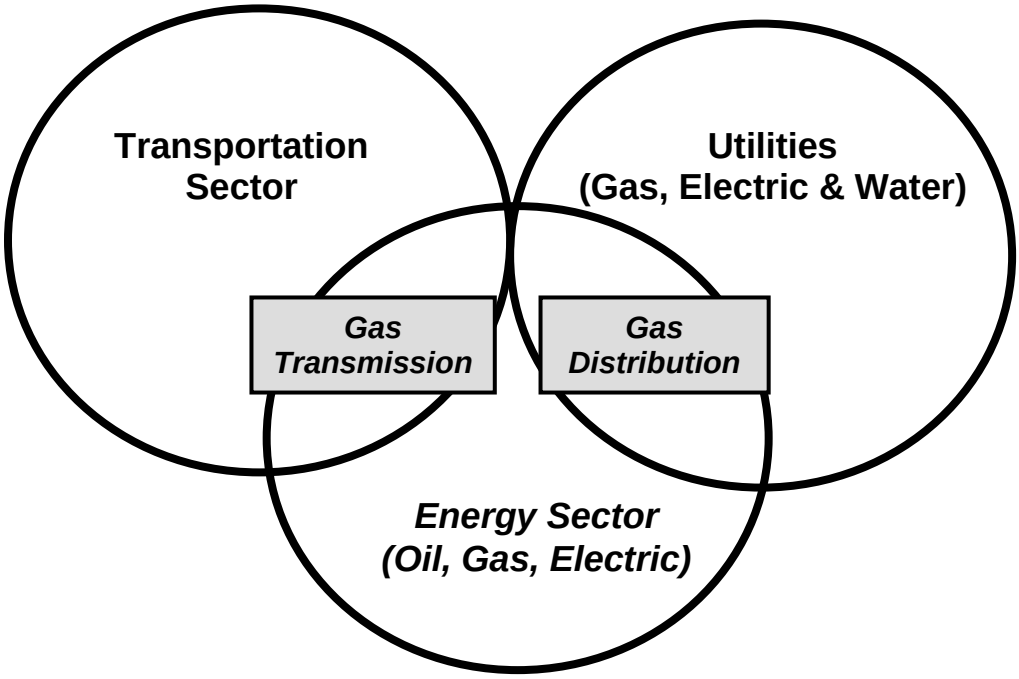
It is also instructive to examine different kinds of industries as well as several key industries. Some industries, such as the high-growth high-tech sectors (e.g., computer software, pharmaceuticals, and scientific instruments) are not comparable to the natural gas transmission and distribution industries. These sectors rely upon the development of new end-use products to achieve growth and should be excluded from the comparison.

Industries that play an integral role in the U.S. economy are instructive to compare (e.g., primary metals, metal products, plastics & chemicals). However, manufacturing industries should be compared to natural gas transmission and distribution with the important caveat that transportation companies only have an indirect stake in the development of new products (they do not make money on the sale of or utilization of the product, but transport more product if the market grows).

This study compares the gas transmission and distribution sectors to three other sectors: 1) the energy sector as a whole (the energy sector includes both gas transmission and distribution), 2) the non-manufacturing transportation sector (including gas pipelines), and 3) utilities (including gas distribution). Within the U.S. economy, the transportation sector (airlines, rail and trucking) is structurally similar to gas transmission. Transportation industries are functionally focused on moving commodities on behalf of others, have largely mature infrastructures and customer bases with moderate to slow growth, are at least partially regulated and have R&D programs that emphasize public safety objectives. Similarly, the network industries - electric and water utilities - are most relevant to gas distribution. They are franchise-based public utilities with rates regulated by state public utility commissions.

In addition, the gas transmission and distribution sectors are a part of the aggregate energy industry. The additional and unique perspective of the energy industry is also insightful for a comparison of R&D program funding levels. How these industries complement and overlap each other is show in Figure 6.1.

Figure 6.1 Sectors for Comparison to Gas Transmission and Distribution



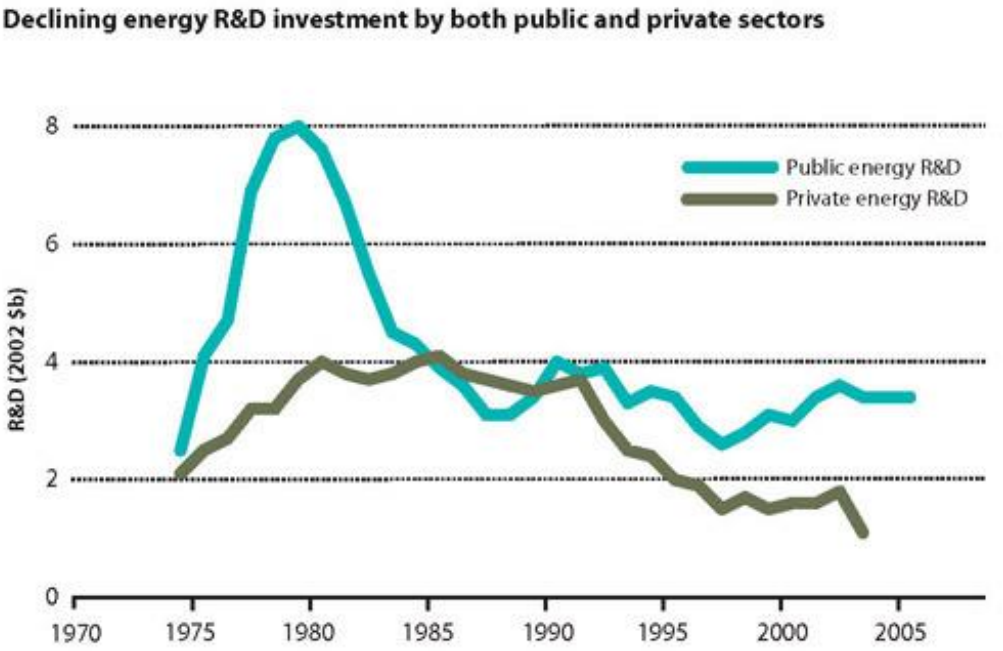
6.1.4 Data Sources for Industry R&D Funding Comparison

The most recognized source of information on U.S. R&D spending is based on a survey conducted by the National Science Foundation. The limitations of this source, as well as the other sources of data identified as part of this study, did not allow an examination of R&D spending at the level of detail of the gas distribution and transmission industries. However, R&D funding levels and intensities are available for aggregate utility, transportation and energy industries.

6.2 The Energy Industry

The energy industry is a crosscutting category of industry research that includes segments from manufacturing (refineries, appliance and vehicle production) and non-manufacturing (mining, oil & gas production, utilities, and pipelines). In 2003, over $2 billion dollars of R&D was performed in the various segments of the energy industry[18]. An additional $2 billion of R&D was performed in government labs with funding from DOE. The R&D intensity for the energy industry as a whole is 0.5%[19].

Figure 6.2 Energy Industry R&D Spending



Sources: R.M. Wolfe, Research and Development in Industry (National Science Foundation, Division of Science Resources Statistics, 2004); M. Jefferson, et. Al., "Energy Technologies for the 21st Century" (World Energy Council, 2001); R.I. Meeles, "Federal R&D Funding by Budget Function: Fiscal years 2003-05" NSF 05-303 (National Science Foundation, Division of Science Resources Statistics, 2004D; R. Margolis, and D.M. Kammen "Underinvestment: "The energy technology and R&D policy challenge," *Science, 285, 690-692 (1999)*

Published in *(Reversing the Incredible Shrinking R&D Budget*, by Daniel Kammen and Gregory Nemet, the Berkeley Institute of the Environment and the University of California, November 17, 2005, in Energy Central's Energy Pulse)

[18] Data provided by National Science Foundation.
[19] *Underinvestment: The Energy Technology and R&D Policy Challenge*, Margolis, Robert M., and Daniel M. Kammen, Science, Vol. 285, July 30, 1999.

The energy industry has been characterized as a critical industry to the U.S. economy and the levels of investment in energy R&D have recently been reviewed[20]. In addition to concern about the declining levels of R&D spending in the energy industry, there was also concern about the nature of the research.

The natural gas transmission and distribution industry, as a component of the energy industry, is part of the national discussion of energy R&D. Two industries, the propane and oil heat industry are also appropriate to examine because of their approaches to R&D.

6.2.1 The Propane Industry

The propane industry is similar to that of natural gas. The retail propane sector is approximately a $10 billion industry, which excludes direct sales as feedstock to the chemical industry[21]. About one-half of this is for wholesale propane fuel[22]. The propane industry includes a fuel delivery infrastructure of over 70,000 miles of pipeline and over 35,000 fuel transport trucks. Over 56,000 people work for about 8,000 retail propane companies serving nearly 17 million residential, commercial, industrial, transportation and agricultural customers.

The Propane Education and Research Council (PERC) formed in 1996 after the Propane Education and Research Act was passed by Congress. PERC is funded by a half-cent surcharge (per gallon) on all odorized propane sales. PERC funding in 2006 is expected to be $50.4 million. These funds are directed toward programs that increase public awareness of propane, improve customer employee and customer safety and fund R&D[23]. Most of the R&D projects are end-use, but retail operations (roughly the equivalent of natural gas transmission and distribution operations) received about 25% of the R&D funds in 2005. This share of the $6 million R&D budget for 2006 is $1.5 million. This equates to an R&D intensity is 0.03%. However, to put this on a common basis with the R&D intensity in the natural gas industry, cofunding and other funding sources would have to be included. The PERC R&D strategy emphasizes partnering with other funding organizations, so cofunding is expected to be important.

6.2.2 The Oil Heat Industry

After a federal law was passed in 2001, the retail oil heat distributors initiated a program similar to the PERC program, with the assessed surcharge at 0.2 cents per gallon. The objectives of the program, administered by the National Oilheat Research Alliance (NORA), are similar to the PERC program in the propane industry in that most of the funds collected are directed toward industry training and consumer education needs[24].

