Enabling the Energy Performance Improvement of Entire Industries and Measuring Success

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ABSTRACT

Improving the energy efficiency of the industrial sector is a key strategy for reducing carbon dioxide emissions that contribute to global climate change. The U.S. Environmental Protection Agency (EPA) pursues this strategy through the banner of the ENERGY STAR® program where entire industrial sectors are engaged in a voluntary process to improve their energy performance over time. This is accomplished by providing energy management guidance that can be applied universally, specific tools that address the knowledge needs of individual companies, recognition opportunities that motivate action such as ENERGY STAR p*lant certification*, and a collective learning experience for the industry. One of the unique tools offered by ENERGY STAR is a statistical benchmarking model embodied in the ENERGY STAR Energy Performance Indicator (EPI). The EPI scores the energy efficiency of individual manufacturing sites or "plants". The score generated by the EPI also provides the basis for which EPA awards ENERGY STAR certification to manufacturing plants. The EPIs for auto assembly and cement plants were recently updated using new baseline data. Through the analysis conducted for updating the baselines used in these EPIs, it was observed that the Cement and Auto industries have achieved reductions of 13% and 12%, respectively, in energy use with similar CO_2 savings.

Introduction

The U.S. industrial sector was responsible for 26% of energy-related greenhouse gas (GHG) emissions in 2009, and 29% of all U.S. GHG emissions. Carbon dioxide (CO_2) is predominant among those emissions, mainly due to energy consumption for manufacturing processes. CO_2 comprises 80% of manufacturing GHG emissions on a CO_2-equivalent basis.[2] Since most CO_2 emission is due to energy consumption, activities which lower CO_2 emissions often involve energy efficiency. Recognizing this, EPA designed ENERGY STAR's program for industry by examining the market barriers to cost-effective energy efficiency in the industrial

[1] This paper was developed at Duke University with funding from the U.S. Environmental Protection Agency's Office of Atmospheric Programs, ENERGY STAR for Industry. The paper and associated analysis would not have been possible without the input of all industry participants in the ENERGY STAR Focuses on Energy Efficiency in Cement Manufacturing and Auto Manufacturing, as well as the Portland Cement Association. Their willingness to provide data, their guidance on important issues affecting cement and auto manufacturing energy use, and their time and energy in testing the models was invaluable. The paper has also been improved by comments from three reviewers. Any errors are the sole responsibility of the authors.

[2] EPA 2011.

sector, one of which is information. The ENERGY STAR approach addresses this barrier by providing clear and accessible information through tools and targeted energy management strategy to industries.

EPA found three key pieces of energy management information are frequently missing for most industries; 1) understanding of how a plant's energy performance compares to the rest of its industry, 2) reliable information on steps and measures for improving plant energy performance and 3) a management framework to ensure effective organization-wide energy management. Each is important for energy decision-making. Without the ability to compare average and best practice energy performance against peers, companies are unable to set competitive goals for plant improvement and are unable to learn from the good performers. In the absence of a comprehensive energy management framework, companies may miss e efficiency opportunities and fail to improve and sustain performance over time. By offering industry ways to fill these gaps, EPA provides unique tools to the industrial energy efficiency marketplace to help strengthen energy management. EPA's focus on whole plant energy performance and corporate energy management complements traditional energy programs at the federal, regional, state and local levels. The ENERGY STAR suite of tools enhances energy management in areas that have not been addressed in other programs. For instance, EPA does not seek to provide process specific tools since these exist elsewhere and are available to industry.

This paper provides an overview of the ENERGY STAR approach and gives examples from auto assembly and cement manufacturing. These two industries have been engaged with EPA since the inception of the ENERGY STAR industrial program, so EPA has developed a long history with these two industries[3].

Engaging an Industry Builds a Community of Practice

The first step in working with industry is relationship building. EPA, through ENERGY STAR, has engaged key companies within the auto and cement industries (see Table 1) to participate in an *ENERGY STAR Focus on Energy Management* (the Focus). The goals of each industry specific Focus was to develop a collaborative environment for learning, produce a sector specific energy guide, and develop metrics and tools for monitoring plant energy efficiency.

