Energy Investment Decisions in the Industrial Sector

Prepared for the Energy Information Administration by

R. Neal Elliott, Ph.D., P.E.

Industrial Program Director

American Council for an Energy-Efficient Economy

Washington, DC

December 9. 2007

INTRODUCTION

In contrast to the other sectors of the U.S. economy, the industrial sector is diverse with respect to its economic activities, how it uses energy, and how it makes its investment decisions that effect energy use. Further complicating the assessment of investment decisions in the sector that affect energy use is that the individual industries have a wide range of different growth patterns, use a wide range of technologies to satisfy a diverse range of service demands, and have a range of facilities sizes from some of the smallest consumers to the very largest. Thus, to respond to the key questions for this exercise directed at the industrial sector:

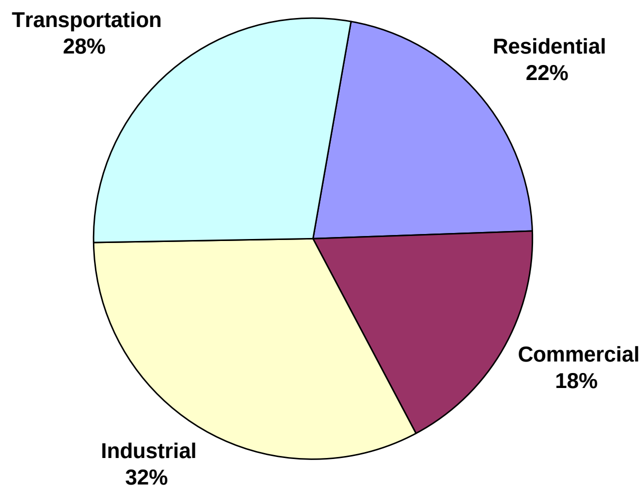
(1) how investment decisions are actually made within each energy market,
(2) how expectations about the future are formed, and
(3) how foresight is actually used in each sector,

what is required is a suite of approaches that reflect the reality in each part of the sector.

THE INDUSTRIAL SECTOR AND ITS ATTRIBUTES

Industry is the largest energy consuming sector of the U.S. economy, accounting for almost one-third of energy consumption (Figure 1). In contrast with the other sectors of the economy, the industrial sector consumes energy for both heat and power, <u>and</u> as a feedstock for the products delivered by the sector. These latter uses range from asphalt in paving and construction materials to hydrocarbon products as chemical feedstocks to electricity that serves as an electron-donor in electrolytic-processes such as aluminum or chlorine production (see Elliott, et al. 2006). Thus energy is essential to the viability of all aspects of the industrial sector.

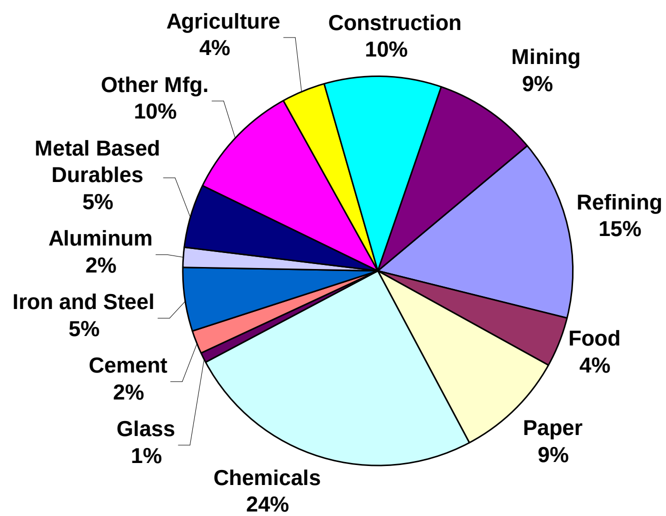
Figure 1. Total Energy Use by Sector



Source: EIA 2007a

The industrial sector is perhaps the most diverse sector of the economy encompassing agriculture, forestry, fisheries, mining and construction. Figure 2 shows the distribution of energy consumption in the industrial sector. Manufacturing accounts for the majority of the energy use in this sector. But even within individual industries such as chemicals or steel, energy use is very different, so generalizing about industrial energy use across all industries is both a challenge and can be misleading.