The R&D program is 4.1% of the budget, which represents $630,000 in 2006. The objectives of the research program include heating equipment efficiency and emissions and environmental and safety aspects of oil storage tanks. The net retail oil heat industry revenues ($3.2 billion) can be estimated by multiplying the estimated volumes carrying the surcharge (7.75 billion gallons) and

[20] Report of the U.S. Task force on energy R&D chaired by Daniel Yergin.
[21] American Petroleum Institute Statistics (*2003 Sales of Natural Gas Liquids*)
[22] Energy Information Administration Petroleum Web Page, U.S. Average 2003 data.
[23] Propane Technology Review, Propane Education and Research Council (PERC), April 2006.
[24] Research objectives and budgets from www.oilheat-nora.org

the net rate for the product ($0.42 per gallon)[25]. This results in an R&D intensity of 0.02%. This figure also does not include cofunding or R&D funding from any other source. A 2006 NYSERDA research project funded at $500,000 to test the performance of oil heat equipment on low-sulfur oil would significantly increase the intensity if factored in[26]. The inclusion of federal government R&D programs would similarly increase the R&D intensity estimate for the oil heat industry.

6.3 Comparison to Transportation Industries

It is a key goal of this project to determine the prudent and correct levels of investment and research for the natural gas transmission and distribution pipeline sectors. This will be completed, in part, by comparing and benchmarking the natural gas industry's investment in R&D with similar types of industries.

The focus of this task was to assess the research objectives and priorities and R&D intensities of the airline, rail, and trucking industries. These industries were selected because, like the natural gas industry, revenues are derived from the transportation of people or products (as opposed to manufacturing or selling products), government regulation is a major factor in business operations, and great emphasis is placed on managing prominent industry safety objectives.

For purposes of contrast and comparison, the R&D intensities of several leading manufacturers were evaluated.

6.3.1 Airline Industry

Six airline companies represent over 90% of the total domestic U.S. passenger traffic: Southwest, American, United, Delta, Northwest, and Continental. Over 402 million passengers have taken over 7 million trips. Most passenger airlines experienced net financial losses in 2005 and have no significant R&D programs. The Air Transport Association, the trade organizations of the principal U.S. airline companies, tracks and influences the program of Federal Aviation Administration but does not apparently pool resources of its members for R&D purposes.

Airplane manufacturers such as Boeing, United Technologies Research Center (UTRC) have large R&D programs that focus on materials and structures. These highly competitive organizations do not disclose details of their R&D expenditures.

The Federal Aviation Administration (FAA) is responsible for enhancing the safety and increasing the capacity of the nation's aviation system. FAA's Office of Aviation Research and Development conducts high-priority research and development to ensure and enhance a safe, efficient, and environmentally acceptable global aviation system. It is the vision of the FAA R&D program to provide the best air transportation system through the conduct of world-class, cutting-edge research, engineering, and development.

[25] Retail (residential product) and wholesale prices were averaged from 2001-2005. The data is from the Energy Information Administration Petroleum Web Page.
[26] NYSERDA PON #1023; www.NYSERDA.org

FAA's R&D portfolio used to be much larger before the September 2001 terrorist attacks; most of the aviation security R&D budgets were transferred to the Department of Homeland Security (DHS) in 2003.

The FAA R&D program encompasses the following program elements:

- Fire research and safety
- Aircraft catastrophic failure prevention
- Aviation safety & risk analysis
- Integrating human factors
- Airport technology R&D
- Materials/structural safety.

R&D (in 2005) addressed facilities, equipment, and operations at a funding level of $130 million. Total revenues from passenger ($124 billion) and air cargo freight ($26 billion) service were $150 billion in 2005. The R&D intensity for the airline industry is 0.09%.

6.3.2 Railroad Industry

In 2000, the entire U.S. railroad system encompassed 660 railroads, 220,000 miles of track, 20,000 freight locomotives, and 8,800 passenger locomotives/coaches. There are seven major freight railroads in the United States representing ~93% of all freight railroad business. In terms of passenger service, Amtrak remains the sole provider of intercity rail service; Alaska Railroad operates intercity rail passenger service in Alaska.

The Association of American Railroads (AAR) represents the major freight railroads. AAR tracks and influences the research agenda of FRA (see below) but does not collect and manage member R&D on behalf of its members. In addition, Class I freight railroads such as CSX Transportation and Union Pacific apply cutting edge technology routinely in their business operations but have no apparent R&D programs.

The Federal Railroad Administration (FRA) was created in 1966 to promulgate and enforce rail safety, administer railroad assistance programs, conduct R&D, rehabilitate Northeast corridor rail passenger service, and consolidate government program rail transportation activities. The demands on a continuously growing system require advance technologies and innovative approaches to improve system effectiveness and efficiency. The highest priority of the FRA program is the safety of the railroad system.

FRA's Office of Research and Development conducts research, development, test, and evaluation projects to support its safety mission and to enhance the railroad system as a national transportation resource. R&D program areas include:

- Railroad Research and Development
- Railroad System Issues – Safety, Security, and Environment
- Human Factors
- Rolling Stock and Components
- Track and Structures
- Track-Train Interactions

- Train Control
- Grade Crossings
- Hazardous Materials and Transportation
- Train Occupant Protection
- R&D Facilities and Equipment.

R&D (in 2002) addressed next generation high-speed rail, magnetic levitation, and other broad research areas at a funding level of $65 million. Total revenues from freight ($42 billion) and passengers/commuters ($2 billion) were $44 billion in 2004. The R&D intensity for the railroad industry is 0.15%.

6.3.3 Trucking Industry

The trucking industry, using 15.5 million trucks, hauled 68.9% of all the tons of freight transported in the United States (2003). The trucking industry is a major employer in the U.S. Across all industries, more than 8.6 million people were employed in trucking-related jobs in 2003; over 3 million of these people were truck drivers.

The American Trucking Association (ATA) is a federation of 50 affiliated state trucking associations and councils representing specialized areas of the trucking industry. The American Transportation Research Institute (ATRI), a part of ATA, is a leader in transportation related research. ATRI's research program addresses the trucking industry's role in a safe, efficient, and viable transportation system. ATRI receives 50% government funds (see below) and 50% private or collaborative funding. Dan Murray, Vice President of ATRI, reports that funding levels are not publicly available.

Truck manufacturers such as Mack Trucks (Volvo) spend considerable research dollars on new product and equipment development including environmental and safety issues. Environmental and safety programs address hybrid electric/diesel vehicles, traffic safety, energy absorbent cab zones, and accident prevention research. Though overall research expenditures are well characterized they are not differentiated to allow comparison and analysis for this project.

The Department of Transportation provides the primary funding of research and development for the trucking industry. Research is conducting under the following programs:

- Federal Highway Administration (FHWA)
- Federal Motor Carrier Safety Administration (FMCSA)
- National Highway Traffic Safety Administration (NHTSA)
- Research and Innovation Technology Administration (RITA).

It is the primary goal of the DOT programs to enhance the quality and performance of the U.S. highway system and prevent commercial motor vehicle-related fatalities and injuries. R&D program areas include:

- Surface transportation
- Highway operations
- Safety

- Pavements
- Intelligent transportation system
- State/local government directed R&D
- Reduce number/severity of commercial motor vehicle hazardous materials incidents
- Occupant protection and biomechanics
- Driver distraction
- Crash causation
- Remote sensing.

R&D conducted by FHWA ($445 million), NHTSA ($62 million), and RITA ($2 million; assuming 50% of total allocated) totaled $509 million in 2006. Total trucking industry revenues were $610 billion in 2003. The R&D intensity for the trucking industry is 0.08%.

6.4 Comparison to Network Industries

Network industries, electricity, water, and telecommunications – are relevant to the natural gas industry experience because of their franchise status in distribution and, in some cases, interstate transmission. Regulatory policy history, jurisdictions, and mix of regulation and competition are very similar. Therefore, it is believed that insights on successful organizational strategies for the network industries would be similar and more relevant to the natural gas industry.

The comparison will focus on the utilities sector. The utilities sector is described by the U.S. Census[27] as "industries in the utilities sub-sector provide electric power, natural gas, steam supply, water supply, and sewage removal through a permanent infrastructure of lines, mains, and pipes." Total revenue for the entire utilities sector is approximately $400 billion, with about three-quarters in the electric industry. In 2003, the overall R&D intensity for the utilities sector was estimated to be 0.1%[28]. This is a significant decrease compared to 1994 when the number was 0.3%.[29].

The telecommunications industry is excluded from a comparison to natural gas transmission and distribution because of its recent high-growth history. However, the experience of the telecommunications industry in maintaining historically effective collaborative R&D structures is relevant to natural gas and is discussed.

6.4.1 Electric Industry R&D

The U.S. electric industry includes power generation, transmission, distribution and consumption. The comparison focused on electric transmission and distribution. Funding sources include industry collaborative (EPRI and NRECA) and government. Other sources are discussed as well.

[27] U.S. Census Bureau, 2002 U.S. Economic Census (utilities are defined as NAICS code 22), http://www.census.gov/econ/census02/data/industry/E221320.HTM

[28] National Science Foundation, Division of Science Resource Statistics, Survey of Industrial Research and Development (2003)

[29] J.J. Dooley. Unintended Consequences: Energy R&D in a Deregulated Market. Pacific Northwest National Laboratory. Washington, D.C. PNNL-SA-28561. February 6, 1997

6.4.1.1 EPRI

EPRI was established in 1973 as an independent, nonprofit center for public interest energy and environmental research. EPRI brings together members, participants, its scientists and engineers, and other leading experts to work collaboratively on solutions to the challenges of electric power. These solutions span the areas of electricity generation, delivery, and use, including health, safety, and environment. EPRI's members represent over 90% of the electricity generated in the United States.

It is the vision of the EPRI program to conduct world-class, collaborative R&D with focus on safe, reliable, economical, and environmentally friendly electricity; increase value of collaborative R&D by enhancing technology transfer and assisting in applying research results. It is EPRI's mission to provide the knowledge, tools, and technology to make fully informed decisions in managing physical and human assets; assist in technology transfer to maximize value to client organizations.

The EPRI program addresses the research areas of power delivery and customer markets, generation, nuclear, and environment. In addition, EPRI sets aside funds for a sustained cross-cutting program, called Technology Innovation, focused on creating new knowledge and stimulating innovation. For purposes of this study, only the power delivery and environmental program elements, which are analogous to activities within gas distribution and transmission, will be fully considered.

Following are the major thrusts of EPRI's R&D Portfolio:

- Maximize useful life of existing assets (e.g., power plants, transmission/distribution lines, facilities)
- Technologies that will enable a high-performance workforce; especially in light of aging workforce and pending retirements
- Assist smooth, resource-effective transition to new assets through supply chain
- Assist in understanding and managing environmental risks associated with distribution, generation, or utilization of electricity; provide scientific basis for informing public policy.