Engagement of companies entails identifying corporate energy managers. In many industries, even energy intensive ones, corporate energy management is not a priority for many companies. The reasons for this are varied. In our experience, executives often lack awareness of the potential savings a corporate wide approach can have. EPA set out to work with senior executives in industry to establish the business case for energy management, define the function of corporate energy management and help the executives establish the function within their organizations, when it was an energy management infrastructure where necessary.

Working with the energy manager for each participating company, EPA introduced its energy management tools, including program evaluation checklists, energy management guidelines, and long term energy strategy recommendations.

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[3] The program has expanded to include Corn Refining, Dairy Processing, Food Processing, Glass Manufacturing, Iron and Steel Manufacturing, Metalcasting, Motor Vehicle Manufacturing, Petrochemical Manufacturing, Petroleum Refining, Pharmaceutical Manufacturing, Pulp and Paper Manufacturing, and Ready Mix Concrete Manufacturing.

EPA began its industry sector programs a decade ago with a focus on the cement and automobile industries (see company list in Table 1).

Table 1. Focus Participants

Auto Manufacturing Focus	Cement Focus
BMW Manufacturing Company	Ash Grove Cement Company
Chrysler LLC	Buzzi Unicem USA
Daimler	CalPortland Company
Ford Motor Company	CEMEX USA
General Motors Corporation	Dragon Products
Honda of America Manufacturing	GCC of America
Hyundai	Giant Cement
Mitsubishi Motors North America	Holcim
Navistar	Lafarge North America
Nissan North America	Lehigh Cement Company
Subaru of Indiana Automotive, Inc	Mitsubishi Cement Corporation
Toyota Motor Engineering & Manufacturing North America	Salt River Materials Group
	Titan America
	TXI Corporation

After initial interactions with the companies in these industries to develop an energy management infrastructure, EPA set out to produce tools to evaluate energy performance, establish transformative energy efficiency goals, motivate change in plant performance, and identify best practices and technologies for improvement.

Inaccessibility to reliable and relevant information is a barrier to energy efficiency. To overcome this, EPA worked with Lawrence Berkeley National Laboratory to prepare industry specific Energy Guides to support each Focus industry in with the industry participants. For auto assembly and cement production, guides were produced that examine available and emerging practices and technologies for improving energy efficiency in a sector[4]. The guides include energy efficiency technologies and measures along with their estimated energy savings, CO_2 savings, investment costs, and operation and maintenance costs[5].

ENERGY STAR Energy Guides have helped the auto and cement industries identify management practices and technologies to apply to their specific plants. Table 2 shows several technologies and measures specific to cement plants. Payback periods are calculated on the basis of energy savings alone. In reality, this investment can be driven by considerations other than energy efficiency (e.g. productivity, product quality) and will happen as part of the normal business cycle or expansion project. Under these conditions, the measure will have a lower payback period depending on plant-specific conditions. Energy Guides are among the most requested documents from the ENERGY STAR website.

[4] Worrell, E. and C. Galitsky (2008 a, b)
[5] ENERGY STAR Energy Guides can be accessed at www.energystar.gov/epis

Benchmarks Address the Barrier to Gauging Plant Energy Performance

When EPA first conceptualized an approach to benchmarking energy efficiency in facilities, very few industries were able to compare the energy efficiency of their plants to similar facilities because there were no plant-level, industry-wide benchmarks. While there may be information about how well process subsystems within a plant perform against "standard" process components, it is another matter to determine if the entire system, including management, is optimized at a whole-plant level. EPA's goals were to enable industry to determine the energy efficiency of a particular plant, how much that plant could improve based on the performance of similar plants in its industry, and what type of goal is reasonable for efficiency improvements.