Figure 2. Distribution of Energy Consumption in the Industrial Sector (2005)



Source: EIA 2007a

The regional distribution of industrial energy is not uniform, with many energy intensive industries concentrated in just a few states. The growth – or decline – of individual industries also varies by state and region. As a result, the application of national level findings at the state level can be highly misleading (Elliott et al. 2003).

Thus, it is critical that any modeling of the industrial sector capture this diversity of markets, use, processes and geography. Unfortunately, the groupings of how energy is used do not correspond with the economic classification systems—historically the Standard Industrial Classification (SIC) system or since the late 1990s the North American Industrial Classification System (NAICS)—used to reflect products produced. As a result some aggregation strategy has to be used to group economic sectors into bundles that use energy in like manners.

In addition, the industrial sector is not static in terms of how or what they produce either, so any representation must be regularly updated to reflect changes in the sector and the energy using processes represented. The current Industrial Demand Module (IDM) of the National Energy Modeling System (NEMS) does a good job of balancing the diversity of energy using processes and differential growth-rates among individual industries and sub-industries (EIA 2007b).

Representation of Technology, Products and Processes

Further complicating energy modeling of industrial sector is that most of the energy use is in various processes, not by discrete end-uses for which discrete technologies choices can be made to determine energy use. Rather, it is the application of the technology and the interaction between the product and process that define energy use. While the magnitude of the identified opportunities for greater energy efficiency have remained the same over the past quarter-century, the nature of the savings opportunities appear to shift with technology evolution and a greater understanding of where to look for savings—often referred to in economic circles as "learning-by-using" (Shipley and Elliott 2006).

These challenges, combined with a changing product mix and evolving technologies and practices require a more robust representation of investment choices to reflect real world behavior. Over the past two decades the modeling of the industrial sector has evolved as research has developed a better understanding of the sector (EIA 2007b, Bataille et al. 2006 and Laitner and Hanson 2006). This work provides a foundation upon which modeling can build.

How Energy Investments are Made in the Industrial Sector

Industrial firms do not make investment decisions related to energy separately from investments in other aspects of the firm's operations. Most of industry does make investment decisions differently than is common practice in other sectors of the economy. Industry's decision approach results from the process-focused nature of most of the assets at industrial facilities, and the focus on the continuous operation of these assets to product a product.

Role of Planning and Investment Cycles

To understand how energy investment decisions are made it is important to place these decisions into a broader context by considering the plant's investment cycle—e.g., whether a proposed investment is part of a retrofit of in-service equipment, replacement of failed equipment, or as a part of a major refit of the production facility. For context purposes, the life cycle of manufacturing plants can be divided into four stages:

(1) New Plant: At this stage, all initial equipment investments in a plant are complete. No more investment is required to place the plant into service.

(2) Operating Plant: At this stage, the plant expenses include operating and maintenance costs. Equipment is replaced only upon failure, or for some compelling reason—usually safety, environmental compliance or productivity, but rarely related to energy use alone.

(3) Old Plant: This stage is characterized by old or outdated equipment on which basic maintenance is infrequently performed. Focus is on maintaining operation with minimum investment.

(4) End of Life: This is the point at which a plant is either completely refitted or demolished.

Industry investments coincide with these plant operational cycles (Steinmeyer 1998). These operational cycles reflect needs for maintenance due to heavy wear on major process components and systems, changes in product mix and incorporation of modernized technology at a facility. Typically, these cycles can run 4-7 years, but will vary according to market forces and industry-specific needs. While routine maintenance outages often occur during these cycles, these brief outages focus on addressing system reliability problems, and seldom involve major equipment change-outs or process modifications. The plant cycles vary in length, determined by the need for major system maintenance and the rates of technology and product change. For example, a glass factory's interval can run a decade or more, while a high-tech facility's interval may consist of only a few years.

Most opportunities for industrial sector energy efficiency exist within the processes that are integral to the operation of the industry. Most firms are unwilling to incur additional costs (e.g., lost production) and risks (e.g., product quality or process reliability) associated with interrupting a process for modification outside of this normal plant cycle. For this reason, industrial energy efficiency efforts have had limited success with retrofit measures (Shipley and Elliott 2006).

