CROSSING THE VALLEY OF DEATH: POLICY OPTIONS TO ADVANCE THE UPTAKE OF ENERGY-EFFICIENT EMERGING TECHNOLOGIES IN U.S. INDUSTRY

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ABSTRACT

Plant managers around the world are interested in improving the energy efficiency of their facilities while both growing and modernizing their manufacturing capabilities. Emerging industrial technologies, both at the component-level and system-level, are one important means of capturing significant, lasting efficiency gains.

Public policy can play a decisive role in enabling and encouraging industrial energy efficiency, whether the efficiency improvements come through equipment upgrades or best operating practices. In the United States the industrial sector is impacted by many policies—fiscal and monetary, economic development, energy pricing, climate legislation, tax code, and direct subsidies, among others—all of which help shape the strategy and health of American manufacturers.

This paper examines the market conditions and policy measures that affect the commercialization and adoption rate of promising, new energy-efficient industrial technologies. Market maturity, macroeconomic health, public and private investment, perceived risk, organizational decision-making, and regulatory certainty are all factors that influence the market penetration of emerging industrial technologies. Understanding their interplay is crucial to providing a policy environment that fosters industrial energy efficiency.

In addition to a thorough literary review, this paper draws from a series of discussions with research experts, government officials, academics, equipment manufacturers, technical experts, trade representatives, and leading spokespersons from industry in the US. Authors then distill key findings into a suite of policy options that can help catalyze private technology investment and increase the uptake of emerging, energy-efficient, industrial technologies. Proposed policy options are organized within four central themes:

1) Greater emphasis on emerging technologies within existing energy efficiency activities;
2) Emerging technology at the intersection of energy efficiency and air quality priorities;
3) Diffusion of reliable information and technical data; and
4) Alignment and coordination of public and private activities.

ADVANCING MANUFACTURING TECHNOLOGY: A KEY TO TOP-TIER EFFICIENCY, COMPETITIVENESS

American manufacturers face fierce international competition as the manufactured products and processes of developing countries become increasingly sophisticated and the world's major economies are progressively globalized. Consequently, American manufacturers are seeking opportunities to modernize their own manufacturing operations to increase efficiency and reduce waste—be it energy, water or material scrap—as a means of increasing product margins and overall competitiveness.

In the U.S., manufacturing innovation deserves special attention. American manufacturers are unable to compete with the low cost of labor in developing countries (Figure 1) (45), and face unique regulatory and statutory responsibilities which require added costs and resources. As such, U.S. firms must compete using other manufacturing attributes—quality, ingenuity, productivity and energy efficiency—as competitive advantages.

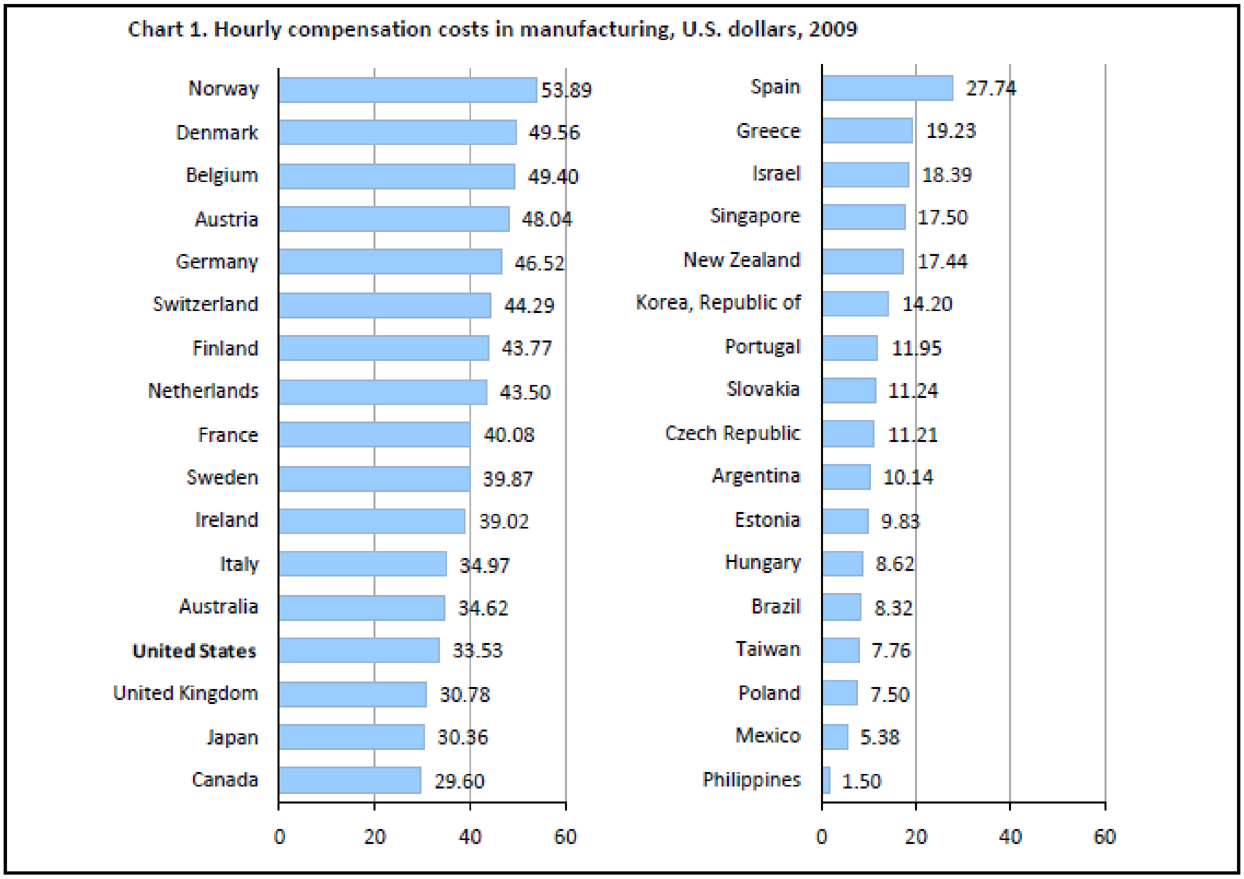

FIGURE 1; Source: U.S. Bureau of Labor Statistics, 2011

Innovation on the Plant Floor: Beyond R&D

Industrial innovation relies on robust research and development (R&D) initiatives—conventionally undertaken by a combination of public and private entities—to maintain a full pipeline of emerging industrial technologies. An effective R&D process requires strategies and funding to pursue both basic research (the study of fundamental scientific understanding) and applied R&D (focused, outcome-based research), each of which are fundamental to technology innovation.

For this purpose of this paper emerging technologies are defined as those that embody the latest in efficiency and productivity design, and are either currently in the late pre-commercial stages, or have recently entered the market, but represent less than 5 percent of current market share. By this definition, technologies are no longer considered emerging after being commercially available for ten years.

The U.S. Department of Energy's (DOE) Industrial Technologies Program (ITP) has championed energy-efficient emerging technologies for industry since 1979. During this time, ITP has supported more than 600 separate research, development, and demonstration (RD&D) projects producing more than 160 new, energy-efficient technologies. Many of these technologies have been commercialized in various industrial settings and ITP has monitored their implementation and assessed their energy savings. Examples of these technologies include an aluminum scrap decoater, an evaporator fan controller for refrigeration, and a variable frequency microwave furnace. The aggregate energy savings resulting from more than 160 completed and tracked projects and other ITP programs over the past three decades is approximately 3.99 quadrillion Btu (quad), representing an energy cost savings of $20.4 billion.

