THE MULTIPLE PATHWAYS TO INDUSTRIAL ENERGY EFFICIENCY

A Systems and Value Chain Approach

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List of Abbreviations

ACC	American Chemistry Council
ACEEE	American Council for an Energy-Efficient Economy
BHAG	Big Hairy Audacious Goal
CDLI	Carbon Disclosure Project Leadership Index
CDP	Carbon Disclosure Project
CFO	Chief Financial Officer
CGGC	Duke Center on Globalization, Governance & Competitiveness
CHP	Combined Heat and Power
CIBO	Council of Industrial Boiler Owners
CSR	Corporate Social Responsibility
DJSI	Dow Jones Sustainability Index
DOE	Department of Energy
DSM	Demand-side Management
EEPS	Energy Efficiency Portfolio Standards
EERS	Energy Efficiency Resource Standards
EPA	Environmental Protection Agency
ESCOs	Energy Service Companies
ESH	Environmental, Safety & Health
GRI	Global Reporting Initiative
GSN	Green Suppliers Network
GVC	Global Value Chain analysis
IRR	Internal Rate of Return
ISO	International Organization for Standardization
MECS	Manufacturing Energy Consumption Survey
MEP	Manufacturing Extension Partnership
NGO	Non-governmental Organization
NIST	National Institute of Standards and Technology
NPV	Net Present Value
ROI	Return on Investment
VAR	Value Added Reseller
WBCSD	World Business Council on Sustainable Development

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Summary

This report examines why and how manufacturers adopt energy efficiency in their internal operations and supply chains. Multiple incentives exist for companies to adopt energy-efficient operational and capital improvements. The legal, economic, and social incentives of companies to adopt energy efficiency improvements are subject to the energy intensity of production, the product market, and the company's position in the supply chain. Consumer-facing product manufacturers in energy-intensive industries are most likely to adopt energy-efficiency improvements because of the cost-savings and marketing value created by reducing the environmental impact of production. Increasing the energy efficiency of a company's supply chain also is driven by these legal, economic, and social incentives to reduce the environmental impact of production.

Companies make a series of decisions about how to set goals, identify, finance, implement, and report energy-efficiency opportunities in their internal operations and supply chains. Several successful approaches exist at each decision point of the energy-efficiency process. Case histories of Bridgestone, DuPont, and Nissan provide examples of how companies progressed through the energy-efficiency process.

Adopting energy-efficiency improvements in a company are, like other innovations, affected by multiple sources of information and learning. The sources for information and learning can be both internal and external to the firm. The capability of in-house engineering service teams is vital to successfully adopting energy efficient manufacturing practices. The trust between plant managers primarily interested in continual quality production, business operation units chiefly interested in revenue growth, and engineering services supporting these internal actors is vital to successfully adopting improvements in energy efficiency. Capital budgeting methods typically used by companies, particularly by engineers, do not suitably account for the full value of capital improvements in energy efficiency. Net present value and other innovative methods allow companies to incorporate their goals in reducing carbon emissions in their capital budgeting decisions.

External actors possess information and expertise about how to increase the energy efficiency of a firm's manufacturing process. Governments, utilities, and for-profit organizations can assist companies in identifying and implementing energy-efficiency opportunities. However, trust between these organizations and internal actors takes time to develop. Industry organizations provide useful venues to diffuse information about energy efficiency because of the existing level of trust between members of the same professional organizations. Information about energy-efficiency improvements can also exist in firms within the manufacturing supply chain of a company.

Large retailers, financial institutions, non-governmental organizations (NGOs), and governments can promote the adoption of energy-efficiency improvements by manufacturers. Large retailers can require eco-labels on products sold in their stores. Financial institutions can increase the weight of sustainability criteria in their evaluation of companies. NGOs can affect the social and legal incentives for manufacturers to become more energy efficient, provide information about existing energy-efficiency resources to companies, develop financial analysis tools that appropriately account for cost savings in energy, and encourage manufacturers to set goals for reducing the carbon emissions of their products. Governments can encourage industry organizations to adopt carbon emission standards for manufacturing or create a price for carbon emissions. These actors have a common ability to create, or promote the creation of, private and public incentives and regulations that result in the increased energy efficiency of manufacturing in the United States.

I. INTRODUCTION

The purpose of this report is to understand why and how manufacturers adopt energy-efficiency improvements in their internal operations and supply chains. We explore the actual experience of companies successfully implementing energy-efficiency improvements in their organizations, and discover that companies – knowingly or not – go through a series of steps we call the "energy-efficiency process." At each point of this energy-efficiency process (goal setting, identification, financing, implementation, measurement, benchmarking, and reporting), companies choose different pathways to achieve improved energy efficiency in their organizations. Global value chain (GVC) analysis, which highlights the competitive context in which individual firms act, heavily influences our perspective on why companies implement energy efficiency in their organizations.

Industrial energy efficiency is a topic that has received considerable attention since the 1970s. The first string of studies after the energy crises of 1973 and 1979 noted the extraordinary opportunity for U.S. manufacturers to lower their operational costs while reducing the environmental impact of industrial production (National Research Council, 2001). The intervening years have not decreased the value proposition of energy efficiency for companies. The EPA reports that if the energy efficiency of industrial facilities improved by 10 percent, companies could save $20 billion and reduce greenhouse gas emissions equal to the emissions from the electricity use of more than 22 million homes for a year (EPA, 2010). The industrial sector used approximately 30% of total U.S. energy consumption in 2009, equivalent to 28.2 quadrillion BTUs. (EIA, 2010).

However, scholarly research and practical business experience has established that, despite rapid pay-back periods, companies are not investing in energy-efficiency projects at the level expected of profit-maximizing firms. This so-called "efficiency gap" between the expected level of investment in energy efficiency and the actual level by firms has been reported in many scholarly studies since the early 1990s (Huntington et al., 1994; DeCanio, 1998; Brown, 2001; Sorrell et al., 2004; Schleich, 2009). Investigations into why these investments are not occurring have discovered various "barriers", including organizational and informational barriers, to profitable energy-saving investments (see Table 1).

TABLE 1: BARRIERS TO ENERGY EFFICIENCY

Barrier	Claim
Cost of energy	• Energy costs as proportion of operating costs are low, which results in insignificant savings to the firm from energy-efficiency projects. • Uncertainty in energy costs makes payback calculations difficult to evaluate
Investment barriers	• Insufficient payback • Insufficient access to capital • Growth bias of manufacturing firms • Cyclicality of industrial investment decision-making
Imperfect information	• Lack of information • Lack of expertise • Lack of time/ other priorities
Split incentives	• Landlord/Tenant: neither the landlord nor the tenant have incentives to invest in energy efficiency because they do not realize its returns • Buyer/User: buyer of industrial equipment is concerned with purchase price and reliability of capital rather than energy operating costs
Organizational barriers	• Separate capital and operating budgets • Lack of built-in incentives (bonuses and other pay structures) to reward energy efficiency • Lack of ownership for energy/carbon emissions within the company/ no departmental accountability • Managers stay in posts only for a short time

Source: Adapted from Sorrell et al., 2004 and Schleich, 2009.

Although these barriers are significant, they can be overcome if energy management is seen as part of a firm's core goals and a way to capture value in existing product-lines and processes. The issues for inquiry shift from why barriers to energy efficiency exist to the reasons and methods companies choose to become more energy efficient. The purpose of this report is to identify the motivations of companies and the pathways taken to improved industrial energy efficiency.

Research Scope and Methods

The scope of research for this report is industrial energy efficiency in manufacturers' internal operations and supply chains. Specifically, it addresses why and how manufacturers implement operational and capital improvements to increase the energy efficiency of their product manufacturing process. We do not consider energy efficiency in the transportation of inputs, the distribution of final goods, residential or commercial buildings, or the supply of energy-efficient products by manufacturers.

The research for this report was carried out in several phases. The first phase examined existing research on industrial energy efficiency, which revealed the existence of the "barriers" and "efficiency gap" research in the academic literature. Particularly useful were the scholarly materials developed by Schleich (2009) and Sorrell, O'Malley, Schleich & Scott (2004), and reports by the Pew Center (Pew, 2006 and Pew, 2010a). The second phase studied existing case studies of companies implementing energy efficiency in their operations. Relevant case material came from the Pew Center's "From Shop Floor to Top Floor" report (Pew, 2010a) and conference (Pew, 2010b), and companies participating in federal programs such as EPA's Climate Leaders program and DOE's Industrial Technologies Program. These case materials served as the basis for developing the "energy-efficiency process" discussed in section three of the report. The fourth phase involved company interviews by CGGC researchers to develop further insights into company-level dynamics leading to successful implementation of energy efficiency. The co-sponsorship by CGGC of a conference on energy efficiency using the "energy-efficiency process" as its organizing framework allowed for additional perspectives on the reasons why and how companies adopt energy efficient practices. [1] The fifth phase comprised of report production and review by experts.

The report consists of three parts and an appendix. After the introduction, Part Two discusses the incentives for companies to adopt energy-efficiency improvements and how their product markets, resource intensity, and position in the supply chain affect their incentives to adopt these improvements. Part Three describes the energy-efficiency process and how companies have implemented each phase of the process. The appendix contains a more detailed discussion of the "barriers to energy efficiency" and the company case studies used to develop the insights contained in this report.

[1] "Capturing the Energy Efficiency Opportunity: Lessons from the EDF Climate Corps," September 17, 2010. The conference was sponsored by the Duke Center on Globalization, Governance and Competiveness (CGGC), the Duke Center for Energy, Development and the Global Environment (EDGE) at the Fuqua School of Business, and the Environmental Defense Fund (EDF). Additional information about the conference can be found at http://cggc.duke.edu/events/energy_efficiency_conf/overview.php

II. MOTIVATION: THE INCENTIVES TO ADOPT ENERGY EFFICIENCY

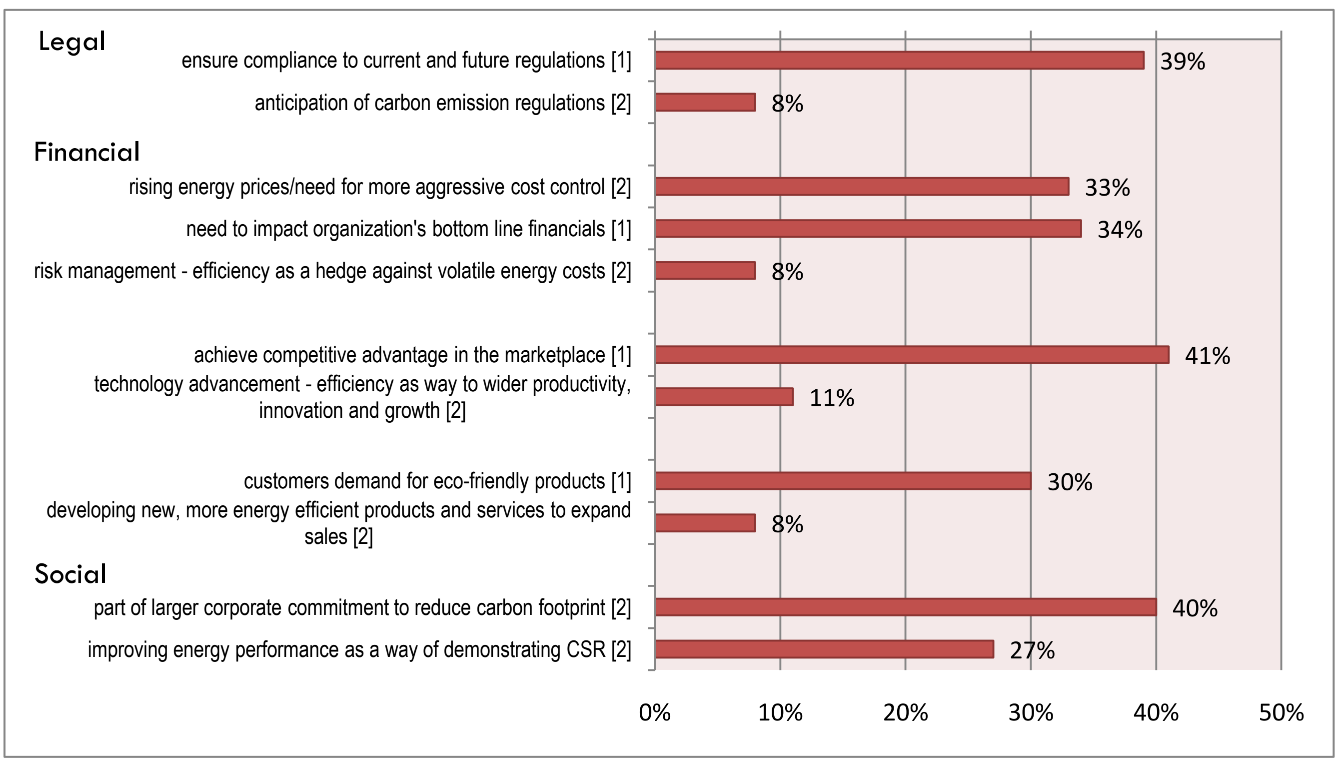
Why do companies seek to become more energy efficient? This section investigates the reasons why companies adopt energy efficiency and how companies' product market, supply chain position, and the energy intensity of the industry affect their incentives to become more energy efficient.

Energy efficiency, for most companies, is part of broad environmental management goals that include air, water, waste, and carbon emissions. These environmental goals, roughly speaking, can be categorized into three areas:

- Legal – compliance with public laws and private regulations
- Financial – cost savings; risk avoidance; brand and new product development
- Social – pressure from internal and external stakeholders

Although the discussion below separates the legal, financial, and social motivations of companies to adopt energy efficiency practices, in practice the motivations of companies are not so easily compartmentalized. As is common of most complex economic and social behavior, a number of factors can simultaneously influence a specific company to adopt environmental goals or energy efficiency practices.

FIGURE 1: COMPANIES' MOTIVATIONS FOR ENERGY EFFICIENCY



Source: Aberdeen Group, 2009 [1]; Pew Center, 2009 [2].

Scientific surveys of what motivates companies to adopt corporate environmental policies find that government legislation or the threat of government legislation is most important. Brand protection, cost savings, pressure from consumers, avoiding risk or responding to an accident, and an organizational champion also were found to be of major importance (in descending order) (Dummett, 2006). The surveys conducted by the Pew Center and the Aberdeen Groups summarized in Figure 1 are generally consistent with these results.

Legal Incentives

Companies must work within the legal frameworks of the societies in which they conduct business or else risk their license to conduct trade. Legal motivations for improving energy efficiency are:

- Regulatory compliance
- Regulatory anticipation (domestic and export markets)
- Response to environmental accidents

A key motivation for companies to monitor their impact on the environment is to ensure compliance with environmental regulations for air, water, and waste emissions. The Clean Air Act of 1970 and the Clean Air Act Amendments of 1990 increased the salience of air regulations for U.S. companies. The declaration of carbon dioxide as a pollutant by the EPA in 2009 and the proposed cap-and-trade legislation placing a price on carbon emissions in the U.S. have influenced some companies to become more aware of, and plan for, the legal implications of their carbon emissions. For example, DuPont increased the management attention paid to carbon emissions and energy efficiency because of carbon pricing legislation passing in the E.U. and regulatory anticipation for carbon pricing in the U.S.