EPRI's membership consists of 175 organizations; 64% are investor-owned and 13% are international. The balance of the membership consists of federal and state organizations (7%), municipalities (7%), cooperatives (6%), and independent power producers (3%). Revenues from membership fees totaled $149 million in 2005.

R&D program funding levels targeting Power Delivery (excluding utilization, retail, power markets & risks) and Environmental in 2006 were $83 million. In addition, longer-term research in these same areas under the Technology Innovation program totaled approximately $5 million in 2006.

6.4.1.2 National Rural Electric Cooperative Association

Cooperative Research Network (CRN), part of the National Rural Electric Cooperative Association monitors, evaluates and applies technologies that help its member co-ops control costs, improve productivity, deliver superior service and keep up with emerging technologies. About $5 million R&D budget administered through a 55 cents per meter surcharge on electric coops representing roughly 8-10 million customers.

Membership in CRN is voluntary, and includes generation and transmission co-ops and distribution co-ops. Six member advisory boards ensure that CRN members have a voice in research-project selection, funding and organizational policy.

CRN currently is focusing its research efforts in six critical areas:

- Clean coal and environmental-management technologies
- Renewable and alternative energy
- End-use solutions that help the customer make better use of electricity
- Distribution system operations best practices
- Broadband communications and information technology
- Transmission capacity and security.

To achieve its research goals, CRN partners with other organizations such as EPRI (see above) and the Department of Energy. CRN transfers knowledge to its members through online and printed studies, reports, newsletters, web conferences, seminars and presentations at industry events.

6.4.1.3 Federal Government R&D Funding Sources

The primary federal funding source for electric transmission and distribution R&D is the DOE. The Office of Electricity Delivery & Energy Reliability manages an R&D program[30] funded at $89 million in 2005 consistent with the following mission: *"The mission of the Office of Electricity Delivery and Energy Reliability is to lead national efforts to modernize the electric grid, enhance security and reliability of the energy infrastructure, and facilitate recovery from disruptions to the energy supply."*

The largest R&D program is in High-Temperature Superconductivity, funded at $53 million in 2005. Electric Transmission Reliability R&D is funded at $15 million, Distribution R&D at $5 million, Storage R&D at $4 million, and other programs (Gridwise and Gridworks) at $12 million.

In addition to these applied programs, the Office of Basic Energy Sciences funds a broad, crosscutting program in basic research on fundamental energy-related science. Programs are organized into two primary research areas: 1) Materials Science and Engineering, and 2) Chemical Sciences, Geosciences, and Biosciences. The total budget for R&D in Basic Energy

[30] Current appropriation for FY 2005 (from DOE's 2007 Congressional Budget Request, Volume 3, dated February, 2006)

Sciences is $3.6 billion. An important component of the Basic Energy Sciences program is research on superconductivity.

The coordination between basic and applied R&D programs in superconductivity requires an on-going effort[31]. The interdependency of basic research and applied research has been noted by DOE[32]:

> *"For BES research to be relevant to the DOE technology programs that fund R&D towards specific near-to-mid-term needs, it is very important to maintain strong, continual coordination activities between BES and other DOE program offices. The intrinsic dissimilarity of research objectives—that the expansive goals of basic research are to understand the fundamentals of phenomena in general, whereas the focused goals of applied research and development are to gain and apply knowledge to achieve specific requirements—represents the primary challenge of meaningfully integrating R&D within DOE."*

6.4.1.4 Other Electric T&D Funding Sources

Many of the electric industry collaborative and government programs include cofunding from individual electric utilities and electric industry equipment providers. Other government agencies besides DOE (e.g., the EPA) have had some on-going research directed at electric transmission and distribution issues. State governments may also fund electric T&D R&D (e.g., NYSERDA funds research in electric T&D). Individual electric utility companies may have their own internal R&D budgets, just as some gas companies.

Industry revenues that apply only to the electric transmission and distribution functions totaled $90 billion in 2003[33] based on EIA's Annual Energy Outlook. Electric industry R&D funds, considering the EPRI program ($88 million), R&D conducted by the National Rural Electric Cooperative Association ($5 million), and federal government funding ($89 million) were $182 million. The R&D intensity for the electric industry is 0.20%.

6.4.2 Potable Water Distribution

Awwa Research Foundation (AwwaRF) was established in 1966 to provide a centralized, practical research program for the drinking water community. The primary source of funding for the organization comes from U.S. water utilities that pay a voluntarily subscription fee. AwwaRF had approximately 889 utility subscribers in 2005 paying revenues of $13 million. In addition, AwwaRF estimates that approximately 7% of the estimated federal funding of $700 million on water related research and development, or $49 million, applies to infrastructure related issues.

---

[31] *Basic Research Needs for Superconductivity, Report of the Basic Energy Sciences Workshop on Superconductivity*, May 8-10, 2006, co-sponsored by the Offices of Basic Energy Sciences and Electricity Delivery and Energy Reliability.

[32] From information on Office of Basic Energy Sciences website: http://www.sc.doe.gov/bes/bes.html

[33] Energy Information Administration, Annual Energy Outlook (AEO) 2006 Supplemental Tables (2004 Data) http://www.eia.doe.gov/oiaf/forecasting.html

It is the mission of AwwaRF to advance the science of water to improve the quality of life. AwwaRF achieves its mission by sponsoring research, developing and transmitting knowledge to stakeholders, and promoting collaboration and partnerships.

AwwaRF's research programs address the following areas: High-quality water, infrastructure reliability, environmental leadership, distribution, and health effects. It is estimated that total revenues associated with providing water distribution service is $33 billion. R&D funding supporting the water distribution infrastructure, engineering, and quality/environmental issues is approximately $62 million in 2006. The R&D intensity for the water industry is 0.19%.

6.4.3 Telecommunications

As a network industry, the telecommunications sector is similar to the natural gas industry. Specifically, the experience with deregulation and R&D applies is some ways to the gas industry.

However, the industry has expanded to integrate voice, video and data and expanded media to include wireless, satellite & cable and broadband fiber. As a result, telecommunications is a high-growth industry that is different from the natural gas industry.

Telecommunications found a workable mechanism to fund industry research through a tax levied on the service revenues of most of the Bell operating companies. This approach was approved by state regulators.

New competitive challenges, however, put pressure on R&D programs. Lower telecommunications prices, and decreasing telecommunications revenues for AT&T, as well as the regulatory pressure to lose market share to new competitors, led to the beginning of the reduction in the long-term, unfettered, fundamental research. Excess infrastructure capacity further squeezed the industry as demand for the installed facilities slowed.

Telecommunications revenues in 2003 totaled $335 billion. Industry R&D in 2001, as captured by the Bell family of laboratories only, totaled approximately $6 billion. The R&D intensity for the telecommunications industry is 1.8%[34].

6.5 Selected Manufacturers

Total research as a percentage of corporate revenues (e.g., R&D intensity) was determined for four manufacturers as surrogates for the broader manufacturing sector: United Technologies Corporation, 3M Corporation, Owens Corning, and Boeing Company.

[34] ***Renewing U.S. Telecommunications Research***, Committee on Telecommunications Research and Development, National Research Council, National Academy of Sciences, 2006

The research focus of all the companies targeted new product development and product extensions. In addition, internal process improvements were conducted by the companies. It is a hypothesis of this study that internal process improvement is more analogous to the operations-oriented R&D of pipelines and distribution utilities. However, to date, it has not been possible to extract R&D funds solely targeting internal process improvements.

In 2005, the R&D intensity for UTRC, 3M, and Boeing was 6.7%, 5.9%, and 5.1%, respectively. Owens Corning exhibited an R&D intensity of 0.9% in 2002; more recent data is not available for this study.

6.6 Summary of Comparison of Natural Gas T&D to Other Industries

- In contrast to the gas T&D industry, R&D spending in U.S. industry as a whole has been increasing. However, R&D spending in the energy industry as a whole, which includes gas transmission and distribution, has been declining. Several national studies have raised concern over these trends. In addition, natural gas R&D has also been declining in other countries that have traditionally supported R&D.

- Key non-manufacturing transportation industries - air, rail and trucking transportation - all have federal government R&D programs generally targeting safety and reliability improvements analogous to the DOT PHMSA R&D program for gas pipeline safety and reliability. The $8 million in gas pipeline R&D includes $4 million from DOT PHMSA and $4 million from MMS for R&D limited to offshore pipelines. The R&D intensity[*] of the combined U.S. government R&D funding is 0.05%. As shown in Table 6.1, the R&D intensity of the corresponding safety agency R&D programs is 0.10% for air transportation, 0.07% for trucking transportation, and 0.15% for rail transportation.

Table 6.1 Gas Transmission US Government R&D Funding

Sector	***Primary Federal Agency***	***2006 Allocation***	***R&D Intensity***
Gas Pipelines	DOT/MMS	$8 million	0.05%
Airlines	FAA	$130 million	0.10%
Trucking	FHSA	$445 million	0.07%
Rail	RRA	$65 million	0.15%

- Government funding of distribution R&D is significantly less than comparable electric and potable water utilities, as shown in Table 6.2. The recent elimination of DOE funding has reduced the government contribution to R&D intensity for gas distribution infrastructure.

[*] R&D intensity is defined as research funds divided by net revenues.

Table 6.2 Gas Distribution US Government R&D Funding

Sector	***Primary Federal Agency***	***2006 Allocation***	***R&D Intensity***
Gas Distribution	DOT	$ 4 million	0.01%
Electric T&D	DOE	$89 million	0.10%
Water Utilities	EPA	$49 million	0.15%

- The U.S. gas distribution industry's collaborative R&D funding is also less than comparable industries. The gas industry R&D intensity (through OTD/ NYSEARCH/GTI) at 0.03% is less than potable water (through American Water Works Association Research Foundation - AwwaRF) at 0.04%. The R&D intensity for all gas T&D collaborative R&D (through OTD/NYSEARCH/GTI/PRCI) at 0.04% is less than half of the electric industry collaborative T&D R&D (through EPRI) at 0.10%.

