How Carbon Policies Advance Industrial Energy Efficiency

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ABSTRACT

Do carbon policies advance industrial energy efficiency (EE), leading to a more competitive U.S. industrial base? We investigate the issue by looking at how companies react to U.S. federal carbon policy, as well as to the more advanced carbon policy in California, where a cap-and-trade program has come into force in 2013.

Concerns over climate change are prompting actions at federal and state levels. A federal framework for regulating greenhouse gas (GHG) emissions under the Clean Air Act is emerging. The U.S. Environmental Protection Agency (EPA) has recently issued important rules that affect facilities emitting GHGs above a certain threshold. In addition, some states are implementing their own policies. For example, California's Global Warming Solutions Act ("AB 32") requires an economy-wide reduction in GHG emissions.

A key way to achieve reductions in GHG emissions is through EE improvements in industrial operations. The California Air Resources Board (CARB) recognizes this in the AB 32 Scoping Plan. In 2011, the larger emitters in the state were mandated to identify EE projects and determine associated GHG emission reductions. Using these findings, CARB is developing EE measures for refineries and oil and gas operators. In addition, the California cap-and-trade program is expected to generate significant EE gains in industrial facilities.

In this paper, we examine the industrial sector's contribution to U.S. GHG emissions alongside industrial EE gains over the last 20 years. We then review carbon policies affecting industrial operations, focusing on California's regulations and corporate actions in anticipation of or in response to carbon policies. Finally, we provide a few conclusions and recommendations.

Introduction

Concerns over climate change are prompting governmental actions at the federal and state levels in the U.S. that affect how industrial manufacturing facilities operate now and will act in the future. Data from the most recent inventory of U.S. GHG emissions indicate that 6,702.3 million metric tons of carbon dioxide (CO_2) equivalent ($MMTCO_2$ eq) were released to the atmosphere in 2011 (EPA 2013a). This is an increase of 8.4% since 1990, but a decrease of 6.9% since 2005 (EPA 2013a).

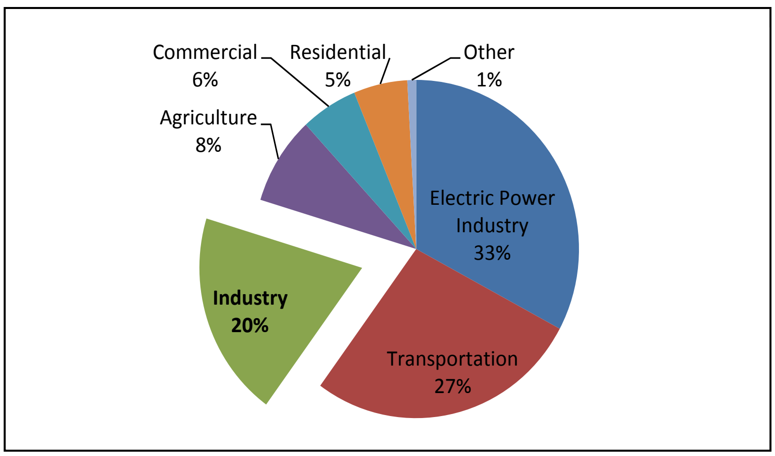
The decrease in total U.S. GHG emissions that has occurred since a peak in 2007 is primarily a result of the economic downturn and a less carbon-intensive electric power sector. Indeed, the greening of the electric power grid due to increasing shares of gas-fired and renewable power production has had a profound effect on U.S.GHG emissions. However, it remains to be seen whether the downward trend in total GHG emissions will continue when the economic turn-around comes into full force. For example, total GHG emissions rebounded in 2010 when the economy started to improve, prior to falling slightly in 2011 due to a relatively mild winter. This suggests that total GHG emissions may rise again in 2012 because of growth in the U.S. economy. Meanwhile, longer term trends seem to suggest continued declines in carbon intensity (kg CO_2 eq / $ GPD), consistent with long-term rises in total and per-capita GDP, and in spite of short-term fluctuations in the business cycle. In other words, switching perspectives from total GHG emissions to an emission-intensity metric related to economic growth may be a stronger indicator of EE, since it reflects longer term trends.

Sustained improvements and additional efforts across all sectors to reduce emissions will likely be required for the U.S. to achieve the Obama Administration's target of a 17% reduction from the 2005 level, which was put forward in the Copenhagen Accord of the United Nations Framework Convention on Climate Change in December of 2011 (UN 2010). To this end, all cost-effective GHG emission reduction opportunities should be considered and implemented to the greatest extent possible. EE improvements in the industrial sector are no exception and stand to provide much farther reaching benefits than GHG emission reductions alone, including potentially enhancing industrial productivity and reducing operating costs, both of which improve industrial competitiveness.

Industrial Sector's Contribution to U.S. Greenhouse Gas Emissions

To achieve significant GHG emission reductions, it is critical to understand what sources and activities contribute to GHG emissions. Since 1990, the U.S. Environmental Protection Agency (EPA) has tracked and analyzed the national trend in GHG emissions and removals in the U.S. For its analyses, EPA uses national energy data, data on national agricultural activities, and other national statistics to determine total GHG emissions for all man-made sources. Each year, EPA publishes a report titled "Inventory of U.S. Greenhouse Gas Emissions and Sinks." The most recent inventory report reveals that three economic sectors account for 80% of total U.S. GHG emissions (EPA 2013a). They include the electric power industry (33%), transportation (27%), and the industrial sector (20%), as illustrated in Figure 1.