Industrial accidents with environmental consequences can also increase the salience of environmental regulations for companies and can lead to increased activity on a range of environmental issues, including carbon emissions.

Financial Incentives

Cost savings are the presumptive reason that firms seek to become more energy efficient. In actuality, cost savings are only one of the many financial motives companies have to become more energy efficient. For many consumer-oriented companies, for example, the increased attractiveness of the brand in the eyes of the customer is a more important reason for investing in environmental management activities than the cost savings generated by energy efficiency.

Financial motives for energy efficiency include:

- cost savings
- risk reduction from volatile energy prices and energy-intensive raw materials
- brand protection or enhancement to attract customers, investors and employees
- new product development

Cost savings: Cost saving is, quite simply, the monetary incentive to use resource inputs more efficiently. As the company scans the horizon for the greatest returns on investment, it may choose to make capital or operational improvements that yield reductions in energy costs. The greater the energy use, measured as a percent of sales or operating costs, the more incentive the firm has to reduce energy costs. Manufacturing companies in energy intensive industries like bulk chemicals, pulp and paper, glass, cement, food and metals have strong financial incentives to invest in energy management systems and manufacturing processes or equipment that reduce their energy use. Non-intensive manufacturing sectors, which include metal-based durables and miscellaneous manufacturing, will have a more difficult time making a purely cost-saving argument for investing in energy efficiency since their energy use and intensity of energy use is not high (see Table 2).

TABLE 2: ENERGY USE AND INTENSITY, BY INDUSTRY

Industry	Projected 2010 Energy Use (Trillion BTU)	Projected 2010 Energy Intensity (thousand BTU per $ of output)
Energy Intensive Manufacturing		
Food	1,182	2.2
Paper	2,986	16.3
Bulk Chemicals	7,921	39.5
Petroleum Refining	3,922	30.3
Glass	219	8.3
Cement	399	61.8
Steel	1,531	19.5
Aluminum	428	10.1
Non-Intensive Manufacturing		
Metal-based durables	2,199	0.8
Balance of mfg.	3,503	2.6

Source: EIA, 2002

Risk Reduction: Companies may also invest in energy-efficiency improvements to reduce their risk from price volatility in energy. Depending on the industrial energy source used by the firm's production lines (coal, oil, natural gas, steam, or electricity), the risk from energy price volatility can be significant. Some firms hedge their risks by purchasing energy futures contracts. Others invest in substitutions of cheap or volatile energy sources with more stably priced energy sources, or move production facilities near cheap and stable sources of energy.[2] Others reduce their energy risk profile by investing in energy-efficiency improvements that reduce the energy intensity of their manufacturing operations. Companies can pursue all three options simultaneously. Again, as in the cost savings argument for energy management activities, the more energy intensive the firm, the more incentive it has to reduce its risk from energy price volatility.

Over the longer term, an evaluation of the company's environmental costs and risks associated with product and process lines may lead it to exit risky production areas and redirect resources toward less risky alternatives (Hoffman, 2001). Companies with energy-intensive inputs in existing production lines have strong incentives to increase resource productivity by adopting technology that is more efficient, developing production methods that are less energy intensive, or redesigning a product to require less energy during its production.

Brand protection and enhancement: Brand protection or enhancement also provides incentives for companies to increase their energy efficiency. Energy efficiency reduces a firm's carbon footprint, and companies have discovered that the perception of a company's sensitivity to environmental issues makes their brand more attractive to some customers, investors, and employees.

Attract customers: "Our customers need to feel good about the product they're buying," stated one industry executive from PepsiCo. "If they don't, they'll buy something that makes them feel that way, and we've seen that in our sales figures. Water bottle sales have plummeted in the U.S. because of their perceived negative environmental impact, while [sales of] SunChips made with solar energy and [which] have sustainable packaging have increased. We work hard to stay on the right side of the consumer" (Duke, 2010). The commitment to environmentally responsible products is a way for companies to differentiate their products, ensure brand loyalty, and charge a premium for their products (Paul & Siegel, 2006). Mounting evidence in a number of industries shows that a price premium exists for more environmentally friendly products (Ambec & Barla, 2006).

[2] For example, aluminum manufacturers and data centers are being sited around the Columbia River Basin for access to cheap hydropower (personal correspondence with DOE ITP program).

Attract investors: Evidence also exists that investors are more likely to invest (on a risk-adjusted basis) in companies with good environmental records, and to avoid those with poor environmental records or with recent environmental accidents. Attracting investors by increasing the company's positive association with environmentally responsible behavior reduces the firm's cost of capital. This positively impacts every investment decision made by the company, and can be a source of competitive advantage for the firm (Heal, 2005).

Banks and financial institutions may be important players in motivating companies to become more environmentally responsible. Banks have become increasingly concerned with a company's reputation as a way to assess and monitor the credit risk of the company. Scholarly investigations of how analysts evaluate companies find that financial analysts, in addition to the traditional methods for company valuation, use an in-depth analysis of intangibles, such as corporate reputation, brand equity, and internal and external relationships to value companies (Vilanova et al., 2009). Banks increasingly monitor companies' rankings in the Dow Jones Sustainability Index (DJSI) and the Carbon Disclosure Project Leadership Index (CDLI) (Duke, 2010). In addition, financing environmentally harmful projects may be perceived as a liability for financial institutions that are subject to shareholder initiatives and NGO action on environmental issues.

Attract employees: Brand development and protection for purposes of employee recruitment and retention are key reasons why companies adopt environmental management activities, including energy efficiency. Corporate social responsibility (CSR) engenders loyalty and goodwill among employees because it increases the reputation of the employer (Portney, 2008). A survey of managers identified the benefits of CSR as reducing employee turnover, increasing productivity, and making recruitment easier (Heal, 2005). A 2004 survey of Stanford MBAs found that 97% of them were willing to forgo 14% of their expected income to work for an organization with a better reputation for corporate social responsibility (Ambec & Lanoie, 2008). In short, CSR enhances the firm's ability to recruit and retain high quality labor. Achieving these goals provides a strong motivation for companies to participate in energy management activities and CSR more broadly.

New product development: Entering new markets with products and services perceived as more environmentally friendly can be an important motivation for (and outcome of) companies' increased focus on energy efficiency. Although the topic of energy-efficient products is largely outside the scope of this report focusing on energy-efficient processes, it is important to note that companies sometimes find new product or service markets as a result of investigating energy-efficiency opportunities in their internal operations or supply chains. For example, a company may offer new energy-saving products, add sub-metering capabilities to existing products, or offer energy management consulting services by an in-house engineering services team experienced in finding energy-efficiency opportunities. Readers interested in company examples of new sustainable product development and its affect on corporate strategy should consult Hoffman (2001) and Orsato (2009).

Social Incentives

Social pressures to increase energy efficiency can be powerful factors for change. Social pressures on the firm can originate from actions and stakeholders both external and internal to the firm. Examples include:

External actions & stakeholders

- investigative reports
- media/internet campaigns by green NGOs
- consumer boycotts
- green consumerism

Internal actions & stakeholders

- shareholder initiatives
- employee expectations
- senior management participation in "green clubs" (ex. WBCSD)

Pressure from external stakeholders such as investigative reports, media/internet campaigns by green NGOs, consumer boycotts, and more generally, the rise of green consumerism can profoundly influence a company to modify its behavior. These pressures from stakeholders external to the firm can highlight the negative externalities of a company's products or business practices on society and the environment. Companies affected by these pressures must respond to the new information in public discourse or risk the long-term viability of the firm. Green consumerism, rather than being a response to specific information about a company's products, refers to the changing nature of consumers' tastes and preferences to prefer "green" products. Consumer-product companies report an increased demand for products with minimal environmental effects. These changing consumer preferences influence companies to modify their products, production practices, and communication strategies to accommodate the demand for environmentally friendly products.

Pressure from internal stakeholders can also influence companies to adopt energy efficient operational and capital improvements, and to take environmental issues, including reductions in carbon emissions, seriously. Shareholder initiatives on sustainability issues typically require companies to:

- conduct annual assessments and report to shareholders the impact climate change has on the company,
- summarize the company's environmental policies and yearly activities in a sustainability report,

- establish a "sustainability committee" at the Board of Directors or shareholder-level to set goals and hold management accountable for the company's sustainability objectives.

If shareholder initiatives succeed, the company provides additional reporting to its shareholders. Even if shareholder initiatives fail, they raise the issue to corporate boards and management, who must present initiatives consistent with corporation by-laws for a vote. The cost of shareholder initiatives varies according to the overall size of the firm, but estimates average between $250,000 to over $1 million each (see, for example, Bebchuck 2007). Repeated shareholder initiatives can convince boards and senior management to establish corporate goals around sustainability issues, which allows shareholders to hold the company accountable to the established goals.

Additional pressure from internal stakeholders can occur when a company's senior leadership participates in "green clubs" (Orsato, 2010). Green clubs can take various forms, including self-regulating business groups like the World Business Council on Sustainable Development (WBCSD), business-NGO partnerships like the World Wildlife Fund's *Climate Savers*, and business-government initiatives establishing emissions and recycling targets. Participation in green clubs that promote sustainability goals can motivate companies to adopt specific standards in environmental performance. Often the motivation of senior leadership to participate in green clubs is driven by branding and competitive positioning goals for the company; however, participation in these clubs adds an independent causal factor for implementing environmental improvements such as energy efficiency.

Employee expectations can also provide the impetus for a company to improve its environmental record. Hiring managers report that employment candidates ask about the environmental record and goals of companies with increasing frequency. Once job candidates become employees, it is natural to expect that they will continue to be interested in the company's environmental performance and seek ways to improve it. These employees challenge the company's current practices on sustainability issues and can take key roles in identifying energy-efficiency opportunities within the company.

Competitive Context

So far, we have analyzed the incentives for companies to become more energy efficient as if they were isolated entities. In reality, firms are part of a production network of companies that buy and sell to one another to produce final goods and services. The participation of companies in these production networks, or *value chains*, affects their incentives to become more energy efficient.

A company's position in the supply chain, the energy-intensity of its industry, and its product market affects its incentives to become more energy efficient (see Figure 2). By supply chain position, we mean proximity to the final customer. All other things being equal, companies closer to the final customer will have greater incentives to become more energy-efficient than companies farther away from the final customer. Companies in lower levels of the supply chain are less exposed to the pressures from external stakeholders that provide the incentives for brand-name firms to be concerned about the environmental impact of their production.

By product market, we refer to consumer and non-consumer product markets. Companies in consumer product markets have multiple incentives to adopt energy-efficiency strategies. Adopting environmentally sustainable production practices, like improved energy efficiency, differentiates products from competitors, increases the attractiveness of a company's brand, ensures brand loyalty, and reduces a company's vulnerability to consumer boycotts or shareholder initiatives. Companies in non-consumer product markets, if they adopt environmental standards at all, are largely driven by legal requirements and financial goals to reduce energy costs and risk from energy intensive process steps or inputs.

FIGURE 2: INCENTIVES TO ADOPT IMPROVEMENTS IN ENERGY EFFICIENCY, BY ENERGY INTENSITY, SUPPLY CHAIN POSITION, AND PRODUCT MARKET

		Product Market	
		Consumer products	**Non-consumer products**
Energy Intensity	**High**	**VERY HIGH** Firms in energy-intensive consumer product markets will have multiple incentives from both internal and external stakeholders to increase the energy efficiency of operations. (LEGAL, FINANCIAL, SOCIAL)	**MEDIUM-HIGH** Firms in energy-intensive industries will have financial motivations to adopt energy efficiency as a cost savings or risk reduction strategy. Level of motivation will vary according to energy intensity of industry. (LEGAL, FINANCIAL)
Energy Intensity	**Low**	**HIGH** Firms in non-energy intensive consumer product markets will be motivated to adopt energy efficiency as a way to protect and enhance the firm's brand to customers, investors, and employees. (FINANCIAL, SOCIAL)	**LOW** Firms in non-energy intensive industrial product markets have low incentives or pressures to increase energy efficiency because there are no significant cost savings available, or external pressures by customers or investors to adopt energy-efficiency practices.
Supply Chain Position	**Downstream** (near final customer)	**HIGH** Multiple motivations – legal, financial, social – from both internal and external stakeholders.	**LOW** Financial and legal motivations, largely from internal stakeholders to reduce costs, risks, or develop new products. Some firms with recognizable brands may also face pressure from investors to reduce carbon emissions and adopt energy-efficiency practices
Supply Chain Position	**Upstream** (away from final customer)	**MEDIUM** Financial motivations driven by consumer-facing customers of the firm's production.	**VERY LOW** Since these firms are within the supply chain of a company that sells only to other businesses, it will have very low pressures and incentives to adopt improvements yielding better energy efficiency. To the extent that they exist, they will be legal incentives to ensure compliance and financial motivations largely from internal stakeholders to reduce costs or risk.

Source: Center on Globalization, Governance & Competitiveness (CGGC), Duke University.

These simple propositions yield powerful insights into the likelihood that companies will adopt energy efficient manufacturing practices and invest in energy efficient capital (see Text Box 1). Firms with direct interaction with customers in consumer-oriented, energy-intensive industries are most likely to adopt these practices, while firms providing product components in non-intensive, non-consumer product markets are least likely to become more energy efficient.

TEXT BOX 1: CONDITIONS FACILITATING ENERGY EFFICIENCY IN COMPANIES

Firms most-likely to adopt energy efficient manufacturing practices and invest in energy efficient capital

- **Consumer-facing firms** – manufacturers selling to consumers and retailers will have branding and competitive reasons to implement sustainable production practices, including energy efficiency. If a retail customer can touch the product, then firms have a number of incentives to become more energy efficient.

- **Firms with energy-intensive production** – manufacturers in energy intensive industries will have financial incentives to adopt energy efficient practices and invest in capital improving the energy efficiency of the firm. This is true of manufacturers in both consumer-oriented and business-oriented supply chains.

- **Firms in consumer-product supply chains** – firms selling inputs to consumer-facing firms will have greater pressure to improve their environmental performance than firms selling inputs to firms in non-consumer markets.

Firms least-likely to adopt energy efficient manufacturing practices and invest in energy efficient capital

- Firms making products with low energy production costs or input requirements.
- Companies providing product components to non-consumer product markets.