7 R&D ORGANIZATIONAL STRUCTURES AND STRATEGIES

The purpose of this section is to present the results of research into R&D organizational structures and strategies in the global market, but also to examine historical and current practices in the gas T&D industry. This section is based on a review of the general business literature on successful R&D models and an assessment of current and historical approaches to gas T&D R&D management. While it is not within the scope of this project to establish the relative success of gas industry R&D investments compared to other industries, it is possible to make some general observations based on the results of this project.

7.1 R&D Investment and Corporate Performance

The linkage between investment in R&D and standard measures of corporate performance is tenuous. Nevertheless, the R&D management professional community believes it is important and valuable to track and measure R&D performance[35].

Many recent studies based on a significant body of business research find a positive correlation between R&D spending and long-term measures of corporate performance [36,37,38]. Various measures of corporate performance were tracked to measure R&D success, including profitability, sales growth, productivity growth, patent production, stock price and market-to-book value.

For example, a recent study found:[39]

> *"Investments in research and development (R&D) and in advertising, although they generally reduce short-term profits, can significantly boost a company's long-term valuation."*

Further, a strong relationship was established between R&D spending and sales growth when a funding threshold was exceeded. No such correlation exists for firms that spend below the industry average. For competitive industries, firms with R&D intensities of at least three percent exhibited sales growth leadership within their industry; firms with R&D intensities of two percent or less were sales growth laggards. A recent industry study concludes[40]:

> "*Spending more doesn't necessarily help, but spending too little will hurt."*

[35] Measuring R&D Productivity, Mark G. Brown and Raynold A. Svenson, Research Technology Management, July-August, 1988.
[36] The Contribution of R&D to Productivity Growth, Leo Sveikauskas, Monthly Labor Review, Bureau of Labor Statistics, March, 1986, Vol. 109, No. 3.
[37] The Stock Market Valuation of R&D Leaders, Baruch Lev, Suresh Radhakrishnan, Mustafa Ciftci, December, 2005.
[38] Advertising Intensity and R&D Intensity: Differences Across Industries and Their Impact on Firm's Performance, Trina Larson Andras and Srini S. Srinivasan, International Journal of Business and Economics, 2003, Vol.2, No. 2, 167-176.
[39] "*The Value of Investments in Intangibles*", Massachusetts Institute of Technology Sloan School of Management. The study was summarized in the Fall, 2001, issue of MIT Sloan Management Review.
[40] Global Innovation 1000-Money Isn't Everything, Booz, Allen and Hamilton, Press Release dated October 11, 2005.

In addition, the literature states that the methods and practices in approaching and managing R&D are critical to obtaining the benefits. A sponsor of a recently completed analysis of R&D spending in U.S. industry concludes:

> *"Successful innovation demands careful coordination and orchestration both internally and externally. How you spend is far more important than how much you spend."*[41]

The Chief Innovation Officer of Dupont states[42]:

> *"Innovation is unstructured, so our management of it must be very structured."*

The success of collaborative or networked projects depends on the use of common procedures, operating systems, and development tools that ensure a common language to communicate and interact, exchange results, and transfer technologies.

7.2 R&D Models and Trends

There are different approaches to R&D management:

- ***Internal R&D:*** This type of R&D is conducted internally within individual gas companies, manufacturers or others.

- ***Joint R&D*****:** Individual companies conduct R&D jointly with or outsourced to suppliers, academia, national laboratories, or independent contract research organizations. In some cases, government co-funding is obtained.

- ***Collaborative R&D*****:** In a collaborative industry model, R&D is conducted jointly with other companies in the same sector (e.g., R&D involving two or more gas companies).

Key advantages of industry collaborative research include being able to participate in basic and high-risk research, spreading the cost and risk of R&D, and having the opportunity to stay on top of new technology developments. Key disadvantages include losing proprietary advantages, control and flexibility, and having to deal with slower administrative response and bureaucracy[43]. Since all participants gain equal access to research results, participating in collaborative research provides no competitive advantage. Since most companies in competitive industries pursue R&D to grow markets and increase operating efficiencies, collaborative R&D options are therefore less compelling. Collaborative R&D offers more advantages for industries that are regulated and non-competitive, such as utilities (gas, electric, water). Pipelines, although they continue to be regulated are much more competitive since open access.

Recent growth in industry R&D consortia (in the 1980s and 1990s) has resulted in a set of "lessons-learned" in best approaches to managing collaborative research[44]. The business literature suggests that the success of collaborative R&D projects depends on the use of common

[41] Global Innovation 1000-Money Isn't Everything, Booz, Allen and Hamilton, Press Release dated October 11, 2005.
[42] Quote from Thomas Connelly in *Barron's*, November 20, 2006.
[43] *Choosing an R&D Consortium*, William E. Souder and Suheil Nasser, Research Technology Management, March-April, 1990.
[44] *Hard Lessons in Cooperative Research*, Jerry Werner and Jack Bremer, Issues in Science and Technology, Spring, 1991.

procedures, operating systems, and development tools that ensure a common language to communicate and interact, exchange results, and transfer technologies.

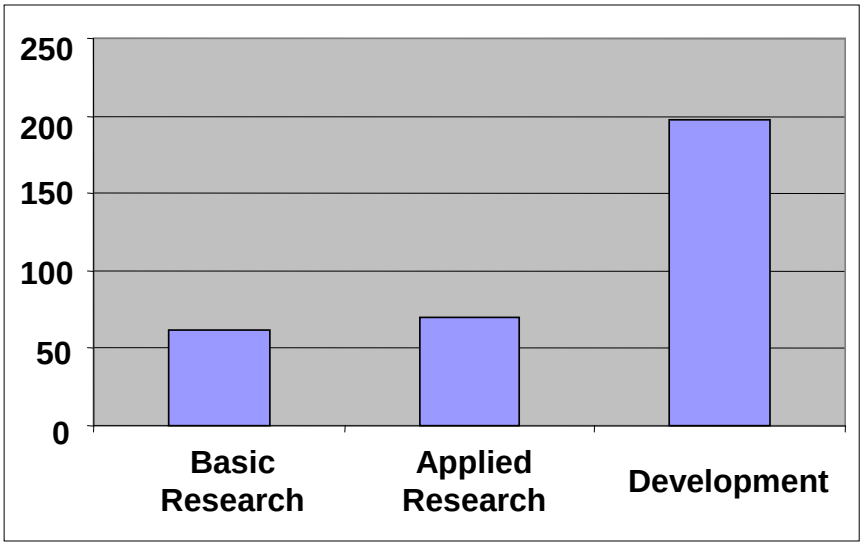
The R&D management and performance infrastructure includes professional staff and laboratory facilities. Developing dedicated facilities and specialized technical expertise involves long lead times. Without the support of adequate and stable funding, this infrastructure will be more quickly redeployed to other needs.

Important national and international trends in R&D spending and management are important aspects of the new global marketplace. Because of the need to reduce overall cost of conducting R&D, more generic technical activities are increasingly being outsourced and conducted abroad. Specialized skills and talents have been developed in Centers of Excellence around the world. Firms are forced to disperse their R&D activities globally; either through physical location or "virtually".

7.3 Basic and Applied Research

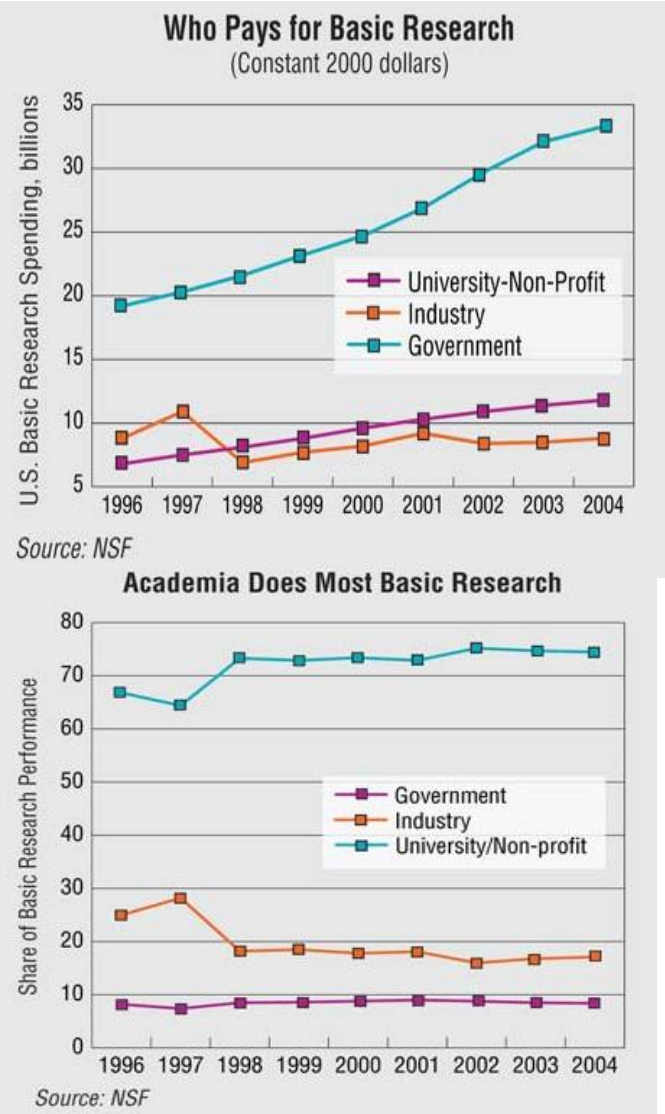
Most of the overall investment in R&D in the U.S. is for applied research and development, as opposed to basic research (see Figures 7.1 and 7.2a and 7.2b). Across all industries, basic research is largely conducted with government funds and performed at universities (some of the R&D is performed at government laboratories and independent research organizations)[45]. Private industry has shifted the proportion of their innovation research investments away from basic research and toward applied research initiatives.

Figure 7.1 Applied versus Basic Research Spending – U.S. Economy
(Source: National Science Foundation)



[45] R&D Magazine's Basic Research White Paper, June 2006.

Figure 7.2a and 7.2b Funding and Performance of Basic Research by Source
(Source: R&D Magazine's Basic Research White Paper, June 2006)



The R&D business literature finds that firms that engage in moderate to higher levels of applied research will see enhanced performance returns from additional investments in basic research; including leveraging basic research findings from government, universities, or others. Conversely, firms that engage in relatively lower levels of applied research see no performance enhancements at any level of investment in basic research.