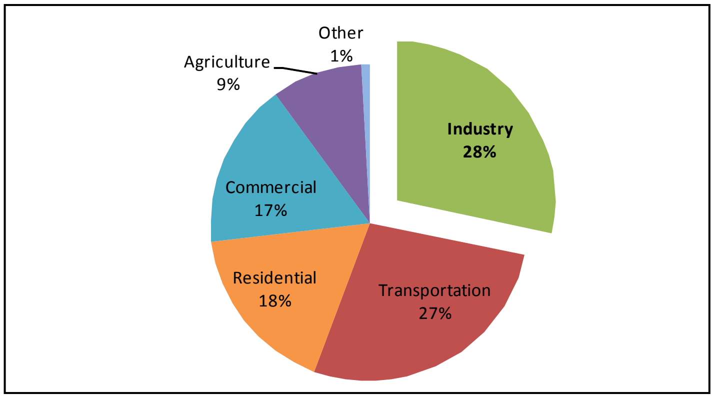
Figure 1. U.S. GHG Emissions by Economic Sectors, 2011



Source: EPA 2013a

If GHG emissions for the electric power industry are distributed to the end-use sectors ultimately using the electricity, the industrial sector accounts for the greatest share (28%) of total GHG emissions followed closely by the transportation sector (27%) (EPA 2013a). This is illustrated in Figure 2. The residential (18%) and commercial sectors (17%) are also significant contributors to total U.S GHG emissions. Because there is no single emission source that represents a sufficiently large share of total GHG emissions to become the primary target for emission reductions, reductions must come from numerous sectors including electric power generation, transportation, industrial, commercial, and residential sectors. As a large contributor to overall GHG emissions, the U.S. industrial sector will play a critical role in achieving total GHG emission reduction.

Figure 2. U.S. GHG Emissions with Electricity-related Emissions Distributed to Economic Sectors, 2011



Source: EPA 2013a

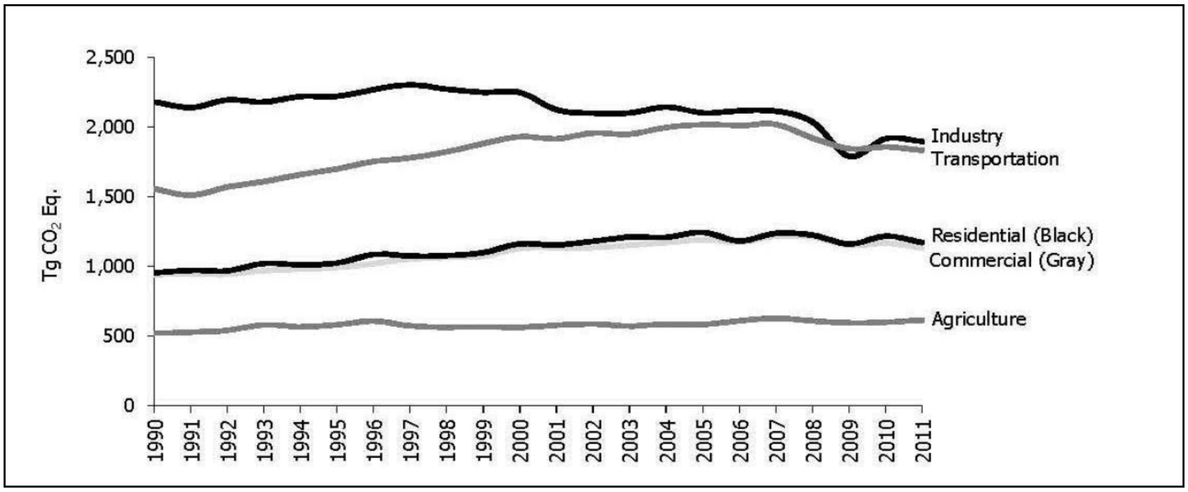
Greenhouse Gas Emissions and Energy Efficiency Trends in Industrial Sector

In contrast to the other end-use sectors, GHG emissions from the U.S. industrial sector have steadily declined during the last 20 years, as illustrated in Figure 3. The slight increase in industrial GHG emissions in 2010 is due to the recovery from the most recent economic downturn. Data just released from EPA indicate a renewed downward trend in GHG emissions from the industrial sector for 2011 (EPA 2013a). Since 1990, overall U.S. GHG emissions have *increased* at an annual average rate of 0.4%. This can be compared to an annual average *decrease* rate of 0.6% for the industrial sector for the same time period. Though the decline over the last two decades is primarily a result of a shift from a manufacturing-based to a service-based U.S. economy, it is also due to the decreasing carbon intensity of the fuel mix consumed to meet industrial demand and because industrial facilities are operating more efficiently.

Figure 4 illustrates trends in carbon intensity of the energy demand in the industrial sector between 1990 and 2011. The carbon intensity is a measure of CO_2 emissions per unit of energy consumption. It includes all industrial end-uses of energy, including heat, power, and feedstock. It also captures industry's share of CO_2 emissions and electrical energy supplied from the electric power sector. The carbon intensity factor excludes other GHGs such as methane, nitrous oxide, and fluorinated gases; however, since CO_2 accounts for the majority of GHG emissions associated with the industrial sector (83.5% in 2011), carbon intensity is a representative measure of industry's GHG contribution per unit of energy demand.