Despite DOE's longstanding support for industrial technology R&D and deployment, total U.S. investment [per GDP] in industrial technology R&D lags significantly behind foreign competitors (25). Nevertheless the U.S. continues to develop innovative energy-efficient industrial technologies. One study conducted in 2000 evaluated approximately 175 emerging energy-efficient industrial technologies across all sectors, then identified, characterized and profiled a sub-group of the 54 most promising of these technologies (22). Despite high marks regarding energy performance, first cost and other quantifiable benefits (eg: productivity, product quality, etc.), authors acknowledged the commercial success of these technologies is highly dependent on other market factors.

Our paper uses this premise as a starting point. R&D programs—including the approach and structure of cooperative research, sources and levels of funding, and strategic research priorities—are each essential to the development of innovative technologies; however, equally important is bringing products to market. Without a concerted effort to get new technologies into the hands of industrial end-users, bright ideas are left to languish and substantial investments go unfulfilled. Conceding the importance of strong and focused R&D initiatives, this paper focuses on technology adoption—that is, supportive policies and programs which promote the uptake of emerging industrial technologies in manufacturing facilities.

<u>Manufacturing Technology Lock-In</u>

Technology lock-in is a principle of self-reinforcement (or a "positive feedback"[i] (46)) whereby technology infrastructure, integration architecture, and manufacturing processes evolve around core technologies. Over time, core technologies develop a robust support network—highly-trained equipment operators, specialized technicians, widely integrated components, sunk investment in technology infrastructure, established parts suppliers—and carve out a defined niche in their respective manufacturing processes. As manufacturers continue to invest in these support networks and core technologies become ingrained in production processes, technological momentum is generated.

In a 2008 report prepared by Oak Ridge National Laboratory (6), authors summarize the powerful lock-in principle using three distinct categories to organize the adoption barriers faced by new technologies: 1. *incumbent technology support systems;* 2. *business risks of innovation;* and 3. *high transaction costs*. Authors refer to these reinforcing factors as the "iron triangle of barriers".

<u>LEGACY TECHNOLOGY: THE PATH OF LEAST RESISTANCE</u>

Lock-in may occur in each economic sector individually, or across all sectors collectively. Within the context of the U.S. industrial sector specifically, manufacturers are highly susceptible to technology lock-in. U.S. manufacturers are subject to a distinct set of technology lock-in barriers—some shared by other economic sectors, others unique to U.S. manufacturing—which impose disproportionately high vulnerability to technology lock-in. Many of these manufacturing barriers are discussed below within the framework of the "Iron Triangle of Barriers" (6). Additional regulatory and statutory barriers are also discussed below.

High Transaction Costs	Incumbent Technology Support Systems	Business Risks of Innovation	Regulatory and Statutory Barriers

• Upfront equipment costs
• Permitting fees (*also see regulatory & statutory barriers*)
• Time/cost of new technology evaluation
• Cost of detailed, trusted technology data
• Dedicated energy staff
	• Highly integrated equipment and processes
	• Long equipment life-cycles
	• Defined investment cycles
	• Established vendor relationships
	• Trained operation and maintenance personnel
		• Technical risk associated with under-performance, equipment integration, and equipment failure
		• Economic risk associated with cash flow and project financing
			• Environmental policy
			  ○ New Source Review
			  ○ GHG regulation under the Clean Air Act
			• Energy policy uncertainty
			• Climate policy uncertainty
			• Fiscal policy
			  ○ Tax treatment of new technologies

Source: Alliance to Save Energy

HIGH TRANSACTION COSTS

Up-front Equipment Costs. Manufacturing equipment is expensive and upfront equipment costs are overwhelmingly cited as the greatest barrier to implementing new industrial technologies (57). In fact, OEM equipment costs could feasibly exceed tens of millions of dollars (3). In addition to retail costs of industrial equipment, a number of other significant costs which are associated with the project implementation can accrue. Feasibility studies, equipment trials, system design, project construction, system integration and equipment calibration are all included in the project cost for new technology adoption (31). Many of these costs are also duplicative when a single technology is implemented across a number of applications and/or plant locations.

To fully understand the barrier of first cost, it is important to note that energy-efficient capital equipment[1] projects typically compete for funds internally against other types of capital projects which may promote added capacity, productivity, or new product lines (15), as well as mandated expenditures required to comply with environmental or safety regulations. Historically, experts have observed a trend in manufacturing investment favoring increased output verses a reduction in production costs (7). For this reason, attractive energy efficiency projects are disadvantaged as compared to projects which explicitly support top-line revenue growth.

Internal competition among capital projects also intensifies hurdle rates for most prospective equipment projects. Today, in a tepid economic climate, most manufacturers require payback periods between 1 and 3 years for all capital projects (and often 2 years or less), including energy efficiency projects (15). Due to strict, rapid payback requirements, many energy efficiency projects offering long-term, low-risk energy cost savings are disregarded without ever reaching a formal internal review.

Time/Cost of New Technology Evaluation. Technology evaluation and procurement tend to differ extensively between large manufacturers and small manufacturers. However, despite the extent to which technologies are researched, trialed, and evaluated, the process requires technical expertise, time and money.

Particularly for small manufacturers, limited technical staff and internal resources often prevent firms from tracking and evaluating equipment innovations (9). Furthermore, many small- and mid-size discrete manufacturers tend to focus on product development and product quality to underpin competitiveness, rather than an efficient manufacturing process which is invisible to customers (3).

[1] For the purposes of this paper, "capital equipment" is defined as items that individually have a cost of $5,000 or more, and have a useful life of two years or more.

For large manufacturers, new equipment evaluation and procurement is a time- and labor-intensive undertaking. Large firms often use their purchasing power to devise a competitive process among vendors to help negotiate an attractive purchasing agreement. Large procurement deals can include vendor-sponsored feasibility studies, equipment trials, warranties and other costly propositions, which may overshadow the energy performance of the equipment (3). A complex equipment procurement process may also deter or delay plant managers from exploring equipment alternatives in instances where equipment repair can extend the useful life of existing production equipment (15).

Cost of Detailed, Trusted Technology Data. Information asymmetry is a fundamental barrier to efficient markets and a significant challenge for emerging industrial technologies to overcome (8). Emerging technologies, by nature, are widely unknown and unproven. In the industrial sector, valid information from trusted sources is critical to technology evaluation and adoption, as nearly every aspect of profitability is subject to technical risk.

Traditionally, technology vendors are the best source of granular technical data, which is a necessity for manufacturing engineers when evaluating a new technology. However, data provided by a technology vendor introduces a clear conflict of interest, and often manufacturers are weary of vendors' performance claims (3).

Public agencies and utilities also provide information on different types of emerging industrial technologies—factsheets, technology profiles, case studies—but typically remain vendor-neutral (3). Despite developing awareness of a given class of technology, vendor-neutral data does not provide the level of specificity needed to prompt technology adoption.

For these reasons, firsthand, word-of-mouth information is frequently cited as the most effective source (29), as technical experts—engineers, consultants, operators—can share direct experience with a given technology's operation, performance, durability and reliability (*Figure 2*). In addition, prospective adopters can ask case-specific questions, which are critical to determining the feasibility of a specific technology application. However, in the absence of public programs to promote the exchange of trusted, firsthand information, manufacturers are often left to hire costly independent technical experts to provide detailed information on new technology options and performance.