Table 2. Energy Efficiency Measures in Dry Process Cement Plants[6]

Energy Efficiency Measure	Specific Fuel Savings (GJ/ton cement)	Specific Electricity Savings (kWh/ton cement)	Estimated Payback Period (years)
Raw Materials Preparation			
Efficient Transport System	–	3.5	> 10 (1)
Raw Meal Blending	–	1.6–4.3	N/A (1)
Process Control Vertical Mill	–	0.9–1.1	1
High-Efficiency Roller Mill	–	11.2–13.1	> 10 (1)
High-Efficiency Classifiers	–	4.7–6.4	> 10 (1)
Fuel Preparation – Roller Mills	–	0.8–1.2	N/A (1)
Clinker Making			
Energy Management & Control Systems	0.1–0.2	1.3–2.8	1–3
Seal Replacement	0.1	–	<1
Combustion System Improvement	0.1–0.4	–	2–3
Indirect Firing	0.1–0.2	–	N/A
Shell Heat Loss Reduction	0.1–0.3	–	1
Optimize Grate Cooler	0.1	–	1–2
Conversion to Grate Cooler	0.2	−2.6	1–2
Heat Recovery for Power Generation	–	20	3
Low-Pressure Drop Suspension Preheaters	–	0.5–3.9	>10 (1)
Addition of Precalciner or Upgrade	0.1–0.6	–	5 (1)
Conversion of Long Dry Kiln to Preheater	0.4–0.7	–	>10 (1)
Conversion of Long Dry Kiln to Precalciner	0.6–1.1	–	>10 (1)
Efficient Mill Drives	–	0.9–3.5	1
Use of Secondary Fuels	>0.5	–	1
Finish Grinding			
Energy Management & Process Control	–	1.7	<1
Improved Grinding Media in Ball Mills	–	2.0	8 (1)
High-Pressure Roller Press	–	7.7–27.5	>10 (1)
High-Efficiency Classifiers	–	1.9–8.0	>10 (1)
Plant-Wide Measures			
Preventive Maintenance	0.1	0–6	<1
High-Efficiency Motors	–	0–6	<1
Adjustable Speed Drives	–	6–8	2–3
Optimization of Compressed Air Systems	–	0–2	<3
Efficient Lighting	–	0–1	N/A

Additionally, by enabling companies to identify the top performing plants, those plants can be studied to identify best practices that can be shared internally or with the rest of the industry through the ENERGY STAR Focus. Within an industrial sector, plants vary by climate,

[6] The estimated savings and payback periods are averages for indication, based on the average performance of the U.S. cement industry (e.g. clinker to cement ratio). The actual savings and payback period may vary by project based on the specific conditions in an individual plant. (Reproduced from Table 3 of Worrell, E., C. Galitsky. Energy Efficiency Improvement and Cost Saving Opportunities for Cement Making)

capacity, utilization, materials used, and products produced. The choice of approach for setting a benchmark, against which to measure efficiency, is not unique or obvious. A whole plant can be compared to itself over time by "base lining." This approach accounts for the plant-specific factors mentioned above, but only when they do not change relative to the baseline year. This is unlikely to be the case over a longer period of time. Base lining does not answer the question of how the plant has improved relative to the rest of the industry. To answer this question a benchmark comparison of plant level performance across an entire industry is required.

Such a comparison can be accomplished in one of two ways. One approach develops a cohort of plants with similar characteristics and computes the distribution or range of performance in terms of key performance indicators (KPI). These KPI may be energy use or cost per unit of product, labor hours, capacity, or floor space. The choice of KPI depends largely on the industry and the relevance of the particular ratios. The cohort approach requires large numbers of similar plants in terms of location, product, and materials; a condition that is rarely satisfied in most industries. Another approach is to develop statistical methods, such as multivariate regression. In this case the plant characteristics mentioned above are variables in a linear model used to predict the average energy use for a plant with those characteristics. The multivariate regression can then be compared to actual energy use in a given plant.

The ENERGY STAR EPI combines the cohort approach with a statistical benchmark approach. First, a selection of "similar" plants within an industry is made. For example, auto assembly plants were separated from engine and transmission plants. Similarly, electric arc steel mills are separated from integrated producers in the steel industry, and pulp mills are separated from integrated paper mills. Within these industry cohorts there may be additional variables that differentiate plants in terms of energy use, so multivariate regression is used to create a benchmark within that sub-group.

Statistical benchmarks, like baselines, are tied to the time period from which they are derived. As plants improve and change relative to their respective baselines, industries change as well. Baselines and benchmarks need to be constantly updated to provide meaningful comparisons.