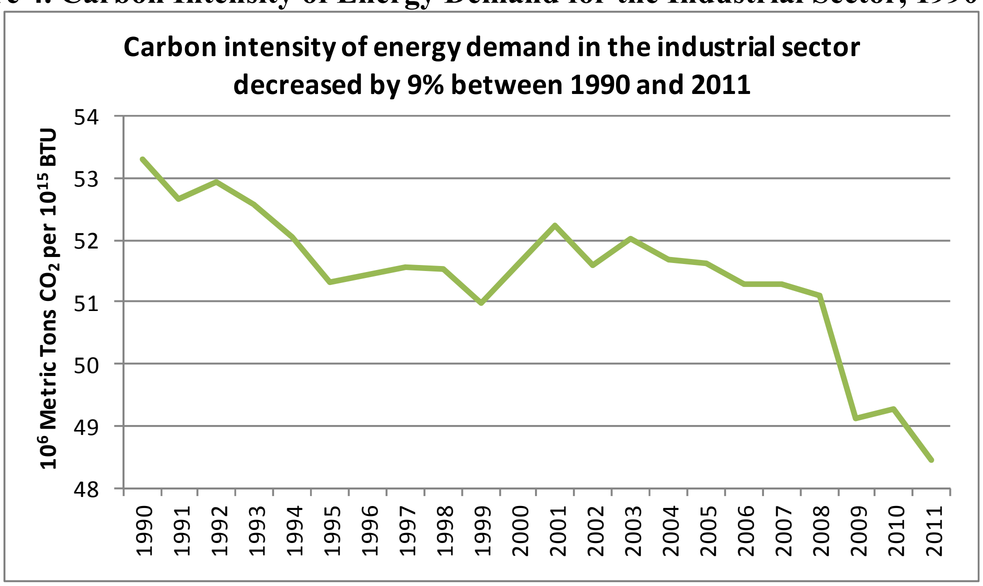
Overall, the intensity declined by 9% between 1990 and 2011, from a value of 53.3 million metric tons CO_2 per quadrillion BTU to 48.4 million metric tons CO_2 per quadrillion BTU. The steepest decline was between 2008 and 2009, when the intensity dropped by 3.9% in one year. The decrease in carbon intensity of industrial energy demand is due to a "cleaner" mix of fuel inputs and changes in how those inputs are used across the industrial sector. For example, electricity generated by the electric power industry has become less carbon intensive in recent years as utilities replace coal-fired power plants with gas-fired power plants. In addition, structural shifts in manufacturing affect overall industrial carbon intensity, since some industrial segments are more carbon-intensive than others. Specifically, the paper industry has relatively low carbon intensity due to significant use of wood byproducts for fuel; on the other hand, the primary metals industry's carbon intensity is quite high due to reliance on coal and electricity (Schipper 2006).

Figure 3. U.S. GHG Emissions with Electricity Distributed to Economic Sectors, 1990-2011



Source: EPA 2013a

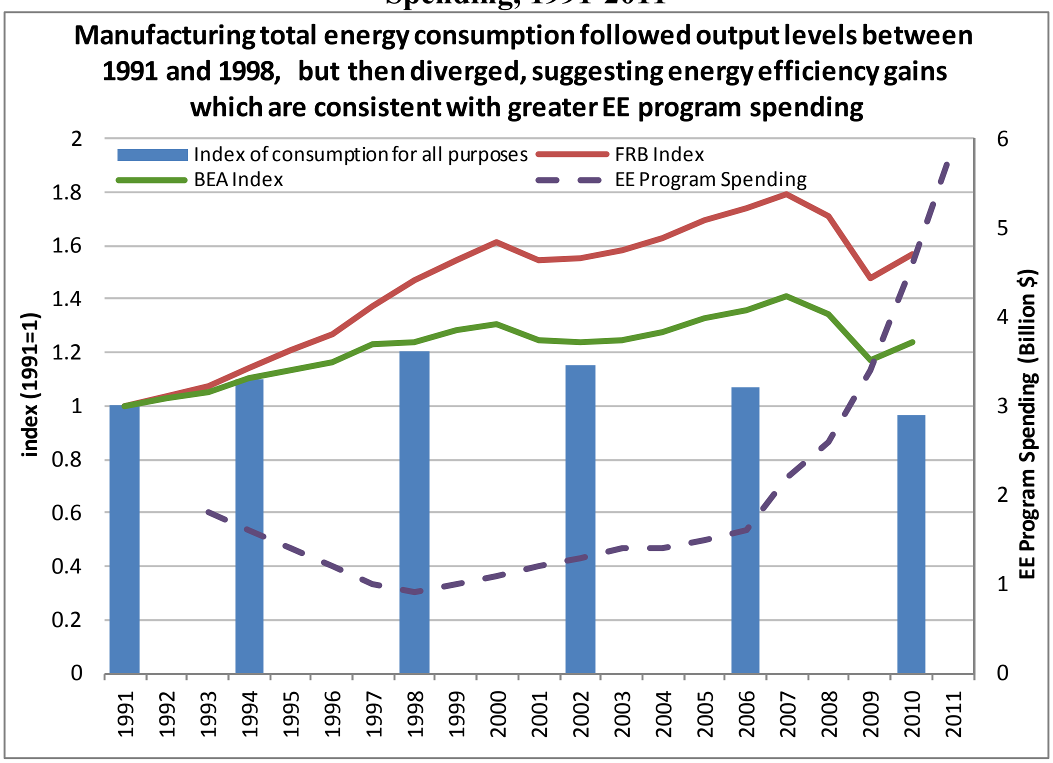
Figure 4. Carbon Intensity of Energy Demand for the Industrial Sector, 1990-2011



Source: Derived using data from EIA 2012a, Tables 2.1d and 11.2c

Within the industrial sector, manufacturing accounts for the vast majority of energy consumption and energy-related GHG emissions when compared with the mining, construction, agriculture, forestry, fisheries, and hunting industries. Therefore, it is interesting to investigate how EE across the manufacturing industries has evolved over the last two decades. Figure 5 presents early release data from the Energy Information Administration's 2010 Manufacturing Energy Consumption Survey (EIA 2012b). The figure compares an index of manufacturing energy consumption with a manufacturing index from the Federal Reserve Board (FRB 2013) that is based on physical production metrics and a manufacturing index from the Bureau of Economic Analysis (BEA 2013) that is based on the dollar value of shipments from the U.S. Census Bureau's Annual Survey of Manufactures. Overlaid on these three manufacturing indexes is a graph showing trends in spending for EE programs derived from an ACEEE report (Foster et al. 2012).[1] The index of energy consumption is derived by dividing the manufacturing energy consumption for a given year by the 1991 value. The manufacturing energy consumption includes energy use for all purposes, including heat, power, and feedstock; it does not include energy losses associated with electricity that has been purchased from the electric power sector. When compared with the FRB physical production index and the BEA economic index, we see that the index of energy consumption falls below the other two indexes after reaching a maximum consumption index in 1998. According to EIA, this divergence suggests EE gains in manufacturing, as opposed to just reduced consumption due to lower production. When the energy index is compared with the graph of EE program expenditures, it is interesting to note the opposite concavity of the two plots. In 1998, expenditures were at a minimum and have since risen at a steady pace.

