DEVELOPMENT OF ENERGY STAR® ENERGY PERFORMANCE INDICATOR FOR INTEGRATED STEEL MILLS

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ABSTRACT

Organizations that implement strategic energy management programs undertake a set of activities that, if carried out properly, have the potential to deliver sustained energy savings. Energy performance benchmarking is a key activity of strategic energy management and one way to enable companies to set energy efficiency targets for manufacturing facilities. The opportunity to assess plant energy performance through a comparison with similar plants in an industry is a highly desirable and strategic method of benchmarking for industrial energy managers. However, access to energy performance data for conducting industry benchmarking is usually unavailable to most industrial energy managers. The U.S. Environmental Protection Agency (EPA), through its ENERGY STAR program, seeks to overcome this barrier through the development of manufacturing sector-based plant energy performance indicators (EPIs) that encourage U.S. industries to use energy more efficiently. This report describes work with the Integrated Steel industry to produce a plant-level indicator of energy efficiency for integrated steel mills in the United States and Canada. Consideration is given to the role that performance-based indicators play in motivating change; the steps necessary for indicator development, including interacting with an industry to ensure adequate data for the indicator; and actual application and use of an indicator when complete. How indicators are employed in EPA's efforts to encourage industries to voluntarily improve their use of energy is discussed as well. The report references a related source, which describes the data and statistical methods used to construct the EPI for plants within the industry.

1 INTRODUCTION

ENERGY STAR was introduced by EPA in 1992 as a voluntary, market-based partnership to reduce air pollution and greenhouse gas emissions associated with energy use through increased energy efficiency (U.S. Environmental Protection Agency 2015). This government program enables industrial and commercial businesses as well as consumers to make informed decisions that save energy, reduce costs, and protect the environment. For businesses, a key step in improving energy efficiency is to institutionalize a strategic approach to energy management. Drawing from management standards for quality and environmental performance, EPA developed the *ENERGY STAR Guidelines for Energy Management* that identify the components of successful energy management (U.S. Environmental Protection Agency 2003).

These include:

- Commitment from a senior corporate executive to manage energy across all businesses and facilities operated by the company;
- Appointment of a corporate energy director to coordinate and direct the energy program and multi-disciplinary energy team;
- Establishment and promotion of an energy policy;
- Development of a system for assessing performance of the energy management efforts, including tracking energy use as well as benchmarking energy in facilities, operations, and subunits therein;
- Conduct of assessments to determine areas for improvement;
- Setting of goals at the corporate, facility, and subunit levels;
- Establishment of an action plan across all operations and facilities, as well as monitoring successful implementation and promoting the value to all employees; and,
- Pursuit and awarding of recognition and rewards for the success of the program.

Of the major steps in energy management program development, benchmarking energy performance by comparing current energy performance to a baseline or a similar entity is critical. In manufacturing, it may take the form of detailed comparisons of specific production lines or pieces of equipment, or it may be performed at a broader system level by gauging the performance of a single manufacturing plant with respect to its industry. Regardless of the application, benchmarking enables companies to determine whether better energy performance can be expected. It empowers manufacturers to set goals and evaluate their reasonableness.

Boyd, Dutrow, and Tunnessen (2008) describe the evolution of a statistically based plant energy performance indicator for the purpose of benchmarking manufacturing energy use for ENERGY STAR. Boyd (2016) describes the basic approach used in developing such an indicator for integrated steel mills, including the concept of normalization and how variables are chosen to be included in the analysis. To date, ENERGY STAR has developed statistical indicators for a wide range of industries (U.S. Environmental Protection Agency 2015). This report and a companion paper describe the basic concept of benchmarking and the statistical approach employed in developing a performance-based energy indicator for the integrated steel industry, the evolution of the analysis done for this industry, the final results of this analysis, and ongoing efforts by EPA to help this industry and others improve the energy efficiency and environmental performance of their operations.

2 BENCHMARKING THE ENERGY EFFICIENCY OF INDUSTRIAL PLANTS

Among U.S. manufacturers, few industries participate in industry-wide plant benchmarking. The petroleum and petrochemical industries each support plant-wide surveys conducted by a private company and are provided with benchmarks that address energy use and other operational parameters related to their facilities. Otherwise, most industries have not benchmarked energy use across their plants. As a result, some energy managers find it difficult to determine how well their plants are performing.

