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Task 10 - Technology Development Integration

Semi-Annual Report
April 1 - September 30, 1997

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TASK 10 – TECHNOLOGY DEVELOPMENT INTEGRATION

1.0 INTRODUCTION

Task 10 activities by the Energy & Environmental Research Center (EERC) have focused on the identification and integration of new cleanup technologies for use in the U.S. Department of Energy (DOE) Environmental Management Program to address environmental issues within the nuclear defense complex.

For the period July 1, 1995, through May 31, 1996, Task 10 was divided into three subtasks (10.1 Technology Management, 10.2 Project Management, and 10.3 Technology Integration) and involved activities by the EERC and a subcontract to the Waste Policy Institute (WPI). Since May of 1996, Task 10 has featured two subtasks — 10A and B— with A encompassing the activities under the WPI subcontract and B encompassing a subcontract with VanNess Feldman. WPI's work was completed in the fall of 1996 with subsequent activities undertaken by the EERC under the direction of Thomas Erickson using carryover. Work under Task 10B continued under the direction of Michael Jones of the EERC.

2.0 ACCOMPLISHMENTS/WORK PERFORMED

Under Subtask 10A, activities focused on a review of technology needs compiled by the Site Technology Coordination Groups as part of an ongoing assessment of the relevance of the EM Cooperative Agreement Program activities to EM site needs. Work under this subtask was completed August 31.

Work under Task 10B featured a subcontract with Mr. Ben Yamagata of VanNess Feldman. This activity had as its goal assisting in the definition and development of specific models to demonstrate several approaches to be used by DOE to encourage the commercialization of environmental technologies. This activity included identification and analysis of economic and regulatory factors affecting feasibility of commercial development of two specific projects and two general models to serve as a mechanism for the transfer of federally supported or developed environmental technologies to the private sector or for rapid utilization in the federal government's efforts to clean up the weapons complex.

During this 6-month period, one report has been completed: "Motivation for Technology Development in the Private Sector." A copy of this report is included as Appendix A.

3.0 WORK PLANNED FOR NEXT 6 MONTHS

Work in the next reporting period will include the completion of a report by VanNess Feldman entitled "Impediments to Land Reuse Encountered During Program Development and Methods for Overcoming Those Impediments." This task will be closed November 15, 1997.

APPENDIX A

REPORT FROM VANNESS FELDMAN

VanNess
Feldman
ATTORNEYS AT LAW

A PROFESSIONAL CORPORATION
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(202) 298-1800 Telephone
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Ben Yamagata
(202) 298-1857

May 7, 1997

Energy & Environmental Research Center
Attn: Michael Jones, Ph.D.
University of North Dakota
PO Box 9018
Grand Forks, North Dakota 58202-9018

Re: Subcontract No. 368048

Dear Dr. Jones:

Enclosed for your information is an invoice from Van Ness Feldman to the Energy & Environmental Research Center dated May 7, 1997. Deliverables covered by this invoice include the following:

Project 2: Briefing to DOE Officials regarding land reuse and LandTech.

Deliverable 1: Report to DOE officials on voluntary cleanup programs and land reuse.

Model 1: Monitor privatization efforts at DOE and report to DOE Officials.

Model 2: Monitor legislative and administrative activities to identify opportunities to promote the use of new technologies.

Develop strategies to facilitate the use of DOE-supported new technologies and systems.

Paper explaining technology development activities in the private sector.

We have also enclosed a copy of the paper on technology development activities in the private sector for you. If you have questions please call me at (202) 298-1857.

Sincerely,

Ben Yamagata

MOTIVATION FOR TECHNOLOGY DEVELOPMENT IN THE PRIVATE SECTOR

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I. Introduction

The purpose of this paper is to examine the factors that motivate industry to develop new technologies. In many cases, technology development is fostered through the cooperation of industry and government, each with its own reasons for wanting to develop a new technology. This paper explores: (1) the motivating factors behind technology development in the private sector; (2) government's motivation for encouraging technology development by the private sector; and (3) the models by which government encourages the private sector to develop new technology.