Equipment failure that occurs during the intervals between refits can represent an opportunity for efficiency improvements. These failure opportunities can be capitalized upon by replacing the failed component with a more-efficient, interchangeable component. For example, a more efficient, compatible motor can often replace an older failed motor at a modest incremental cost. Most upgrades of operating equipment will however be deferred until the next plant level refit when energy efficiency measures can be included among larger, cyclic investments <u>if</u> they are identified early in the planning cycle (typically 12-18 months from initiation of refit). The efficiency savings implemented as part of a plant refit can often be highly cost-effective, since incremental costs attributable to the measure are very small.

It is also important to realize that most plants are not operated as stand-alone entities, but are rather an element of the overall productive capacity of a firm. The firm will allocate production to different facilities based on the site's location, cost of production, and product mix. The likelihood of a major investment will normally change based upon the facility's position within the company's overall operating capacity. Less attractive investments are frequently made at the most modern and productive facilities—"flagship plants"—while highly attractive investments will often be deferred at marginal facilities. This apparently anomalous behavior results from the greater likelihood of the flagship facility's continued operation during economic downturns, while production is decreased at marginal faculties or the facilities are closed (Steinmeyer 1998).

Economic Criteria

Calculation of simple payback is one of the most common methods to evaluate a capital improvement. The payback period is defined as the period of time during which the initial capital expenditure of an investment is recouped. Engineers in particular use payback as their economic evaluation criteria. Many firms arbitrarily select a specific payback period as a method of investment appraisal. For example, in 1995 the Industrial Assessment Program surveyed 104 business managers of small and medium-sized facilities. Eight six percent of respondents stated that a payback period of 24 months or less is attractive for energy efficiency recommendations. Fifty-five percent of respondents replied that they would prefer a payback period of 12 months or less (Muller, Barnish, and Polomski 1995). In contrast, larger companies, or companies with a large amount of corporate backing, often accept 3-year paybacks.

Firms also use internal-rate-of-return calculations to evaluate discretionary investment opportunities. These criteria include both return on investment (ROI) and return on net-assets (RONA). Financial analysts are more likely to use these criteria. While most of the external attention is focused on ROI by financial analysts, many manufacturing firms frequently focus on RONA. It is important that RONA can be increased by either increasing income <u>or</u> by reducing net assets through retiring assets, or with plant consolidations with acquisitions of competitors.

Major energy efficiency investments are also frequently reviewed on a capital budgeting basis. In capital budgeting, funds must be identified and approved prior to the budget cycle so the project can be initiated during the fiscal cycle (Jones and Verdict 1995). This capital rationing approach is used for major investments, and can interact with the plant capacity dispatch order discussed previously to steer investments toward some plants and away from others.

External Market Forces

External market forces also drive industrial investment cycles. These forces can be near-term, affecting timing of the next plant refit cycle, or can be longer-term macro-effects that result in structural changes in the industry. The near-term forces are usually driven by the overall economic cycles, while the macro-changes result from major policies, such as treatment of investments or global forces such as changes in national consumption and competition for raw materials. Current and anticipated market demand for the facility's product and relative cost of manufacturing will influence these macro cycles.