In 2000, EPA began developing a method for producing benchmarks of energy performance for plant-level energy use within a manufacturing industry. Discussions yielded a plan to use a source of data that would nationally represent manufacturing plants within a carefully defined industry, create a statistical model of energy performance for the industry's plants based on these data along with other available sources for the industry, and establish an energy performance benchmark for the comparison of the best-performing plants to the industry. The primary data sources would be the Census of Manufacturing, Annual Survey of Manufacturing, and Manufacturing Energy Consumption Survey collected by the Census Bureau, and any potential data offered by trade associations and individual companies when warranted by the specific industry circumstances and participation.

3 EVOLUTION OF THE INTEGRATED STEEL MILL EPI

This paper describes the spreadsheet tool that was created to provide a benchmark of the integrated steel industry throughout the U.S. and Canada. The technical analysis underlying the tool has been thoroughly detailed in *A New Benchmark of Energy Performance for Energy Management in U.S. and Canadian Integrated Steel Plants*[1] (Boyd, Doolin, Dutrow, & Zhang, 2016), which was presented at AISTech 2016 and is available online at https://www.energystar.gov/buildings/facility-owners-and-managers/industrial-plants/measure-track-and-benchmark/energy-star-energy-5. This companion paper

[1] Boyd, G., Doolin, M., Dutrow, E., & Zhang, S. (2016). A New Benchmark of Energy Performance for Energy Management in U.S. and Canadian Integrated Steel Plants. *AISTech*. Pittsburgh: Association for Iron and Steel Technology. Retrieved from https://www.energystar.gov/buildings/tools-and-resources

describes the statistical approach used in the model, the evolution of the integrated steel mill Energy Performance Indicator (EPI), energy boundaries, data and results, and overviews of the ENERGY STAR industrial program and the certification it offers to mills that achieve top quartile energy performance as is proven by earning an energy performance score of 75 or higher.[2] U.S. EPA approached integrated steel producers in the United States with the goal of producing an energy management tool that would enable them to evaluate energy performance of individual plants relative to their industry and to set informed goals for improvement. Natural Resources Canada joined with U.S. EPA in 2015 and engaged the Canadian mills in a collaborative effort.

4 SCORING INTEGRATED STEEL MILL EFFICIENCY

The goal for this work was to produce a tool that would score individual steel mills' energy performance based on a comparison of a plant to the entire integrated steel industry in the U.S. and Canada. Based on the analysis described in *A New Benchmark of Energy Performance for Energy Management in U.S. and Canadian Integrated Steel Plants* (Boyd, Doolin, Dutrow, & Zhang, 2016), a spreadsheet tool was created. Suggestions for how to use the tool and interpret the results are also shown below.

4.1 How the EPI Works

The integrated steel mill EPI rates the energy efficiency of fully integrated steel plants operating in the United States and Canada. To use the tool, the following information must be available for a plant.

- Electricity (converted to MMBtus by the spreadsheet tool)
  - Electricity used in the plant
  - Electricity transferred off site or to a utility
  - Electricity used in the coke oven, sinter plant, or to produce oxygen
- Fuel use for all fuel types in physical units or MMBtu
  - Natural gas used in the plant
  - Natural gas used in the coke plant or sinter plant
  - Blast furnace gas used in the coke plant or sinter plant
  - Propane, diesel, fuel oil, tar, or steam used in the plant
  - Propane, diesel, fuel oil, tar, or steam used in the coke plant or sinter plant
  - Coke oven gas made available to the plant plus any flared coke oven gas
  - Coal injected into the blast furnace, not including coking coal
  - Coke charged to the blast furnace regardless of source
- Final and Intermediate Products
  - Liquid iron produced in tons

[2] ENERGY STAR plant certification is available for integrated steel mills whose energy performance score using the EPI is 75 or higher using an ENERGY STAR EPI and whose compliance history meets EPA specifications defined at www.energystar.gov/plants.

    - Steel slabs produced in tons
    - Maximum steel slab capacity in tons
    - Slabs charged to the hot mill
    - Slabs finished on-site
- Inputs
    - Scrap charged to the blast furnace
    - Oxygen used only in the blast furnace

Based on these data inputs, the EPI reports an Energy Performance Score (EPS) for the plant in the current time period that reflects the relative energy efficiency of the plant compared to that of the industry. It is a percentile score on a scale of 1–100. An EPS of 75 means a particular plant is performing better than 75% of the plants in the industry, on a normalized basis. ENERGY STAR defines the 75th percentile as efficient, so plants that score 75 or better are classified as efficient. The model also estimates what the energy use would be for an "average" plant (defined as the 50th percentile), with the same production characteristics. This overall score is complemented with similar efficiency scores for electricity and fuels consumption. While the underlying model was developed from industry supplied data, it does not contain or reveal any confidential information.