This paper uses numerous illustrative examples to give the reader a background, and more fully explain, the motivations behind technology development. The paper outlines approaches that have and have not been successful. The paper does not define a cure-all approach but rather looks at the positive aspects of several successful methods.

II. Motivating Factors For Technology Development in the Private Sector

A. Government Regulation

The private sector often undertakes efforts to develop new technologies in response to new regulations or the threat of new or more restrictive regulations. There are several examples of companies developing new technology to deal with strict new environmental standards on the state and federal level.

In 1992, New Jersey began enacting special battery management programs to deal with the threat of toxic mercury seeping into the household water stream. By 1993, Duracell and Eveready had reduced the mercury in their batteries to less than one part per million. The threat of state regulation sparked the reform. The technology development was furthered by the perceived threat of regulation.[1/]

Another example of regulation as a catalyst for technological innovation is El Pollo Loco, a chain of fast-food restaurants located almost exclusively in Los Angeles, California. California regulators ordered the restaurant chain to cut its daily air pollution to one pound of smoke per outlet. El Pollo Loco first tried industry's traditional approach: an "end-of-the-pipe" technology. However, the company could not find an available technology that was effective and cost-efficient enough to satisfy the pollution standard. El Pollo Loco, therefore, had to develop its own pollution control technology to meet the state standard. The company eventually discovered that if the chicken was hung vertically on a chain-driven conveyor and passed through red-hot grids, it cooked in half the time, the taste was better, fewer chickens were

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[1/] Gregg Easterbrook, A Moment on the Earth 263 (Michael Carlisle et al. eds., Penguin Books 1996) (1996).

wasted and the smoke was almost completely eliminated.[2] Chief Operating Officer James Verney said the pollution control requirement was "really an economic opportunity for us because it compelled us to be more creative and innovative than we would have been without the clean-air challenge."[3]

B. Technology Threats

Companies are also pushed to develop new technology through perceived technology threats. Threats can be caused by evolutionary and predictable shifts from one generation of existing technology to another. Threats can also be caused by complete displacement of an old technology with a new technology.[4]

These technology threats can be created by government as well as by competitors. In California, the effort to develop alternative fuels has driven companies to develop new technologies. The State has made a concerted effort to encourage the development of these alternative fuels. This has created private industry efforts that range from electric motorcycles to methanol-fueled water trucks. Confronted by the prospect that they could lose their market share to these alternative fuels, California's refineries responded by producing lower-polluting "reformulated" gasoline that is now available commercially.[5] The threat of new technology eroding the refineries' market share was enough to push them toward new technology development.

C. Competition

Businesses sometimes pursue new technology development in order to defend their present position or retain existing market share. Private industry's investment in research and development (R&D) helps fuel the technology development. R&D funding can be broken down into two major categories: (1) basic research, which is research undertaken primarily to gain fuller knowledge or understanding of a subject and to contribute to the knowledge base in the field; and (2) product-oriented research, which has commercialization as its goal. Today, competition has caused companies to focus

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[2] Curtis Moore & Alan Miller, Green Gold 2-3 (Deanne Urmy & Andy Hrycyna eds., Beacon Press 1994) (1994).

[3] Id. at 3.

[4] George Day, New Directions for Corporations: Conditions for Successful Renewal, Eur. Bus. J., June 1993, at 230.

[5] Moore & Miller, supra note 2, at 110. There were a host of factors that played a role in the California refineries' decision to develop reformulated gasoline, not the least of which was a regulatory mandate. For our purposes, however, the paper focuses on the technology threat factor that fostered the innovation.

on product-oriented research, or short-term R&D, in order to provide them a competitive advantage.

Regulated companies have historically been able to invest in long-term R&D because government allowed them to pay for that R&D through their rate base. For these companies, long-term R&D was a practical reality because a guaranteed return on the investment afforded them the luxury of thinking about the future.