The EPI can normalize for whatever exogenous variables in conditions are included in the statistical model, e.g. capacity utilization, changing product mix, or weather, to update a plant level baseline. The conditions of the plant are input into the model for each time period, producing two sets of predictions for the median (50th percentile) plant. The difference between the two predictions for average energy use is the baseline adjustment. If the energy use for the average plant under current characteristics has increased relative to the energy use for the average plants under the baseline year characteristics (e.g. because of changing product mix etc,), this difference would be added to the baseline. To illustrate, if the plant energy use in the current year rose by 1 million Btu (MMBTU) relative to the base year at the same level of production, this would suggest a decline in efficiency. However, if the EPI reveals that a shift to a more energy intensive product would have raised the median plant energy use by 2 MMBTU, then adding that 2 MMBTU to obtain an adjusted baseline shows that the current year performance is actually an improvement of 1 MMBTU in efficiency.

Demonstrating the Need to Update the Benchmark

The need to update a benchmark is driven by the rate of industry performance, either measured through aggregate trends or as reported by industry. For example, at one point several

Toyota automobile assembly plants had achieved the highest energy performance score possible (100) on the EPI based on the prior benchmark year. The company believed that additional performance improvements were achievable, but was finding it difficult to motivate plant managers at those facilities to pursue additional energy efficiency projects. Other companies in the industry agreed, and the base benchmark year was updated.

Companies in the cement industry also demonstrated major changes that suggested the benchmark should be updated. For example, a cement plant in Clarksdale, Arizona was built in the 1950s and over time upgraded to improve operating efficiency and increase kiln capacity. Most of the new equipment was capital-intensive, but the company continued to invest as part of a commitment to maintain cement quality and maximize energy efficiency. The plant upgrades included:

- Vertical roller mills for raw materials, coal/petcoke, cement
- Five-stage, low nitrogen oxide preheater/calciner kiln
- Crossbar clinker cooler
- New kiln burner
- Raw kiln feed sweetening and blending system

The new equipment improved energy performance substantially across major energy-intensive processes, affecting energy use in raw crushing and grinding (67 percent reduction in kilowatt-hours per short ton of clinker), pyro and coal grinding (37 percent reduction) and cement grinding (39 percent reduction). Prior to upgrades, the cement plant EPI produces a baseline ENERGY STAR performance score of 61. When the plant improvements were evaluated, the plant received a revised score of 98, placing this plant clearly in the top quartile for energy use nationally. In 2008 the plant rated 100 due to further energy efficiency improvements (relative to the 1997 baseline EPI, as the updated baseline analysis was not completed in time). The plant earned EPA's ENERGY STAR certification for its energy performance from 2007 – 2010. Based on similar experiences of performance improvement among U.S. cement plants, the base benchmark year was updated.

Updating the Cement EPI

This section explains the process used for updating the cement EPI to a new base year. The original cement EPI is described in Boyd (2006) [7]. The prior EPI analysis for cement uses confidential plant level data collected by the U.S. Bureau of the Census (1997 Census of Manufacturing and 1998 Manufacturing Energy Consumption Survey) combined with data from the Portland Cement Association (PCA) *U.S. and Canadian Labor-Energy Survey* (LES)[8]. The PCA LES data is a proprietary annual survey detailing U.S. and Canadian cement plant labor and energy usage and is gathered from the members of PCA. The PCA survey includes energy consumption by fuel type (including waste fuels) to compile aggregated historical labor and energy efficiency trends summarized by type of process, size of kiln, and age of plant. Comparison of the 1997 PCA and Census data found a high level of agreement between the

[7] Updates for the first two EPIs released by ENERGY STAR, auto assembly and cement, are now complete. A third, wet corn refining, is underway.
[8] The LES data was used for plant level waste derived energy in the original model.

production and energy data from the two sources, so it was decided to use data for the updated model from the PCA LES since it provides more detail.

The PCA data for the update encompass the eight years from 2000-2008, in contrast to the single 1997 benchmark year for the original model. All data described below are annual. The final year of the data is the updated benchmark year. Table 3 provides the summary statistics for major variables in this paper.