SOURCES OF TRUSTED TECHNOLOGY INFORMATION			
Rank	**Large Manufacturers**	**Foundries**	**Small- and Medium-sized Manufacturers**
1	Internal Staff	Subsector Peers	Consultants
2	Consultants	Trade Associations	Govn't Sponsored Energy Audits
3	Conferences & Seminars	Consultants	Internal Staff
4	Vendor Information	Internal Staff	Subsector Peers
5	Utilities	Conferences & Seminars	Conferences & Seminars
6	Subsector Peers	Written Sources	Vendor Information
7	Written Sources	Govn't Sponsored Energy Audits	Utilities

FIGURE 2; Source: Palm, J. and Thollander, P., 2010. (12)

Cost of Dedicated Energy Staff. Upwards of 90 percent of U.S. manufacturing facilities are considered small- or medium-sized—that is plants that employ less than 500 employees[ii] (38). Given recent economic pressures, many U.S. manufacturers, particularly small manufacturers, are carrying a lean staff, employing only those essential to daily operations. As a result, most small- and medium-sized manufacturers do not employ dedicated energy managers who may conduct, or contribute to the evaluation of new production technologies, manage the equipment procurement process and oversee the project implementation. In the absence of a qualified, accountable party, small manufacturers are unaware of technology innovations, or lack the expertise to identify advanced equipment alternatives (57).

Improvements in productivity and product quality (in addition to energy efficiency) are important considerations when evaluating the economic attractiveness of a new technology. However, small firms without specialized staff have particular difficulty quantifying the ancillary benefits of new technology adoption and rarely include them in cost-benefit analyses (33).

Finally, another important role of a dedicated energy professional may be to adapt equipment replacement schedules to reflect new equipment alternatives and energy consumption (on a per unit basis) rates. In the absence of this planning, many small manufacturers are accustomed to using existing equipment until the end of its useful life when equipment is prone to breakdown or failure. The replacement of failed equipment outside of planned shut-downs adds external pressures (eg: productivity loss, accrued overhead expenses, delivery schedules, etc.) to expedite equipment selection. In these instances, plant personnel are more likely to replace failed equipment or components with identical or similar models to minimize extra time/cost associated with internal project approval, system modifications, or employee training (10).

INCUMBENT TECHNOLOGY SUPPORT SYSTEMS

Integrated Equipment and Processes. Each piece of manufacturing equipment is designed to perform a key function, or set of functions, as part of a larger manufacturing process. In many instances, a new technology must be integrated into pre-existing system infrastructure and/or integrated with other systems. For this reason, the interoperability of a technology with other equipment or systems is paramount.

By the same token, devising, designing and investing in a manufacturing process comes at a significant cost to manufacturers (9). For plants that have functioning production lines in place, most existing equipment represents a sunk cost. New manufacturing technologies that ignore or eliminate legacy system infrastructure must account for a manufacturer's previous investment into existing infrastructure.

Long equipment life-cycles. Manufacturing equipment is built to withstand uninterrupted production schedules with reliability and throughput often considered key performance metrics. With adequate preventative maintenance and servicing, most manufacturing equipment is expected to last for decades. In fact, the results of one depreciation study conducted by the Office of Industrial Economics found an estimated mean equipment lifetime to be 17 years across a broad cross-section of industrial subsectors (56). However, this figure can vary significantly based on plant type and company.

Long equipment lifetimes reduce the frequency of scheduled equipment replacement, and therefore inhibit the rapid diffusion of emerging industrial technologies. In other words, convincing manufacturers to replace equipment before the end of its useful life requires a compelling business case, and is unlikely based on energy savings alone (56).

Defined Investment Cycles. For many industrial firms, significant strategic purchases are evaluated against an overarching investment cycle which takes into account the age of the plant, its status and functionality in a given company's plant stock, and strategic plans for future investment. An investment cycle helps to determine required levels of equipment maintenance, equipment replacement schedules and the incorporation of modernized technology within a given plant (15). Although investment cycles can vary significantly by plant type, cycles typically run from 4 to 7 years (9).

Depending on the emerging industrial technology, investment cycles may or may not represent a significant barrier to adoption. For example, if the technology can be integrated seamlessly, and offers a high degree of energy savings at a modest price point, then it is a sensible option to introduce outside of planned investment cycles. Otherwise, most significant investments in operating equipment will be deferred until the next plant-level refit, which coincides with pre-defined investment cycles (15).

Established Vendor Relationships. For emerging technology vendors seeking to gain market entry, vendor allegiance presents a significant barrier to reaching industrial customers. Particularly for small manufacturers, vendors may provide a broad range of services—equipment performance data, equipment training, process engineering, and technology customization, among others—to gain a competitive advantage and retain customers (9). For many small manufacturers with a lean technical staff and tight capital budgets, free vendor services have helped to forge strong, lasting relationships between manufacturers and their equipment providers.

Furthermore, the existing manufacturing equipment within a given plant is supported by networks of parts suppliers and specialized technicians, in addition to vendor representatives. For manufacturers who have cultivated strong business-to-business relationships with suppliers and service technicians, adopting a new type of technology—or even a different make of equipment—can jeopardize these established and trusted relationships.

Specialized Operation and Maintenance Personnel. Modern manufacturing relies on skilled equipment operators to oversee process equipment and cross-cutting industrial systems. Equipment operators typically develop firsthand mastery of equipment capabilities, functionality, and their role and responsibilities as part of the larger manufacturing process over years of equipment operation. Introducing new technology to the manufacturing process can require significant training and time to achieve adequate, then optimal, equipment operation. Educating equipment operators regarding the energy performance of the technology, as well as identifying best operating practices, are also necessary to optimize the energy efficiency of a new technology (23).

Maintenance of both core process equipment and supporting cross-cutting systems are also critical to consistent, uninterrupted production. Maintenance schedules are developed according to individual equipment specifications and executed by trained, knowledgeable technicians. Changes in equipment can present significant challenges for maintenance staff, and require considerable training and extra time to learn a new technology.

BUSINESS RISKS OF INNOVATION

Manufacturing equipment and production represent the heart and soul of a manufacturing facility—each directly linked to profitability. As such, minimizing risks associated with the plant operations is a fundamental priority for manufacturers.

Technical Risk. Many modern manufacturers employ 24/7 production cycles and make strategic plans and predictions accordingly (11). For manufacturers, equipment reliability is of utmost priority, as periods of line and/or plant shut down result in massive productivity losses. According to one study, an unplanned outage in the automotive sector is estimated to result in productivity losses estimated at $181,500 per hour (12). Emerging industrial technologies, like all emerging technologies, do not have a proven track record that can allay concerns of equipment reliability and durability. Therefore, despite anticipated benefits of adopting new technologies, early-adopters of emerging industrial technologies inherently face a certain level of exposure to technical risk.

Depending on the size and resources of a given manufacturer, technical risks are mitigated in different ways. Large manufacturers typically conduct rigorous field tests and trials to evaluate the performance of a new technology. Small manufacturers who do not have the resources to conduct equipment trials are more apt to rely on public demonstration projects, vendor-sponsored trialing or simply wait and see for a better sense of equipment performance and capabilities (3). One 2006 study states that manufacturers often require technology refinement over two to three development generations—or 10-20 years—before they're firmly convinced of a technology's reliability (21).

Economic Risk. A manufacturer's ability to finance the purchase and implementation of a new industrial technology is dependent on access to capital and the ability to repay any debt accrued—each are subject to economic externalities. In fact, some experts have noted capital investments in the industrial sector have a higher correlation to economic growth than investment in other sectors (57). The primary reasons are two-fold.