Increased competition in regulated industries, however, has led such companies to focus more on short-term technology development. According to the National Science Foundation, corporate funding for basic research is down nearly $500 million since 1991.[6/] The same forces that have led AT&T to cut costs and increase profits are behind the push to change its approach to R&D. At AT&T, the shift has been away from basic research towards product-oriented research in order to generate the biggest payoff for the company in its new competitive environment.[7/]

Electric utilities are another example of an industry that is reducing its long-term R&D funding in order to prepare for increased competition. A recent GAO report found that the nation's investor owned utilities spend nearly one-third less on R&D today then they did three years ago.[8/] Preparing for deregulation and competition was the main reason for the cutbacks in long-term R&D funding.[9/] Moreover, these companies shifted funding to product-oriented research. In a more competitive marketplace, utilities will be forced to price electricity to compete with other utilities and independent power producers. As a result, the R&D managers now evaluate potential R&D projects on the basis of their likelihood of providing a near-term return to the utilities that will allow them to reduce electricity rates.[10/]

D. Overcoming Slow Growth

A further justification for development of new technology is the need to maintain growth in the face of the inevitable slowdown or decline in the presently

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6/ Federal Research: Changes in Electricity-Related R&D Funding, (GAO/RCED-96-203, August 16, 1996).

7/ Steven Pearlstein & Dale Russakoff, At Bell Labs: Product is King, Wash. Post, Nov. 25, 1996, at A1, A12.

8/ GAO Report (GAO/RCED-96-203), supra note 6, at 6.

9/ Id. at 7.

10/ Id.

served market. Companies believe that growing markets are more vibrant and offer greater opportunities for their workers.[11]

Good examples of companies trying to overcome slow growth can be found in the defense industry. For years, the Cold War provided a steady stream of business to defense contractors across the country. With the end of the Cold War, the defense industry has begun to move toward greater consolidation with only a few major suppliers working for the Pentagon. Other contractors, therefore, have chosen to focus on commercial opportunities. To overcome the decline in defense spending, these contractors are looking to new markets for application of their sophisticated technologies. These technologies, however, must be adapted and further developed for the commercial market.

One such company is RMI Titanium Co. The end of the Cold War meant an end to defense contracts for this company that supplies titanium, a strong but light metal used in military aircraft. A researcher at Mizuno Corp., a giant sporting goods company, discovered that the lightweight titanium was perfect for creating a lighter, stronger golf club. The metal is now being used for golf clubs as well as eyeglass frames, watches, bicycles and cameras.[12]

Hughes Aircraft is another example. In 1991, the aerospace company claimed 70 percent of its income from weapons work. In an effort to reduce the level of dependence on the Department of Defense (DoD), Hughes began looking to develop new markets. Currently, it has plans to use technology it has developed for General Motor's Impact, a battery-powered car currently available.[13]

E. Enhancing Shareholder Value

Corporations are not governments or charities. They are motivated primarily by profit. Managers whose priority is to increase shareholder value through appreciation of their equity value are under continued pressure to pursue growth opportunities.[14] Companies such as Dow Chemical and Westinghouse have implemented waste

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11/ Day, supra note 4, at 231.

12/ Richard Bierck, How Golf Saved a Defense Supplier, U.S. News & World Rep., Dec. 2, 1996, at 56.

13/ Moore & Miller, supra note 2, at 118.

14/ Day, supra note 4, at 231.

reduction strategies that have saved million of dollars since the mid-1980's.[15] Chevron saved $10 million in waste disposal costs and reduced hazardous waste by 60 percent in the first three years of its "Save Money and Reduce Toxics" (SMART) program.[16] These efforts were motivated by the bottom line. Waste reduction meant more profit.