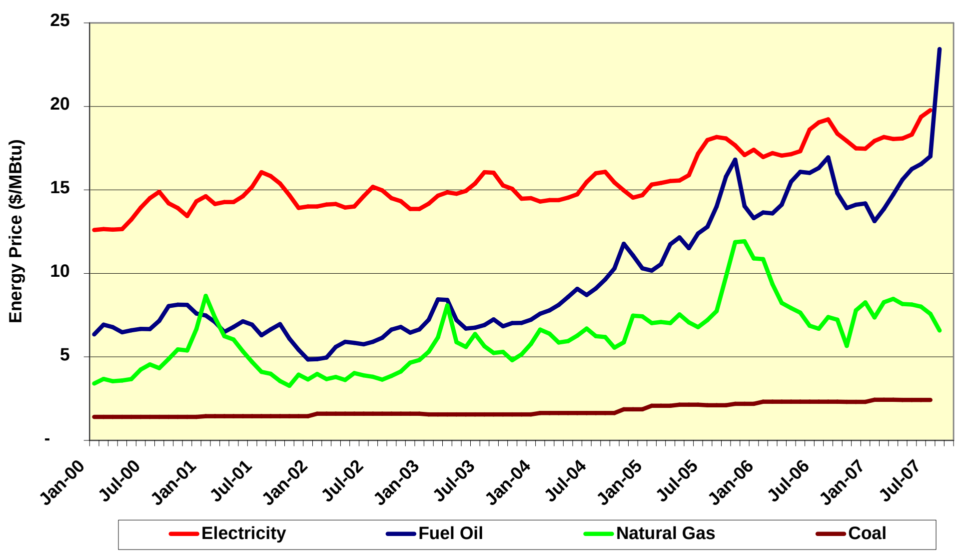
A number of major energy-intensives materials manufacturing industries have been impacted by these macro-cycles during the last 15 years. It is important to understand these economic forces if we are to anticipate future investment behavior by industrial firms. Unfortunately, economic trends are really only seen in retrospect. While an understanding of the current situation is important, the reader needs a context of what has transpired over the past decade to frame their understanding of current and future trends.

Effects over the Past Decade

Over the past 10 years, the economic outlook for industrial customers has changed due volatility in external economy and within the industrial markets. During this time-frame factors such as energy price (Figure 3), industrial consolidation and globalization have influenced industrial investment decisions. These trends can provide insights into future investment patterns.

For example, a global corporate consolidation cycle that has resulted in a reduction in excess manufacturing capacity and a shift to secondary production has remade the aluminum and steel industries. These effects have reduced a global excess of the commodities on the market that has allowed manufacturers to increase prices relative to their cost of production, allowing an increased rate of return on net assets. The capacity that has been retained is the more modern and most productive.