Due to the high costs associated with significant equipment investment projects, many manufacturing firms—particularly small- and medium-sized firms—require outside financing to augment internal capital budgets. During times of economic stagnation, sources of credit diminish, significantly limiting manufacturers' access to external sources of low-cost capital (13).

Manufacturer capital investment is also limited by a reduction in revenues, or more specifically cash flow, each of which is directly impacted by the macroeconomic climate. Reduced cash flow affects a firm's ability to make preexisting credit payments to lenders—but also influences a creditor's willingness to make new loans. Even for companies in strong financial stead with access to large capital reserves, capital budgets tighten during times of economic stagnation. Strategically, this frees up liquid assets to avoid borrowing outside capital with high interest rates (13).

REGULATORY & STATUTORY BARRIERS

Statutory and regulatory environments often impact the efficiency of markets. The U.S. manufacturing sector is no exception. Today's manufacturers are not subject to "manufacturing regulation," but instead are affected by broader environmental, energy and fiscal policies.

Regulation is used by policy makers as a means to an end. However, without a detailed understanding of market complexities, regulation can induce unintended consequences. Effective regulation must also keep up with market transformations, as outdated regulation may inhibit growth or innovation of markets (5). Nevertheless, regulation is a necessary tool to protect public interests and welfare, as well as to shape and stimulate modern markets.

Below we discuss select environmental, energy, and economic policies, and explore their impacts on manufacturing energy efficiency.

ENVIRONMENTAL REGULATORY BARRIERS

EPA's New Source Review. New Source Review (NSR) is a permitting process instated under the 1977 Amendments to the Clean Air Act (CAA). NSR applies to "large sources" of criteria air pollutants as defined by the CAA, including many industrial facilities. NSR requires the U.S. Environmental Protection Agency (EPA) to conduct a pre-construction review of all significant modifications to existing facilities, or newly proposed expansions, to ensure adequate environmental controls are included. The NSR process can be both lengthy[2] and costly to manufacturers and others in pursuit of facility upgrades, adding an extra hurdle to many energy efficiency projects (17).

Despite an intent to encourage the adoption of newer, cleaner technology solutions, the current NSR process has been cited as a significant deterrent to industrial energy efficiency projects, as many manufacturers are concerned that equipment upgrade projects will trigger a facility-wide NSR. As a result, the NSR permitting process undermines the business case of many otherwise attractive energy efficiency projects, including new equipment adoption. According to Brown and Chandler, "NSR thus imposes pollution controls where they are least needed and artificially inflates the value of the dirtiest plants"(5).

GHG Regulation under the Clean Air Act. On January 2nd, 2011, the U. S. Environmental Protection Agency (EPA) began regulating greenhouse gases (GHGs) as required under the Clean Air Act (CAA)[3] (48). To satisfy its directive, the U.S. EPA has chosen to include GHG regulation in its Prevention of Significant Deterioration (PSD) permitting program, under New Source Review.

According to the EPA's tailoring rule, the first phase of regulated entities includes only those currently subject to the Prevention of Significant Deterioration (PSD) permitting program—and of those, only for projects resulting in GHG increases of 75,000tpy (on a CO2e basis). According to EPA estimates, approximately 1,600 facilities will be subject to the first phase of GHG regulation (52) including power plants, refineries and cement production facilities (51). However, EPA plans to expand regulations to cover additional large sources (any project resulting in GHG emissions >100,000tpy CO_2e) between 2011 and 2016. After 2016, EPA will examine GHG permitting for smaller sources (51).

Many speculate that the inclusion of GHGs under the PSD permitting process will intensify NSR as a statutory barrier to energy efficiency; however, its influence on manufacturer decision-making remains to be seen.

Another important consideration under the current PSD permitting program is the technical expertise of permitting authorities (1). Each project proposal subject to PSD permitting is evaluated by an individual air quality regulators against "best available control technologies" (BACT) requirements with cost-effectiveness, commercial availability and equipment reliability in mind (53). In the future, if EPA pursues GHG permitting on a broader basis, requiring a subjective BACT analysis for manufacturing projects assumes state permitting authorities are intimately familiar with manufacturing processes across all local subsectors, and that permitting authorities are abreast of any and all industrial equipment innovations that could satisfy BACT requirements. Without an up to date understanding of manufacturing equipment options, BACT requirements could significantly stifle the uptake of promising emerging technologies.

Carbon Regulatory Uncertainty. The prospect of comprehensive U.S. carbon regulation has been discussed for over a decade in the greater context of climate change. Many fore-thinking industrial firms have positioned and prepared for expected regulation, and some have undertaken aggressive greenhouse gas (GHG) emission reduction initiatives. But without clear regulatory mandates, manufacturers are left to anticipate congressional action in the absence of explicit guidance.

According to a 2009 Pew Center survey of 100 large U.S. and multinational companies, "almost all" respondents expected comprehensive U.S. climate legislation to be enacted by 2012, with a majority

[2] According to the Industrial Energy Consumers of America, NSR adds an average of 18 to 24 months to the implementation of energy projects (19).

[3] On Dec. 7, 2009, the Administrator of the U.S. EPA signed the "Endangerment Finding," formally acknowledging that the six core anthropogenic greenhouse gases—carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and hexafluoride—each posed a significant threat to public health and welfare. This action was taken as a matter of course after a Supreme Court ruling on April 2, 2007 (Massachusetts v. EPA), which determined that GHGs should be included as air pollutants covered by the Clean Air Act (49).

expecting legislative action in 2010 (30). In fact, a similar Pew Center study conducted in 2006 concluded that 90 percent of companies surveyed considered climate legislation to be "imminent" (18). Nevertheless, no federal climate legislation has been enacted.

Climate legislation is expected to be a primary driver of industrial energy efficiency, as it would likely impose a price on carbon and other GHG emissions, which are directly related to fossil fuel combustion. Subsequently, the price and use of conventional energy—both electricity and the combustion of primary fuels—is predicted to change dramatically.

Under proposed "cap and trade" schemes introduced in a series of climate bills[4] between 2007 and 2009, carbon reductions are measured by incremental improvements against an annual baseline of emissions (presumably the baseline is proximal to the date of enactment). Without a clear picture of future climate regulation, some firms are reticent to undertake extensive energy efficiency upgrades, unsure if their improvements will be credited towards anticipated legislative mandates. A 2009 study validates this notion, determining regulatory uncertainty contributes to the deferment of energy efficiency investments by industrial energy managers (20).

ENERGY REGULATORY UNCERTAINTY

U.S. federal energy policy has a direct impact on price, availability, and therefore end-use of energy. For the industrial sector—representative of approximately one-third of the nation's energy consumption (47)—energy is embedded in every manufacturing process, and is intimately linked to profitability and competitiveness. Recognizing this, the focus of U.S. energy policy for many decades has been market security, enabling highly-reliable sources of energy at low cost (28).

More recently, largely since 2005, energy policy has begun to reflect new priorities in addition to market security—environmental integrity, national security and energy independence. As such, energy efficiency has begun to play a growing role in federal energy policy as it underpins security, environmental and competitiveness objectives concurrently (28).

The challenge for policy makers, especially in regards to industrial energy policy, is leveraging energy efficiency to its fullest potential to promote a productive, clean and efficient manufacturing sector without negatively impacting the domestic economy, including job creation and U.S. competitiveness.

To underscore this delicate balancing act, some observers have noted that when energy prices do not reflect the "real" costs of energy (without subsidies or environmental externalities), then consumers will necessarily under invest in energy efficiency (57). In counterpoint, rapidly rising energy costs can present a clear threat and "serious harm to America's manufacturing sector and all consumers of energy" (26).