However, this pressure to increase shareholder value cuts both ways. The fear that the results of a wrong choice could be devastating prevents risk taking. As Moore and Miller explain in their book Green Gold:

> Few companies enjoying reasonable profits are willing to expose themselves voluntarily to the risks entailed by tinkering with products and production lines, because the risk of failure usually outweighs the reward of success in the minds of executives with their eyes on the next quarter's profits.[17]

Thus, companies are always mindful of new opportunities to reduce costs through the use of new technologies while being careful not to take the company down a risky path toward profit loss.

III. Government's Motivation for Encouraging Technology Development by the Private Sector

A. Public Policy

The primary government motivation for developing new technology is America's self-interest. In the past, government development of new technology was motivated by the desire to win the Cold War or to be the world's leader in space exploration. Today, much of the government's technology development efforts are driven by economics and job creation.

In many instances, the impetus for a new government policy regarding technology development is an impending crisis situation. In 1957, the United States was determined to top the Russian space program. By investing enormous amounts of money in the American space program, the government unleashed a flood of technological innovation. The origin of many of today's environmental technologies can be traced to the space program of the 1960s and 1970s. Environmental technologies created during the space race include:

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[15] John Hood, How Green Was My Balance Sheet: The Environmental Benefits of Capitalism, Policy Review, Fall 1995, at 81.

[16] Id.

[17] Moore & Miller, supra note 2, at 4.

- solar photovoltaic cells, developed to make electricity from sunlight in order to fuel satellites;

- fuel cells to convert hydrogen and oxygen into pure water and electricity for the Apollo and Gemini manned space programs;

- jet engines, the precursor to today's advanced turbines, which were created to speed the flight of rockets and military aircraft.[18/]

Another example of government policy fostering development of technology is the 1973 Arab oil embargo during which the Arab oil-producing nations eliminated supply of petroleum to most of the world. This crisis led the United States to mount a massive "energy independence" program so that America would not have to rely on the fuel of other nations to drive its economy.[19/] The Congress created incentives which prompted natural gas and electric utilities to start putting money into fuel cells; oil companies to begin investing in solar power technology development; and jet engine manufacturers to start using their jet engines at pulp and paper mills, chemical plants, and other facilities.[20/]

IV. Government Models for Encouraging Technology Development in the Private Sector

A. Procurement Model

Whether government encourages the private sector by paying for a new technology or government provides incentives for the private sector to develop a new technology, the results are often the same: new technologies are developed and commercialized. A successful method by which government encourages the private sector by paying for a new technology is through the procurement model.

Government procurement is a highly successful means of fostering innovation in high technology areas. One important example of this is the defense industry. The government's desire to win the Cold War helped justify the spending of billions of dollars a year on defense-related technology development activities. These dollars were spent by the government to fill the need for defense technologies, while at the same time helping the technology developer meet a commercial market need. RMI and Hughes, discussed earlier, are good examples. RMI Titanium needed DoD funding to

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18/ Moore & Miller, supra note 2, at 9-10.

19/ Id.

20/ Id.

perfect its technology and make it available for other commercial applications. Hughes needed DoD funding to perfect its radar technology as well.

The space program is another example of the success of the procurement model. Technologies developed at the National Aeronautics and Space Administration (NASA) have been extremely successful in the private sector. Computers and jet engines are two examples. However, these technologies also required the pull of a government-created market to perfect them to the point that they were ready for commercialization.

NASA takes a different approach today to the commercialization of new technology. Because NASA funding is not as strong as it was at the height of the space race, NASA is searching for new ways to commercialize technologies it has developed through its technology transfer program. Part of its marketing strategy is to hold trade shows displaying technologies to the private sector and demonstrating how they can be commercially used. Astronaut suits can be altered for firefighters; temperature control devices can provide better air quality in people's homes; and motion sensing cameras can be used for home security systems. All of these technologies are available for commercialization and patent.[21/] NASA hopes private companies will pick up the technologies, further develop them and license them for commercial use.[22/]

<u>B. Regulatory Model</u>

In many technology development scenarios, there is an existing market for the technology that the private sector wants to develop. In those cases, the government does not strive to create a market or provide capital. Instead, the government function is to make the transition from laboratory to marketplace as smooth as possible.