Figure 3. Average Monthly Industrial Energy Prices

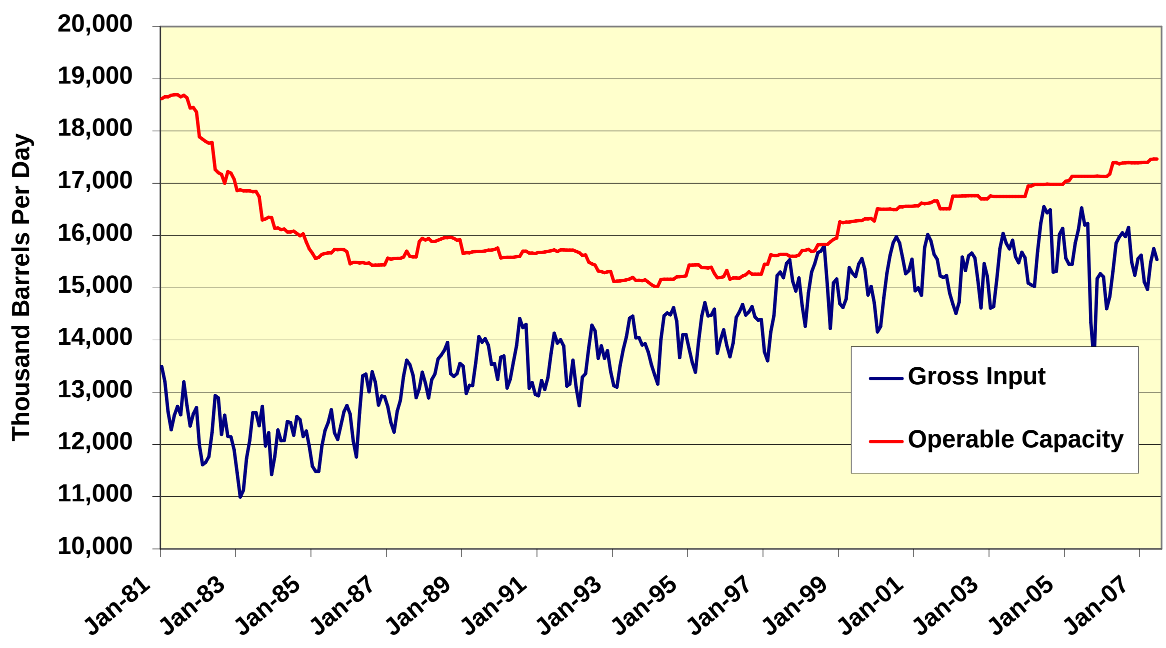


Source: ACEEE from EIA 2007d

In the organic chemical industry, the domestic price of feedstocks has dramatically increased costs leading to a shift in the industry from an export focus to a largely domestic focus resulting in the shedding of excess domestic capacity. The chemical industry, as with other industries that are faced with these capacity reduction situations, eliminated the least productive and least cost-effective capacity, shifting production to higher performing, more energy efficient facilities, thus reducing production costs. The recent increase in base energy efficiency of facilities is the result of the combination of this consolidation that eliminated much of the least efficiency capacity from the operating base, combined with continued investments in more efficient technologies at the surviving facilities.

The petroleum industry represents another excellent example. With demand for refined goods slowing in the 1980s, the industry found itself with an excess of capacity resulting in depressed prices for much of the 80s and 90s, leading to a wave of consolidations in the 1990s (Figure 4). As demand grew to better balance available capacity, the profitability of refining improved. Hurricanes Katrina and Rita in the fall of 2005 disrupted a significant fraction of domestic capacity, resulting in very tight markets for refined goods. Following the outages, petroleum refining facilities sought to defer maintenance and upgrades as they pushed plant output to satisfy demand in a very profitable market. Although refiners were able to obtain high prices in tight markets, deferred-maintenance resulted in unscheduled outages in early 2007, with some loss of earnings. In response to these favorable market conditions, the industry began planning the first major domestic investments in decades (Elliott 2006, Campoy 2007 and DOE 2007c). However, as uncertainties in the overall economic outlook emerged, along with concerns about the impact of fuel policies for long-term product demand, the industry began to retrench its investment plans (Reuters 2007). This hesitance to commit to an investment in capacity due to market uncertainty is common in industry, and has become increasing common in the recent past.

Figure 4. Domestic Refining Capacity and Production

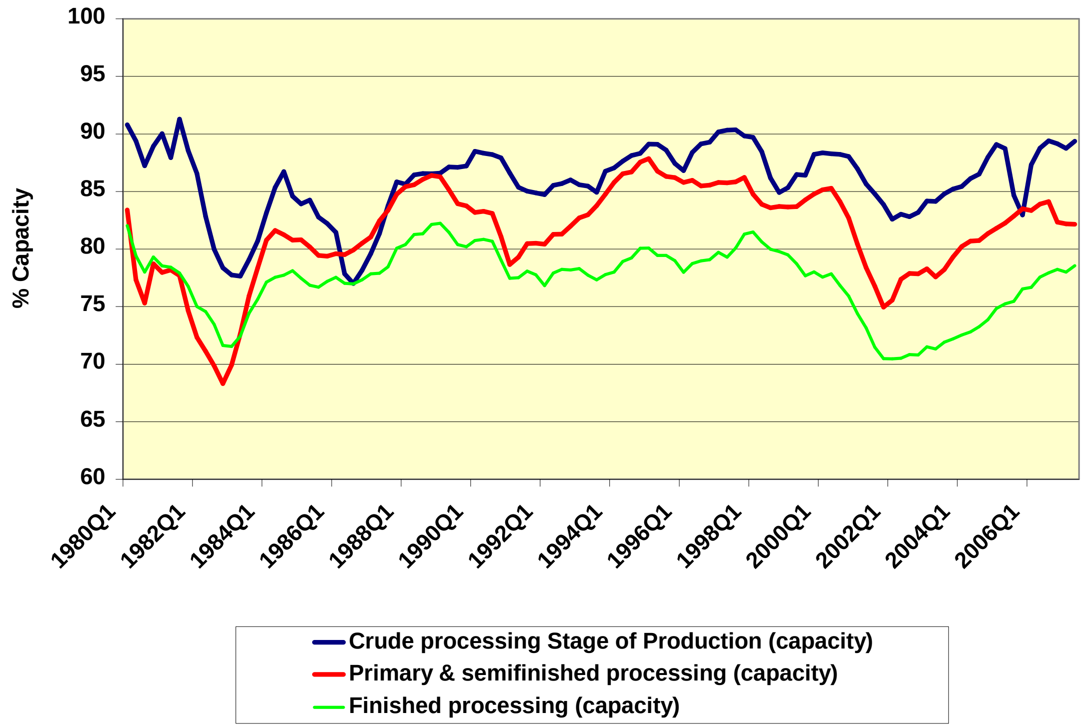


Source: ACEEE from EIA data (2007d)