Additional factors to consider:

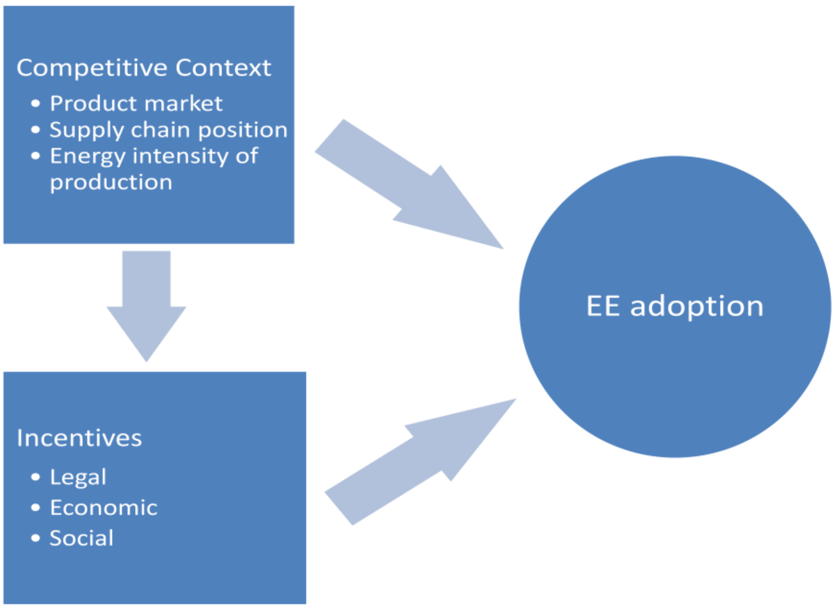
- **Company size** – small firms have less capacity to identify, finance, and implement energy efficient practices and capital.
- Participation in **business "green clubs"** – if a firm's senior leadership (corporate board or senior management) has formally committed to achieving the aims of a business organization promoting the benefits of reducing the environmental impact of industrial production, "green clubs", then a greater likelihood exists that the company will adopt energy-efficient capital and practices, independent of other factors.

Source: CGGC, Duke University.

The impact of consumer preferences has grown stronger in recent years for durable as well as non-durable consumer-goods companies alike. For example, motor vehicle manufacturing generally has been considered a producer-driven sector, not subject to the level of consumer choice exercised in goods sold in buyer-driven industries dominated by large retail chains and global brands (Gereffi, 1994). However, because of better information gathering and batch production capabilities by product manufacturers, companies in this sector are now subject to, and better able to accommodate, the disparate and changing preferences of retail customers in this sector. The likelihood that this trend will continue in a number of other consumer non-durable industries is high.

Figure 3 summarizes the discussion about what motivates companies to become more energy efficient. The competitive context and legal, economic, and social incentives affect the likelihood that companies will adopt energy efficient practices.

FIGURE 3: COMPETITIVE CONTEXT AND INCENTIVES AFFECT THE MOTIVATION OF COMPANIES TO ADOPT ENERGY EFFICIENCY



Source: CGGC, Duke University.

An explanatory model of energy efficiency adoption can supplement the heuristic model illustrated in Figure 3. Figure 3 is "heuristic" because it does not provide the specific cause-effect relationships necessary to fully explain an outcome, which in this case is the adoption of energy efficiency practices by companies. The factors increasing the likelihood of adoption are participation in consumer product markets, proximity to the final customer, and intensive use of energy in the manufacturing process. Legal, economic, and social incentives increase the likelihood of adoption of energy efficient practices by companies. As with any complex social phenomena, the independent variables affect one another. Specifically, the competitive context affects the incentives of companies to become more energy efficient. For example, a company's product market, supply chain position, and the energy intensity of its production affect its economic incentives to become more energy efficient.

III. THE ENERGY-EFFICIENCY PROCESS

The organizing framework for this section of the report is the "energy-efficiency process" described in Figure 4. The energy-efficiency process is a series of steps through which companies proceed on their pathway to energy efficiency. Relevant questions to ask about how companies adopt energy efficiency include:

> **Goal-setting:** How were goals for energy efficiency set? Who set the goals?
>
> **Identification:** How was information about the opportunities for energy efficiency in a company gathered? What actors or organizations were involved in identifying the opportunity for energy efficiency in the organization?
>
> **Financing**: How were energy-efficiency projects financed? What financing mechanisms were put in place to fund investments in energy efficiency? What payback thresholds existed for projects?
>
> **Implementation**: Who was responsible for implementing energy efficiency in the organization? What incentives were provided for organizational or behavioral changes?
>
> **Measurement, Benchmarking and Reporting:** How is energy measured and monitored in the organization? Were industry standards used to benchmark the organization's progress in energy efficiency? How is the firm's energy management reported to internal or external audiences? How does the firm's current performance affect goal-setting for the company?

This section describes the energy-efficiency process and the pathways companies take to become more energy efficient. We developed our insights from existing company case studies on the adoption of energy efficiency and on our own case studies on Bridgestone, DuPont, and Nissan. The appendix to this report supplements the framework discussion of the energy-efficiency process with detailed case histories of these companies.

FIGURE 4: THE ENERGY-EFFICIENCY PROCESS

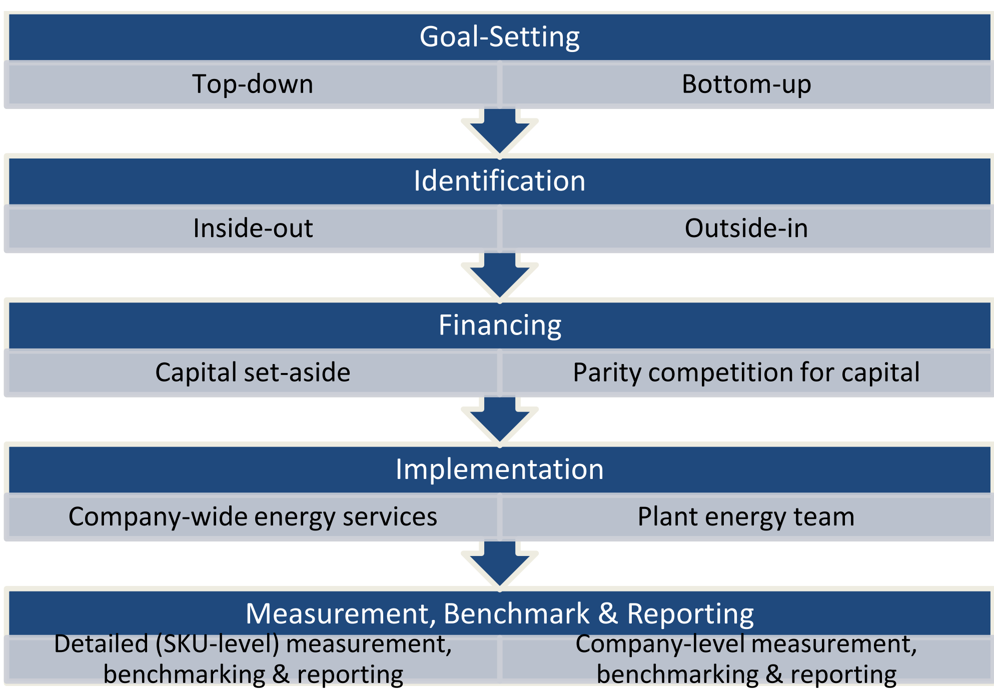
Source: CGGC, Duke University.

At a conceptual level, companies can choose among a number of approaches for each phase of the energy-efficiency process. For example, one company may choose external consultants to identify the capital investments or process improvements that provide the highest return to the firm, while another may choose to give its energy services team primary responsibility. Similarly, in financing capital improvements that increase the energy efficiency of the manufacturing process, one company may extend the number of years expected for the return on investment, while another may require that all capital projects compete according to the same criteria.

The pathway to energy efficiency that a particular company chooses is subject to organizational decision-making routines appropriate to the company. The decisions about how to set goals, identify, finance, implement and measure energy efficiency are a function of the company's past practices and the management style of its leaders. Rather than endorse a single pathway or "best practice" around energy efficiency for all companies to adopt, the goal of this section of the study is to illustrate the range of choices available to companies on their pathway to energy efficiency.

Figure 5 summarizes the different options available to companies at each phase of the energy-efficiency process. These options were developed from our review of existing company case studies on the adoption of energy efficiency and our own case studies on Bridgestone, DuPont, and Nissan.

FIGURE 5: THE MULTIPLE PATHWAYS TO ENERGY EFFICIENCY



Source: CGGC, Duke University.

Table 3 summarizes the pathways to energy efficiency of the three company case histories conducted for this report, Bridgestone, DuPont, and Nissan. Extended case history material on these companies is available in the appendix. The appendix also includes a "pathways" table for additional companies reviewed for this report from the recent, broader literature we surveyed.

TABLE 3: SUMMARY OF "PATHWAYS TO ENERGY EFFICIENCY" TAKEN BY CASE STUDY COMPANIES

	Bridgestone	DuPont	Nissan
Goal Setting			
top-down (corporate-level mandate)	X (2010)	X	X
bottom-up (goals primarily at plant-level)	X (1990-2009)		
Identification			
inside-out (internal energy services lead)	X	X	X
outside-in (external actors take lead)			
Financing			
capital set-aside	X	X	
parity competition			X
Implementation (primary responsibility)			
company-wide energy services	X	X	
plant energy team			X
Measurement, benchmarking, and reporting			
SKU level		X	
Company level	X		X
Use of industry benchmarks			X
Internal reporting	X	X	X
External reporting		X	X
Supply Chain	no engagement	no engagement	
Energy Monitoring & Capacity Building			X
Scorecards			
3rd Party Certification			

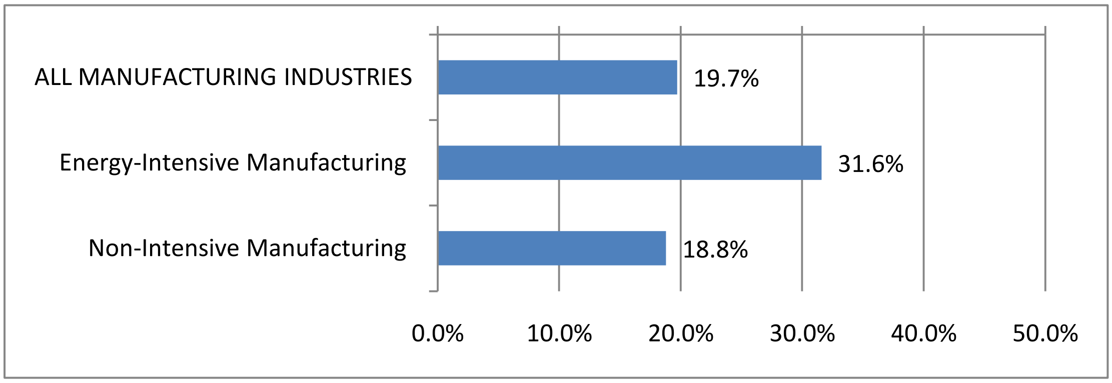
Source: CGGC, Duke University

The remainder of this section describes each stage of the energy-efficiency process, illustrated with examples of how companies implemented each phase.

Goal-setting

Goals for energy-efficiency can either be set from the "top-down" or "bottom-up." By top-down, we mean that company presidents or CEOs announce energy-efficiency goals without a lot of consultation or analysis by lower levels of the organization. By bottom-up, we mean that equipment maintenance personnel, plant-level engineering departments, or plant managers set the goals for resource efficiency at the plant, which together constitute the goal for the company as a whole. Survey data from the Energy Information Agency report that approximately 20% of firms set goals for energy efficiency in 2006. Firms in energy-intensive manufacturing reported higher rates of goal-setting than companies in non-energy intensive manufacturing (Figure 6).

FIGURE 6: PERCENT OF FIRMS REPORTING SETTING GOALS FOR ENERGY EFFICIENCY



Source: MECS 2006, EIA (table 8.4)

"Top-down"

DuPont's CEO announced in 1999 that, by 2010, it would hold total energy use flat from a 1990 baseline, and reduce greenhouse gas emissions by 65% from 1990.

> At the time, it was primarily the corporation that was trying to raise the awareness of everyone in the company, that this was an area that we were going to work on, that we were serious about working on it, and we were so serious that ***we were actually announcing a goal to the public that we didn't even know how we were going to achieve***. We gave ourselves 11 years to hit the target, and I think the senior leadership would have said, in 1999, that would be plenty of time for us to figure out how to do this. So by the time 2010 rolls around, we've actually got a very granular process for driving improvement, and we've made significant improvements along the way. They just trusted that our people would be able to put the right things in place to make it (Bailey, 2010a).

The benefit of the top-down approach is that it can stimulate progress in an organization by "forcing action" to turn goals into results. As recounted by PepsiCo at the recent Pew Center Conference on energy efficiency, big, hairy, audacious goals ("BHAGs") announced by a company's top leadership signal the importance of the goal to the company, and can create the necessary excitement around it to effect change.[3] The benefit of the

[3] Big, hairy, audacious goals ("BHAGs") is a term used in Collins (2004) *Built to Last: Successful Habits of Visionary Companies*.

BHAG approach is that 1) no one really knows the correct number anyhow; 2) it saves time on analysis; and 3) it creates excitement about projects with big goals because it inspires change. PepsiCo stated that doing the reverse of BHAGs "which is, you know, launching a huge program and ramping up an effort. And only after doing two years of work are you able to say, 'here's what we think we can deliver, because here's all the work we think we can do' " is a costly and time-intensive way of setting goals around energy efficiency (Pew, 2010b).

The weakness of the approach is that while it may illustrate boldness and create excitement, no underlying analytic basis exists for achieving the goal. Top-down pronouncements may create confusion among personnel responsible for achieving the goal. As Bill Bailey of DuPont stated:

> When that goal was announced in 1999, I would say the vast majority of people who work in our plants would have asked the question, 'What's our part of that goal?' And it really was not communicated to them, in 1999 when the goal was announced, what was expected of them in terms of energy-efficiency improvement. I would say that in [the first three years] I had many conversations with people at the plants who were still confused about what that goal meant to them and how they were going to achieve them. No one really had, in the early part of the decade, a sense of 'what is my responsibility towards this goal?', and 'what is my management specifically looking at me to do that is going to ensure that we meet this goal?'

"Bottom-up"

Goal-setting from the bottom-up relies on line employees, facility engineers, and plant managers to collectively set company goals on energy efficiency. The benefit of the bottom-up approach is that goals set for energy efficiency are achievable because the company has invested time to identify specific energy-efficiency processes or capital improvement projects. The goals, therefore, are clear and achievable, and specific actors or plants can be held accountable for project implementation and goal attainment. Toyota, for example, sets targets on energy efficiency on a monthly basis and holds plant managers and line employees accountable for reaching the energy-efficiency targets (Pew, 2010a). Bridgestone, GE, and IBM also use this approach to setting energy-efficiency targets.