Facilitating technology innovation in the medical technology field is an excellent example of the regulatory model. The medical technology approval process is administered by the Food and Drug Administration (FDA). In order to facilitate the development of these new technologies, the FDA attempts to quickly approve them for the marketplace. The FDA categorizes the technologies based on their threat to human health. Class I products pose the least risk; Class II products pose moderate

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21/ Kimberly Sanchez, <u>NASA Eyes Commercial Successes</u>, Chi. Sun-Times, Oct. 30, 1995, at 43.

22/ <u>Id.</u>

risk; and Class III products pose the most significant risk. The degree of control the FDA demands over the product is based on the level of risk the technology poses.[23]

Depending on the individual device, clearance can be obtained through a pre-market notification (510(k)) or a premarket approval (PMA). Products cleared through a 510(k) are "substantially equivalent" to an earlier, legally marketed device. These products tend to reflect incremental innovations. Products approved through the PMA represent greater potential risk to patients and are not substantially equivalent to an earlier device. These products tend to represent breakthrough technologies.[24]

Large companies focus on incremental improvements during more mature stages of innovation. Small companies, which make up almost 75 percent of the medical technology industry, are more innovative and are involved during the early stages of development. However, these small firms usually do not have the resources or expertise to manage the uncertainty and resistance often associated with innovative technology development.[25]

Therefore, venture capital plays a large role in helping to commercialize new medical technologies. Because there is already a market for these technologies, venture capital from private sources has grown at a much faster rate than venture capital spending in general.[26] FDA's streamlined approval process helps these small companies, who may have some venture capital, clear the regulatory hurdles as quickly as possible before that capital is no longer available.

C. Subsidized Research and Development

Subsidies for private research and development can come in many different types. One form of subsidized R&D is the regulated monopoly form of subsidy. Examples of these types of industries can be found in the electric utility industry as well as the telephone service industry. As described before, the electric utilities and AT&T were allowed to build research and development into the rates they charged their customers. This provided companies the opportunity to think long-term and develop new, breakthrough technologies while being ensured a reasonable rate of return. That dynamic has changed as these industries have been opened up to competition. In today's competitive marketplace, these companies are investing in

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[23] Candace Littell, Innovation in Medical Technology: Reading the Indicators, Health Affairs, Summer 1994, at 231.

[24] Id.

[25] Id. at 232-33.

[26] Id. at 229.

technology development that can be achieved in the near future, perhaps within three years.

In the past, AT&T's system separated the scientists from the developers. This model of innovation allowed scientists to follow their curiosity toward important breakthroughs. They then passed the results over to those responsible for commercializing the technology. This approach led to development of technologies such as the laser, fax, answering machine, cellular telephone and transistor. The results, however, on AT&T's commercialization of these technologies were not as impressive. Scientists were unable to see the commercial aspects of the technology and failed to communicate with technology developers. This prevented AT&T from capitalizing on its own innovation and allowed other companies time to develop and profit from AT&T's innovation.[27/]

There are other forms of subsidized R&D as well. Some states have programs designed to provide seed money to companies to subsidize their product development. In California, the Technology Advancement Office (TAO) uses money derived from pollution fines, and a dedicated surcharge on car registrations, to fund promising new technologies to combat smog in Los Angeles.[28/] Likewise, the California Energy Commission (CEC) gives grants to California businesses so they can compete against countries like Germany and Japan in the environmental technology field. California believes that companies cannot keep up with technological advances occurring in their industries if they do not get involved in the world market.[29/]

The California state legislature has also included R&D provisions in its recent electric industry restructuring legislation.[30/] The legislation establishes a statewide rate component to be included as part of local distribution service by the investor-owned and municipal utilities in California. Funds collected pursuant to the rate component are estimated at approximately $780 million over four years. The funds are to be spent on: (1) cost effective energy efficiency and conservation activities; (2) public interest research and development not adequately provided by competitive and regulated markets; and (3) in-state operation and development of existing and emerging renewable resource technologies.