Longer-Term Market Trends
Overall, industrial capacity utilization rates[1] appear to be trending up. Industry made major capacity additions in the 1970s. A slowing economy in the 1980s resulted in a decline in utilization as available capacity exceeded market demand. Excess capacity, during the 1980s depressed prices for many products ranging from primary materials to manufactured goods. Beginning in the late 1980s and throughout the 1990s industrial consolidations and increased growth in demand eliminated much of this excess capacity. Concurrent with this period productivity increased dramatically (as is discussed in the next section), thus increasing industrial capacity without the need to actually investment new production infrastructure – the building of new plants, often referred to by industry as "bricks and mortar."

An economic downturn followed the 9/11 attacks. However, since 2002, industrial capacity utilization for finished (consumer-level) goods has been on a steady upward trend (Figure 5). For both crude processing (i.e., raw materials transformation), and primary and semi-finished goods processing (the raw materials that manufacturers purchase to make finished goods), a similar upward trend with a small dip occurred in the 3rd quarter of 2006 resulting from economic disruptions due to the hurricanes Katrina and Rita. Since hurricanes Katrina and Rita disrupted crude oil processing capacity in the 3rd and 4th quarter of 2005, utilization has recovered to levels close to historically records.

Figure 5. Utilization of U.S. Manufacturing Capacity from 1980-2006



---

[1] "Industrial capacity utilization rates" describes the extent to which an industrial sector's production capabilities are utilized. The Federal Reserve (Yamarone 2004) defines production capacity as "the greatest level of output that a plant can maintain within the framework of a realistic work schedule, taking into account normal downtime and assuming sufficient availability of inputs to operate the machinery and equipment in place."

Source: Federal Reserve 2007.

In general, a high rate of capacity utilization is a positive indicator of economic health. When capacity rates are high or increasing, industry is more likely to make investments. The data for the past 24 months indicates that capacity rates for crude, primary/semi-finished goods and finished goods are approaching the historical highs of the early 1980's and late 1990's. This situation suggests that industry is preparing to make a new round of investments to expand productive capacity.

Impact of Market Uncertainty on Industrial Decision Making

While a number of indicators suggest that many industries are on the verge of a major new capacity investment cycle, market uncertainties ranging from energy prices to exchange rates to the global economic outlook to climate change appear to be unsettling many manufacturers. As a result, ACEEE has been hearing anecdotally that many manufacturers are behaving in a like manner to the domestic refining industry, and deferring investment decisions until more certainty emerges in the outlook (Monroe 2007).

In this environment, energy savings payback considerations are less a determining investment decision for facilities in the near-term. Currently manufacturer's primary concern appears to be maintaining production and output. The primary interest of many plant manager or business owner is to increase productivity to maximize production in a favorably priced market, while complying with safety, labor, and environmental regulations in order to maintain operations. Investments that are directly related to these aspects of business operations will be the highest priority. Investments related to reduction of expenses, are not currently receiving the same amount of attention.

Energy-efficiency falls under the category of 'reduction of expenses,' so unless other benefits like additional environmental and productivity improvements can be attributed to a measure these measures may not be compelling today. Many technologies that improve energy efficiency also offer benefits in productivity, safety, or environmental performance. Improvements in productivity and quality contribute to the economic attractiveness of a given technology and may be the largest deciding factor when considering technology investments (Martin et al. 2000). Unfortunately, many industrial firms, large and small, fail to account for such ancillary benefits. Small firms in particular have difficulty quantifying ancillary benefits and rarely include them in cost analyses (Shipley et al. 2002).