Figure 5. Comparison of Manufacturing Indexes with Energy Efficiency Program Spending, 1991-2011

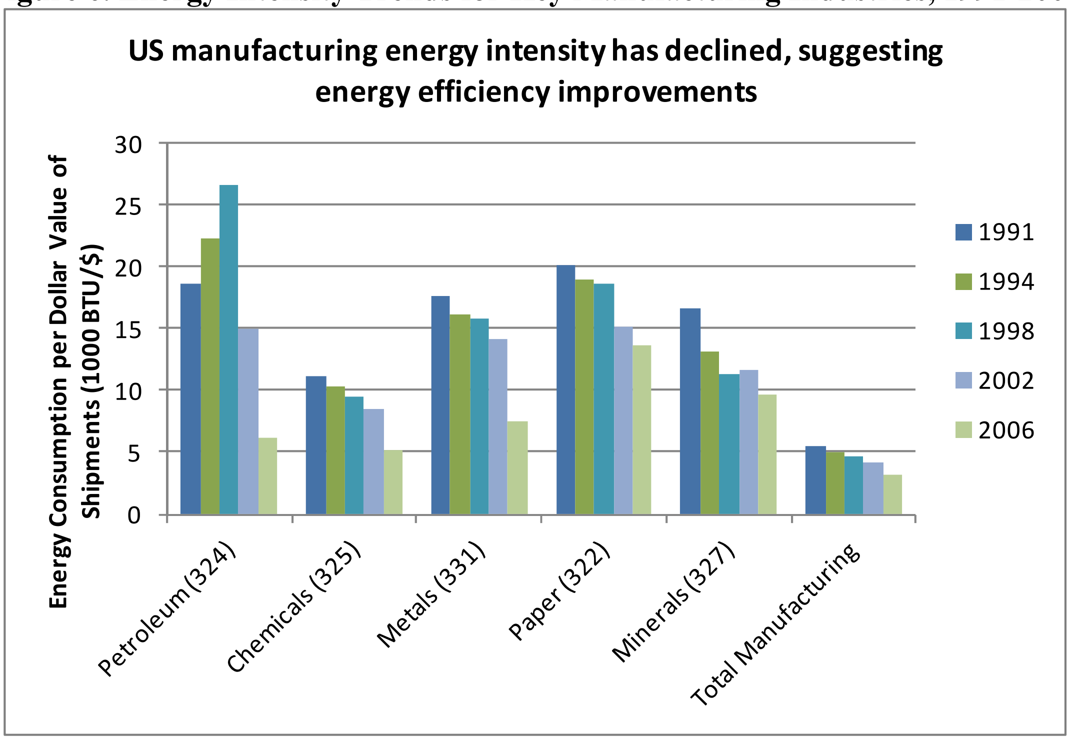


Sources: EIA 2012b, FRB 2013, BEA 2013, Foster et al. 2012

[1] The data from Foster et al. represent actual program spending from 1993-2008 and program budgets from 2009 through 2011. From 1993-2004, the values are for electric efficiency programs only; after 2004, expenditures include gas efficiency programs. Values for years with missing data (1994, 1995, 2001, 2002, and 2005) were derived from linear interpolation in order to illustrate spending trends.

Figure 6 further suggests progress in manufacturing EE by showing the decline in energy intensity for manufacturing as a whole and for five key segments: petroleum, chemicals, metals, paper, and minerals. Energy intensity is defined here as energy consumption for heat and power (i.e., excluding use as feedstock) divided by the monetary value of shipments for the given industries. Energy losses associated with electricity generated by the electric power sector and purchased by the manufacturing sector are not included. The data in this figure are from MECS 1991-2006; analogous data from MECS 2010 have not yet been released. The figure shows that the energy intensities of all five key industry segments and the manufacturing sector as a whole have decreased relative to 1991 values. In most cases, the intensities have decreased each year, with the exception of the petroleum and mineral segments. Overall, some of the most significant reductions have occurred for petroleum, chemicals, and metals. Though these energy intensity trends are indicative of improvements in EE, EE is not the only contributing factor. Relative increases in the value of the products also heavily influence the intensity values.