27/ Pearlstein & Russakoff, <u>supra</u> note 7, at A12.

28/ Moore & Miller, <u>supra</u> note 2, at 116.

29/ <u>Id.</u> at 119.

30/ AB 1890 (passed Aug. 28, 1996).

D. Government As Partner

Another model for technology development is when government acts as a partner with industry. This approach is similar to the procurement model. Many companies that were involved in cooperative R&D efforts with the federal government are now beginning to withdraw because of decreased funding of these efforts by the federal government. States are also cutting back on government co-funded R&D. In a recent GAO report, researchers found that there was a 30 percent reduction in state funding, from $83 million to $58 million, since 1993 in the nine states examined. Most of these programs involved energy efficiency and generation technology R&D.[31/]

According to many utility R&D managers, the move is away from collaborative projects benefiting all utilities to proprietary R&D efforts that give their individual companies a competitive edge. More than half of the 80 utilities contacted by GAO reported reduced funding for collaborative R&D. They believe that they are putting their companies at a competitive disadvantage to other utilities that are not making such investments.[32/]

Utilities are moving away from long-term R&D like the advanced gas turbine and new fuel cells. The focus is on short-term projects that are profitable and provide a competitive advantage in the near term. However, these companies are concerned that if these reduced efforts in long-term R&D continue, the result will be decreased technology development. In addition, DOE officials have stated that reductions in the renewable and fossil energy programs will delay penetration of technologies into the market and change the way that some projects are being carried out.[33/]

E. Technology Forcing

The federal government has also used technology forcing as a way to spur technology development, especially in the field of environmental technology. One example of innovation in response to regulatory need is the development of substitutes for chlorofluorocarbons (CFCs), chemicals that decompose in the stratosphere causing damage to the ozone layer.

31/ GAO Report (GAO/RCED-96-203), supra note 6, at 8-9.

32/ Id. at 10.

33/ Id. at 12.

Although regulation of CFCs began in 1978, they continue to be used today.[34] As late as 1986, industry studies found that no satisfactory substitutes for CFCs existed or were on the horizon. Nevertheless, environmental concerns led to the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. The protocol mandated a ten-year, 50 percent reduction in CFC use but did not restrict specific applications or otherwise dictate how the target would be achieved. The United States imposed a cap on production but allowed trading by producers. The U.S. also mandated steadily increasing taxes on CFCs to ensure a steady rise in prices.[35]

A 1988 EPA regulatory impact study concluded that the 50 percent reduction was attainable by the year 2000, but would be achieved largely by adoption of new chemicals with billions of dollars in added costs. However, because the allocation of supply was uncertain and price increases in CFCs were guaranteed by the tax, companies did not simply accept new chemicals. Instead, they took a fresh look at the production process and products. They examined the alternatives, finding many that were technically superior and less expensive.

Two years after the initial EPA study, a reexamination of the costs found that a complete elimination of CFC production would cost less than had been originally estimated for the 50 percent reduction. The process accelerated when the protocol was amended in 1990 to require a complete phase-out of CFCs. Almost two-thirds of the projected market for CFCs is expected to be either eliminated by conservation practices or satisfied by non-CFC alternatives by 1996.[36]

F. Tax Incentives

Another method for encouraging the development of new technologies is through the use of tax incentives. Governments are increasingly turning towards this approach, motivated by growing evidence that industrial research is not just valuable for business but to society as a whole.[37]

A recent survey found that all the G-7 countries, except for Britain and Germany, have substantial tax incentives for companies that increase spending on research. Recent studies conclude that for every dollar of tax revenue lost by the government, as much as two dollars of R&D might be carried out by the companies

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[34] Alan Miller, Environmental Regulation, Technological Innovation, and Technology Forcing, Nat. Resources & Env't, Fall 1995, at 66.