Table 3: Summary Statistics

Variable	Mean	Standard Deviation	Low Decile	Upper Decile
Energy (Trillion Btu)	4.93	2.39	2.69	7.75
Capacity (ThousandTon)	1.01	0.54	0.47	1.64
Clinker (ThousandTon)	0.90	0.47	0.45	1.44
Cement (ThousandTon)	0.97	0.50	0.47	1.58
Labor Tthousand hours)	293.9	101.10	184.00	423.85
Number of Kilns	1.75	1.08	1	3
Wet Kiln Ratio	0.23	0.41	0.00	1.00
Clinker-to-Cement Ratio	0.93	0.11	0.83	1.01
Clinker-to-Capacity Ratio	0.91	0.12	0.77	1.01
Energy Usage per Clinker (MMBtu/ton)	5.73	1.19	4.44	7.44
Ave. Kiln Capacity (Thousand ton)	730.1	463.00	235.33	1435.60

Energy is total source energy usage for the plant (electricity is converted as 11,396 Btu/kWh which accounts for U.S. grid aggregate source conversion and line losses[9]). *Capacity* is the total kiln capacity for producing clinker. *Clinker* is the produced amount of clinker for the year. *Cement* is the annual production of cement. *Kiln* is the number of kilns that a plant has. *Wet Kiln Ratio* is the ratio of the number of wet kilns to total number of kilns in a plant. *Labor* is the labor usage. *Clinker-to-Cement Ratio* is the ratio of clinker production to cement production. *Clinker-to-Capacity* is the ratio of clinker production to kiln capacity. *Energy Usage per Clinker* measures energy usage to produce a ton of clinker. *Average Capacity* is the producing clinker capacity divided by the number of kilns. The database included 862 plant-year observations across 96 unique plants.

The original model was based on the following equation (1)[10].

$$\ln(\text{energy})_{i,t} = \beta_0 + \beta_1 \ln(\text{capacity})_{i,t} + \beta_2 \ln(\text{kiln})_{i,t} + \beta_3 \ln(\text{labor})_{i,t} + \beta_4 \ln(\text{cement}) + \beta_5 \text{wet}_{i,t} \qquad (1)$$

The original model accounts for clinker capacity, number of kilns, total labor and total cement produced. It is not necessary to account separately for clinker and cement, if they are always produced in the same proportion. Historically the fraction of clinker in finished cement has not varied much, but this is changing as new formulations that allow "clinker substitutes" are being used. In addition, plants may have inventories of clinker that were produced in the prior year, so the ratio of clinker production to cement finished and shipped may also vary from year to year. The updated model (equation 2) accounts for differences in the ratio of clinker and

[9] These factors may be viewed as region specific, but the goal here is not a carbon footprint exercise but a cross industry comparison of efficiency. We would not want to call a particular cement plant more "efficient" simply because it was located in a region where electricity was produced more efficiently.

[10] For purposes of the update the same basic statistical approach described in Boyd (2006) was used, but with a slight modification to the model equation used.

cement production between different plants. The updated model also accounts for production of clinker with a quadratic function of the ratio of clinker to capacity. This allows for the energy intensity at full production to be based on the "design" of the plant, but to vary in a non-linear manner when clinker production is less than kiln capacity. Since we expect that the number and average size of the kilns influence the energy use, we include two dummy variables for plants with two and three or more kilns interacted with average capacity. Table 4 shows the coefficients estimated using ordinary least squares[11].

$$\ln(energy)_{i,t} = \beta_0 + \beta_1 \ln(capacity)_{i,t} + \beta_2 \ln(labor)_{i,t} + \beta_3 wtr_{i,t} + \beta_4 cl\_ce_{i,t} + \beta_5 cl\_ca_{i,t} + \beta_6 cl\_ca2_{i,t} + \beta_7 int(lnac\_kl2)_{i,t} + \beta_8 int(lnac\_kl3)_{i,t} \quad (2)$$

where the new independent variables are defined as the following.