Figure 6. Energy Intensity Trends for Key Manufacturing Industries, 1991-2006



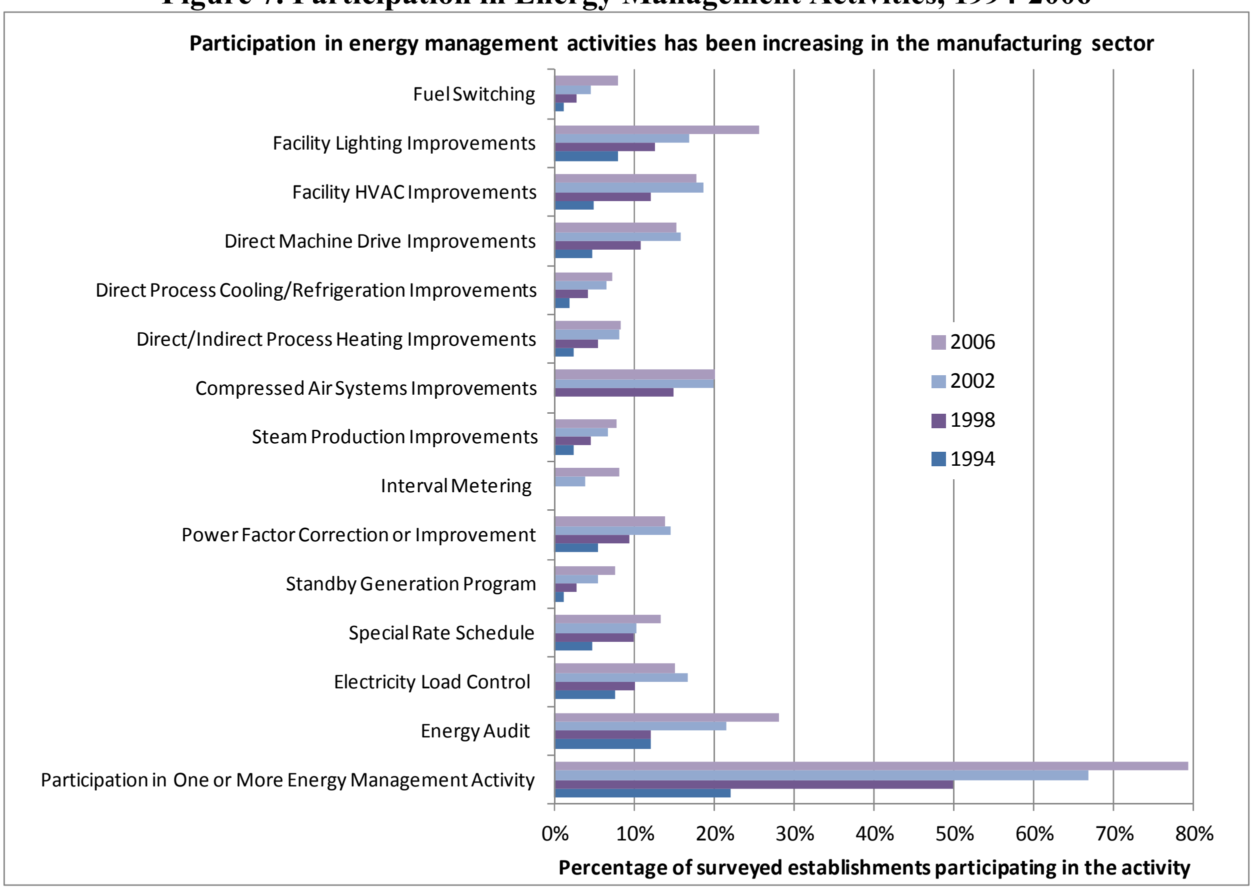
Sources: EIA 1991, 1994, 1998, 2002, 2006.

Another good measure of EE gains in industry is the degree to which establishments participate in energy management activities. Figure 7 presents MECS data illustrating how the shares of manufacturing establishments participating in specific energy management activities steadily increased between 1994 and 2006. Of particular note, only 22% of surveyed establishments reported participating in any energy management activities in 1994, whereas the reported participation rate was 79% in 2006. The activities with greatest participation rates include energy audits and improvements associated with lighting, compressed air, HVAC, machine drives, and load control. It is clear that an increasing number of manufacturing plants have realized that opportunities for significant energy savings can be identified by an energy audit and many of the opportunities have very favorable returns on investments. The increasing availability of utility funding tips the balance even more favorably toward pursuing EE improvements, as do corporate sustainability goals and/or other mandates.

Results from a recent survey of 630 U.S. industrial facilities conducted by EnerNOC in 2012 indicate that energy management decisions in industry are typically not influenced by the ability to impact carbon reductions (EnerNOC 2012). Indeed, only 5.5% of the respondents selected the "ability to impact carbon reductions" as one of the top three factors influencing their energy management decisions. Instead, most respondents selected pure energy (cost) savings, such as "$ savings on your utility bill" and "kWh savings", as the primary factors. This illustrates that the cost of GHG emissions is still not of a great concern to most industrial operations in the U.S. and reductions in GHG emissions is often considered only as a secondary benefit of EE gains. However, this is expected to change significantly in the next few years, as emerging cap-and-trade programs assign a price on carbon. For example, the cap-and-trade program in California is forcing industrial operations to evaluate whether to purchase the right to emit GHG emissions or invest in projects that will reduce GHG emissions. Carbon policies may soon be on equal footing to some of the other drivers of EE in industry, stimulating further advancements in a sector where the potential for EE improvements is still significant (EPRI 2009).

The remainder of this paper provides an overview of federal carbon policies and California GHG emission regulations. This overview is followed by a discussion of how industries are anticipating and reacting to carbon policies, thereby advancing EE gains.

Figure 7. Participation in Energy Management Activities, 1994-2006



Source: EIA 1994, 1998, 2002, 2006

Federal Carbon Policies Slowly Emerging

Beginning in 2010, the EPA has issued a series of rules that put the framework in place for regulating GHG emissions under the Clean Air Act. The Mandatory Greenhouse Gas Reporting Rule and the GHG Tailoring Rule are two important rules affecting industrial operations.

Mandatory Greenhouse Gas Reporting Rule

The Mandatory Greenhouse Gas Reporting Rule was published in 2009 ("40 CFR Part 98") and came into effect in 2010 (EPA 2011). It requires the largest emitters to submit GHG emission data to EPA annually through the Greenhouse Gas Reporting Program (GHGRP). Specifically, the EPA collects facility-level GHG emission data from all electric power plants, fossil fuel suppliers and specific types of industrial facilities, as well as facilities that emit 25,000 MTCO2 eq or more per year from stationary combustion. The facilities report direct emissions of carbon dioxide, methane, nitrous oxide, and fluorinated gases. EPA estimates that about 85-90% of total U.S. GHG emissions are currently covered by the GHGRP (EPA 2013b).

In 2011, about 7,900 facilities reported direct GHG emissions of 3,294 $MMTCO_2$ eq to the EPA using an electronic GHG reporting tool called e-GGRT (EPA 2013b). This was an increase from 6,200 facilities reporting in 2010. Most reporting facilities are electric power plants, but many industrial facilities also reported, including chemical manufacturers (548 facilities), oil and gas producers (547), natural gas processors (372), minerals manufacturers (362), metals manufacturer (297), food processors (299), pulp and paper manufacturers (230), ethanol producers (162), refineries (145), and other manufacturing (338) (EPA 2013b). The 295 largest-emitting[2] facilities, which consist primarily of power plants, refineries, metals manufacturers, and chemicals manufacturers, accounted for 57% of total GHG emissions reported in 2011 (EPA 2013b).