The weakness of the approach is that keeping energy efficiency in the "boiler room" keeps energy efficiency as a cost-minimization strategy rather than as part of a company's strategic plan to reduce its environmental footprint or to continually improve its processes. Even when they extend beyond the operational level to upper management, these approaches tend to result in the announcement of conservative goals because they are easily attainable by the line operators and plant managers tasked with their implementation. A second weakness of the incremental approach is its intensive use of staff time to identify viable process and capital improvements yielding only 1-3% improvements in overall energy efficiency. The cost/benefit analysis can be difficult to defend in organizations where energy costs are not a significant portion of operational costs.

Concluding thoughts on goal-setting

The two goal-setting approaches have both been successful. DuPont and PepsiCo have developed energy-efficiency goals using a "top-down" style, while Bridgestone, Toyota, and GE have approached goal-setting in a more "bottom-up" or incremental way. Both approaches have been successful for developing goals for industrial energy efficiency.

While it would be intellectually satisfying to state that one or the other approach is that of a "leader" and the other that of a "learner," the evidence reviewed for this report doesn't support this generalization. Instead, a more useful perspective is that the two goal-making styles can be usefully sequenced within a single organization. For those companies beginning their industrial energy-efficiency programs with a "top-down" approach, additional goals may be set using more of an incremental, bottom-up approach once more information about remaining opportunities for energy efficiency becomes available through experience. For those companies using a "bottom-up" approach to set their initial targets for energy efficiency, a useful question to consider is whether they are being too conservative in setting their energy-efficiency goals; perhaps they could achieve faster results by challenging plant managers and line employees to reach goals developed from a comprehensive evaluation of how the company uses energy resources.

Identification

The identification stage of the energy-efficiency process discovers energy-efficiency opportunities in the company. The opportunities that companies can find are in two general categories: process improvements and capital improvements. *Process improvements* include discovering ways that the manufacturing production method can become more energy efficient by, for example, optimizing equipment operation, eliminating production steps, or adopting new production techniques. Examples include 'just-in-time', lean production methods, or training equipment operators to work within the operation limitations of energy-intensive production equipment.

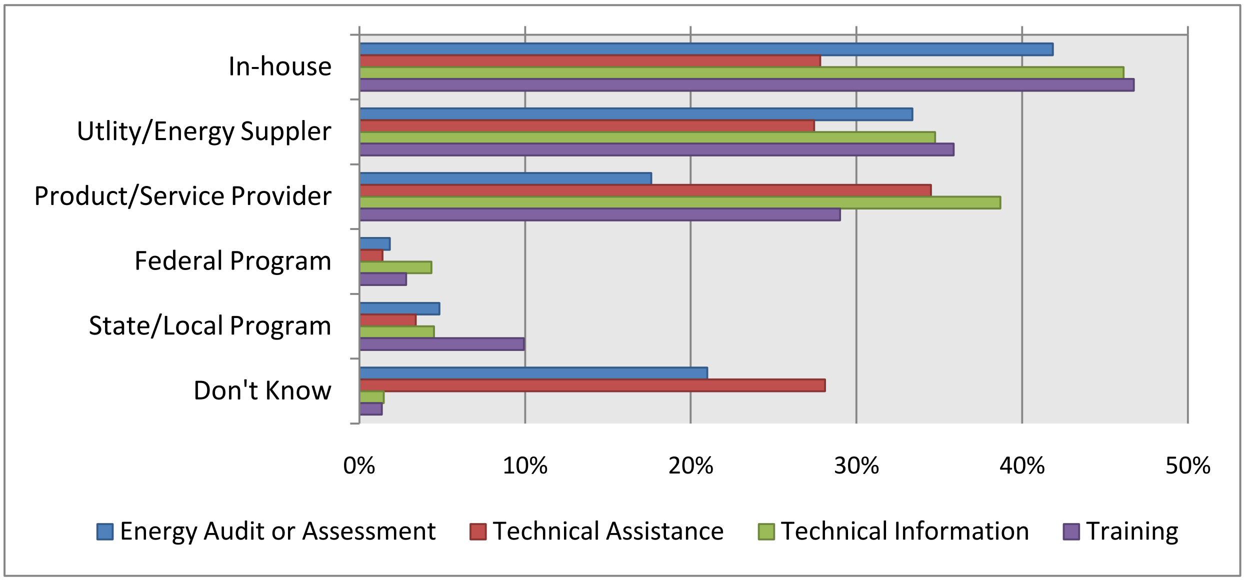
Capital improvements include purchasing more energy-efficient equipment, substituting the current industrial energy system, or redesigning the production facility to be more energy efficient. Examples include purchasing higher efficient variable-speed pumps and motors, switching to more efficient industrial energy systems, and co-generation of energy on-site (CGGC 2009, 2010). The solution set for what capital improvements are appropriate to a company is highly specific to the industrial energy system used at a plant. Engineering knowledge of how energy is used in a particular plant or company is important for identifying what opportunities exist for energy-efficiency improvements.

The trade-off between operational improvements and capital improvements is, roughly speaking, between lower energy-efficiency gains achieved immediately versus higher energy-efficiency gains achieved with a higher investment of time and money. Operational improvements can provide significant immediate energy savings at a relatively low cost. The difficulty with focusing on just operational improvements is that there is a natural limit to what they can offer if the capital is not also improved, or if a redesign of the production process does not occur. Similarly, if capital replacement is not accompanied by operational improvements such as operator training, then some of the long-term energy-efficiency gains can be lost.

Companies tend to use two general approaches for identifying energy-efficiency opportunities: inside-out and outside-in. By “inside-out” we mean that the identification of energy-efficiency opportunities is predominantly conducted by actors internal to the firm. Relevant internal actors include company-wide energy services or engineering departments, and plant-level site energy champions reporting to either plant managers or company-wide departments responsible for energy management. By “outside-in” we mean that the identification of energy-efficiency opportunities is predominately conducted by actors external to the firm, such as ESCOs (energy service companies, sometimes also called “performance contractors”), utilities, and various levels of government.

The Manufacturing Energy Consumption Survey (MECS) conducted by the EIA asks companies whom they relied on for identifying energy-efficiency improvements. The results for 2006 are shown in Figure 7.

FIGURE 7: 2006 COMPANY ENERGY EFFICIENCY IDENTIFICATION PRACTICES, BY SOURCE AND TYPE OF ASSISTANCE



Source: MECS, EIA 2006

The results of the survey show the importance of the in-house energy management capability. The plurality of companies responded that in-house actors were the most important for identifying energy-efficiency opportunities, and for receiving technical information and training. Product/service providers are the most important for technical assistance.

INSIDE-OUT

The "inside-out" model for identifying energy-efficiency opportunities relies primarily on actors internal to the firm to discover operational and capital improvements that increase the efficiency of energy used at the firm. The classic example of the inside-out model is the "treasure-hunt" model developed by Toyota and successfully adopted by General Electric to identify energy-efficiency opportunities. Treasure hunts (or Kaizen "blitzes" in Toyota's terminology) are events in which cross-functional teams walk through a plant during various process and equipment-readiness stages to record how energy is used at the facility. The teams document areas of energy waste, prioritize energy-efficiency opportunities based on criteria such cost savings and company investment hurdle rates, and provide recommendations to site management about specific projects to implement.

As used by General Electric,

> The treasure hunts begin on a Sunday afternoon with teams of 4-6 employees from cross-functional units visiting a plant in "sleep" mode. The teams identify opportunities where energy is needlessly

> wasted, such as lights, equipment, and motors left on, and quantify those opportunities using a software tool called Eco-Prospector for follow-up throughout the event. On Monday morning, teams interview facility employees about the opportunities identified during the plant's sleep mode, and continue to observe the site's energy use during the start-up mode, production mode, and break mode throughout the day. By Tuesday afternoon, each team has a list of at least 10 quantified ideas for energy savings that are reported to site management during a "report-out" event (Hancock, 2009).

A number of factors lead to the success of the treasure hunt. Treasure hunt teams should combine experience in the plant's product and process with alternative perspectives developed from external sources. Experienced site employees in operations, maintenance, and ESH (environmental, health, and safety) should work on the same team with representatives from utilities, contractors, and personnel from other plant locations or companies to provide important perspective about alternatives. Operator buy-in of proposed changes and facility leadership committed to implement some of the projects identified during the event are crucial. A corporate culture in which employees are trained to solve problems, work in teams, and accustomed to working in the complex reporting environment of a matrix organization is also important to implementing successful treasure hunts (Hancock, 2009).

In reviewing how companies identify energy-efficiency opportunities, we have noticed a second "inside-out" model that we call the "start small" or "incremental" approach to identifying energy-efficiency opportunities. The approach focuses on one plant or business unit within the company that is particularly energy-intensive or innovative. Once energy-efficiency projects have been successfully implemented at one location, the personnel responsible for identifying and implementing the projects are asked to identify opportunities at other plant locations. Bridgestone's experience with energy efficiency is an example of this approach. The plant engineer at one of Bridgestone's major production plants successfully identified and implemented energy efficiency improvements. The plant engineer then engaged corporate headquarters in Japan to determine whether he could assist energy teams at other Bridgestone plant locations to identify energy-efficiency opportunities. After corporate permission was granted, the plant engineer began identifying opportunities at other U.S. plant locations and working with facility plant engineers to implement the projects. The former plant engineer eventually became the leader of the energy services team at Bridgestone Americas responsible for visiting plants every two years to identify new energy-efficiency projects.

The two "inside-out" models (treasure hunt and "start small") for identifying energy-efficiency opportunities are not mutually exclusive. The major benefit of the "start small" model is that it develops trust and experience in energy-efficiency projects, which then can be transferred throughout the company. Our case studies point out that trust between persons positioned similarly in operating units assists in the diffusion of energy-efficient practices. Trust is important because employees are showing their peers how energy-efficiency projects can be implemented. The benefit of the treasure-hunt model is that it is flexible enough to be adopted at either individual plants or company-wide.

An "inside-out" approach to identifying energy-efficiency opportunities has proven successful in companies in which comfort with teamwork, complex reporting structures, an orientation toward continual improvement, and in-house technical expertise exist. The "treasure-hunt" model, in particular, has strengths in combining operational and technical expertise gathered at the facility-level by teams of employees with a company-wide evaluative model that can be applied uniformly across a company's operations. Thus, the treasure hunt model has a flexible structure that can be modified to operational situations employing a broad range of industrial energy systems. In addition, developing operational buy-in and presenting viable options to plant management within a three-day period are a very attractive feature of treasure hunts. Companies with business cultures different from that of Toyota or General Electric, yet possessing in-house technical or engineering expertise, may be more comfortable with a more limited set of actors responsible for identifying energy-efficiency opportunities throughout the organization. DuPont and Bridgestone are examples of this latter approach.

What both inside-out approaches have in common are matrix reporting structures and the resource of internal engineering experts who understand how energy is used in the company and what feasible alternatives exist. For companies without internal engineering capabilities, the inside-out approach is unlikely to be an appropriate approach for identifying energy-efficiency opportunities.

OUTSIDE-IN

The "outside-in" model relies on actors external to the firm to find energy-efficiency opportunities for the firm. Two categories of external actors exist: for-profit organizations, such as ESCOs, engineering firms, and equipment vendors, and not-for profit organizations, such as public utilities, various levels of government, and non-profit organizations.

For-Profit Organizations

Energy Service Companies "Performance Contractors" (ESCOs)

ESCOs manage the energy use of customers, and through the application of technology or expertise in energy management, are able to achieve cost savings that are shared with the ESCO (Elliot et al., 1996). The promise of ESCOs is that industrial customers receive some of the benefits of improved energy efficiency through outsourcing energy management, yet allow the industrial firm to focus on what it does best: manufacturing products its customers want.

Although many cases of successful partnerships with ESCOs exist, their promise has largely been unrealized in the industrial market (Elliott, 2002). The reasons for this failure include:

- High cost of opportunity identification and deal completion
- Limited replicability site-to-site
- Low energy prices
- Perception that energy is not a core issue
- Lack of expertise in specific industries
- Unwillingness of industry to allow "outsiders" make process modifications[4]
- Limited access to decision-makers within industrial firms
- Difficulty in evaluating success of projects

A recent review of energy-efficiency practices by the Pew Center also found that "performance contracting" with outside parties (i.e., ESCOs) to implement energy-efficiency savings was "unworkable because such contracts typically are long-term, running 10 years or more, well beyond most companies' planning or decision horizons" (Pew, 2010a, p. 45). In a specific instance, Dow found that:

> Energy services companies typically require long-term agreements to make their financing structures work, and most corporations are not inclined to enter into such long-term contracts. Performance contracts also tend to require long repayment terms to enable energy savings to exceed payments, because they must roll all of the development costs, interest costs, and other 'overhead' factors into debt service payments on top of direct capital costs. Moreover, in a complex industrial operation like Dow's, establishing the critical baseline energy use calculation on which savings are based can be too difficult and uncertain to build into long-term agreements…Dow uses (ESCOs), but tends to use them for more specific technology and service contracts on a traditional sales or fee basis (Pew, 2010a, pp. 81-82.)

Internal obstacles to using ESCOs exist as well:

> [DuPont] talked to a number of firms. [We] actually got pretty far down the road with one or two of them, and each time we would reach a point of decision where we had to go to our corporate finance folks. And each time they would say, 'Now tell me again why we are using someone else's money here?' And we would tell them, 'Because we have these projects with really good returns and our businesses don't want to execute…' And they reminded us that our money is cheaper than anyone else's money and that if these projects really are a good thing for us to be doing, then we ought to be able to find a way to do them ourselves…We've got very strong signals from them that we will not use energy service companies or third party financing to implement these types of projects (Bailey, 2010a).

[4] PepsiCo stated that, "we would never let outsiders touch our processes" (Pew, 2010b).

Engineering firms

While traditional ESCOs have not been very successful, the American Council for an Energy-Efficient Economy (ACEEE) found that engineering firms and equipment vendors are key actors in providing energy services. The advantages of engineering firms are that they are "perceived as sources of expertise; with knowledge of the plan and processes, they can position their projects to respond to plants' needs; and perhaps most importantly, they have access to company decision makers. Often, engineering firms will have an alliance with their industrial customers where the firms are effectively the facilities' engineering department" (Elliott, 2002, p.3). This has been an increasing trend in industrial customers as they (somewhat ironically) both reduce their in-house energy management staff, yet increase their interest in energy-efficiency projects as measured both by energy-efficiency budgets and expanded project activity. Industrial customers manage the risk of losing institutional memory inherent to outsourcing by tending to have durable relationships with external partners (Elliott, 2002).

The advantages of engineering firms over traditional ESCOs in energy management are:

- **Expertise –** ESCOs' expertise is seen as a financial structuring partner for an industrial facility but they have little knowledge about the unique needs of an industrial facility, which the ESCO subcontracts to other entities. Engineering firms, by contrast, have an existing relationship with the company, which relies on its expertise for ongoing operations. Relatedly, engineering firms are seen as being onsite and able to identify opportunities for improving energy efficiency. Staff will bring opportunities for improving energy efficiency to the attention of the contractor, rather than going through internal channels, because of established relationships and their intimate knowledge of the plant and production processes.