7.4 R&D Organizational Structures and Strategies in the Gas T&D Industry

The natural gas industry has a continuous, solid record of success in providing safe, reliable, and economical energy service to millions of residential, commercial, and industrial customers over several decades. This outstanding service and performance history was made possible, in part, by the many decades of research, development, and deployment conducted by many organizations, including Gas Research Institute, the Gas Technology Institute, NYSEARCH, PRCI, GMRC, the federal government, vendors, and others.

Research had yielded major benefits that have positively impacted gas operations such as high-performance polyethylene pipe, underground directional drilling equipment, techniques to rehabilitate aging gas pipe, and distribution automation technology. Funding, however, has sharply dropped due to the decline and elimination of the FERC program managed by GTI and federal dollars managed DOE. State-authorized gas customer funding and gas industry collaborative research represents only a fraction of the earlier funding levels.

An important outcome of these changes has been the elimination of formal industry avenues for long-term basic research. With the exception of GTI's SMP program, which focuses LDC's investments on "mid-term" R&D[46], the gas industry's R&D funds are focused on near-term developments Through their primary industry R&D collaboratives (EPRI and AwwaRF) and their government R&D funding agencies, both the electric and water industries each maintain basic research programs oriented at longer-term industry goals[47]. Interestingly, the business literature suggests that firms that engage in moderate to higher levels of applied research see enhanced performance returns from additional investments in longer-term basic research (e.g., university R&D).

Comparable industries (electric utilities, water, propane, and heating oil) all have significant collaborative industry R&D programs administered through either a voluntary or a surcharge/fee-based mechanism. These organizations - EPRI, AwwaRF, PERC and NORA - are research management organizations and are seen as the research arm of their respective industries. The natural gas distribution industry does not currently have an analogous centralized R&D structure.

A decline in research funding and new pressures to generate near-term results with limited, available funds may adversely affect the ability to develop the next generation of technological innovations to maintain and advance the stellar safety and performance record of the natural gas industry.

This challenge and problem may be compounded by the diversity of players in the natural gas industry and the lack of a central organization or coordinating body to facilitate Funder's input to define industry needs and drive innovations from concept to commercialization.

---

[46] *Sustaining Membership Program Overview*, Gas Technology Institute, January 2005.

[47] The AwwaRF basic research program, funded at 15% of the total budget, is called the "Unsolicited Program", From *Overview of AwwaRF Research Programs*, Awwa Research Foundation, January 2004.

GRI and DOE programs were planned and implemented with public funds. The R&D priority-setting and budget planning processes were open. The resulting R&D plans and "roadmaps" were public documents. Therefore, every interested stakeholder had the ability to know what research was being conducted and to gauge progress. Today, gas distribution R&D programs are conducted in a more competitive, proprietary environment. This environment creates a greater demand for the industry to coordinate R&D activities and it creates a greater need for communications.

An additional implication of the recent decline in funding is the residual imbalance in industry funding. The funding of gas distribution collaborative R&D is not equitably shared among utility companies. While about three-quarters of the gas industry is funding some industry R&D program, many large distribution companies are not participating at all. The financial contribution toward meeting industry objectives through R&D is unequal and disproportionate among the utilities. Delta funding is growing and is probably the largest source of collaborative funding, but the regulatory approval of Delta funding for R&D has only been approved in less than have the states where natural gas distribution companies operate.

APPENDICES

Appendix A. U.S. and Canadian Organizations Related to Natural Gas R&D
Appendix B. Natural Gas R&D Study Research Categories

Note: Program budget details provided in the appendices may capture data or other information not included in the body of the report.

Appendix A. U.S. and Canadian Organizations Related to Natural Gas R&D

U.S. Federal Government Sources

U.S. Department of Energy/National Energy Technology Laboratory
(www.netl.doe.gov)

The Strategic Center for Natural Gas and Oil, part of the U.S. Department of Energy's (DOE) National Energy Technology Laboratory (NETL) is headquartered in Morgantown, West Virginia. NETL's funding has been zeroed out for natural gas transmission and distribution (T&D) infrastructure, and natural gas storage research since fiscal year (FY) 2005. Only a few carry-over projects still existed in FY 2006. The total value of this carry-over research is $12.4 million:

- $2,827,323 (with $1,220,281 in cofunding) for distribution
- $2,890,049 (with $1,986,190 in cofunding) for transmission
- $6,707,482 (with $3,748,074 in cofunding) for storage.

The amount of storage funding includes $4.2 million from DOE/NETL (and $1.8 million in cofunding) for the Gas Storage Technology Consortium (GSTC) allocated for 2003 - 2008.

However, there has been no new research funded in this area since FY 2005 and there are no current plans for near-term funding for research on T&D through NETL.

Department of Energy/Gas Storage Technology Consortium
(www.energy.psu.edu/gstc)

The Gas Storage Technology Consortium was established in June 2004 with a five-year contract from DOE NETL. Currently there are 45 members in the U.S. and one in Canada. GSTC is administered by Pennsylvania State University, College of Earth and Mineral Sciences, The Energy Institute (University Park, PA). Since 2004 the GSTC has co-funded 12 projects totaling $1.69 million. As mentioned above NETL allocated $4.2 million with $1.8 million in gas industry cofunding pledged for GSTC. Funding remains until 2008. Cofunding is collected through PRCI, which allocated $315,767 in 2006 and will provide $680,000 in 2007.

GSTC's mission is to assist in the development, demonstration and commercialization of technologies to improve the integrity, flexibility, deliverability, and cost-effectiveness of the nation's underground natural gas/hydrocarbon storage facilities. Projects selected for funding are based on those that best accomplish the GSTC's goals.

The GSTC is governed by bylaws and is an industry-driven consortium. Members submit proposals and elect the Council. The Council selects the projects that are to be co-funded. The various GSTC memberships available are: Full Members (both corporate and individuals); Affiliate Members (for trade associations); and Universities/Colleges.

U.S. Department of Energy/National Laboratories

The U.S. Department of Energy maintains several national laboratories for energy research and development activities. These laboratories are:

- Argonne National Laboratory (Argonne). Argonne does not have a specific natural gas program. However, projects associated with tuned-diode lasers have been active within the Energy Technology Division advance remote natural gas leak locating technology. At this time, no specific natural gas research funding was identified at Argonne in 2006.
- Brookhaven National Laboratory (BNL). BNL's Energy Resource division research performs R&D on Energy Efficient Buildings, and Advanced Fuels and Renewable Energy Projects. BNL also conducts R&D on hydrogen storage technologies and manages the natural gas vehicle fuel program for the DOE Office of Transportation Technologies/ Heavy Vehicles (OHVT). While other research at BNL includes RDD&D that advances technologies useful to natural gas transmission and distribution (T&D) activities, no specific research projects or funding was identified for 2006.
- Idaho National Laboratory (INL). No specific research activities or funding impacting on natural gas transmission and distribution were identified at INL for 2006.
- Oak Ridge National Laboratory (ORNL). ORNL acted as a contractor in PHMSA-funded R&D on EMAT pipeline sensors, which concluded in May 2006. No current independent activities or funding was identified for natural gas T&D research at ORNL in 2006.
- Pacific Northwest National Laboratory (PNNL). Most recently, PNNL researched an inspection device for determining natural gas pipeline integrity. This R&D led to the development of the ultrasonic strain measurement technology used to detect strain in metal pipe caused by mechanical damage resulting in gouges or dents in the pipeline. This project, funded through DOE, was officially completed in 2005. No other specific, independent funding or research affecting natural gas T&D operations at PNNL in 2006 was identified.
- Sandia National Laboratory (Sandia). No specific, independent funding or R&D activities for natural gas T&D was identified in 2006 for Sandia.

U.S. Department of Transportation/Office of Pipeline Safety/Pipeline and Hazardous Materials Safety Administration
(http://primis.phmsa.dot.gov/rd/index.htm)

Under the U.S. Department of Transportation's (DOT) Office of Pipeline Safety (OPS), the Pipeline and Hazardous Material Safety Administration (PHMSA) conducts and supports research to support regulatory and enforcement activities and to provide the technical and analytical foundation necessary for planning, evaluating, and implementing the pipeline safety program. PHMSA, headquartered in Washington, DC, sponsors research and development projects that provide near-term solutions to increase the safety, cleanliness, and reliability of the U.S. pipeline system.

R&D projects conducted by PHMSA focus on:

- Leak detection
- Detection of mechanical damage
- Damage prevention
- Improved pipeline system controls, monitoring, and operations
- Improvements in pipeline materials.

These projects are designed to produce technological solutions that can quickly be implemented to improve pipeline safety, and encourage the participation of stakeholders. Funds are provided through recommendations by Steering Groups that are organized each fiscal year.

PHMSA research covers onshore and offshore pipelines for both gaseous and liquid lines. The Mineral Management Service (MMS), while also providing funds for research programs dealing with offshore pipelines, generally separate their responsibility from PHMSA to the initial 20 feet upstream of the production platform.

Guidance comes from external, stakeholder and peer reviews. The President's Office of Management and Budget (OMB), the Secretary of Transportation, the National Transportation Safety Board (NTSB), and the Government Accountability Office (GAO) provide guidance on the overall program. The program is driven by a number of laws and regulations that codify these requirements including:

- The Pipeline Safety and Integrity Act of 2002 (PSIA-2002)
- The Performance Assessment Rating Tool (PART) evaluation process for the OMB
- The President's Management Agenda R&D Investment Criteria
- The Government Performance and Results Act (GPRA).

Oversight and input in evaluating the budget and the performance of PHMSA is supplied by:

- The U.S. Congress
- Interagency Agreements between agencies with complementary pipeline R&D programs

- Safety advisory committees, State pipeline safety organizations such as National Association of Pipeline Safety Representatives
- National standards organizations such as American Society of Mechanical Engineers
- Industry trade and technology organizations; and
- Public meetings and R&D workshops.

Over any given year, PHMSA is involved with several activities aimed at providing quality assurance for R&D activities and outputs. These activities are organized into external-, stakeholder-, and peer-review approaches that apply to both program and project level activities.

In 2006, PHMSA research programs relating to natural gas T&D totaled $27,817,127. Of this total, $11,875,536 came from a combination of PHSMA and other government funds while $15,941,551 was received in cofunding.