GHG Tailoring Rule Establishes Clean Air Act Permitting for GHG Emissions

Starting in 2011 and under the Clean Air Act, EPA also requires all sources, including industrial sources, to obtain Prevention of Significant Deterioration (PSD) and Title V Operating Permits—typically referred to as New Source Review ("NSR") and "Part 70" permits, respectively—if they emit GHG emissions above a certain threshold (EPA 2012).

Specifically, the GHG Tailoring Rule requires new facilities with GHG emissions of at least 100,000 $MTCO_2$ eq per year and existing facilities with emissions of at least 100,000 $MTCO_2$ eq per year making changes that will increase emissions by 75,000 $MTCO_2$ eq or more to obtain NSR permits (EPA 2012). Facilities that already must obtain NSR permits to cover other regulated air pollutants must also address GHG emission increases of 75,000 $MTCO_2$ eq or more per year, even if they do not meet the threshold new source review requirements for other pollutants. New and existing facilities with GHG emissions above 100,000 $MTCO_2$ eq per year must also obtain operating (or "Part 70") permits. In most states, the environmental agency, rather than the EPA, will be issuing the permits.

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[2] Largest-emitting facilities are those emitting in excess of 2.5 $MMTCO_2$ eq per year.

EPA's NSR permit regulations require the use of Best Available Control Technology (BACT) for new or modified major sources of air pollution to minimize pollution. BACT is an emissions limitation which is based on the maximum degree of control that can be achieved, taking energy, environmental, and economic impacts into consideration. BACT can be add-on control equipment or modification of the production processes or methods.

State Carbon and Energy Efficiency Policies Ahead of Federal Regulation

Because the federal government has been perceived as slow to regulate GHG emissions, numerous states have developed carbon policies ahead of federal regulation. Indeed, 20 U.S. states have established GHG emission reduction targets (C2ES 2013). The first states that established GHG emission reduction targets include Maine, Rhode Island, Vermont, and New York. Not only has the Northeast led the way for setting state GHG emission reduction targets, the Northeastern states were also instrumental in creating the Regional Greenhouse Gas Initiative (RGGI), a regional cap-and-trade program covering electric power plants. Of the 20 states with GHG emission reduction targets, it is not surprising to note that 14 also have established EE resource standards (EERSs) or mandatory EE targets, namely Hawaii, California, Washington, Arizona, New Mexico, Colorado, Minnesota, Illinois, Michigan, New York, Massachusetts, Connecticut, Rhode Island, and Maryland (C2ES 2012).[3] Additionally, four other states out of the 20 have voluntary EE goals in place (Oregon, Maine, Vermont, and Florida).

In 2006, California enacted the Global Warming Solutions Act, commonly referred to as AB 32, which set the goal of reducing GHG emissions statewide to 1990 levels by 2020 into law. California is the first state in the country to mandate an *economy-wide* emissions cap on covered sectors that includes enforceable penalties. The impact of California's carbon policy on industrial facilities is discussed next.

California's Economy-wide Carbon Policy Offers Risks and Opportunities to Industrial Facilities

When AB 32 was adopted in 2006, the California Air Resources Board (CARB) was directed to develop a climate change plan to identify actions required to achieve the statewide 2020 GHG emission limit. The plan—the "AB 32 Scoping Plan"—was approved by the ARB Board in December of 2008 and subsequently approved by the Board's Executive Officer in May of 2009. The AB 32 Scoping Plan was updated and re-approved again in 2011 (CARB 2011a). At the time of the first approval, the AB 32 Scoping Plan outlined actions required for reducing emissions by 169 $MMTCO_2$ eq by 2020, a 28% reduction from the state's projected 2020 business-as-usual emissions (CARB 2008). Because of the recent economic recession as well as reduction measures that are already in place,[4] the projected 2020 business-as-usual emissions were adjusted downwards in 2010. This, in turn, has resulted in the lowering of the required reduction of GHG emissions from 169 $MMTCO_2$ eq to 80 $MMTCO_2$ eq, a 16% reduction below the revised 2020 business-as-usual emission levels. Despite the lowering of required reductions, drastic changes are still needed to reach the 2020 target of 427 $MMTCO_2$ eq.

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[3] An EERS is a requirement for utilities to reduce annual energy use by a specific quantity that increases each year.

[4] Reductions from measures already in place include 26 $MMTCO_2$ eq from vehicles standard and 12 $MMTCO_2$ eq from Renewable Portfolio Standard.

Because no single sector in California has a sufficiently large share of total GHG emissions to become the primary target for emission reductions, reductions must come from many sectors including the transportation, electricity, industrial, and commercial and residential sectors. Indeed, the AB 32 Scoping Plan outlines a combination of numerous command-and-control measures and a market-based cap-and-trade program required to achieve the 2020 GHG emission limit. Examples of industrial command-and-control measures include mandatory EE audits for larger industrial facilities, a cap-and-trade program and specific measures to control fugitive emissions from refineries, oil and gas extraction operations, and gas transmission.

Mandatory reporting of GHG emissions helps pinpoint measures in targeted industrial sectors. California's Regulation for the Mandatory Reporting of GHG Emissions preceded the U.S. EPA's GHG reporting requirement by 2 years. In accordance with U.S. EPA reporting requirements, all petroleum refineries and cement, lime, and nitric acid production plants operating in California must report GHG emissions annually regardless of amounts. Other types of industrial facilities operating in California must report if the facility's total annual emissions are equal to or greater than 10,000 $MTCO_2$ eq (CARB 2012a). Total emissions include emissions from stationary combustion and process emissions, but may exclude vented and fugitive emissions. Collectively, about 180 California industrial facilities reported GHG emissions of 154 $MMTCO_2$ eq in 2011, accounting for about 37% of all reported emissions (CARB 2012b). These emissions account for roughly 33% of total statewide GHG emissions (CARB 2012c).