Today, the U.S. lacks a clear and comprehensive energy strategy to address both environmental concerns and issues of secure, affordable energy. Energy uncertainty poses significant harm to the strategic planning of American manufacturers. Without clear national goals and milestones, manufacturers are left to predict the priorities of political leadership, or wait for comprehensive national energy policy to emerge. Energy policy uncertainty prompts investment indecision (15), and in many ways stifles the progress of energy efficiency within U.S. industry.

FISCAL REGULATORY BARRIERS

Federal Tax Code. According to U.S. federal tax code, manufacturing equipment is treated as an asset which contributes to a firm's overall tax exposure. Over the course of its useful life manufacturing equipment depreciates in value according to the Modified Accelerated Cost Recovery System (MACRS), which in turn reduces the firm's tax liability.

From an accounting standpoint, experts have noted that the federal tax code discourages the turnover of capital equipment, as older, fully depreciated equipment does not contribute to a firm's tax obligation while the taxes associated with new equipment adds another layer of cost for technology adopters (5). This disincentive to technology adoption can delay the retirement of obsolete manufacturing equipment.

[4] Over the course of 2007 through 2009, three major greenhouse gas (GHG) cap and trade schemes were introduced in federal legislation:

- S. 2191, America's Climate Security Act of 2007 ("Lieberman-Warner")
- H.R. 2454, the American Clean Energy and Security Act of 2009 ("Waxman-Markey"); and
- S. 1733, the Clean Energy Jobs and American Power Act of 2009, ("CEJAPA")

The MACRS is a document devised by the U.S. Internal Revenue Service (IRS) and was last updated in 1986 as part of the IRS Reform Act (6). As such, it has developed inconsistent treatment of energy-related equipment and fails to reflect modern manufacturing equipment innovations. For example, Brown and Chandler point out that according to the MACRS, a new back-up generator is depreciated over 3 years verses a new combined heat and power (CHP) system is depreciated over 20 years (5). Recently however, federal legislation has used accelerated depreciation as a policy tool to incentivize select technologies, including CHP.

GOVERNMENT INTERVENTION: THE APPROPRIATE ROLE FOR PUBLIC POLICY

Philosophical debates regarding the appropriate role for state and federal governments in technological innovation and diffusion have gone unresolved for a large majority of the 20th century. Despite conflicting ideologies, it is well understood that the government plays a critical role in shaping the innovative progress of U.S. markets, both through determining the direct and indirect regulatory environments, but also through contributions of public investment. With a proper understanding of both the innovation and commercialization processes of new manufacturing technologies, modest public investment in targeted activities can yield significant outcomes (54).

A point of less contention is the federal government's interest in a healthy manufacturing sector. In 2008, manufacturing accounted for 11.5 percent of the total U.S. GDP (34), valued at $1.63 trillion (55) and directly employed 11.8 million workers. In many ways manufacturing also serves as an economic engine to the domestic economy, as the sector helps to drive American innovation and boasts the highest multiplier effect per dollar of any economic sector. In fact in 2008, manufacturers accounted for approximately 45 percent ($160 billion) of all privately-funded research and development (R&D) in the United States (34).

Despite its vital role in the American economy, total investment in manufacturing [as a percentage of GDP] has declined in recent years (*see Figure 3*). Public policy can be a useful tool to minimize existing barriers that currently inhibit cost-effective private investment in energy-efficient technology, as well as promote a healthy and competitive manufacturing sector. In fact, experts have noted the direct correlation between manufacturing competition and process innovation (24). Thus, a regulatory environment that stimulates competitiveness is one that is friendly to technological advancement.

At present, the culmination of technology adoption barriers discussed above compounded by a bleak short-term economic outlook have resulted in a decade of widespread deferment of capital investment. Despite the somber perspective, this represents a great opportunity for public policy as it implies American manufacturers are poised for significant reinvestment based on traditional investment cycles. Using targeted public policy, legislators can help to shape manufacturing investments to prompt greater energy efficiency as a means to fortify the U.S. manufacturing base, its competitiveness, and its potential for job creation.

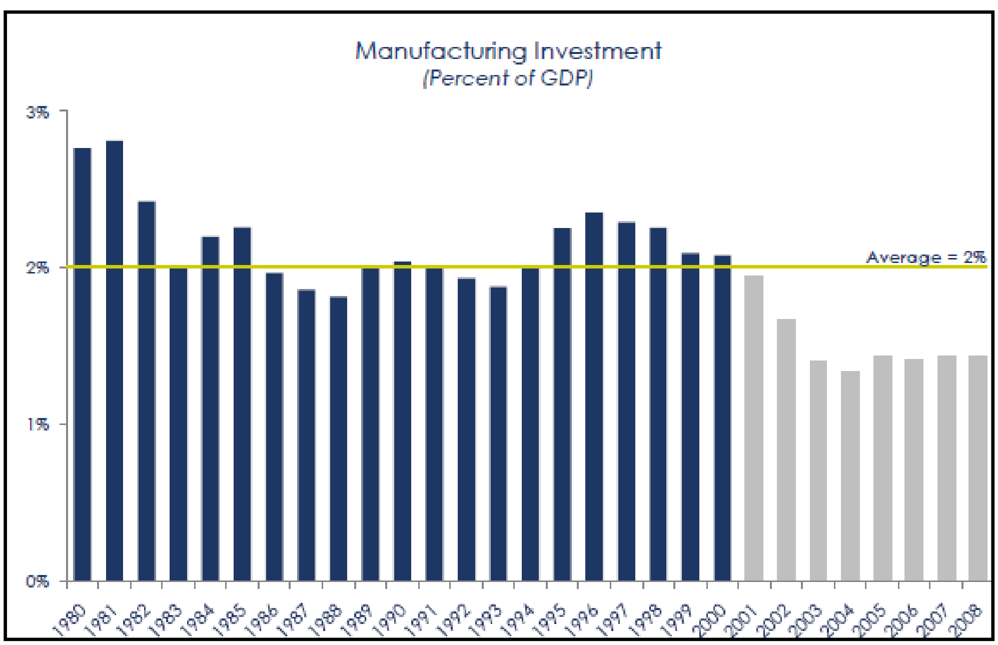

FIGURE 3; Source: Keybridge Research, LLC (prepared for Industrial Energy Consumers of America)

PUBLIC POLICY: PROVEN TOOLS TO CATALYZE THE MARKET

Historically, policy makers have drawn from a long list of tools to promote the diffusion of new, or under-utilized technologies. Using public policy to shape market conditions can help to accelerate the commercialization process, catalyzing the power of the free market to define a clear path to market.

As discussed above, U.S. manufacturers are directly impacted by energy, environmental and tax policies, which collectively contribute to an overarching manufacturing regulatory environment. Creating a regulatory framework that promotes a healthy, competitive manufacturing sector encourages private-sector investment and efficiency gains.

Policy mechanisms can vary widely by cost, applicability, and effectiveness, so it is important to identify specific commercialization barriers when crafting public policy, and tailor policy packages accordingly. Below is a list of policy mechanisms historically used to accelerate technology commercialization.

DIRECT POLICY MECHANISMS

Access to low-cost capital. Energy efficiency projects are often treated as capital projects within manufacturing firms. As such they must compete for capital budget dollars with other capital projects that may benefit productivity, product quality or safety. Due to this treatment of energy projects, many attractive energy efficiency opportunities are foregone because of a limited capital budget, or unwillingness to pay market rates to borrow outside capital.