- **Access to key decision-makers –** Because outsourcing contracts are increasingly managed at the corporate level, the engineering firm has access to a key decision-maker, typically the comptroller or chief financial officer (CFO). The access allows the engineering firm to present proposals for additional work and involve key internal decision-makers necessary to finance the proposal. Traditional ESCOs do not have this same level of access to or confidence of key decision-makers, or much knowledge about who they are (Elliott, 2002).

Engineering service firms typically are contracted by industrial firms to design a process-line or to provide technical support during the installation of a major piece of equipment. Historically, this "project focus" of engineering services firms in designing systems meant that the financing and operation of these systems lay outside their area of expertise. ESCOs, in contrast, provided a range of services without maintaining expertise in any one. Thus, while ESCOs could offer a broad range of services ("go wide"), they couldn't "go deep" in any one area.

This traditional distinction between ESCOs and engineering service firms has diminished over time. Some engineering firms have expanded their offerings by supplying operations staff and contracting with financial service companies to provide project financing. The provision of full-service design, build, finance, and operation to their customers means that engineering service companies are "functionally indistinguishable" from an ESCO. The danger to engineering firms, however, is that as they increase their product offerings they also increase their level of risk because of the expansion into areas where engineering service firms traditionally have not had a large role. Notable power project failures have occurred, including projects by Stone and Webster and the Washington Group (Elliott, 2002).

Equipment vendors

Equipment vendors to industrial customers seek to add services to their product offerings to enhance the total value of the relationship, a notion captured by the term "value-added reseller" (VAR). Equipment vendors see efficiency "tune-ups" and upgrades as ways to increase the value of the commercial relationship, but also ways to increase their service reputation with customers, and to develop "green" reputations with the public (Elliott, 2002).

In the industrial energy market, vendors in water boilers, compressed air, and motor equipment have taken the lead. Ingersoll-Rand has taken a lead in offering value-added services in the compressed air industry. The company has offered system optimization, end-use measures, maintenance and controls, which can be expanded throughout the industry.

Input suppliers

During our interviews, we discovered that input suppliers will sometimes offer their customers energy-efficiency consulting services for some of the same reasons as equipment vendors: increasing their service reputation with customers and continuing a relationship that leads to a contract renewal. DuPont's marketing arm, for example, sometimes assists customers with engineering services as a substitute for price reductions during contract negotiations.

Peer competitors

Peer competitors will sometimes share information on how to identify energy-efficiency opportunities. For example, DuPont consulted Corning about their experience in identifying energy-efficiency improvements at Corning's Wilmington, NC plant (Bailey, 2010a). These discussions often develop because of membership in the same industry associations, such as the American Chemistry Council (ACC) and the Council of Industrial Boiler Owners (CIBO). Professional networks are important for transferring knowledge, even among competitors. In addition, as illustrated by GE, treasure hunt teams will sometimes include members from other companies who have experience in identifying efficiency opportunities in the industrial energy system used by a plant. Collaboration among competitors, whether through industry associations or not, requires a discussion among participants delineating competitive from non-competitive information. The boundaries between these types of information will vary among industries, but information about manufacturing practices increasing energy efficiency will usually be in the non-competitive category. Information about energy efficiency would diffuse much faster if companies and industry associations developed more formal, routinized methods for exchanging non-competitive information about innovative energy practices.

Not-for-profit organizations

Governments

Government at all three levels – federal, state, and local – has developed energy efficiency programs to assist businesses and residents in identifying energy efficiency opportunities. The ACEEE has compiled a list of state and local programs as part of its State Energy Efficiency Policy Database.[5] At the federal level, the Department of Energy (DOE), the Environmental Protection Agency (EPA), and the National Institute of Standards and Technology (NIST) sponsor programs for manufacturers. Federal programs by these agencies are discussed below.

U.S. Department of Energy

DOE's Industrial Assessment Centers, as part of the DOE's Industrial Technologies Program, have partnered with universities since 1976 to conduct energy audits and industrial assessments at companies with fewer than 500 employees and annual energy bills of less than $3 million. Almost 15,000 free assessments by 26 partner universities have been conducted since 1980. The program maintains a searchable database of its assessments by industry, product, and geographic location. A search of this database reveals remarkable gaps between identified energy-saving opportunities and implemented investments by companies. Even when industrial assessment centers have conducted expert assessments, companies participating in the program make only 19% of identified energy investments (DOE, 2010a).[6]

DOE's *Save Energy Now!,* also part of DOE's Industrial Technologies Program, has assisted large manufacturers with identifying energy-saving opportunities since 2000. As currently organized, the program provides access to DOE energy experts on specific industrial energy systems (compressed air, fans, process heating, pumps, and steam) for major industrial plants in the United States. These companies receive a three-day assessment to analyze energy use and help find ways to improve energy efficiency. Companies participating in the program are encouraged to improve their energy

[5] The ACEEE state policy directory is available at http://www.aceee.org/sector/state-policy.
[6] The ITP database is available at http://iac.rutgers.edu/database/index.php

efficiency by 25% in ten years (the LEADER commitment). However, the program will assist all large industrial plants with a high level of energy use and a strong likelihood for implementing energy-efficiency opportunities.[7]

EPA

The Combined Heat and Power (CHP) partnership is an EPA effort to improve energy efficiency and reduce the environmental impact of industrial production by promoting co-generation of heat and energy near its use. Members of the industrial partnership include individual companies, state and local economic development, environment, and energy agencies, and other supporting organizations such as the Association of Energy Engineers. Companies participating in the program conduct a feasibility study of co-generation at their facility. EPA's energy teams then conduct additional analyses to determine the amount of energy savings at the site, a cost-benefit assessment of different energy strategies, and discuss options for financing the identified opportunities. [8]

ENERGY STAR™ for Industry is a combined EPA and DOE effort to provide training, expert assistance, and networking opportunities to industrial users of energy. The program offers assistance to manufacturers developing energy management systems at their plants and recognition for their efforts. EPA also runs an industry challenge program in which individual manufacturing plants pledge a 10% reduction in energy use over 5-years.[9]

National Institute of Standards and Technology

NIST's Manufacturing Extension Partnership (MEP) was created in 1989 to improve the competitiveness of small and medium-sized manufacturing firms in the United States. It maintains a national network of independent extension centers at universities, community colleges, and state governments to assist individual plant sites in implementing lean manufacturing techniques. Companies participating in the program work with their local MEP center to identify lean manufacturing techniques, including the identification of energy-efficiency opportunities at the plants. [10]

NIST, EPA, and the U.S. Department of Commerce collaborated to create the Green Suppliers Network (GSN) in 2003, which uses the expertise of the Manufacturing Extension Partnership's national extension centers to identify energy efficiency opportunities in companies' supply chains. The program has two levels of participation. Small and medium-sized manufacturers participate at the

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[7] Additional information about the Save Energy Now program can be found at http://www1.eere.energy.gov/industry/saveenergynow/assessments.html

[8] Additional information about the CHP partnership can be found at http://www.epa.gov/chp/index.html

[9] ENERGY STAR for Industry program website is at http://www.energystar.gov/index.cfm?c=industry.bus_industry. Challenge for industry program information available at http://www.energystar.gov/index.cfm?c=industry_challenge.take_the_challenge

[10] Information about the MEP program can be found at http://www.nist.gov/mep/

"partner" level, while large firms participate as "corporate champions." "Partner" companies receive a technical review of their operations "to identify sources of non-value added time or materials, identify opportunities to increase efficiency, and develop a plan for implementing improvements" (GSN, 2010). "Corporate champions" identify five supply chain partners, which then are provided with technical assessments by MEP experts. The EPA offers programmatic support, environmental information, and tools. The U.S. Department of Commerce offers programmatic support of the GSN.[11]

Utilities

Utilities have long received attention as key actors in identifying energy-efficiency opportunities. Since the 1970s, "demand-side management" (DSM) practices by utilities have provided information to residential, commercial, and industrial customers about how to reduce their consumption of electricity. During the 1980s and 1990s, utilities began offering energy audits to their customers and provided rebates or low-interest loans to help finance energy-efficiency improvements. In many cases, utilities also provided "direct-installation programs" that installed energy-efficiency improvements identified during the course of the energy audit. In the late 1990s, utilities began focusing their attention on equipment and product manufacturers to improve the energy efficiency of their products, and on contractors, builders, and distributors to adopt or install more energy efficient equipment or products. These "market transformation programs" sought to achieve greater energy efficiency by having market actors adopt more energy efficient products "upstream" from the final consumer (Hirst, 2010). Utilities may be particularly effective in assisting small and medium sized enterprises who may not have the expertise necessary to identify opportunities or have the financing available to implement capital improvements to increase the company's energy efficiency.

The incentives of utilities to identify energy-efficiency opportunities is guided by state-level mandates requiring that a certain percentage of energy used is re-captured through energy-efficiency programs. These "energy efficiency portfolio standards" (EEPS) or "energy efficiency resource standards" (EERS) require utilities to meet part of their annual increase in energy demand through energy-efficiency measures rather than new generation. EEPS regulations in 23 states have mandated that utilities engage their customers in identifying energy efficiency measures as a way to manage the demand for new power generation and to illustrate their commitment to the environment (Furrey, 2009; EPA, 2010b). Although legally required to fulfill these mandates, the role of utilities in identifying and financing energy-efficiency opportunities runs counter to their core interests of maximizing sales at the lowest cost possible.[12]

[11] More information about the GSN program is available at https://www.greensuppliers.gov/

[12] "Decoupling" increases the incentives of utilities to be more active in energy efficiency by guaranteeing a rate of return on investments, independent of how much energy is used. See the Regulatory Assistance Project website (http://www.raponline.org/Feature.asp?select=78) for details.

Key points on identification

The decision whether to use internal or external experts to identify energy-efficiency opportunities often will depend on the level of trust between external partners and the internal decision-makers responsible for energy management. We heard throughout our interviews that "we don't let outsiders touch our product," which is a characteristic response of operational managers responsible to corporate management for hitting their production numbers at the expected level of quality. The difficulty with outside actors is that, well, they are "outsiders": outsiders to the corporate culture, outsiders to the production methods and product, and outsiders to the clients for whom the company is making the product. Internal actors possess high levels of knowledge about the company, the product, current production methods, and their clients. External actors may have high levels of knowledge about alternative production methods and capital improvements that can increase energy efficiency, but if the level of trust between external and internal actors is low, turning to external actors to identify energy-efficiency opportunities simply will not occur, regardless of the expected payoff for the company.

As in the discussion on goal-setting, no single method for identifying energy-efficiency opportunities is critical for success. Both outside-in and inside-out strategies for identifying energy-efficiency opportunities can be successful. However, companies with in-house technical and process engineering experience tend to rely on internal actors for information about the range of opportunities available for improving the energy efficiency of specific industrial systems. Furthermore, these companies rely on internal actors to decide whether and how to engage external partners to increase their capabilities. Companies with lower levels of in-house technical expertise will tend to turn to external actors, either to more technically proficient members of their supply chain, or to utilities and government programs. In essence, these companies seek to import external expertise rather than to develop this expertise in-house.

The willingness of companies to evaluate how they use energy, and their willingness to turn to external actors to evaluate their production processes, is dependent on corporate culture. Companies that have internalized the notion of being a "learning organization" and have existing institutional support and management mechanisms in place to continually challenge how they conduct business are more likely to turn to external actors to identify energy-efficiency opportunities in their operations.

Financing

Manufacturers approach the decision to finance energy-efficiency capital improvements in one of two ways: parity competition for capital or capital set-asides. Under parity competition, capital improving the energy efficiency of the firm is evaluated in the same manner as other capital investments. Common methods for evaluating capital projects are simple payback, internal rate of return (IRR), return on investment (ROI), and net present value (NPV). In capital set-asides, a percentage of the firm's annual capital improvement budget is reserved exclusively for energy-efficiency projects. Examples of these financing mechanisms, and observed variations in these two general models, are discussed below.

Parity competition for capital

Firms use a variety of methods to decide what long-term capital investments to make. Common capital budgeting decision methods are simple payback and different methods accounting for the time value of money. The most common methods are briefly discussed below.

Simple payback

The simple payback method is defined as the expected number of years required to recover the original investment (Brigham & Daves, 2009). More generally, it divides the cost of a project into the cash inflows generated by the project over a period. For example, a $5 million project generating $1 million in revenues per year has a 5-year payback period. A 1995 survey by the DOE's Industrial Assessment Center of 105 business managers in small-and-medium sized enterprises reported that 86% of business managers expected payback periods of 24 months or less, while 55% expected paybacks of 12 months or less. Larger firms with a tolerance for increased risk due to cost overruns and delays in realizing planned returns will accept 3-year payback periods or longer (Pye, 1998). Toyota, for example, reports that it has a five-year payback period threshold for most capital improvement projects (Pew, 2010b). Engineers, in particular, tend to use simple payback as the preferred method for evaluating the economic viability of projects (Elliott, 2008). The method is flawed from a financial management perspective because it does not quantify the benefits generated beyond the payback period, nor does it take into account the time value of money, namely that a dollar today is more valuable than a dollar next year.

To account for the time value of money, some firms use a variant of the simple payback period called the discounted payback, which takes into account the project's cost of capital in calculating the expected cash flows. The discounted payback is defined as "the number of years required to recover the investment from discounted cash flows" (Bringham & Daves, 2009, p. 427). Cash flows are discounted by the firm's cost of capital. Discounted payback is calculated by dividing each cash inflow by $(1+k)^t$, where *k* is the firm's cost of capital and *t* is the year. Thus, a $5 million project generating $1 million in revenues per year with a 10% cost of capital has a 7.3 year payback period.

NPV

The net present value (NPV) of a project is the sum of cash flows generated by a project over its anticipated life, discounted by the firm's cost of capital. The key advantage of NPV is that it allows for an easy decision-rule for accepting projects. A positive NPV means that the project has returns exceeding the investment and improves the financial position of the firm. A negative NPV indicates the project loses money, while a NPV equal to 0 means that the project does not affect the position of the firm. In the example used, the NPV of a $5 million project generating $1 million in revenues for 8 years with a 10% cost of capital is 334,926. The project should therefore be accepted since the NPV is positive. NPV also permits the easy comparison of projects. If project A has a NPV of 100 and project B has a NPV of 150, project B is preferred to project A despite both having a positive NPV.

NPV is preferable to discounted payback because it evaluates the net benefits of a project into current, present day terms over the entire course of the project. An energy-efficiency project with high upfront costs and returns in more than two or three years might be rejected using the payback method, yet still provide material benefit to the firm's financial position. Using NPV rather than payback would allow the company to accept the project.