Mandatory energy efficiency and co-benefits assessments of large industrial facilities. The Energy Efficiency and Co-Benefits Assessments of Large Industrial Facilities Regulation requires all facilities that emitted 0.5 $MMTCO_2$ eq or more in 2009 and all cement manufacturing plants and refineries that emitted at least 0.25 $MMTCO_2$ eq in 2009 to conduct a one-time assessment and reporting of the facility's fuel and energy uses. As a result of this regulation, 45 industrial facilities filed an assessment report with ARB in 2011. As part of the assessment, each facility had to identify potential EE improvement projects. Furthermore, each facility had to identify reductions in GHG emissions, criteria pollutants, and toxic air contaminants associated with those projects that affect 95% of the equipment, processes, or systems emitting GHG emissions. ARB staff is currently preparing the public versions of the assessments.

Cap-and-trade program serves as a backstop. The California cap-and-trade program was adopted on October 20, 2011 and took effect on January 1, 2012. Because it places a hard and declining "cap" on GHG emissions from covered sectors, it serves as the state's backstop to achieving the GHG emission target by 2020. The emission reduction currently required from the cap-and-program's covered entities is 18 $MMTCO_2$ eq, or 20% of total emission reductions required by 2020. The covered sectors include power plants, transportation fuels, refineries, cement manufacturing plants, and large industrial combustion sources. The California cap (334 $MMTCO_2$ eq) covers approximately 80% of the state's total GHG emissions (CARB 2011a and 2011b; LAO 2011). When the program is fully implemented, about 350 of California's largest GHG emitters will be participating (Taylor 2012). The cap-and-trade program has two compliance periods:

- **First compliance period:** Starting in 2012, stationary sources emitting at or above 25,000 $MTCO_2$ eq per year are covered in the cap-and-trade program. Such sources include in-state electricity generating facilities, importers of electricity, and large industrial facilities.

- **Second compliance period:** Starting in 2015, the upstream treatment of industrial fuel combustion at facilities with emissions at or below 25,000 $MTCO_2$ eq per year, and commercial and residential fuel combustion regulated where the fuel enters into commerce will be phased into the cap-and-trade program. Additionally, transportation fuel combustion regulated where the fuel enters into commerce will be added to the cap.

The cap-and-trade program provides the "covered entities" flexibility in achieving GHG emission reductions. Because the compliance instruments for GHG emissions can be traded, the market price of GHG emissions yields an enduring price signal across the economy. This price signal, in turn, provides incentives for the market to find new and cost-effective ways to reduce emissions. Participants in the cap-and-trade program must surrender one compliance instrument for each covered $MTCO_2$ eq at the end of each compliance period.

The compliance instrument is either an allowance or an offset credit, and both may be traded. An allowance allows its owner the right to emit one $MTCO_2$ eq. It can only be used for emissions on or after its vintage year. An offset credit can be used in lieu of a one $MTCO_2$ eq direct emission reduction by sources subject to the cap. For example, a refinery may pay a dairy (which is not otherwise regulated) for offset credits. The refinery would then be credited for the GHG emissions reductions achieved by the dairy. Though capped sector participants are allowed to use offset credits to cover 8% of their GHG emissions, there is a great concern among cap-and-trade participants that there will not be sufficient offset credits for purchase, especially in the second compliance period. There is also concern from environmental parties about linked jurisdictions' offsets protocols not meeting the requirements of AB 32 offset credits.

The total number of allowances provided freely and auctioned to industry each vintage year is still an unknown. To prevent gaming of the market, CARB has adopted strict limits on the number of allowances any trader or company can hold. Most companies that are required to participate in the auctions can hold no more than 15% of the allowances that are available for sale. Traders can hold no more than 4%.

A covered entity must determine if it is more cost-effective to purchase a compliance instrument or reduce GHG emissions. At the first auction, on November 14, 2012, CARB sold the 2013-vintage allowances and 2016-vintage allowances at $10.09 and $10.00 per allowance, respectively. This can be compared to $14.00 for the 2013-vintage allowances and $10.71 for the 2015-vintage allowances at the third auction on May 16, 2013. EE improvement projects offer numerous opportunities for industrial facilities to achieve GHG emission reductions, and they can typically do so less expensively than purchasing allowances and offsets. Consequently, many industrial operations in California are actively pursuing EE improvement projects. This trend is reinforced by the significant EE Program funding in California.

Examples of How Carbon Policies Advance Industrial Energy Efficiency

Because governments, customers, consumers and shareholders are increasingly demanding to know how industrial facilities are achieving sustainability and what specific steps are taken to reduce GHG emissions, more and more companies are motivated to take action and implement corporate carbon policies. For example, shareholders recently requested ExxonMobil, Cabot Oil & Gas Corporation, ConocoPhillips, Emerson, and CLARCOR to adopt quantitative goals, based on current technologies, for reducing GHG emissions (ICCR 2013). They also demanded reports describing the companies' plans to achieve the GHG reduction goals. In the first 5 months of 2013, as many as 30 companies have been asked by shareholders to develop sustainability reports and/or adopt GHG emission reduction goals (ICCR 2013). Furthermore, shareholders are increasingly requesting executive compensation to be linked to sustainability criteria. For example, executives at Alcoa, Intel, and Xcel Energy are compensated based in part on GHG emission reductions.

In California, refineries and oil and gas operations are under intense pressure to reduce GHG emissions, as these facilities account for a significant share of total industrial GHG emissions. Indeed, the top 15 industrial facilities with greatest GHG emissions include 13 refineries and two oil and gas operations, accounting for 80% of total industrial GHG emissions in the state (CARB 2012c). Because EE gains can generate significant GHG emission reductions, refineries and oil and gas operations are actively pursuing EE measures. Indeed, EnerNOC assisted several oil and gas extraction operations with Energy Efficiency and Co-Benefits Assessments in 2011, where the team identified EE projects that collectively generate close to 1,100 $MTCO_2$ eq in reductions per year. Table 1 presents example EE measures implemented by oil and gas operations to achieve GHG emission reductions. For most EE measures in Table 1, the California investor-owned utilities provide incentives.