wtr	= Wet Kiln Ratio = number of wet kiln / number of total kiln
cl_ce	= Clinker-to-Cement Ratio = clinker / cement
cl_ca	= Clinker-to-Capacity Ratio = clinker / capacity
cl_ca2	= Squared Clinker-to-Capacity Ratio = $(clinker / capacity)^2$
int(lnac_kl2)	= interaction between log of average capacity and 2 kilns dummy = ln(capacity/kiln)*dummy_klin2
int(lnac_kl3)	= interaction between log of average capacity and 3 and more kilns dummy = ln(capacity/kiln)*dummy_klin3

Table 4. Regression Results - Updated EPI

Variable	Coefficient	Standard Error	t-Statistical Ratio
ln(Capacity)	0.7918	0.0129	61.23
ln(Labor)	0.1276	0.0191	6.69
Wet Kiln Ratio	0.2028	0.0105	19.35
Clinker-to-Cement Ratio	-0.1613	0.0369	-4.38
Clinker-to-Capacity Ratio	2.2051	0.2367	9.32
Squared Clinker-to-Capacity Ratio	-0.6925	0.1465	-4.73
Interaction between ln(avercap) and 2 Kilns Dummy	0.0083	0.0007	11.35
Interaction between ln(avercap) and 3 and more Kilns Dummy	0.0133	0.0009	14.17
Constant	16.1910	0.1594	101.60
Adjusted R^2	0.9273	Sigma	0.0127

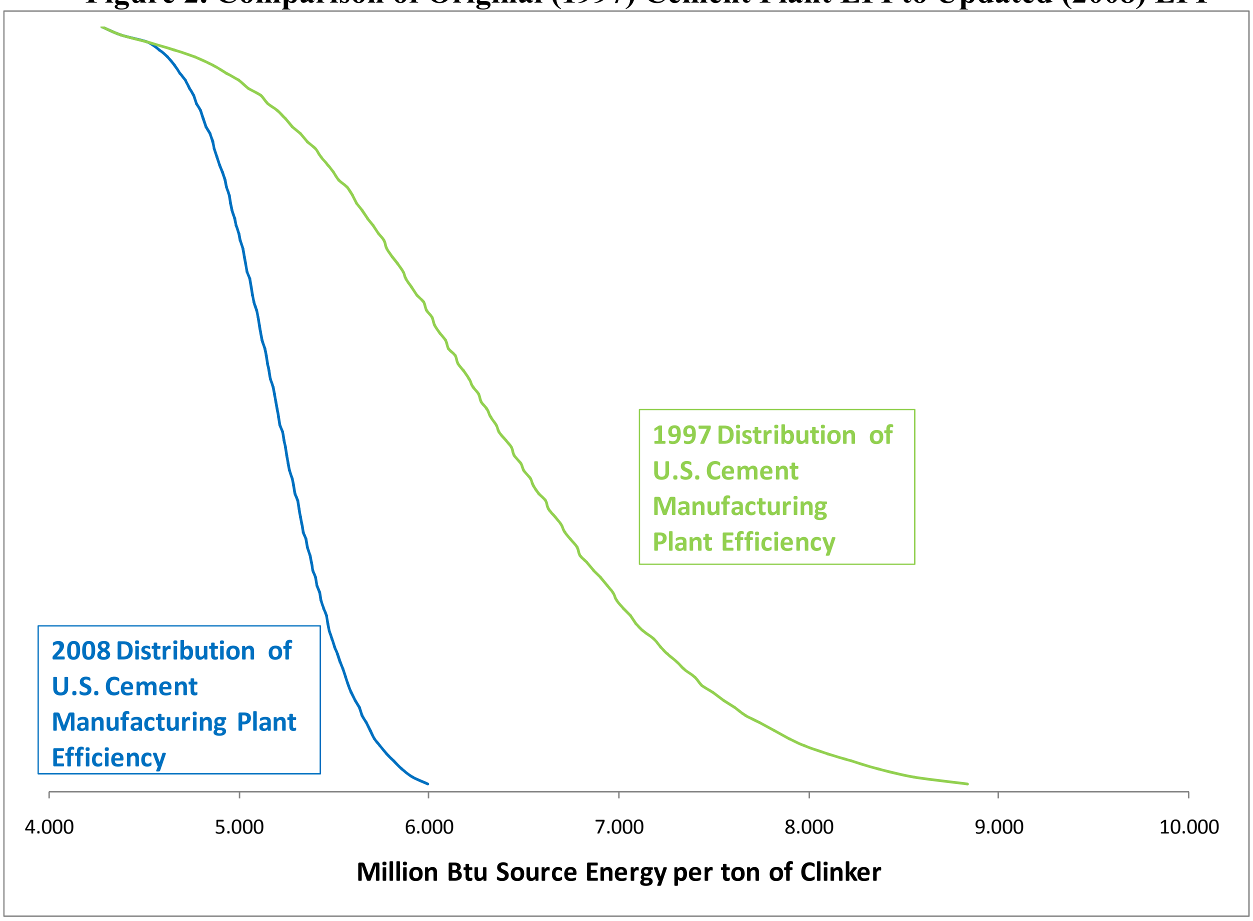
The sum of the capacity and labor coefficients (0.92) suggest that there are slightly decreasing returns to scale with respect to energy use, i.e. larger plants have lower energy use, consistent with expectations. Wet kilns have approximately 20% higher energy use. The negative coefficient is consistent with the incremental energy use of finish grinding of cement for a given level of clinker production. The quadratic function for clinker/capacity ratio implies that energy intensity increases (at an increasing rate) with a reduction in utilization. For example, at 90% utilization the intensity is 1.6% higher; at 70% it is 5% higher. Plants with multiple kilns have slightly higher economies of scale, also as expected.