IRR

The internal rate of return (IRR) is the interest rate corresponding to a zero net present value. Specifically, it is the discount rate that equalizes the present value of a project's cash inflows to the present value of its expected costs (Bringham & Daves, 2009). The benefit of the IRR is that it can easily be compared to the firm's cost of capital or other internal "hurdle rates" established by management. The IRR of a $5 million project generating $1 million in revenues for 8 years is 11.8%. Since this is greater than the firm's 10% cost of capital, the project would add material benefit to the firm's financial position.

ROI

The return on investment (ROI) is the ratio of benefits and costs of a project in present value terms. A ratio above 1 indicates that the benefits to the firm exceed the costs, while a ratio below 1 indicates that the project's costs exceed the benefits. The ROI of $5 million project generating $1 million in revenues for 8 years is 1.07, indicating that for every dollar invested the firm will receive 1.07 in returns on a net present value basis.

The "best" method

Financial theorists are virtually unanimous in declaring NPV the preferred method for evaluating investments (DeCanio, 1998; Ryan & Ryan, 2002). In actual business practice, however, NPV is used along with IRR and other methods to make capital budgeting decisions. In fact, NPV has only recently become the most commonly used capital budgeting method. Use of NPV was practically unheard of before 1980, but became increasingly adopted throughout the intervening decades to the point that 85% of CFOs in Fortune 1000 companies surveyed in 2002 reported using NPV "always or often" in making capital budgeting decisions. IRR comes in a close second with 77% (Ryan & Ryan, 2002).

Energy-efficiency investments tend to be evaluated using payback rates rather than discounted cash flow analysis… engineers in particular use payback as their preferred economic evaluation criteria. This is contrary to financial theorists' recommended method for evaluating capital investments.

Energy-efficiency projects, however, tend to use capital budgeting evaluation methods other than NPV. DeCanio (1998) reports "the nearly universal practice of firms contemplating or carrying out [energy efficiency] upgrades is to use measures such as simple payback and internal rate of return to evaluate prospective investments" (444). Elliott (2008) finds that "engineers in particular use payback as their economic evaluation criteria" (p.4). Train (1985) found that energy-efficiency investments "tend to be evaluated using payback rates rather than discounted cash flow analysis with the required rates of return exceeding those for business development projects" (Sorrell et al., 2004, p. 75).

The method used in practice does not matter if the different evaluative methods for capital projects derive the same result. And under certain conditions, they do. Payback and IRR will yield equivalent results as long as the IRR is between 0 and 200% (DeCanio, 1998). NPV, IRR, and ROI will all yield positive results when annual returns are greater than the firm's annual cost of capital. As pointed out by Bringham & Daves (2009), NPV, IRR, and ROI will mathematically always result in the same accept/reject conclusions if projects are evaluated *independently*.

In most cases, however, firms will want to evaluate projects *comparatively* to determine what investment generates the greatest benefit to the firm. IRR and NPV will result in conflicting rankings when projects differ in scale (small v. large), timing of returns (early v. late), and have large late cleanup costs (Bringham & Daves, 2009). When IRR and NPV provide conflicting rankings, it is better to use NPV because of its superior method for accounting how income streams from the project are reinvested by the firm. NPV assumes that income streams from the project are reinvested at the firm's cost of capital, while IRR incorrectly assumes they are reinvested at the project's IRR (ibid.). NPV is always the preferred method for evaluating capital projects for firms, assuming equivalent project lives, levels of risk, a constant future cost of capital, and access to capital markets (ibid.).

NPV is also superior to ROI in evaluating capital projects because it evaluates the benefits of a project in dollar terms rather than as a ratio of return per dollar spent (Bringham & Daves, 2009). For a profit-maximizing firm with no capital constraints, larger returns are preferred to smaller returns. Therefore, when the two measures conflict, projects should be evaluated using NPV rather than ROI (ibid.).

NOVEL APPROACHES

A compelling topic of discussion among companies and financial theorists is how capital budgeting can give weight to corporate goals in energy efficiency. Our review of capital budgeting decision-making in firms finds that companies can extend payback periods, develop "shadow" carbon costs, evaluate energy-efficiency projects at lower levels of risk, and a "portfolio" method to increase the level of investment in energy-efficiency projects.

Extending payback length for energy-efficiency investments

Some companies extend the payback period for capital projects that improve the energy efficiency of their operations. Toyota, for example, extends the payback period from 5 years to 7 years for capital improvements that increase the energy efficiency of their operations (Pew, 2010b). This provides incentives for the company to invest in energy efficiency capital projects.

Evaluating projects with carbon emission costs

Some companies evaluate capital investments with a "shadow" carbon emission cost. It is a shadow carbon cost because the United States, unlike the European Union, has no mandatory system, like "cap-and-trade", to charge for carbon emissions. Various accounting methods exist for including carbon emission costs in capital budgeting decisions (Berk & DeMarzo, 2010). Perhaps the simplest method is to discount future earnings by an anticipated carbon cost when calculating the NPV of a project. Some U.S. multinational corporations use \$10/ton of CO_2 in their capital budgeting analysis. The net effect of the calculation is to reward capital improvement projects with better environmental performance by discounting future cash flows less than heavily polluting projects. [13]

Evaluating projects with different levels of risk

Capital budgeting evaluates both the comparative value and the associated risk of capital improvement projects. Some companies have concluded that the risk associated with energy-efficiency projects is substantially lower than others in their portfolio of potential capital projects. The reasoning is that projects improving the energy efficiency of processes for existing products are safer investments than, for example,

[13] Examples of existing models for evaluating projects with carbon emission costs are available at the EPA Climate Leaders case studies website at www.epa.gov/climateleaders/casestudies.

expansion into a new product line. PepsiCo, in particular, evaluates energy-efficiency projects as having a lower level of risk than other capital projects. (Pew, 2010b).

Portfolio method

An innovative approach to capital budgeting worthy of consideration is the portfolio method. The portfolio method selects a basket of energy-efficiency capital projects that achieve the company's goals in energy efficiency, but leaves the evaluation of what projects best achieve those goals to the environmental services or engineering services group in the company. For example, if a company establishes a goal to reduce carbon emissions by 50% in ten years, the typical approach is to find individual projects in a company that annually reduce the carbon emissions by around 5%, given thresholds for payback and ROI. In the portfolio approach, the entire range of available projects is evaluated to deliver the desired level of carbon reduction at minimal cost. Thus, the basket of projects is maximized, not individual projects for an individual year. The result is that projects with long paybacks, but which are effective in decreasing the carbon emissions of the company, can be combined with projects with short paybacks. The key evaluative criterion is whether projects deliver on the reduced carbon emission goals over a span of time, rather than the project-level "low hanging fruit" model typically employed by companies. Diversey, a producer of industrial cleaning products, uses this capital budgeting model (Duke, 2010).

Capital set-aside

Some companies have determined that capital set-asides for energy-efficiency projects are the most effective way to achieve corporate sustainability goals in energy efficiency. In a capital set-aside program, a fixed amount, or percent, of the company's annual capital budget is dedicated towards a special category of projects that achieve an important corporate goal. Best practices in some countries recommend capital set-asides for energy-efficiency projects. For example, the British Energy Efficiency Office recommends that 5% of a company's annual energy costs should be dedicated toward an energy-efficiency budget (Sorrell et al., 2004).

Many reasons exist for dedicating a portion of a company's capital budget toward a specific energy efficiency goal. Perhaps among the most common reason is that the status-quo capital budgeting decision-making process is not satisfactorily meeting the goals of executive management. The case of DuPont is illustrative. Business units at DuPont are responsible for making capital and operations decisions that best meet the growth objectives of their units. Often capital improvement projects that both improve a business unit's energy efficiency and have a high return on investment get overlooked during the capital budgeting process because other projects are evaluated to be more important to the unit's revenue growth, or because plant managers do not want to interrupt the production process to achieve something for which they are not rewarded in their report cards (see Text Box 2).

TEXT BOX 2: STRATEGIC PRIORITIES, THE INCENTIVES OF PUBLIC COMPANIES, AND FUNDING ENERGY EFFICIENCY PROJECTS

The strategic priorities of top management provide insights into why energy efficiency projects tend to be underfunded. A DOE study found that energy efficiency investments may be classified as discretionary maintenance projects, which are given a lower priority than either strategic business development investments, such as a new manufacturing plant, or essential business maintenance projects, such as replacing a failed pump. Why? Senior managers are primarily concerned with ensuring the long-term survival of their organization, which involves focusing on the strategic direction of the company, such as the introduction of new products and the development of new production facilities. Given the severe constraints on time and attention of senior management, the reductions in costs available from energy-efficiency investments can easily be downgraded and overlooked, even when these projects have frequently been shown to have higher rates of return than large projects that receive more management attention. The other major actors that can affect energy efficiency, plant managers, are focused on their plants' production and production process. They seek continuous operation of capital assets to produce as much product within manufacturing specifications as needed. This focus is unlikely to change until energy becomes more of a strategic issue for companies.

Incentives of public companies. Public companies have tremendous pressure on them to deliver positive quarterly results to shareholders. This focus has a significant impact on the interest of companies to invest in energy efficiency because earnings growth, rather than the return on invested assets, is the standard by which company management is held accountable by its shareholders and financial markets. One of the companies we interviewed stated that this fundamental difficulty, that of focusing on earnings growth rather than the return on investment, was the major reason why he couldn't get more energy efficiency projects funded in his organization. Capital investment opportunities yielding ROIs of 50% or more were overlooked in a firm with average ROIs of around 18% because of the focus on revenue growth by decision-makers. "Their focus is first on growing the business," stated one engineering services manager. "Everything else, except safety, comes in second." In the manufacturing sector, investing in cost effective, energy efficiency measures is hampered by a common preference to invest resources to increase output and market share as the preferred route to expanding profits.

The result is a classic prisoner's dilemma-type problem, in which what is in the best interest of the individual unit is suboptimal for the corporation in achieving its broader environmental performance and investment goals. One solution to this problem is to reduce the capacity of individual units to make all investment decisions related to their area of operations, and insist that certain projects be undertaken because they achieve corporate, not business-unit, priorities. This is precisely what DuPont did in its 2007 Bold Energy Plan.

DuPont created a $60 million capital set-aside to fund energy-efficiency projects for two years. The set-aside was sold to top corporate management as a way to achieve goals announced in 2004. Corporate management accepted the proposal because, in the words of one knowledgeable actor, “Our request was less than two percent of annual capital spending. Given that the risk was so low, we decided to give it a try.” (Bailey, 2010b). The projects undertaken with the capital set-aside reduced energy costs at DuPont by $70 million, delivered $170 million in NPV, and achieved a 60% internal rate of return, while reducing carbon emissions by 6%. Over 60 projects were funded that continue to provide returns to the company (Bailey, 2010a).

Capital set-asides, in general, are effective ways to fund corporate goals that would otherwise be unlikely to receive funding. One challenge of capital set-asides, however, is that they use a different process for evaluating investments in energy efficiency than other corporate investments. In a company that allows budgeting decisions to be made by business units, the practice sends mixed signals about holding business units accountable for their profitability and growth, and consequentially, their capital investment decisions. The confusion caused by these mixed signals may be reason alone to avoid creating capital set-asides. DuPont, for example, recently extended its Bold Energy Plan through 2012 without a capital set-aside for energy-efficiency projects precisely because it wanted to avoid sending these mixed signals (Bailey, 2010b).

If a company’s motivation to become energy efficient is simply to reduce operational costs, then capital investments in energy efficiency should be evaluated in the same way as the firm’s other capital investments. How those capital investment decisions can be made to give weight to corporate goals in energy efficiency is a separate topic of discussion. As explored in the section titled “Parity Competition for Capital,” companies can extend payback periods, develop “shadow” carbon costs, evaluate projects increasing the energy efficiency of existing product lines as less risky than other projects, or use the management by objectives approach inherent in the portfolio approach to capital budgeting.

External financing

The discussion has thus far not introduced the use of external funders (“performance contractors”) to finance capital improvements in energy efficiency. Using performance contractors is clearly an option for companies with capital budget restrictions or a cost of capital that is higher than external providers. Under these conditions, it may make financial sense to use external funders to finance a company’s investments in energy efficiency. The companies we spoke to, however, were hesitant to use performance contractors for the following reasons:

- Internal cost of capital was lower than performance contractors’ financial offer;

- Operational management objected to allowing performance contractors to re-engineer the production process;
- Long-term agreements required by ESCOs to achieve a suitable return exceeded the planning or financial horizon of management;
- Baseline energy use, which is fundamental to how ESCOs function, was too difficult to accurately report;
- Financial reporting requirements (Sarbanes-Oxley) and required insurance for third-party investments reduced the attractiveness of external funding.

Implementation

Two general models exist for how companies organize for energy efficiency. Some companies maintain company-wide energy services teams that identify and implement energy-efficiency opportunities throughout the company. Others rely on plant-level energy services to implement the identified energy-efficiency opportunities.

Company-wide energy services

The role of company-wide energy service teams is to act as the primary point of contact for energy systems throughout the company. The energy service teams are typically comprised of engineers familiar with the industrial energy systems used at different manufacturing locations. These energy service teams are responsible for identifying energy-efficiency projects for the company, and work closely with corporate-level finance teams to implement projects that overcome the company's financial hurdles. Company-wide energy service teams report to corporate-level operations and financial managers.

One variation we have observed is the coordination with site-specific "energy champions" responsible for notifying the company-wide energy services team about projects at specific manufacturing locations. Energy champions are personnel tasked with finding savings at manufacturing plants. Energy champions at all but the largest, flagship facilities typically have additional operational responsibilities in addition to identifying energy-efficiency improvements.

Plant energy services

Plant energy services are site-specific engineering services responsible for the identification and implementation of efficiency improvements. Plant energy services report to plant managers. Typically, plant energy services are extremely knowledgeable about the manufacturing process at specific plants. Plant-level energy service teams can identify upgrading opportunities in existing processes to improve the energy efficiency of operations through, for example, substituting better performing motors when old motors and drives need replacement. Many of the energy-efficiency improvements since the 1970s have occurred at the plant-energy services level. Indeed, this “boiler-room” perspective has been important for increasing the energy efficiency of plants over time. Although plant energy services are knowledgeable about the specific manufacturing process and industrial energy system used at the plant, they may not be as aware of broader process improvements and energy system reconfigurations that may require outside expertise.

In practice, company-level and plant-level energy services are not mutually exclusive. Some companies use employees at the plant-level to identify projects and then report projects to plant or division-level supervisors. These projects are then evaluated at the plant-level and/or by company-wide engineering service departments to determine whether they meet necessary thresholds for implementing improvements. DuPont, for example, uses site energy champions who report both to their plant managers and to the company-wide engineering services department. In addition, site energy champions and plant managers in four business units using energy most intensively also report to full-time business-unit energy managers. Bridgestone North America has a similar matrix reporting structure for energy efficiency. Plant energy representatives report to plant engineering departments and plant managers, in addition to the person responsible for energy efficiency throughout Bridgestone North America. UTC develops energy teams tasked with identifying projects for each business unit. Green factory teams, reporting to the company-wide energy team, exist for each factory or plant. They identify projects that are entered into the company-wide database, which are then evaluated by capital budgeting personnel. Company-level energy service teams can be an additional important layer to plant-level service teams, or vice versa. The tendency, however, is that one or the other service team level tends to be dominant in identifying and implementing energy-efficiency opportunities for manufacturers.