The Carbon Disclosure Project (CDP) year after year ranks numerous chemical companies such as BASF, Air Products & Chemicals, Dow Chemical and Praxair, high on carbon disclosure (CDP 2011b). Specifically, the CDP, which represents in excess of 720 institutional investors globally, requires disclosure from companies on their GHG emissions and climate change management activities (CDP 2012). In 2011, over 3,000 companies responded to the "Investor CDP" questionnaire (CDP 2011a). Many chemical companies also rank high on carbon performance, a new ranking component introduced by CDP in 2009. CDP awards performance points for actions considered to contribute to climate change mitigation, adaptation, and transparency.

There are several reasons why chemical companies typically rank among the top on climate change activities. First, many chemical companies have created a climate change task force to integrate board oversight with executive-level actions on GHG emissions. Indeed, some of the larger chemical corporations, such as DuPont and Dow Chemical, have had their board directors oversee climate change activities for more than 15 years now. Second, most chemical companies have committed to absolute GHG emission reduction targets and they often proactively disclose their climate risks and opportunities in securities filings and other public documents. Indeed, CEOs of chemical companies often embrace climate change and carbon policies publicly by discussing near-term opportunities and risks.

Though some less energy intensive industries initially were slow to address climate change, consumer demand for products with lesser carbon footprints has also forced them to engage on carbon management throughout the entire supply-production-distribution chain. For example, Nestle, Coca-Cola, PepsiCo, ConAgra Foods, Kraft Foods and Danone use the CDP to mitigate environmental risk in their supply chains (CDP 2012). Therefore, public awareness and perception of carbon policies eventually affect industry behavior regarding efficiency as consumer demands change.

Table 1. Example Energy Efficiency Improvement Projects and Associated Reductions in GHG Emissions at Oil and Gas Operations

EE Improvement Description	Annual Energy Savings (MMBTU)	Annual GHG Emission Reductions (metric ton CO2 eq)
Installed insulation on steam lines to reduce heat losses	3,270,000	173,000
Replaced wellhead IC engines with electric motors to drive wellhead pumps	2,250,000	122,000
Installed insulation on flow lines to reduce heat losses	2,050,000	109,000
Installed pump-off controllers on wells to continuously monitor pumping system dynamics and shut down pumping unit when the fluid level in the well bore is not sufficient to completely fill the pump	804,000	42,600
Retrofitted heat recovery steam generators (HRSGs) by replacing single-pass configuration with split-pass configuration, resulting in significant pressure drop through steam generators; steam generator was also retrofitted with high-efficiency convection section	601,000	32,100
Use of high-efficiency electric compressors instead of gas-driven compressors in new cryogenic gas plant, and reinjection of waste gas streams into the production strata to help maintain reservoir pressure rather than flaring	556,000	30,300
Installed pump-off controllers on wells to continuously monitor pumping system dynamics and shut down pumping unit when the fluid level in the well bore is not sufficient to completely fill the pump	537,000	29,000
Installed pumps of higher efficiency than existing system (gas lift to rod pump) or rod pumps if new drills (progressive cavity pumps, long-stroke Rotaflex pumps)	376,000	20,400
Added low-pressure collection systems to reroute gas that is being produced at an adequate pressure around the vacuum suction screw compressors, decreasing the work required by the screw compressors to transport field gas across the facility	307,000	17,000
Installed a continuous steam generator monitoring system to optimize the use of higher capacity and more efficient steam generator units, improving overall steam generator efficiency	206,000	11,000
Installed non-selective catalytic reduction on IC engines to better control emissions and reduce engine fuel consumption	167,000	9,100
Retrofitted single-pass steam generators with high-efficiency convection section	156,000	8,300
Installed VFDs on lift pumps, including rod pumps and electrosubmersible pumps	147,000	8,000
Turbine overhaul of cogen units; overhaul included cleaning, testing, stator rewind, rotor balancing, reconditioning of existing precision bearings and replacement of rotor split rings	109,000	5,900
Installed VFDs on pumps and blowers	73,000	3,900

As sustainability initiatives become more common, management of industrial facilities will increasingly be called upon to develop and report sustainability key performance indicators (KPIs) associated with energy efficiency, GHG emissions, and carbon foot printing (Deloitte 2009a and 2009b). KPIs are required not only to effectively manage corporate and facility sustainability programs, but also to fulfill disclosure requirements. For example, most refineries use the Solomon Energy Intensity Index (EII®) to benchmark their operations and numerous oil and gas operations have developed KPIs in the form of energy consumption per barrel of crude oil produced to track overall efficiency.

Conclusions and Recommendations

The US industrial base is increasingly competitive, driven significantly by the co-benefits of EE and GHG savings, which is reflected in persistent long-term carbon intensity trends. The recent resurgence in US manufacturing is a good illustration of the confluence of increased availability of affordable, lower carbon-intensity energy sources and more energy efficient technologies, processes, and practices. Because industrial EE has been demonstrated to be a key vehicle for responses to carbon policies in California, larger-scale carbon policies can be expected to also drive industrial EE.

Though the industrial sector in the U.S. has achieved significant EE gains already, as illustrated by Figures 4-7, prime opportunities still exist in industrial operations for additional energy savings, and, thus, reductions in GHG emissions. Indeed, the potential for additional improvements in energy intensity in the U.S. manufacturing industry and oil and gas operations is significant as suggested by Figure 7 and Table 1. Additionally, the increasing availability of utility funding tips the balance even more favorably toward pursuing EE improvements, as do corporate sustainability goals and other mandates. Indeed, U.S. EE program funding in 2011 was approximately $6.8 billion, an increase of 27% from 2010 (Figure 5). Therefore, instead of waiting for breakthrough technologies to manage GHG emissions, it is highly recommended industrial facilities increasingly position themselves to compete in a carbon-constrained world by actively pursuing EE gains, improving production processes, and developing KPIs to track efficiency annually or even quarterly.

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