[11] Since the assumption of a normal distribution may not be appropriate for the relationship between energy and production, a Stochastic Frontier Analysis (SFA), e.g., in Gale A. Boyd, (June 2010) is also applied in each industry. Application of the SFA found that the error term in the cement industry is distributed approximately log-normal. We do not report the SFA results here, but focus on ordinary least squares.

Comparison of Original and Updated EPI Benchmarks

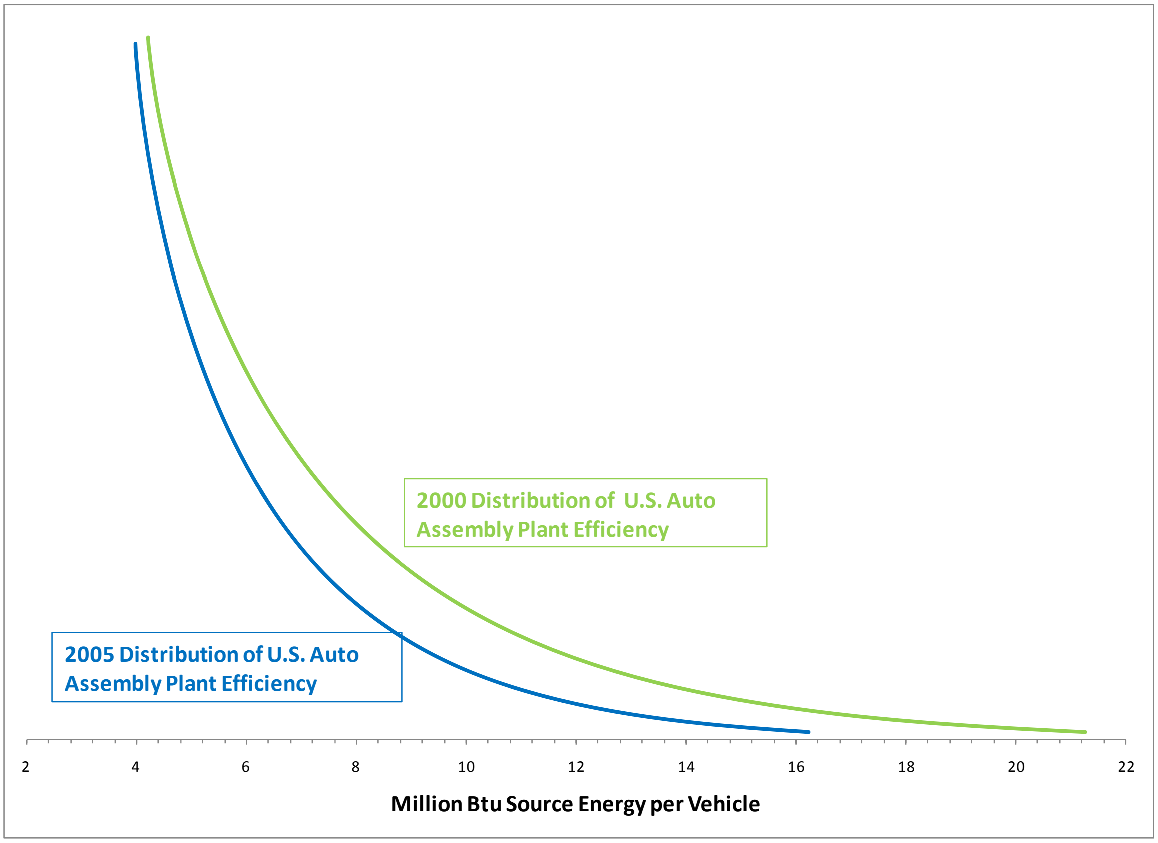
To illustrate how the industry has changed we compare the results from the original and updated EPI. The EPI show the predicted range of performance, across the entire industry, for any given plant, based on the data from the benchmark period. Comparing the two models provides a comparison of the change between those periods. Figure 1 compares the original 1997 Cement EPI (green) against the updated model (blue). The results show the percentile distributions per MMBtu/ton of clinker for a plant with two kilns with annual cement production of 900,000 tons per year and 96% kiln capacity utilization. For example, the figure shows that the average (50^{th} percentile) plant in the original EPI was 6.5 MMBtu/ton, but the updated EPI is 5.8 MMBtu/ton; 0.7 MMBtu/ton lower. One interesting characteristic of the update is that it appears that the best plants are maintaining their positions and the long tail of inefficient plant has improved. If we multiply this plant specific change in energy intensity by the level of clinker production for each plant operating in the industry in 2008 and total over all plants, this is a reduction of 60.5 trillion Btu in energy use. This is relative to an average annual total source energy consumption of 473 trillion Btu per year; an almost 13% reduction. This represents an annual reduction of 5.4 billion kg of energy-related CO2 emissions.