U.S. Environmental Protection Agency

(www.epa.gov/)

The Environmental Protection Agency (EPA) has traditionally funded projects that impact the natural gas T&D industry. The Office of Research and Development (ORD), the scientific research arm of EPA, conducts research on ways to prevent pollution, protect human health, and reduce risk. EPA is also one of 12 federal agencies that participate in the Small Business Innovation Research (SBIR) Program established by the Small Business Innovation Development Act of 1982. The purpose of this Act was to strengthen the role of small businesses with respect to federally funded R&D and to help develop a stronger national base for technical innovation. A small business is defined as a for-profit organization with a maximum of 500 employees.

Other EPA centers, laboratories and branches were surveyed. These included the National Risk Management Research Laboratory (NRMRL), which would include R&D for pipelines, Urban Watershed Management Branch; Subsurface Protection and Remediation Division; and the Technology Transfer and Support Division. The National Center for Environmental Assessment and the National Center for Environmental Research for emissions regarding compressor prime movers were also surveyed. In addition the Office of Air and Radiation, Climate Change Division, was also contacted for natural gas T&D related funding in 2006.

Past projects at EPA have addressed emissions from compressor facilities, fugitive natural gas, and salt brine disposal. In 2006, however, there was no natural gas funding identified other than funds for identifying emission point sources in the Climate Change Division predominately in production; the Natural Gas STAR program; and the Methane for Markets program.

EPA has announced that as part of its Methane for Markets program, 2007 funds are available. The agency has solicited proposals for projects that advance near-term, cost-effective methane recovery and use as a clean energy source, and support the goals of the Methane to Markets Partnership. These projects could include measures for reducing emissions from natural gas pipelines and distribution systems. The funding appropriation is $2.5 million, with grants

possible ranging from $25,000 to $300,000. EPA expects that approximately 20 awards will be made.

For 2006, only the Gas STAR program efforts and a small study ($20,000) on emissions from plastic pipe in the Climate Change Division impact on natural gas T&D. However, the Gas STAR program and the company expenditures for participation and implementation of the best practices for reducing fugitive methane emissions is considered a maintenance activity, and is not included as an T&D R&D activity.

U.S. Department of the Interior/Minerals Management Service
(www.mms.gov/tarphome/)

The Minerals Management Service, headquartered in Washington, DC, has a national scope, including two major programs, Offshore Minerals Management and Minerals Revenue Management. The offshore program, which manages the mineral resources on the Outer Continental Shelf (OCS), comprises three regions: Alaska, Gulf of Mexico, and the Pacific. Although the Minerals Revenue Management program is headquartered in Washington, DC, it is operationally based in Denver, Colorado.

The overall role of the MMS in U.S. energy supply is to manage the mineral resources on 1.76 billion acres of the OCS, including leasing and resource management functions. MMS funds cooperative natural gas programs with PHMSA and PRCI to address its role in offshore activities. These activities are handled through the Technology Assessment & Research (TA&R) Program.

The TA&R Program is a research element encompassed by the MMS Regulatory Program. The TA&R Program supports research associated with operational safety and pollution prevention, as well as oil spill response and cleanup capabilities. The program is comprised of two functional research activities: Operational Safety and Engineering Research (OS&ER); and Oil Spill Research (OSR). Natural gas-related projects are associated with the former category under sub-categories of Pipelines, Measurement and Materials. Other projects deal with international activities, as well as remedial work and damage estimates for hurricane-related effects**.**

The TA&R Program operates through contracts with universities, private firms, and government laboratories to assess safety-related technologies and to perform necessary applied research. Participation in jointly funded projects with industry, other Federal and States agencies, and international regulatory organizations, has become the primary funding mechanism. Because of the overlap of issues and challenges, as well as a broader recognition that participation in these joint projects, it is the most effective and efficient means to leverage available funds. For the most part, MMS' responsibility ends approximately 20 feet from the platform and PHMSA's responsibility begins.

The value of the MMS research program impacting natural gas offshore transmission in 2006 is approximately $18 million, including industry cofunding. A significant amount of this research goes through Texas A&M University, Offshore Technology Research Center (OTRC – http://otrc.tamu.edu) operated by Texas A&M University (College Station, TX) and the

University of Texas at Austin. TA&R also sponsors workshops in issues affecting natural gas transmission and materials.

The FY 2006 budget for MMS is $4.3 million in government funds, with industry cofunding totaling $4.7 million.

Miscellaneous U.S. Government Agencies Associated with Natural Gas R&D

Several other U.S. government organizations that have a history of funding natural gas R&D activities were reviewed. These organizations included --

- The National Institute of Standards and Technology (NIST) (www.atp.nist.gov/). In the past, projects for natural gas technology have been funded through ATP, and although no new projects have been funded since 2004, staff is hopeful that future projects will be funded.
- The Office of Basic Sciences oversees funding of the U.S. Department of Defense (DOD) Laboratories (www.dtic.mil/techtransit/business/dodlabs.html). Each year, the Naval Research Laboratory and NACE International support university research grants for general corrosion research totaling $40,000. However, no specific and independently funded projects for natural gas T&D operations were identified in 2006 for any DOD laboratory.
- The National Science Foundation (NSF) (www.nsf.gov/). Emerging Frontiers in Research and Innovation (EFRI) is a new division within the Directorate for Engineering (ENG) at the NSF. This division could provide opportunity for advanced research in technologies affecting natural gas T&D operations. In 2006, however, no specific and independently funded R&D activities for natural gas T&D were identified.
- The National Regulatory Research Institute (NRRI) (www.nrri.ohio-state.edu). In 2006, NRRI completed three studies related to natural gas purchasing, decoupling tariffs and natural gas electric generation. The budget for natural gas projects in 2006 is between $150,000 and $200,000 for gas studies associated with regulatory issues.

State Government Sources

New York State Energy Research and Development Authority (NYSERDA) (www.nyserda.org)

The New York State Energy Research and Development Authority (NYSERDA) is a public benefit corporation created in 1975 by the New York State Legislature. NYSERDA derives its basic research revenues from an assessment on the intrastate sales of New York State's investor-owned electric and gas utilities, federal grants, and voluntary annual contributions by both, the

New York Power Authority and Long Island Power Authority. Additional research dollars are provided by limited corporate funds.

NYSERDA funds natural gas programs in end-use efficiency, production and vehicle-fuel use; and has funded a project to evaluate natural gas storage technologies for electric power generation. No projects relating to natural gas T&D were identified in NYSERDA's 2006 program.

California State Energy Commission

(www.energy.ca.gov/research)

The California Energy Commission's (CEC) Public Interest Energy Research (PIER) Program supports energy R&D projects that will help improve the quality of life in California by bringing environmentally safe, affordable and reliable energy services and products to the marketplace.

The PIER Program annually awards up to $62 million to conduct the most promising public interest energy research by partnering with R&D organizations including individuals, businesses, utilities, and public or private research institutions.

In August of 2004, the California Public Utilities Commission (CPUC) issued Decision (D.) 04-08-010, making funds available for public interest natural gas research and development (R&D) projects. Public Interest Natural Gas Research must conform to all of the following criteria:

- Advances science or technology
- Research benefits accrue to California citizens
- The research is not adequately addressed by competitive or regulated entities.

Legislation enacted since 2004 has added new responsibilities to the Energy Commission as administrator of the PIER Natural Gas (NG) program. The Budget Committee (SB 76), in Chapter 81 of the Statutes of 2005, added Section 901 to the Public Utilities Code, requiring the Energy Commission and the California Air Resources Board (ARB) to jointly develop a strategic research plan. The Energy Commission is expected to allocate one-half of the PIER NG funds in any given program year consistent with that plan. SB 76 allows that up to one-third of the program funds may be used for transportation-related public interest energy research and development provided the research provides natural gas customer benefits.

In general, the research funded through this program should improve natural gas energy efficiency and environmental quality, develop renewable technologies, and otherwise provide benefits to the public. The research program is administered by the California Energy Commission, and the annual budget for 2005 was not to exceed $12 million.

The California PIER NG research plan for 2007-2011[48] does include, as part of its major energy drivers for California, the following:

- **Technology**: Advanced meters and communication
- **Regulatory and Policy Framework**: Aging and inadequate electricity, natural gas and transportation infrastructure.

For T&D R&D to be included in this program, it would have to meet several criteria:

1) Does the research seek to improve the affordability of energy services and products; or

2) Does the research seek to improve the safety and/or reliability of energy services and products; or

3) Does the research seek to reduce the impact on or restore the environment through energy services and products?

If the research meets one of these above-mentioned criteria, the next filter is:

1) Does the research effort develop, demonstrate, or help to commercialize new or improved technologies;

2) Does the research advance scientific knowledge upon which new technologies, services, products, or policies can be developed.

The final filter is:

1) Is the research focusing on science or technology that would otherwise not be developed during the desired time frame for the intended application; or

2) Is the research addressing a public need for which there is insufficient research activity in competitive and regulated markets

Arguably, down to the last filter, most of the R&D activities for T&D supported by the gas industry would meet the criteria. How the last filter will be implemented will be decided on a case-by-case basis. However, it's difficult to see how important T&D research will be so unique to California not to be supported through some other source.

[48] California Energy Commission, "Public Interest Energy Research Program, 2007 – 2011 Natural Gas Research Investment Plan," CEC-500-2006-017-CMF, August 2006.
http://www.energy.ca.gov/2006publications/CEC-500-2006-017/CEC-500-2006-017-CMF.PDF

Canadian Federal and Provincial Government Sources

Office of Energy Research and Development
(www2.nrcan.gc.ca/es/oerd/english/)

The Office of Energy Research and Development (OERD) is the Canadian Government's co-coordinator of energy research and development activities. OERD is responsible for the Program of Energy Research and Development (PERD) and the Technology and Innovation Research and Development initiative that support the energy-related R&D activities of federal departments, including Natural Resources Canada.

OERD also coordinates Canada's involvement in international energy R&D activities through linkages with the U.S. Department of Energy, the International Energy Agency (IEA), the European Union and the Asia-Pacific Economic Co-operation (APEC).

PERD currently funds 27 energy R&D programs. One such program supports the regulation and maintenance of aging pipelines and the regulation and construction of new systems. Activities focus mainly on:

- Assessment of terrain conditions and natural hazards for new and existing pipelines
- Testing and assessment of the performance of pipeline materials
- Development of a risk-based framework for the pipeline industry and regulators.