[35] Id.

[36] Id.

[37] William Brown, Give Industry A Break, New Scientist, Feb. 6, 1993, at 12.

receiving the tax incentives. Some economists, however, are not convinced that tax incentives have such a dramatic effect on R&D spending. A company that is growing could increase R&D expenditures regardless of whether it receives a tax incentive.[38]

However, tax incentives provide tangible results according to the National Science Foundation (NSF). In a study performed by the NSF, researchers concluded that society as a whole makes a return on investment of between 30 and 40 percent on R&D tax breaks. Some companies view tax incentives as better than grants because they allow companies to decide which research to pursue. Opponents of tax incentives argue that tax incentives lead many companies to try and reclassify other activities as R&D.[39]

G. Regulation Creating Innovation

Flexibility in regulatory structure also encourages the development of new technologies. David Gardiner, EPA assistant administrator for policy, planning and evaluation, told a joint House subcommittee on Technology, Energy and Environment in June that:

> Environmental standards that are currently in place tend to "lock in" the use of existing technologies because they are based on reference technologies that were already well demonstrated when standards were promulgated. Even where companies are legally permitted to use alternative methods to meet a standard, they are usually unwilling to risk non-compliance by implementing a relatively unknown or unproven technology. Enforcement personnel do not normally grant exceptions for businesses that make bona fide attempts to comply using an innovative approach but need extra time or fall short of the regulatory mark. Since companies are given no reward for trying a new approach and no protection against failure, conventional technologies tend to be used over and over again, freezing out newer and more effective options.[40]

For EPA the answer, therefore, is not just strict regulation. Strict regulation alone will only stagnate innovation. When using regulation to foster innovation, the answer seems to be stricter environmental standards coupled with regulatory flexibility. Only then will companies have the incentive (strict standards) and the ability (flexibility) to develop new and innovative technologies.

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[38] Id.

[39] Id.

[40] Environmental Regulation: A Barrier to the Use of Environmental Technology Before the Subcomm. on Technology and the Subcomm. on Energy and Environment of the House Comm. on Science, 104th Cong., 2d Sess. 14 (1996).

V. Conclusion

Private companies are motivated to develop technology through a number of factors including: (1) government regulation; (2) technology threats; (3) competition; (4) to overcome slow growth; and (5) to enhance shareholder value. In the past, industry responded to these factors through a combination of long-term and short-term R&D. However, cutbacks in federal funding of R&D as well as increased competition in regulated industries means less money is available to invest in long-term R&D. Therefore, many companies are investing in short-term R&D that focuses on near-term technology commercialization.

These private sector motivations are distinct from those that drive government to encourage private sector development of technology. Fundamentally, private industry is driven by economics. If there is a market for the technology and the company can realize a profit, it will pursue development. If the market is forced on industry through regulation, it will pursue development of, at a minimum, an economically viable technology. American self-interest has typically been the government's motivation. It was fairly simple to convince the public that government should encourage private sector development in order for the United States to win the Cold War or find a solution to the energy crisis. Today's government interest is economic security and job creation. This is a more fragmented self-interest and the public perceives less need for the government to encourage private sector technology development.

In the current environment, therefore, some industries are more focused on short-term R&D because they have lost their incentive for a long-term R&D approach. A competitive, deregulated environment makes long-term R&D a luxury many industries cannot afford at this time. There is still a role for government, however, either to further enhance the short-term R&D efforts or to move some of the industry focus toward long-term R&D.

Government has several successful models that have led to technology development in the past including: (1) procurement, which creates the market; (2) creating a regulatory framework that streamlines the path from innovation to marketplace; (3) subsidized R&D; (4) government partnerships; (5) technology forcing; (6) tax incentives; and (7) technological innovation sparked by regulation. These models, or some hybrid form of them, could be used to enhance technology development in the private sector.