Figure 2. Comparison of Original (1997) Cement Plant EPI to Updated (2008) EPI



This change in cement industry performance can be contrasted with the one revealed by the update of the auto assembly EPI. Figure 2[12] compares the original (green line) and updated (blue line) auto assembly EPI. The two industries share one common characteristic; the "tail" of the distribution representing the least efficient plants is reduced in both sectors. This impact is much more pronounced in the cement industry, although the time period difference between the two industry updates is also much longer for cement than autos. However, the auto industry does show slight improvement in the "best plants," i.e. a shift in the updated EPI relative to those in the upper left hand corner. The change in the auto industry benchmark reflects a 2% reduction in electricity use, a 12% reduction in fuel use for a combined reduction of 0.6 Billion kg of CO_2.

Figure 3: Comparison of Original (2000) Auto Assembly Plant EPI with Updated (2005) EPI



Conclusions

One of the main objectives of the EPA's ENERGY STAR program is to aid the improvement of the energy efficiency of specific industrial sectors by providing an energy performance benchmarking tool combined with technical and management guidance to support the implementation of projects and programs. Through the analysis conducted to update the baselines used in ENERGY STAR Energy Performance Indicators for Cement and Automobile Assembly plants, it is clear that the overall efficiency of those industries has improved. During the period in which this improvement took place, these industries where actively involved in the

[12] Boyd (2010)

ENERGY STAR industrial program. With EPA's assistance and encouragement, the majority of the companies in these industries refined or built productive energy management programs. This suggests that this program has contributed in some degree to the improvement in energy efficiency that is being observed today. While the exact degree to which the ENERGY STAR program has impacted these industries is beyond the scope of this paper, we are able to demonstrate that industry-wide energy performance benchmarking tools can be used to evaluate how energy efficiency is changing across an industry sector. Updating the underlying benchmark year data and analysis for the auto assembly and cement plant EPIs has enabled EPA to quantify the improvement in these industries, not only on the aggregate changes in an industry, but also to understand that the change in the distribution of plants within these industries has been a major source of this improvement.

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