In the longer-term, many firms may be poised to enter a period of major new capacity investments. This period represents a once in a generation opportunity to make major changes in the energy efficiency of new capacity that will be operated for coming decades. Many of future investments will represent major re-engineering of the production process, and in some cases, entirely new "green-field" facilities (e.g., new facility built on new sites) will be built. There is an upcoming opportunity to merge energy efficiency into the facility and its processes in a way that was not feasible or cost effective with existing production processes. Many of the efficiency opportunities will be optimization of systems, rather than equipment that is more efficient, such that the incremental costs of efficiency will be modest, in comparison to large savings.

It is not clear when the market will shift to favor new investment. As noted previously, the global economy will likely drive this change. Suggestions have been made that this transition in investment behavior could begin in the next 3-5 years (Monroe 2007). It is also important to remember that investment planning for many firms may have already begun.

Challenges Facing Modeling Industrial Decision Making

Because of the diversity in the industrial sector, the modeling of industrial decision making is both more complex and more data-intensive. Unfortunately, with shrinking budgets for data collection and research, we have seen both these critical needs go unmet, creating additional challenges for modelers and analysts. In addition, as programs such as the Industrial Technology Program have shrunk over the past decade, important information of future technology trends has been lost making it more difficult to gain insights into the energy future of the manufacturing sector.

Lack of Timely and Robust Data on the Industrial Sector

Perhaps the greatest challenge facing the industrial analyst is the limited and deteriorating quality of industrial sector data. Shrinking budgets at Census and EIA have lead to reduced sample sizes and relays in the timely release for primary data streams such as MECS, Census of Manufacturing and Annual Survey of Manufacturing. This smaller sample size means that analysts loose either individual industry sector detail or regional detail, forcing them to make estimates in order to do state and regional analyses. In addition, some important product data series on manufactured products such as electric motors have recently been terminated by Census further reducing the scope of available data.

Suggestions for Representation of Industrial Decision Making

Critical to understanding industrial energy investment trends is an understanding the range of opportunities for energy efficiency in the industrial sector. While the current NEMS model does a good job of capturing current technology and practice, is has a somewhat static representation of the opportunities for energy efficiency. The identified opportunities for energy efficiency have remained relatively constant over the past quarter-century (Shipley and Elliot 2006), though the nature of the opportunities have changed. A new model should explore the implementation of “learning by doing” and “learning by using.”

Representation of Uncertainty

The industrial sector is becoming increasingly a global sector, and market trends can now have impacts on how capacity is dispatched throughout the world. As a result, it is increasingly important to explore various scenarios for this sector so as to capture the range of possible futures for domestic manufacturing. Thus an expanded scenario exercise that looks at both various technology as well as economic and fuel price futures can provide important insights into the future of this important sector.

Summary and Conclusions

The industrial sector is perhaps the most diverse sector of the economy, from an economic activity, energy use and geographic perspective. Much of the energy use is concentrated in the manufacturing sub-sector, and the energy use in this sub-sector is focused on the wide range of processes that are used to produce the diverse products that manufacturing industries produce. Thus energy use is determined more by how technologies are implemented in a system context, than in the inherent efficiency of the technology.

Because of the process focused nature of the industrial sector, investment decision making related to energy use differs from other sectors. Except for maintenance and regulatory compliance investments, most major investments are made within the context of a plant investment cycle driven by market trends, and changes in products and technology. The criteria used for energy investments also take into consideration the full range of non-energy costs and benefits of the investment, so it is important to understand the total benefits.

These investment cycles are also influenced by external market forces, with uncertainty tending to discourage investment for which a compelling near-term benefit does not exist. Economic indicators suggest that the industrial sector is poised for a new period of major capacity investments because existing capacity is approaching full utilization. Without new capacity, industry will not be able to meet growth in demand for their product.

However, a number of market forces currently appear to be encouraging many industries to defer investment plans for the immediate future. The forces deferring investments include global market uncertainty, tight capital markets and the unsustainable tight markets certain industries have created to increase prices. At some point, many industries will enter a new period of major capacity investment not seen for perhaps 30 years. This period will represent a major opportunity to influence the energy efficiency of these facilities for generations to come.