Low-cost capital, often available through revolving loans funds or government loan programs, offers manufacturing firms access to investment capital below market rates. Providing low-interest public loans over extended periods can significantly improve the economic attractiveness of energy efficiency projects and stimulate capital investment.

Technology Demonstrations. Manufacturers depend on reliable, consistent production as the foundation of profitability. As such, change—whether in the production process or process equipment—represents risk. Manufacturers are highly vulnerable to technical risks associated with new technologies including underperformance, integration complications, equipment breakdown or failure (3).

To foster a sense of comfort with a new technology, demonstrations are vital to provide end-users with valuable, independently-measured test data—often a prerequisite for technology adoption. Further, both technical staff and non-technical managers can physically witness the capabilities of a new technology which has been proven to increase a buyer’s comfort with vendor performance claims (31).

To stress the importance of technology demonstrations, one 2001 study found that adopters only accepted the results of a technology demonstration if data was gathered in a system design similar to their own (57). As a result, the UK’s Best Practice Programme has begun to demonstrate cross-cutting technologies in a number applications to increase end-users’ comfort across various sub-sectors and technology contexts (57).

Tax Credits and Rebates. The use of federal subsidies, often in the form of tax credits or direct rebates, have historically been a popular approach to generate market demand for targeted products thought to promote social welfare (57). Subsidies essentially discount the retail price of a given technology, either at the point of sale, or through a dollar-for-dollar credit from a company’s tax obligation. In theory, federal subsidies can accelerate market forces by reducing consumer prices and therefore stimulating increased product demand.

Over the past decade, the U.S. has used a number of federal subsidies to increase market demand for energy-efficient products across all sectors of the economy, including the industrial sector. However, due to the diversity of industrial subsectors and process equipment, subsidies are best suited to incent technologies that cut across many manufacturing systems and subsectors.

As an example, the Energy Improvement and Extension Act of 2008 introduced a new 10 percent investment tax credit (ITC) covering the first 15 megawatts (MW) of qualified[5] combined heat and power (CHP) projects (35). CHP projects are an attractive option for federal subsidy due to their high price, large potential for energy savings and their flexibility in system design.

[5] Eligible CHP projects are capped at 50MW and must demonstrate system energy efficiency greater than 60 percent.

Another promising example which was included in draft legislation, but never enacted, is the so-called "Motor Crusher Credit," included in both the American Clean Energy Leadership Act (ACELA) and the American Clean Energy and Security Act (ACES). Under the proposed Motor Crusher Credit program, the federal government would issue $25 per horsepower rebates for the purchase of new, NEMA Premium motors, and $5 per horsepower rebates for the retirement of old, obsolete electric motors. Energy-efficient motors are another attractive technology to subsidize as electric motors currently account for an estimated 60 percent of U.S. electricity usage across all sectors. Replacing old motors with new, premium motors has been proven to save approximately 15 to 25 percent of electricity without impacting power or performance (4).

Other Targeted Tax Incentives. The manipulation of federal tax code is a valuable tool to create financial incentives that shape private markets. Most commonly, the federal government uses temporary tax credits or tax deductions (*see "Purchaser Subsidies"*) to impact both buyer and seller behavior, but other tax mechanisms are also available.

Accelerated depreciation is a tool that essentially overwrites the MACRS depreciation schedule for capital assets on a temporary basis. Using accelerated depreciation, the federal government can incentivize high-performing technologies by reducing their associated tax liability.

For instance, between 2008 and 2012, under the Energy Improvement and Extension Act of 2008, CHP systems (among other technologies) are depreciated over a 5-year lifetime as opposed to the traditional 20-year lifetime (40). As such, accelerated depreciation provides a financial incentive for CHP implementation, as technology adopters can significantly reduce their federal tax liability.

Another innovative tax mechanism, which has prompted great interest from the energy efficiency community, is the 1603 Program: Cash Grants in Lieu of Tax Credits, introduced under the American Recovery and Reinvestment Act (ARRA) of 2009, then extended in December of 2010 (41). This program offers a defined tax credit for qualified technology adoption; however, it also gives taxpayers the option to receive the financial incentive upfront in the form of a cash grant, rather than a tax credit which is filed the following fiscal year. For energy efficiency projects, this tax program is very attractive as it offers both a financial incentive for select technologies, but also provides upfront capital, which is critical throughout the early phases of a large capital project.

Government Procurement. The federal government represents the largest consumer in the United States, accounting for an estimated 24.1 percent of GDP in FY2010 (36). Managing its purchasing power through targeted procurement policy and contractual obligations, the federal government can create significant demand in private markets which has the potential to drive innovation (14).

Private sector innovations typically involve an element of market risk. That is, private companies may dedicate capital, time and resources to the research and development of a given technology, but without market demand, there is no mechanism to recoup its investment or generate a profit. However, using strategic government procurement, the federal government can alleviate the pressures of market risk, assuring a minimum level of market demand.

Perhaps the most widely recognized example of government procurement driving private sector innovation is the relationship between the U.S. Department of Defense and private sector defense contractors; however, procurement initiatives have also been employed in the energy space. For example, section 104 of the Energy Policy Act (EPACT) of 2005 requires federal agencies to purchase energy-efficient products. In this case, federal purchasing power is being used to drive market innovation for a wide range of energy-efficient products and equipment, including a number that benefit the industrial sector: boilers, chillers, lighting and motors, among others (44).

Another high-profile example federal procurement spurring innovation is the L-Prize competition, initiated in 2007. As part of the Energy Independence and Security Act (EISA), the U.S. Department of Energy was directed to devise a national competition among lighting manufacturers to develop energy-efficient solid-state lighting alternatives to conventional incandescent and halogen lamps. All entries were required to meet detailed product specifications, including rigorous limitations on energy consumption. Among the prizes for competition winners were opportunities for federal purchasing agreements which represented significant mid-term revenue streams for product manufacturers (43).

Education and training. To complement capable, energy-efficient technologies, the industrial sector requires a trained workforce with a fundamental understanding of energy use and energy management to operate and maintain new technologies.

Historically, federally-sponsored or -subsidized training in the industrial sector has been approached a number of separate ways—three of the most successful include public/private collaborations, professional credential development, and post-secondary vocational training.

Propagation of technical knowledge. The public sector plays a valuable role in providing independent, vendor-neutral information on the performance of industrial technologies and best practices in system design, equipment operation, and equipment maintenance. Often this data is distributed in published data sets, factsheets, whitepapers and case studies. Using a broad network of public resources—government laboratories, not-for-profit organizations, universities and federal employees—the federal government has broad access to qualified technical experts that can provide unbiased evaluation and assessment of emerging technologies.

For the private sector, trusted, independent data is extremely valuable in evaluating claims of technology vendors. For this reason, publically funded technology testing and data collection is an important tool in accelerating the diffusion of promising industrial technologies.

Equipment Standards and Product Labeling. Equipment standards and product labels are two mechanisms to distinguish products deemed "energy-efficient" from alternative options on the open market. This method of differentiation helps consumers who value energy performance to make informed decisions more easily.

Equipment standards have seen great success across a number of market segments—particularly in residential and commercial appliance market—but limited equipment standards have experienced traction in the U.S. industrial sector. Equipment standards can either be mandated by federal or state governments, or developed simply to recognize high-performance products. For the latter, product labels may be also be applied to promote a market awareness of best-in-class technologies.

ENERGY STAR, managed jointly by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE), is a program that tests and certifies qualified energy-efficient appliances, then labels them to promote consumer awareness. Today, ENERGY STAR has grown to be the most widely recognized appliance rating and labeling program in the United States, identifiable to more than 75 percent American public (50). As of 2009, the ENERGY STAR certified over 40,000 individual product models made by nearly 3,000 manufacturers internationally (50). It is estimated that the ENERGY STAR program helped Americans save nearly $17 billion in energy savings throughout 2009 alone (50).