Incentives for employees

Companies have a variety of ways to motivate employees to become more energy efficient in their area of responsibility. Some companies provide financial incentives to all employees to achieve energy-efficiency goals. Toyota, for example, holds plant-level competitions to track progress toward energy-efficiency goals and attaches variable pay with performance towards achieving energy-efficiency goals at the plant.

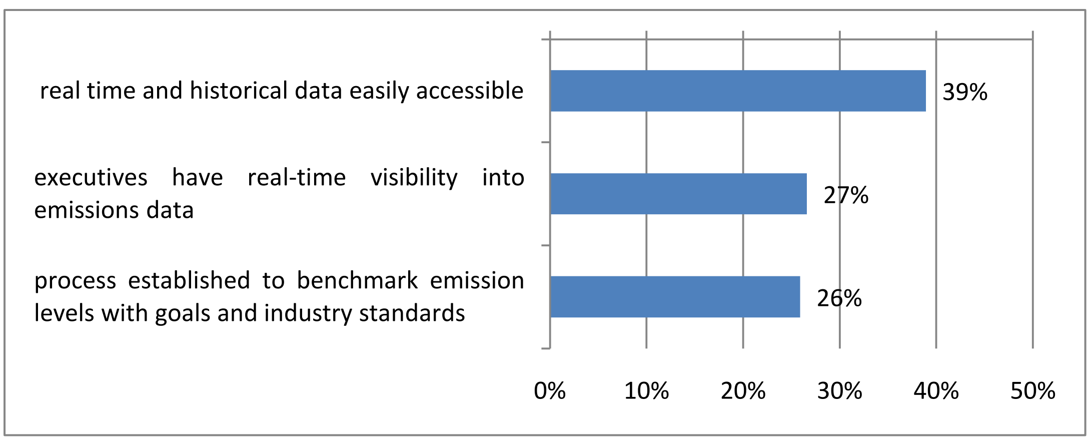
Other companies include energy efficiency in the plant manger’s report cards. Toyota and PepsiCo, for example, rate their plant managers on the basis of how well they manage the energy use at their facilities (Pew, 2010b). Other companies, like DuPont, are evaluating whether adding energy management to the report cards of plant managers is appropriate.

Tying energy efficiency to plant manager incentives is an effective method for increasing the energy efficiency of plants. The difficulty, as illustrated by the discussion on measurement below, is that appropriate measures for energy management are not widely adopted by the companies we interviewed. Holding management accountable to industry energy efficiency or resource management standards is appropriate only if they reflect what plant management can control. Developing appropriate measurement systems is one of the greatest challenges we have seen in the adoption of energy-efficiency practices, as discussed in the section below on measurement, benchmarking and reporting.

Measurement, benchmarking, and reporting

Measurement, benchmarking and reporting to internal and external audiences is important to determine whether the company is becoming more efficient in its operations and to let external audiences know of its sustainability efforts. Survey data from the Aberdeen Group reports that almost 40% of responding firms have energy data available, while just over a quarter of firms provide executives with emissions data (Figure 8). A quarter of firms also report that they have benchmarked emission levels with company goals and industry standards.

FIGURE 8: PERCENT OF FIRMS REPORTING MEASUREMENT AND BENCHMARKING ACTIVITIES, BY TYPE



Source: Aberdeen Group, 2009

Measurement

From a theoretical standpoint, measurement of a plant's energy intensity requires data on two of three data points. First, data on the plant's baseline energy use is necessary. We define baseline as the quantity of energy required to place the manufacturing equipment and supporting infrastructure (lights, HVAC) in a production "ready" state.[14] Second, data on the quantity of energy used to produce a unit of output (or the number of units produced by a quantity of energy) is required. Third, data on the plant's total energy use is necessary. The simple equation $b + (m * q) = t$, where b is the "baseline", m is the "marginal" per unit energy requirement, q is the "quantity" produced, and t is the "total" energy used, illustrates this relationship.

A plant's energy use can be reduced by decreasing the baseline energy use (b) or by decreasing the amount of energy used to produce a unit of goods (m). The relative payoffs on per-unit or baseline efficiency will vary by industry, plant, and the specific product produced. However, marginal efficiencies (m) are likely to be easier to achieve than affecting the baseline (b) energy use, since marginal efficiencies presumably deal with process improvements while baseline energy use deals with improving the industrial energy system of the plant.

Although simple from a theoretical standpoint, these data are difficult to obtain in practice. A plant's baseline energy use is rarely known by facility engineers, and it is nearly impossible to determine without turning off the production process, which operations personnel are not apt to like. One solution to obtaining these data is to measure the use of energy at a plant throughout the various phases of equipment readiness: sleep mode, start-up mode, full operations mode, and shutdown as recommended by "Treasure Hunts." A second solution is to run a regression on production volumes and energy usage. The coefficient will be the marginal energy requirement and the constant will be the baseline. The U.S. Department of Energy's Industrial Technologies Program is currently evaluating this solution for program participants, according to correspondence between the authors and the DOE.

> ***"The dirty little secret of energy efficiency is that energy use in industrial facilities is difficult to measure without equipment sub-metering capabilities."***

In reviewing how companies measure their energy efficiency, we were surprised that most simply divide the plant's total energy use by the number of product-units produced, where product-units are the number of units of each product-line produced at a plant. This calculation would be valid if the goal were to measure the energy footprint of a product, but not the resource efficiency of a production process. As illustrated by the recent economic downturn following the October 2008 financial crisis, production volumes can vary significantly. Companies reporting energy-efficiency figures saw a spike in per-unit energy use. Yet the product was not being produced in any particularly different way than in the past. Essentially, the per-unit spike was an artifact of the crude energy measurement system, and illustrates the difficulty of using total energy divided by production-units as a measure of energy efficiency. A better practice would be to accurately measure a

[14] Our definition of "baseline" should not be confused with the term "base year" referring to the energy used in a single year for comparison purposes for future energy efficiency efforts in programs like *Save Energy Now Leaders, Energy Star for Industry*, and *Climate Leaders*.

plant's baseline energy use and a product's marginal energy requirement. These measures can then be compared across time and across plants to determine the relative efficiency of different production locations.

In our discussion with firms about measurement, we noticed that many were resigned to using what we have called a conceptual flaw in the commonly used measure for evaluating a company's energy efficiency. Companies continue to use it because it is easy to measure, and provides useful quarterly data across plants, products, and business units.

Dashboard systems for monitoring the energy use at plants have been adopted by some companies. A 2009 survey by the Aberdeen Group found that 28% of respondents had dashboards or other analytic systems to monitor energy use at their facilities (Aberdeen, 2009). DuPont, the only company we spoke to that implemented a dashboard system in its flagship Sabine Plant, did so because one of their engineers developed the system at the plant. The company is currently assessing the extent to which the system is suitable for other plants. Replication is difficult because the dashboard system requires calibration of specific industrial systems at each plant to be effective (Bailey, 2010b).

Benchmarking

Benchmarks for energy efficiency can be created for products, plants, companies, and industries using a number of bases for comparison. For example, energy data can be compared to a plant's five year average or to an industry average. Choosing a benchmark is a company and industry specific decision. For example, car manufacturers use industry benchmarks developed by the "Energy Star for Industry" Program (Boyd, Dutrow & Tunnesen, 2008). Other examples of standards in energy efficiency are the proposed ISO 50001 standard being developed by the International Organization for Standardization, the Superior Energy Performance program being developed by the U.S. Council for Energy Efficient Manufacturing, and the Six Sigma quality management strategy (Chittum, Elliott & Kaufman, 2010). [15]

Industry benchmarks can be difficult to use when plants produce multiple or unique products. DuPont, for example, conducted a study in the early 1990s to determine what benchmarks would be appropriate for its plants. It ultimately determined that, because of the uniqueness and number of products produced at its plants that it would only benchmark according to the specific products produced at each plant. Thus, DuPont only uses product-level benchmarks based on past energy requirements to assess performance in energy efficiency (Bailey, 2010b).

Reporting

[15] Additional information on ISO 50001 can be found at www.iso.org. Additional information about the Superior Energy Performance can be found at http://www.superiorenergyperformance.net/

INTERNAL REPORTING

Internal reporting refers to the development of reports to corporate management about the use of energy in the company. Broadly speaking, it is the output of the energy management system that identifies the quantity and cost of energy at a product and plant level, what projects were implemented over the reporting period, and additional energy-saving opportunities identified through the course of the reporting period. Some companies have extensive internal reporting systems resulting in the ongoing examination of the company's energy-efficiency practices. DuPont's annual Bold Energy Plan report to senior management is one example of an extensive internal reporting system. UTC provides quarterly reports to its president tracking achievement of goals by separate business units. A survey by the Aberdeen Group found that 37% of its respondents had internal reporting capabilities (Aberdeen, 2009).

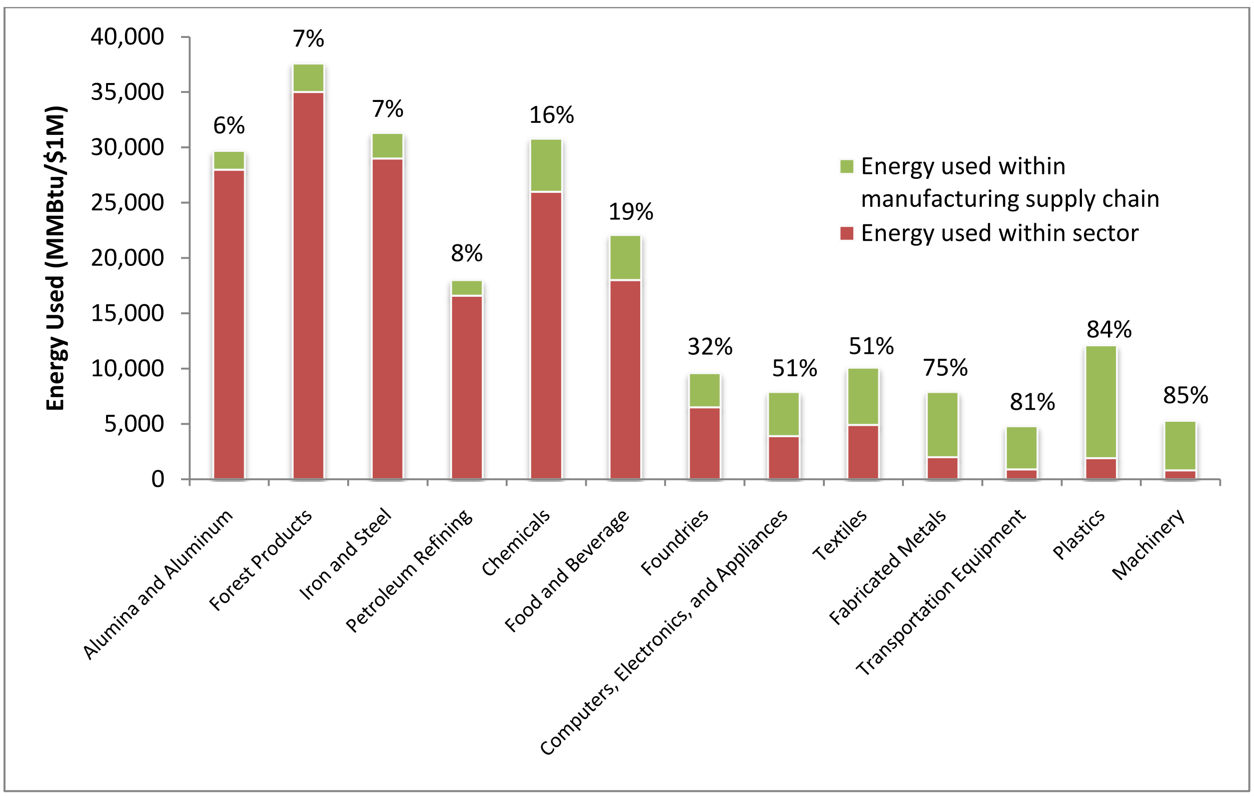
EXTERNAL REPORTING

A key motivation for companies entering the energy-efficiency arena is to communicate their activities to interested external audiences. These audiences include shareholders, customers, and supply chain partners. Communicating the firm's energy efficient investments and practices to these audiences enhances the firm's image and brand. In essence, the practice distinguishes the firm's brand and products from those of its competitors to audiences concerned about the environmental performance of companies and products. Firms communicate the message about energy efficiency through corporate environmental reports, annual reports, marketing materials, and participation in environmental forums and reports on the issue. Repeating the message to audiences about the firm's environmental activities is a key theme of many reports on energy efficiency and business communications. Pew (2006) is an example of this type of report stressing the importance of communicating to external audiences about the company's efforts in energy efficiency and environmental sustainability more generally.

Models of Supply Chain Engagement

The contribution of the supply chain to a company's carbon footprint varies by industry (see Figure 9). Companies in energy-intensive industries use most of the energy required to make a product within their internal operations, while companies in non-energy intensive manufacturing sectors use most of the energy within their supply chain. For example, the supply chains for aluminum and steel production contribute 6-7% of the total energy used in the sector, while the supply chains of textile manufacturing and electronics sectors contribute 51%. These data imply the level of supply-chain engagement by lead firms will vary according to the supply chain's contribution to the total carbon footprint of the product.

FIGURE 9: ESTIMATED CONTRIBUTION OF SUPPLY CHAIN TO TOTAL ENERGY USED IN MANUFACTURING, BY SECTOR



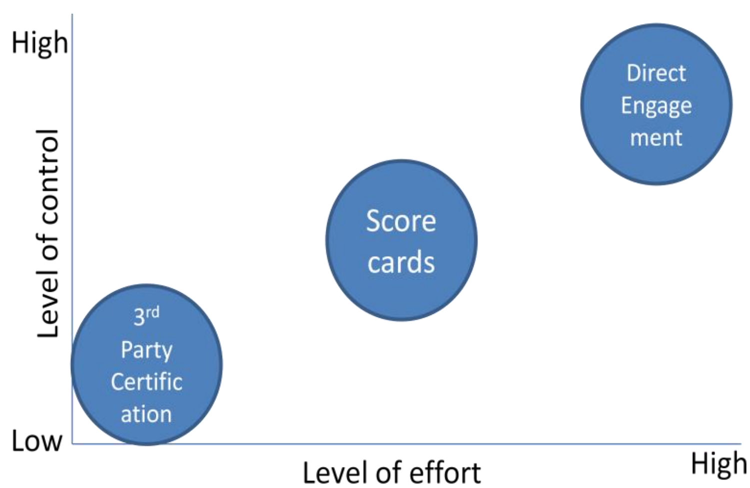
Source: DOE, 2010b

Firms actively seeking to increase the energy efficiency of their supply chain have done so in one of three ways. The first method has been direct engagement of suppliers, which includes the participation of the lead firm's energy services team to identify and help implement energy-efficiency improvements in a supplier's operations. For instance, PepsiCo and Toyota are two companies that offer the services of their engineering teams to suppliers. In return for access to these services, some companies require suppliers to provide their energy data to track progress toward energy-efficiency goals. PepsiCo, for example, requires suppliers who voluntarily participate in their energy-efficiency programs to supply data to the firm on a quarterly basis (Duke, 2010 & Pew, 2010b). This active monitoring by lead firms requires high levels of effort but also allows for high levels of control over the energy management activities of suppliers (see Figure 10).