It is important to appropriately understand and represent industrial investment decisions if energy modeling is to inform policy makers about what is likely to happen with respect to industrial energy use and emission in the future.   Unfortunately, the lack of robust industrial energy use data represents a significant challenge to improving the representation in industrial decision making in models. It will be essential to improve data resources to support better modeling.

In addition, as energy modeling is called upon to assess the impacts of a range of policies including major decisions about energy taxes and climate policies, it is important to accurately reflect the anticipated response by industry. While the industrial sector represents the largest carbon emitting sector, it is already leading the rest of the economy with respect to reducing energy intensity. If policies are to reduce energy use economy wide, they must be able to influence the industrial sector.

REFERENCES

Bataille, C., M. Jaccard, J. Nyboer and N. Rivers. 2006. "Towards General Equilibrium in a Technology-Rich Model with Empirically-Estimated Behavioral Parameters," *The Energy Journal*, Hybrid Modeling of Energy-Environment Policies: Reconciling Bottom-Up and Top-Down, pp. 93-112.

Campoy, A. 2007. "Refiners Cash in on High Gasoline Prices," *Wall Street Journal*, May18; Page A10.

Elliott, R.N., A.M. Shipley, E. Brown, R. Cleetus and S. Bernow. 2003. "State-Level Analysis of Industrial Energy Use," in the Proceedings of the *2003 ACEEE Summer Study on Energy Efficiency in Industry*. Washington, DC: American Council for an Energy-Efficient Economy.

[EIA] Energy Information Administration. 2007a. *Annual Energy Outlook 2007*, including supplemental tables, http://www.eia.doe.gov/oiaf/aeo/index.html. Washington, D.C.: U.S. Department of Energy.

_____. 2007b. *Model Documentation Report: Industrial Sector Demand Module for the National Energy Modeling System*, http://tonto.eia.doe.gov/FTPROOT/modeldoc/m064(2007).pdf. Washington, D.C.: U.S. Department of Energy.

______. 2007c. *Refinery Outages: Description and Potential Impact on Petroleum Product Prices*, http://www.eia.doe.gov/oiaf/servicerpt/refinery_outages/SROOG200701.pdf. Washington, D.C.: U.S. Department of Energy.

______. 2007d. Historical industrial price data from website http://www.eia.doe,gov accessed November. Washington, D.C.: U.S. Department of Energy.

Hanson, Donald A., and John A. "Skip" Laitner. 2006. *The AMIGA Modeling System, Version 4.2: Disaggregated Capital and Physical Flows of Energy within a General Equilibrium Framework*, Argonne National Laboratory, Argonne, IL

Laitner, J.A. "Skip" and D.A. Hanson. 2006. "Modeling Detailed Energy-Efficiency Technologies and Technology Policies within a CGE Framework." *The Energy Journal*, 2006, Special Edition, Hybrid Modeling of Energy-Environment Policies: Reconciling Bottom-Up and Top-Down, pp. 151-69.

Martin, N., E. Worrell, M. Ruth, L. Price, R.N. Elliott, A.M. Shipley, and J. Thorne. 2000. *Emerging Energy-Efficient Industrial Technologies*. Washington, DC: American Council for an Energy-Efficient Economy.

Monroe, R. (Steel Founders Society of America) 2007. Personal communications to Neal Elliott and Anna Shipley, July-September, Crystal Lake, IL.

Reuters. 2007. "U.S. Refiners Cut Expansion Plans," June 4.

Shipley, A.M., R.N. Elliott, and A. Hinge. 2002. *Energy Efficiency Programs for Small and Medium-Sized Industry*. ACEEE Report IE002. Washington, D.C.: American Council for an Energy-Efficient Economy.

Shipley, A.M., and R.N. Elliott. 2006. *Ripe for the Picking: Have We Exhausted the Low-Hanging Fruit in the Industrial Sector?* Washington, D.C.: American Council for an Energy-Efficient Economy.

Steinmeyer, D. 1998. *Trading Capital for Energy*, ACEEE report IE984. Washington, D.C.: American Council for an Energy-Efficient Economy.

Yamarone, Richard A. 2004. *The Trader's Guide to Key Economic Indicators.* New York, N.Y.: Bloomberg Press.