In the industrial sector, equipment standards are considered fairly difficult to implement due to the broad diversity of manufacturing equipment. However, for specific, cross-cutting technologies (eg: motors) some equipment standards do exist.

Included in the Energy Policy Act (EPACT) of 1992 where minimum efficiency performance standards for all electric motors[6] sold within the United States, whether manufacturing domestically or internationally (27). This regulation triggered a step-change in electric motor energy performance, eliminating all obsolete models of electric motors from the U.S. market.

In 2001, the National Electrical Manufacturers Association (NEMA)—in partnership with the U.S. Department of Energy and a coalition of electric motor manufacturers—implemented its own premium motor standard to recognize the market's most energy-efficient electric motors. Today, NEMA Premium® is considered the gold standard of energy-efficient electric motors.

Public Extension Services. For a number of economic sectors, the federal government has established networks of specialists to assist small businesses throughout the U.S. to operate more efficiency and competitively. In the case manufacturing, this network is called the Manufacturing Extension Partnership (MEP) with federal funding provided through the U.S. Department of Commerce's (DOC) National Institute of Standards and Technology (NIST). MEPs are unique public-private collaborations involving federal and state governments, non-profit organizations, academic institutions, and private technical service providers.

[6] This excludes two specific types of electric motors: definite purpose motors and special purpose motors.

Today, NIST's network of MEPs has grown to over 400 centers and field offices dispersed across every state in the nation and Puerto Rico (37). In over 20 years of operation, MEPs have assisted small- and medium-sized manufacturers with sustainable growth and competitiveness focusing on the provision of technical services including plant performance assessments, project identification, productivity improvements, technology evaluation and workforce training. However, beginning in early 2009, NIST unveiled a second phase of strategic support to U.S. manufacturers centered on five new principles: technology acceleration, supplier development, workforce training, sustainability and continuous improvement (39).

MEPs have an extensive reach across the U.S. and have forged strong relationships within the private sector. Leveraging both public and private technical specialists, MEPs represent a powerful mechanism to provide unbiased technical endorsements on emerging industrial technologies.

INDIRECT POLICY MECHANISMS

Energy Policy. Comprehensive energy policy, including a mid- and long-term roadmap for a viable American energy scheme is a critical step to reducing energy price volatility, increasing energy reliability and security, and creating a sense of certainty across U.S. markets. A long-term energy plan dictates the policy framework within which the private sector operates. Establishing an accepted policy framework substantially reduces the risk of private innovation and capital investment.

Comprehensive U.S. energy policy should reflect the priorities of federal government, namely the protection of public interest and welfare, which includes consideration of both economic and environmental impacts, as well as long-term viability.

Environmental Regulation. Environmental regulation—namely the regulation of carbon emissions and other greenhouse gases (GHG)—has the potential to fundamentally change the cost of manufacturing operations in the United States. Carbon emissions are directly linked to the consumption of fossil fuels and indirectly linked to the use of electric power. Therefore, imposing a price on GHG emissions will prompt greater attention to energy use and dramatically alter the valuation calculations (ROI, NPV, simple payback) to make energy efficiency investments more attractive.

Historically, select environmental regulations have accomplished a great deal in advancing technological innovation. Among the more successful examples are the Corporate Average Fuel Economy (CAFÉ) standards instituted in 1975 in response to the Arab Oil Embargo of 1973. Similarly the Clean Air Act which underwent significant amendments in 1970 and 1977 to successfully address SO2 emissions from power plants—a contributor to acid rain—is widely seen as a success story (2).

Policy Mechanism	Market Barrier Addressed	Direct or Indirect Intervention
Access to low-cost capital	High transaction costs	Direct
Demonstration projects	Technical risk	Direct
Purchaser subsidies	Upfront equipment costs	Direct
Other targeted tax incentives	High transaction costs	Direct
Government procurement	Upfront equipment cost;Technical risk	Direct
Education and training	Trained operation and maintenance personnel	Direct
Propagation of technical knowledge	Cost of trusted technical data; Trained operation and maintenance personnel	Direct
Equipment standards	Time/cost of new technology evaluation; Technical risks	Direct
Public extension services	Time/cost of technology evaluation; Lack of dedicated energy staff	Direct
Comprehensive Energy Policy	Regulatory uncertainty	Indirect
Environmental Regulation	Regulatory uncertainty	Indirect

Source: Alliance to Save Energy

KEY POLICY CONSIDERATIONS

Upon completion of this study, authors have developed a series of policy options to increase the uptake of emerging and underutilized energy-efficient industrial technologies. Proposed options are organized within four central themes:

1) Greater emphasis on emerging technologies within existing energy efficiency activities;
2) Emerging technology at the intersection of energy efficiency and air quality priorities;
3) Diffusion of reliable information and technical data; and
4) Alignment and coordination of public and private activities.

Each policy option is intended to address specific gaps or barriers in today's industrial technology adoption process, and subsequently support a more complete market transformation process.

1) Greater emphasis on emerging technologies within existing energy efficiency activities

- *Establish a centralized revolving loan fund intended to catalyze investment in industrial energy efficiency on a national scale*. Cost continues to represent the largest barrier for energy efficiency within the industrial sector. Today, most industrial energy efficiency projects require 1 to 3 year payback periods—and often two years or less (15)—to compete for capital budget dollars within a given firm.

  Establishing a centralized revolving loan fund targeting industrial energy efficiency opportunities would help to address this barrier. Further, an included mechanism providing preference for qualified "emerging technologies"—in the form of a percentage set aside or treatment as a "priority project"—could accelerate market penetration of new industrial technologies.

  Low-cost capital helps to improve the business case for energy efficiency by augmenting internal capital budgets with modestly-priced external capital. When applied to project implementation costs, it helps to encourage investment in projects that may not otherwise get funded. With additional access to low-cost capital, U.S. manufacturers can pursue low risk projects yielding high energy savings, unlocking as much as 18 percent energy savings, sector-wide, based on 2020 consumption projections (16).

  Today, 24 states have mechanisms in place to support their industrial base with various sources of low-cost capital (42). However because of the fragmented nature of state offerings, manufacturers who operate in multiple states find it difficult to navigate the individualized requirements of separate financing programs. As a result, many state-level financing programs are underutilized. A simple, centralized revolving loan fund focusing on mid-term payback periods and verified energy savings would help to drive energy efficiency projects across all sizes of manufacturing facilities. A federal loan fund also introduces the possibility of leveraging federal funds with state, utility, and private dollars to enhance the impact of federal capital.

- *Integrate system-specific technology developments into DOE qualified specialist, energy expert and end-user trainings.* DOE has developed valuable professional credentials to certify the proficiency of specialists in a number of cross-cutting industrial systems: compressed air, pumping, process heating, steam and fan systems. These trainings support and endorse a detailed understanding of best practices in both system operation and maintenance.

  To promote the diffusion of technical knowledge, a small portion of these trainings should be dedicated to a discussion of the technological developments within a given industrial system. This provides an opportunity to discuss verified performance data of various equipment designs, as well as late-stage technology developments which are expected on the commercial market within the mid-term. Incorporating an emerging technology component into qualified specialist and end user curricula could be an effective strategy to get unbiased technical data into the hands of practicing professionals.