Pipeline projects through PERD focus on environmental aspects of pipeline design in permafrost, tundra, other unstable soils, and seabed ice scouring; and pipe coatings for external and internal corrosion control of steel pipelines. The 2006 budget at OERC from PERD was $1.7 million Canadian ($U.S. 1.5 million). This is multiplied through the use of A-Base funding at the Canadian Federal Government laboratories where the work is performed, as well as from industry cofunding. In all the total funds directed at these activities is more than $4 million Canadian ($U.S. 3.5 million).

The Alberta Energy Research Institute
(www.aeri.ab.ca/)

The Alberta Energy Research Institute (AERI) was established in 2000, by the Alberta Science and Research Authority Act. The Institute is responsible for all energy-related research for the province.

AERI assumed responsibility for the oil and gas research programs previously administered by the Alberta Oil Sands Technology and Research Authority (AOSTRA). A major building block of the Alberta Provincial government commitment is the comprehensive strategy developed by AERI, through consultations with various industry and government stakeholders. This strategy will help the province address environmental concerns while developing an integrated energy industry, focused on Alberta's conventional and non-conventional resources.

AERI advises the Minister of Innovation and Science, and the Alberta government, on energy research policy and supports applied research that will lead to technology implementation in Alberta's energy industry.

AERI on occasion does contract research with universities in regard to transmission activities. Their focus is on reservoir engineering and other production issues. AERI did no research on natural gas T&D in 2006.

U.S. and Canadian Association/Non-Profit Organization Funding

Several associations and non-profit entities deal either specifically or indirectly with natural gas R&D. The associations reviewed for this study include:

- American Gas Association. AGA's R&D efforts focus on supporting those goals and consist of providing data on the gas industry, public policy and advocacy-support white papers. AGA's research funding efforts focus on the development of issue papers in support of policy positions without a specific annual budget.

- American Gas Foundation. AGF is an independent source of information research and programs on energy and environmental issues that affect public policy, with a particular emphasis on natural gas. Funding for the AGF comes from financial contributions by industry and stakeholders in support of specific public research studies or with annual contributions in support of the overall AGF program. To date, the AGF public policy research studies range in the amount of $50,000 to $150,000. The overall budget of the AGF is approximately $700,000.

- APGA Research Foundation. APGA RF collected approximately $1 million in 2006 dues. Members agreed to provide $500,000 to the OTD R&D program. The Foundation also allocated $100,000 for annual dues to GTI's Sustaining Membership Program (SMP). These two programs perform most of their R&D in the area of distribution operations (see section below for Gas Technology Institute).

- Interstate Natural Gas Association of America. INGAA provides a forum for industry and regulatory, legislative and business advocacy on issues of importance to natural gas pipeline companies. The budget for these types of activity is approximately $200,000.

- INGAA Foundation, Inc. The Foundation's primary activity is to sponsor research aimed at promoting natural gas use and safe, efficient pipeline construction and operation. Projects focus on key industry issues such as environmental impacts of energy use, improved pipeline construction practices, pipeline safety procedures, new technologies and market opportunities for natural gas. During 2006, INGAA Foundation staff and contractors provided technical workshops and white papers on various aspects of the pipeline industry. The

organization's 2006 budget for these types of activities is approximately $300,000.

- The Canadian Gas Association. CGA develops energy industry policy positions, and makes submissions to organizations, such as parliamentary committees and the Council of Energy Ministers. CGA also produces educational and environmental information for consumers and organizes training schools, workshops, seminars and conferences. CGA was involved with code and standards development, or appliance certification. CGA sold its standards and certification business to the Canadian Standards Association who continue to publish the B-149 codes and appliance standards and offer natural gas appliance testing and certification services.

- Gas Manufactures Research Council. GMRC is a subsidiary of Southern Gas Association (SGA). GMRC conducts an applied research and technology program directed toward improving reliability and cost-effectiveness of the design, construction, and operation of mechanical and fluid systems with an emphasis on compression facilities.

As of 2006, GMRC has 79 members that fall into four categories: Operating; Engineering and Fabricating; Associate; and Foreign. GMRC also has Alliance Partners as well as Co-Funding Partners.

GMRC's 2006 budget is $575,000. This includes member cofunding, and funds derived from royalties and licensing fees that it receives from products developed through its program. For example, SwRI provides GMRC a royalty from the operation of its pipeline and compression design facility that was established by GMRC in the 1950s. In 2007, GMRC's budget will be approximately $760,000.

- NACE International. NACE International has an annual budget of approximately $12 million, with $500,000 directly allocated to codes and standards development. Its committees use research data from other funded projects to assist in formulating new, or making changes, to existing codes and standards.

The amount of natural gas industry funds used for this activity is not available.

- The American Petroleum Institute. API leads the development of petroleum and petrochemical equipment and operating standards. The maintenance and the development of new of codes and standards are performed through API's committee system, and through workshops and conferences.

Collaborative Industry Funding

Gas Technology Institute
(www.gastechnology.org)

Gas Technology Institute, of Des Plaines, Illinois, is a research, development and training organization specifically serving the natural gas industry and energy markets. It was established in 2000 through the merger of the Institute of Gas Technology and Gas Research Institute. IGT was formed in 1941 and GRI in 1979. GTI is an independent technology organization, established as an Illinois not-for-profit corporation. GTI is tax-exempt under Section 501(c)(3) of the Internal Revenue Code. GTI also operates the following offices and facilities:

- GTI Washington Operations Office
- GTI Catoosa Test Facility (near Tulsa, Oklahoma)
- Houston Office in Sugar Land, Texas
- Process Research and Evaluation Group (for gasification research) in Birmingham, Alabama.

GTI revenues come from several sources:

- Contracts from customers for research, program management, technical services, technology development and education programs; approximately 65% from the OTD research funds
- Royalty and license fees from GTI technologies incorporated into commercial products/services
- The Sustaining Membership Program, by which its investors support collaborative, mid-term technology development
- Returns from the activities of GTI's subsidiaries and other technology investments.

GTI's Sustaining Membership Program is a collaborative research and development program managed and performed by the organization. It was founded in 1985. The objective of the SMP is to build the natural gas technology base for member companies through the development of new ideas and innovative concepts beyond the near-term horizon. It is the intention of the SMP to develop the technology up through the "proof of concept" phase, at which point the most promising technologies would be continued through short- to mid-term R&D programs such as Operations Technology Development, Utilization Technology Development and Environmental Issues Consortium. The SMP concentrates its research activities within three technology development areas:

- Distribution Pipeline Technology
- Energy Utilization
  - Combustion
  - Distributed Energy
- Environmental Science and Forensic Chemistry.

The SMP is governed by both an executive and technical body. The executive-level steering committee is SIMRAC (Sustaining GTI Member Research Advisory Committee). The governing technical body is the Technical Guidance Committee (TGC). Each SMP member company is encouraged to nominate a representative to the TGC.

GTI currently collects approximately $2 million per year from the SMP members. These funds are leveraged with Federal and State funding to provide approximately $7 - $10 million per year in research and development. Additionally, the royalties generated from SMP patents flow back into the SMP, providing additional funds.

Northeast Gas Association/NYSEARCH

(www.northeastgas.org/nysearch)

A subsidiary of the Northeast Gas Association, NYSEARCH, is a natural gas research, development and demonstration organization headquartered in New York City. For over 15 years, NYSEARCH, through its collaborative work among New York State's natural gas utilities has produced a number of R&D results in distribution operations. NYSEARCH's business model is to monitor technology developments, identify common utility needs, perform market research, evaluate potential technical solutions, and conduct product development.

In recent years, NYSEARCH has expanded its scope, with voluntary participation among New York and Northeastern LDCs, and now includes the participation of several associate companies interested in gas technology R&D throughout the U.S., Canada and overseas. NYSEARCH 2006 membership includes 18 U.S. gas distribution companies.

NYSEARCH is organized by a committee of its members and NYSEARCH staff, which oversees the selection of research projects for the funds contributed by its members. The committee meets on a regular basis to review potential opportunities to ask for Requests for Proposals, or to review submitted proposals. While each member does not have to participate in the funding of every project supported by NYSEARCH, each member does have access to the results of that project. From time to time, *ad hoc* working groups are formed to monitor and provide input into specific R&D activities.

In 2006, as part of the Northeast Gas Association, NYSEARCH manages over 40 projects in various stages of development, with a budget for new projects of $3.8 million, and a program value of $9,514,015.

Operations Technology Development Company

(www.otd-co.org)

Operations Technology Development Company (OTD) is a collaborative effort to develop advanced technologies for the natural gas industry. OTD is a not-for-profit Illinois company and is administered by the Gas Technology Institute, located in Des Plaines, IL.

OTD is a member-controlled partnership of natural gas distribution companies formed to develop, test, and implement new technologies. The objective of OTD is to address a wide range of technology issues relating to gas operations and its infrastructure. OTD projects are designed to:

- Enhance system safety
- Improve operating efficiencies
- Reduce operating costs
- Maintain system reliability and integrity.

The OTD Board of Directors consists of one member from each participating company. The Board meets twice annually to establish policies and procedures, provides strategic guidance on program priorities, and helps set long-term goals and objectives.

The Technical Project Committee (TPC) -- comprised of participating company representatives with expertise in gas industry operations -- identifies the overall focus of individual research projects. TPC members serve as the main conduits for disseminating the results and deliverables from the program into their companies. The participants choose the projects to pursue through a formal, weighted voting process based on a participant's level of investment and the amount of interest (investment) a project generates. In 2006-07, OTD has 18 participating LDCs.

In 2006 the OTD research budget is $7.8 million. It has 43 projects with a total value of $21.8 million.

Pipeline Research Council International, Inc.

(www.prci-inc.com/, and www.prci.com)

Pipeline Research Council International, Inc. (PRCI), is a tax-exempt, not-for-profit corporation comprised of 34 member operating energy pipeline companies located in the U.S., Canada, Europe, the Middle East and South America. Augmenting the pipeline membership are 15 Associate member companies that serve the industry as pipe and equipment suppliers, service providers and vendors. Through their annual voluntary subscription and supplemental contributions, PRCI sponsors research to enhance the safety, reliability and productivity of energy pipelines, both gas & liquid (which includes crude oil and refined products). PRCI does not conduct any research in-house, and is headquartered in Arlington, Virginia.