Scorecards are a second way companies can engage their supply chain on energy efficiency. Scorecards rank suppliers according to desired evaluative criteria, including energy management.[16] Companies meeting thresholds on their scorecards are included within the supply chain, while companies failing to meet thresholds are either not included in a company's supply chain or given a period to meet required standards. Lead firms may assist suppliers in becoming compliant through capacity building. For example, a lead firm may help the supplier to identify energy-efficiency improvements in its operations. This model of supply chain engagement allows for a moderate expenditure of effort by the lead firm and yields a moderate level of control over the energy management activities of its suppliers.

A third way to engage the supply chain is to require that suppliers provide third-party certifications that their production practices are consistent with desired energy management practices. Commonly used third parties are the Carbon Disclosure Project (CDP), Global Reporting Initiative (GRI), and the International Organization for Standardization (ISO). This is the least active level of supply chain engagement by a lead firm and allows for the least level of control over the energy management activities of suppliers.

FIGURE 10: SUPPLY CHAIN ENGAGEMENT MODELS



Source: CGGC, Duke University

[16] An example of a supply chain scorecard is available at http://www.pgsupplier.com/environmental-sustainability-scorecard.

Supply chain engagement on energy issues is in its early stages for most companies. While many companies consider supply chain sustainability to be an important issue, few have implemented carbon reduction initiatives in their supply chain (McKinsey, 2008). The key barriers to increased attention on the energy used by suppliers include the monitoring costs required and the benefit derived from the firm's expenditure of management resources on companies several levels removed from the firm's product. In industries where the salience to customers of the carbon footprint of a product is low, it is very difficult to make supply chain upgrades in energy efficiency meaningful enough for lead firms to expend the time necessary.

The salience of supply chain management on energy issues may increase for firms as energy prices and energy price volatility increases. A rational strategy for companies with energy-intensive steps in their production lines is to externalize the risk of rising energy prices and price volatility through supply chain partners. The increasing price and volatility in energy may result in some companies deciding to "buy" their energy-intensive inputs through supply chain partners, rather than to "make" them in-house, as a risk mitigation strategy. Sophisticated energy supply-chain management practices will likely become an increasingly important competitive issue for companies as energy prices or volatility increase.

The interest of firms in *how* supply chain companies make product components increases the monitoring and coordination costs to ensure compliance with the firm's standards. As these costs increase, relationships between the firm and its suppliers will diverge from purely market transactions to becoming more oriented toward networked and hierarchical means of production (Humphrey & Schmitz, 2002). As a result of these mutual costs, the relationship between firms and their suppliers will be longer-term, and – because fewer suppliers can meet the new process requirements – supply chains will become leaner.

> ***"Environmental upgrading of value chains is not only a top-down process, but also a bottom-up process in which suppliers can assist the lead firm in adopting energy efficiency improvements."***

Increased monitoring and coordination costs between firms and suppliers may eventually lead to mutual dependence. For lead firms, the vulnerability is increased dependence on suppliers to provide key components for their products, which could result in suppliers exerting their market power on firms to extract better prices for their products. Firms can reduce their vulnerability by maintaining a number of capable suppliers, maintaining in-house capability, and through technological innovation. Suppliers are also vulnerable to capture by firms, particularly if production costs increase as a function of being compliant with the firm's specifications, thus making its products less competitive in the broader market. Suppliers can reduce their vulnerability by limiting the percent of sales to any one customer, or working with industry associations to design energy efficiency standards adopted throughout the industry.

The discussion thus far has referred to environmental upgrading as if it were a top-down process, in which a lead firm placed process standards on its suppliers to be more energy efficient, and the supplier complied with the lead firm's requirements. In actuality, it is a more dynamic process. Environmental upgrading can occur both as a top-down process, or as a bottom-up process in which suppliers assist the lead firm in adopting energy efficiency improvements. For example, DuPont's engineering services team assisted an industrial customer to upgrade its manufacturing process to become more energy efficient in return for maintaining the price on a key input produced by DuPont. Companies seeking to increase the energy efficiency of their operations should look both up and down their supply chain to identify supply chain partners with similar industrial energy systems who have already implemented energy-efficiency improvements. Since energy intensive industries have strong financial incentives to improve energy efficiency, these companies within a company's supply chain can be important partners. Useful sources of knowledge for a firm seeking to increase its energy efficiency can exist throughout its supply chain. This fact underscores a larger point that adopting energy-efficiency improvements in a company are, like other innovations, subject to multiple sources of information and learning.

Leverage Points of Economic Actors and Recommendations

Economic actors throughout the economy can affect the incentives of manufacturers to adopt energy efficiency. As the discussion of motivation in Section Two suggests, a variety of external and internal stakeholders are important in providing the incentives for companies to increase their energy efficiency. Retailers, consumer-product manufacturers, regulators, financial institutions, and NGOs have important roles in affecting the adoption of energy efficiency in the manufacturing sector. The actors most relevant to environmental upgrading and their leverage points are described in Figure 11. In this context, we mean by "leverage points" the unequal ability of specific actors to affect the incentives of manufacturers to adopt energy efficient practices.

FIGURE 11: LEVERAGE POINTS AND RECOMMENDATIONS FOR PROMOTING ENERGY EFFICIENCY ADOPTION

	Economic Actors					
	Retailers	Consumer product manufacturers	Financial and bond-rating institutions	Industry organizations	NGOs	Government
Leverage points	Product specifications and certifications	Product specifications and certifications	Access to capital	Knowledge of industry practices; technical expertise	Social and legal pressure; diffusion of knowledge	Regulatory requirements; diffusion of industry practices
Recommendation	Require products sold to have life-cycle assessments and carbon foot-printing analyses; require reductions in carbon footprints over time.	Assess suppliers on production processes or third party certifications of production processes.	Increase weight of environmental criteria on the evaluation of risk and for accessibility to funds.	Adopt formal standards for carbon emission levels; partner with government programs to deepen the penetration of energy-efficiency experts throughout the manufacturing sector.	Market to consumers the value of green products; push government to adopt legislation placing a cost on carbon emissions; work with companies in energy intensive manufacturing to achieve industry averages in energy efficiency.	Support legislation placing costs on carbon emissions; actively engage industry to increase adoption of energy efficient capital and operational improvements.

Source: CGGC, Duke University.

Retailers: Large retailers have the ability to increase the energy efficiency of the manufacturing sector by requiring products sold in their stores to list their carbon footprint. The reporting mechanism could either be through product labels stating the total carbon emissions created during the manufacturing process, or as required process certification from third parties. Some U.S. retailers have already implemented eco-labels. Walmart, for example, announced in July 2009 that it would assist in the creation of a product sustainability index that reports to consumers the product's carbon footprint and the likely pollution caused by its use. In a further step, retailers could require carbon footprint reductions over time, or that manufacturers be within a performance band for the product's sale in its stores. Retailers are implementing product sustainability labeling as a branding initiative in response to consumer preferences and as a cost saving measure.

C*onsumer product manufacturers:* Manufacturers of products sold to retail customers have branding and competitive incentives for implementing sustainable production practices, including energy efficiency. Consumer product manufacturers can increase the energy efficiency of the manufacturing sector by adopting energy efficient production practices and working with input suppliers to improve their energy efficiency. Manufacturers can actively assist their supply chain in improving their production practices or can assess suppliers with balanced scorecards or third party certifications. To promote increased energy efficiency, manufacturers can require the participation of suppliers in energy-efficiency programs or process certifications, or increase the weight of sustainability criteria on supplier scorecards.

Financial institutions: Banks and bond-rating agencies are in a unique position to promote energy efficiency throughout the manufacturing sector because of their control over financial capital. Financial institutions are already important actors in promoting the adoption of sustainability practices by companies by assessing companies on intangibles, such as corporate reputation and brand equity, influenced by environmentally responsible behavior. Banks also monitor whether firms are listed in the Dow Jones Sustainability Index and the Carbon Disclosure Project Leadership Index. Financial institutions can increase the weight of environmental criteria on their evaluation of companies to promote the greater adoption of carbon reducing manufacturing practices like improved energy efficiency.

Industry organizations: Industry organizations have as their asset professional networks and established personal relationships among people faced with similar problems in similar industries and industrial energy systems. These peer-to-peer networks can increase the adoption of sustainable production practices by providing a forum of exchange among companies. Interviews conducted for this report indicate that informal or ad hoc exchanges among companies in the same industry association have been important in transferring knowledge about energy-efficiency practices. Industry organizations could make this information exchange more routinized or formal by hosting panel sessions at annual conferences, or establishing partnerships with government programs specializing in energy efficiency.

In addition, industry organizations could choose to adopt standards for carbon emissions or production practices. This acts as a voluntary or "private" regulation on the industry. This strategy may be particularly effective in avoiding government regulations on carbon emissions, since mandatory regulations are less likely if government regards industry as a leader in voluntarily adopting environmental standards.

Government: Regulation, or the threat of regulation, is the chief leverage point of governments in influencing companies to become more energy efficient. Environmental regulations in the past have been important in affecting the adoption of more environmentally-friendly technology and manufacturing practices in the United States (CGGC, 2010b). Regulatory anticipation of carbon pricing in the United States resulted in increased management attention paid to carbon emissions and energy efficiency at some of the companies we interviewed. Put simply, regulations create the legal framework in which companies must compete, and result in environmental issues receiving management attention as a strategic issue. Regulations may also increase the cost of energy, which increases the incentives of companies to invest in energy-efficient practices and capital.

Government has also used its role as a provider of public goods to encourage industry to increase adoption of energy efficient capital and operational improvements. Government-industry partnerships, like the DOEs Industrial Technologies Program, have had an important role in diffusing information about how to implement energy-efficiency improvements in the manufacturing sector. The difficulty has been, in the words of one government regulator at a recent energy efficiency meeting, the customized, day-to-day “hand-holding” needed to entice companies to become more efficient in their manufacturing processes. The regulator’s experience illustrates the point that the level of trust between internal and external actors is important to the adoption of energy efficiency practices, yet takes time to develop.

NGOs: Non-governmental organizations can affect the social and legal incentives of manufacturers to become more energy efficient. NGOs can increase the social incentives of companies to become more energy efficient by working with external stakeholders in the firm. Examples include marketing to consumers the value of sustainable products, working with industry associations to adopt environmentally sustainable production standards, developing with financial institutions mechanisms to increase the role of sustainability criteria in the valuation of companies, encouraging shareholder initiatives on carbon emission reductions, and working with large retailers to require carbon footprint information on products sold in their stores. NGOs can increase the legal incentives of companies to become more energy efficient by pushing government to adopt legislation placing a price on carbon emissions.

NGOs can also directly engage companies to encourage the adoption of energy efficient manufacturing practices. An important consideration is which companies to engage given limited time and resources, and what options for company engagement exist. We offer our reflections on these two points below.

Which companies to engage: The discussion in Part Two identified key differences in the incentives of companies to become more energy efficient because of their product market, energy intensity of production, and supply chain position. We stated that companies in consumer markets with energy-intensive production near the final customer have a number of legal, financial, and social incentives to become more energy efficient.

If the goal of the NGO is to maximize the reduction in carbon emissions by promoting energy-efficient manufacturing practices, then selecting companies in energy-intensive industries is most appropriate. Companies with energy-intensive production admittedly have long-standing financial incentives to become more energy efficient, yet firms are unequal in adopting practices due to the regional differences in the cost of energy and peculiarities in company management. Working to improve the performance of companies in energy-intensive manufacturing that lag behind industry averages in energy efficiency would yield significant reductions in carbon emissions. This strategy has the added benefit of providing significant cost savings to company.

If the goal of the NGO is to maximize the number of manufacturing firms adopting energy efficient practices, then selecting companies in non-consumer product categories is most appropriate. As illustrated in Figure 2, the incentives of companies in this product category are lower than in the consumer product market. As a result, companies in this product market likely have not adopted efficiency practices to the extent of companies in consumer product markets. Thus, the opportunity to diffuse energy efficiency in the manufacturing practices of a company in this product market is greater.

The two goals (maximizing carbon reductions and maximizing the number of energy-efficient firms) are not mutually exclusive. NGOs should consider beginning with firms with energy-intensive production in non-consumer product markets, effectively the upper right-hand corner of Figure 2, and moving to other portions of the matrix as time and resources permit.

<u>Options for engagement</u>: Three options exist for NGOs seeking to engage companies on energy efficiency. The first option is to provide technical assistance on increasing the energy efficiency of particular industrial energy systems or manufacturing processes. To the extent that this leverages the existing expertise of government or public utility programs in industrial energy efficiency, or works with industry associations and leading manufacturers to conduct energy assessments, this may be a good option to pursue. Providing knowledge to companies about existing programs that effectively increase the energy efficiency of manufacturing operations should be the priority for NGOs pursuing this option.

A second option is to work with companies to develop capital investment criteria and evaluative procedures that support the company's goals in reducing carbon emissions. This option would include developing, with companies, financial analysis tools that appropriately account for cost savings in energy. The "novel approaches" discussed in the financing portion of Section Three (pp. 42-43) are highly relevant financial models for achieving this goal. Working with capital budgeting personnel to drive the appropriate evaluative procedure throughout the organization will be a key to success for NGOs pursuing this option. Engineers, particularly those responsible for evaluating energy-efficiency capital investments, will need to be engaged by NGOs and the company's internal capital budgeting personnel in order to drive these innovative capital budgeting procedures throughout the organization.

A third option for NGOs is to encourage companies to conduct carbon emission assessments of their products and develop internal goals for reducing the carbon footprint of their products. Manufacturers, large retailers, existing government programs, and NGOs can be allies in creating the incentives and capacity building necessary to implement this option. Large retailers can provide the necessary incentives by requiring eco-labels on products sold in their stores, while NGOs and government programs like the Green Suppliers Network can provide the capacity-building necessary to conduct carbon footprint analysis and drive improvements to energy efficiency throughout the supply chain. We consider this third option to provide the most benefit for both companies and the environment because it comprehensively reviews the input requirements and operational procedures used to manufacture products. The assessment can lead to reconfiguring production practices, optimizing supply chains, and re-designing products to minimize their environmental impact.

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