2) Emerging technology at the intersection of energy efficiency and air quality priorities

- *Targeted Reform of New Source Review*. As currently implemented, New Source Review (NSR) represents a significant barrier to energy efficiency projects for many U.S. manufacturers. Navigating the NSR permitting process is often time-consuming and expensive, discouraging many otherwise attractive energy efficiency projects in existing manufacturing facilities. Thus, the current permitting process can, at times, undermine the intent of NSR and constrain innovation throughout the industrial sector. For both manufacturers and air quality agencies, this is problematic.

To address this perverse incentive, permitting processes associated with NSR should be reexamined to explore more effective models which promote both improved air quality and industrial equipment upgrades. Establishing regional exchanges between industry leaders, air quality regulators, and U.S. EPA officials would identify key barriers—real and perceived—within existing permitting processes, and initiate an important dialogue to support better alignment of mutual interests. Regional exchanges would also benefit the regulatory process in regards to sharing nuanced technical information and addressing concerns of permitting consistency.

- *Establish U.S. EPA-qualified baseline to measure verified GHG emission reductions.* Many speculate that federal legislation will eventually regulate GHG emissions from large emitters, including manufacturers. However, until legislation is enacted, it is unclear how regulations will be structured, and how qualified emissions reductions will be measured. In the meantime, GHG regulatory uncertainty represents a major barrier to capital investment for many manufacturers.

  In the absence of comprehensive climate legislation, a statutory mechanism could be adopted by the U.S. EPA to establish a baseline year—or a short range of qualified years—against which manufacturers can voluntarily measure verified GHG emission reductions. These verified savings could then be voluntarily reported to EPA in addition to existing GHG reporting requirements.

  By establishing qualified GHG baselines, legislators have a preexisting mechanism to account for early emission reduction actions undertaken by U.S. manufacturers. As a result, these verified emission reductions could be credited under a future climate regulatory regime. In the absence of comprehensive climate policy, qualified baselines and approved emission reduction reporting are a productive step to eliminate some of the energy efficiency impediments of regulatory uncertainty.

3) Diffusion of reliable information and technical data

- *Develop a public-private approach to performance testing of emerging industrial technologies.* In today's commercial markets there exists a frequently-cited need for more independent technical data on emerging industrial technologies. Trusted data is critical to making actionable evaluations of new technologies, and without it, manufacturers are unlikely to assume the added technical risk.

  Performance testing of new technologies is well understood and there are many actors with the technical expertise and resources to provide independent testing including national laboratories, engineering universities, independent laboratories and some utilities. However, without a widely-accepted approach to testing—test procedures, control conditions, key performance metrics, etc.—performance data is often distrusted or not useful to industrial end-users.

  Collaboration between public and private stakeholders to devise an accepted testing approach is an essential first step to making independent performance data more available and more credible, at lower cost. Recognizing the broad diversity of industrial equipment, the establishment of validated testing procedures paves the way for subsequent equipment or component standards, where suitable, at a later stage.

- *Reinforce MEPs/IACs as central points of technology diffusion*. Both Manufacturing Extension Partnerships (MEPs) and Industrial Assessment Centers (IACs) comprise an important network of trusted technical professionals with access to the internal operations of thousands of manufacturing plants on an annual basis (32).

  Recognizing that MEPs were developed in part to promote technology diffusion across the industrial sector, historically, budgetary limitations have restricted these networks' abilities to engage in technology transfer as a core element of their mission. Instead, both MEPs and IAC have experienced great success assisting small- and medium-sized manufacturers with energy assessments, productivity consultation, project identification and dissemination of best practices.

  With continued support and additional funding, these centers could bolster their capacity to: provide detailed information about emerging technologies; offer technology training to assist with new technology adoption; facilitate demonstration projects; support equipment testing processes; and help to provide qualified vendor referrals.

  MEP and IAC technical professionals also represent a valuable feedback loop to inform the research and development priorities of the public sector. With exposure to plant floors of thousands of working facilities, these technical professionals have a unique perspective on opportunities to enhance energy efficiency on both a sector and sub-sector level. Formalizing a feedback process to capture research recommendations of both MEP and IAC professionals will help to strengthen the effectiveness and value of publicly-funded research and development initiatives.

- *Develop and maintain a database of emerging industrial technologies*. For manufacturers of all sizes—and particularly for small manufacturers—navigating the torrent of information related to emerging technology developments can be overwhelming, time consuming and costly. As a result, many manufacturers are unaware of new technology options when upgrading or replacing existing process equipment.

  A database classifying and cataloging new, market-ready technologies could dramatically enhance the exposure of emerging technologies and their capabilities. For manufacturers, this resource could serve as a first stop in the equipment procurement process, providing a high-level market landscape of available technology options. For more detailed, actionable equipment information and performance data, manufacturers could then contact technology vendors directly.

  It is important to note that since the outset of this study the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) has launched a Energy Innovation Portal (http://techportal.eere.energy.gov/) which features a broad listing of federally-sponsored technology developments, including those commercially available as well as others available for licensing, patents, and patent applications.

  To maximize its value to industry, the Energy Innovation Portal should be expanded to include qualified privately-developed industrial technologies, and then segmented by cross-cutting and subsector-specific technologies. Additional information on where and how to purchase listed equipment should be also be included. Usability is paramount to the effectiveness of a technology database. Devising a user-friendly resource to cover the rapid developments of commercially available industrial technologies would be a tremendous asset to advance the uptake emerging technologies.

4) Alignment and coordination of public and private activities/interests

- *Establish regional demonstration hubs.* Demonstration is often an essential component of technology diffusion, particularly to manufacturers, who are heavily exposed to technical risks. To accelerate the uptake of promising technologies, the public sector can help to defray risk for U.S. manufacturers by subsidizing the demonstration of select technologies.

  Regional demonstration hubs would provide a mechanism to match sector-specific technology demonstrations with targeted, regionally-concentrated manufacturing subsectors. Through targeted demonstration projects, technologies can be demonstrated in an application that is familiar to a number of manufacturers within a common subsector. Demonstration hubs would also help to concentrate and coordinate various sources of demonstration funding including the public sector, technology vendors, trade associations, utilities and industrial end-users.

  A limited network of regional demonstration hubs could also compliment independent equipment testing. Under this model, regionally-concentrated subsectors could establish equipment testing consortia to define explicit test criteria by which technologies are evaluated. Data collected from equipment demonstrations would then be publically available to benefit all U.S. manufacturers on a "pre-competitive" basis.

- *Establish/support regional working groups to convene around energy efficiency best practices and emerging industrial technologies.* Peer-to-peer dialogue is critical to fostering comfort with new industrial technologies. Word-of-mouth referrals are highly regarded in the industrial space, and due to the high level of technical sophistication inherent in most technology projects, prospective adopters need the opportunity to discuss technology options in a case-specific context.

  Establishing a forum to connect energy managers and plant personnel that face common barriers to emerging technology evaluation, performance testing, project feasibility and project implementation provides an opportunity to develop valuable relationships, have firsthand exchanges and share qualified vendor referrals. An active working group also convenes appropriate members to discuss international technology developments and best practices that directly support U.S. competitiveness.

Staging working groups at the regional-level is important to an effective model. Regional participation enables manufacturers to share focused input on various state models of policy, incentives and regulation, while also discussing localized resources and specialists. The regional model also tracks well with utility jurisdictions, which is important is promoting healthy working relationships between utilities and their industrial accounts.

The Southeast Energy Efficiency Alliance (SEEA) has experienced great success with its Industrial Coalition, founded on a similar peer-engagement model. Based on the effectiveness of SEEA's coalition, it is worth exploring similar initiatives in other regions of the country.

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