PRCI is organized around five technical planning committees:

- Integrity & Maintenance
- Design, Materials & Construction
- Compressor & Pump Station
- Underground Storage
- Measurement.

PRCI employs a project selection process centering on individual member allocation of subscription funds to projects, rather than group voting on budget elements. Potential projects are submitted by either the Technical Planning Committees or individual Board members, and are aggregated to form an annual voting "ballot". Members then allocate their individual funds to specific projects. Projects that attract sufficient funds to exceed a minimum funding threshold, but do not achieve the full amount of requested funds, are reassessed for their potential to either attract additional member funding or cofunding, have their work scopes reduced, or are withdrawn. Project management is conducted by project teams comprised of members who vote funds to the project, though all PRCI members share in the project results.

Member contributions in 2006 were approximately $8.1 million through subscriptions and member supplemental funding. There is a strong emphasis on leveraging PRCI's resources through cofunding and in-kind funding. PRCI has been successful in this regard, as the 2006 program attracted approximately $8 million of external support, yielding a total program size of approximately $16 million.

The 2007 program continues a five-year trend of increasing research spending by PRCI's member companies, and is more than 20% higher than the 2005 program, reflecting an increase in the pipeline and associate membership, some planned increases in subscription rates, and member supplemental funding to specific projects.

Southwest Research Institute
(www.swri.org)

Southwest Research Institute (SwRI) is an independent, nonprofit applied research and development organization. The staff of 3,000 specializes in the creation and transfer of technology in engineering and the physical sciences. The Institute occupies more than 1,200 acres in San Antonio, Texas, and provides nearly two million square feet of laboratories, test facilities, workshops and offices. It is one of the oldest and largest independent, nonprofit, applied R&D organizations in the United States.

Founded in 1947, SwRI provides contract research and development services to industrial and government clients. The Institute is governed by a Board of Directors, which is advised by approximately 100 trustees.

SwRI consists of 11 technical divisions that offer multidisciplinary, problem-solving services in a variety of areas in engineering and the physical sciences. Historically, nearly 2,000 projects are open at the Institute at any one time. These projects are funded almost equally between the government and commercial sectors. SwRI's total revenue for fiscal year 2005 was $435 million, with approximately equal shares being provided by government and commercial clients. During 2005, SwRI provided $4 million to fund innovative research through its internally sponsored R&D program. Among its many research areas, SwRI performs R&D in oil and gas exploration, pipeline technology and prime mover development.

SwRI is a contractor on many PHMSA, MMS and PRCI-funded research projects. SwRI also serves as the R&D program manager for the GMRC R&D program, which is conducted primarily at SwRI. Specific to natural gas, the Institute has developed technologies and

capabilities key to the safe operation of onshore and offshore pipelines and natural gas distribution systems.

SwRI provides research into gas well drilling and completion technologies; natural gas metering; safety and accident prevention; and pipeline inspection technologies, including non-destructive testing capabilities.

In its role as a Pipeline Technology Center, SwRI provides research, development, design, and field engineering services in the following areas:

- Pipeline integrity and risk management
- Machinery reliability, efficiency, and environmental compliance
- Pipeline facilities design, operation, and monitoring.

The Technology Center has been funded largely by the pipeline industry, and services are available to the international pipeline community. Among the specialized facilities at SwRI for natural gas T&D R&D are:

- Metering Research Facility (established in 1991 through GRI), which supports a large share of the pipeline industry's metering R&D, as well as providing commercial meter calibration services and engineering support.
- Gas Machinery Research Council (GMRC) Compressor Station Design Center
- The fully automated Valve Test Facility to evaluate production gate valves as recommended in API Specification 6A, Appendix F, PR2 level. The facility can accommodate up to 4-inch, 15,000-psi valves and actuators.
- A virtual, long multiphase test-loop in order to study multiphase transport of fragile solids.

The Institute has invested more than $35 million in additional specialized oil and gas research facilities and laboratories, with most of these funds provided by client sponsors.

Additionally, SwRI periodically conducts training workshops in pipeline technology to satisfy client needs in areas such as the SwRI/GMRC Gas Compressor Engine Workshop; the Fundamentals of Engines and Compressors; the Controlling Pulsations in Compressor and Piping Systems; the Applied Compressor Mounting and Foundation Design Workshop; the Ultrasonic Gas Flow Meter Workshop; the Factors in Gas Meter Station Design and Operations Short Course; and the Probabilistic Analysis and Design Course.

The 2006 SwRI budget for natural gas T&D activities is approximately $2.175 million in about 20 projects. These projects involve activities in metering/measurement, corrosion control, NDE/inspections, compressors and integrity management.

Battelle Memorial Institute
(www.battelle.org)

Battelle Memorial Institute (Battelle), which began operations in 1929, is a global science and technology enterprise that develops and commercializes technology and manages laboratories for customers. Headquartered in Columbus, Ohio, Battelle has19,000 staff members and conducts $3.4 billion in annual research and development.

Battelle is governed by a self-perpetuating Board of Directors and is a Section 501(c)(3) charitable trust organized as a non-profit corporation under the laws of the State of Ohio.

Battelle serves the U.S. Department of Energy in the operation or co-management of five national laboratories. The laboratories are:

- Brookhaven National Laboratory (managed by Brookhaven Science Associates, LLC -- consisting of Battelle and SUNY Stony Brook)
- Idaho National Laboratory (managed by Battelle Energy Alliance, LLC, of which Battelle is the sole member, and a team consisting of Battelle; BWX Technologies, Inc.; Washington Group International; Electric Power Research Institute; and an Alliance of University Collaborators led by the Massachusetts Institute of Technology)
- National Renewable Energy Laboratory (co-managed by Midwest Research Institute and Battelle)
- Oak Ridge National Laboratory (managed by UT-Battelle, LLC -- consisting of Battelle and the University of Tennessee)
- Pacific Northwest National Laboratory.

Specifically in natural gas, Battelle has been working with the Interstate Natural Gas Association of America to provide scientific bases for items like pipeline reinspection testing frequency and inspection methodologies. In this way, the correct inspection/testing tool can be applied to the right set of conditions at the appropriate interval. This work is funded through PHMSA, PRCI and other industry sources. Battelle does not internally fund significant amounts of T&D research.

Battelle also maintains a Pipeline Flow-Loop Facility and Pipeline Simulation Facility (PSF), to assist in the analysis and development of various sensors and robotic platforms for integrity management. Battelle also assesses such issues as PE pipe failure mechanisms and joining techniques.

Natural Gas Technologies Centre
(www.ctgn.qc.ca/)

The Natural Gas Technologies Centre (CTGN), located in Boucherville, Québec, is a Canadian enterprise performing research and development activities in natural gas with 25 full-time employees. CTGN was established in 1991 through the Canadian Technology Outreach Program (TOP), and is incorporated as a not-for-profit entity. In 1994, Gaz Métropolitain and Gaz de France joined the Centre as founding members.

CTGN's mission is to carry out, in partnership with the natural gas industry, applied research, development and technology transfer projects for its clients, thus contributing to their competitiveness. CTGN provides the following services on a contract basis:

- Technical and techno-economic studies
- Technology scans
- Product evaluation, improvement and adaptation on technical, economic or market aspects
- Technology development including proof-of-concept and commercial product development based on client specifications
- On-site technology demonstration and implementation
- Consultancy services: techno-economic, management of technology and university research.

The 2006 CTGN research budget of less than $3 million was allocated (30% - 50%) in support of projects related to distribution operations and construction, with the remaining being allocated to gas utilization.

Appendix B. Natural Gas R&D Study Research Categories

Improve Monitoring and Assessment of System Integrity

– Inspection
- In-line Cameras
- Robotic Platforms
- Sensors
- Pigs
- Direct Assessment
- Regulatory Requirements
- Non-Destructive Testing

– Distribution/Transmission Leak Detection
- Vehicles
- Hand-held
- Aerial Surveys
- Pinpointing

– Storage Leak Detection
- Aboveground Facilities
- Belowground Facilities

– Facilities Surveillance

Enhance System Flexibility and Throughput and Reliability

– Distribution/Transmission Cathodic Protection / Corrosion Control
- Rectifiers
- Anodes
- Coatings
- Inhibitors
- ECDA Methods
- Pipe-in-Casing

– Storage Cathodic Protection / Corrosion Control
- Aboveground Facilities
- Belowground Facilities

– Measurement / Pressure Regulation / Quality Control
- Metering
- Regulators
- Gas Quality Measurement and Control
- Advanced AMR
- Quality / Interchangeability

– Compression
- Operating Flexibility
- Operations & Maintenance
- Efficiency

– Materials
- Cast Iron
- Steel
- Plastic
- Basic Research

Reduce Incidence and Cost of Subsurface Damage

– **Facilities Locating & 3rd Party Damage Prevention**
- HDD Sensors
- Tracer Wire
- GPR
- Non-EM
- Acoustic
- ROW Encroachment (e.g., fiber optics, acoustics, smartpipe)
- Mechanical Damage Detection

– **New Technologies (e.g., RFIDs, smart sensors)**

Improve Capability of Cost Effective Construction, Maintenance and Repair

– Repair/New Construction
- Cast Iron Mains
- Steel Mains
- Plastic Mains
- Steel Services
- Plastic Services
- Meters / Regulators
- Pavement Breaking / Removal
- Excavation
- Backfilling / Compacting
- Pavement Restoration
- In-Trench Safety
- Trenching New Practices
- Keyhole Techniques and Tools

– Trenchless Construction
- Trenchless Construction New Practices

– **Storage Repair / New Construction/Drilling**

- Aboveground Facilities
- Belowground Facilities
- Deliverability Enhancement

Improve Data Quality and Timeliness for System, Operation, Planning and Regulatory Acceptance

– **Automation/GPS/GIS/SCADA**

- Fieldcrew Optimization
- Enterprise Management
- GPS
- GIS
- SCADA

– **Utility Crews**

- Trucks
- Equipment
- Training
- Improved Efficiency

– Soft Studies

- General Studies
- Modeling
- Codes and Standards
- Regulatory Compliance
- Knowledge Base

– **Reservoir Management**

Identify and Mitigate Environmental Issues

– **Distribution/Transmission Environmental**

- Belowground
- Aboveground
- Indoor

– Storage Environmental

- Water/Brine Disposition
- Solid Waste Disposal

– **Compressor Emissions**