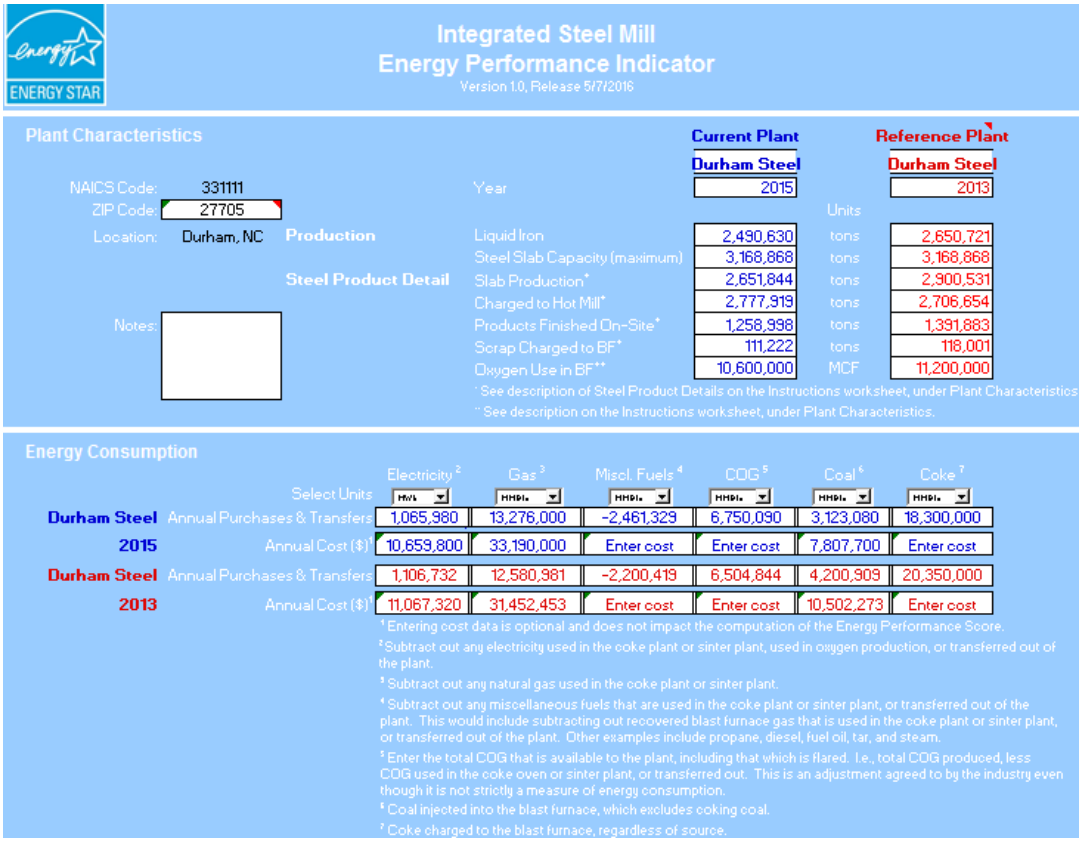
4.2 Spreadsheet Tool

To facilitate the review and use by industry energy managers, a spreadsheet was constructed to display the results of the EPI for any range[3] of plant-level inputs. During the testing phase, energy managers were encouraged to input data for their own plants and then provide comments. A version of this spreadsheet corresponding to the results described in this report is available from the EPA ENERGY STAR web site.[4] Example inputs and outputs of the spreadsheet tool are shown in Figures 1 and 2.

[3] In other words, for real plant data that may not have originally been in the data set used to estimate the model equations.

[4] http://www.energystar.gov/epis

Figure 1 Input Section of the Integrated Steel Mill EPI Spreadsheet Tool



Integrated Steel Mill
Energy Performance Indicator
Version 1.0, Release 5/7/2016

Plant Characteristics

NAICS Code: 331111
ZIP Code: 27705
Location: Durham, NC

Notes:

		Current Plant: Durham Steel	Units	Reference Plant: Durham Steel
	Year	2015		2013
Production	Liquid Iron	2,490,630	tons	2,650,721
Steel Product Detail	Steel Slab Capacity (maximum)	3,168,868	tons	3,168,868
	Slab Production*	2,651,844	tons	2,900,531
	Charged to Hot Mill*	2,777,919	tons	2,706,654
	Products Finished On-Site*	1,258,998	tons	1,391,883
	Scrap Charged to BF*	111,222	tons	118,001
	Oxygen Use in BF**	10,600,000	MCF	11,200,000

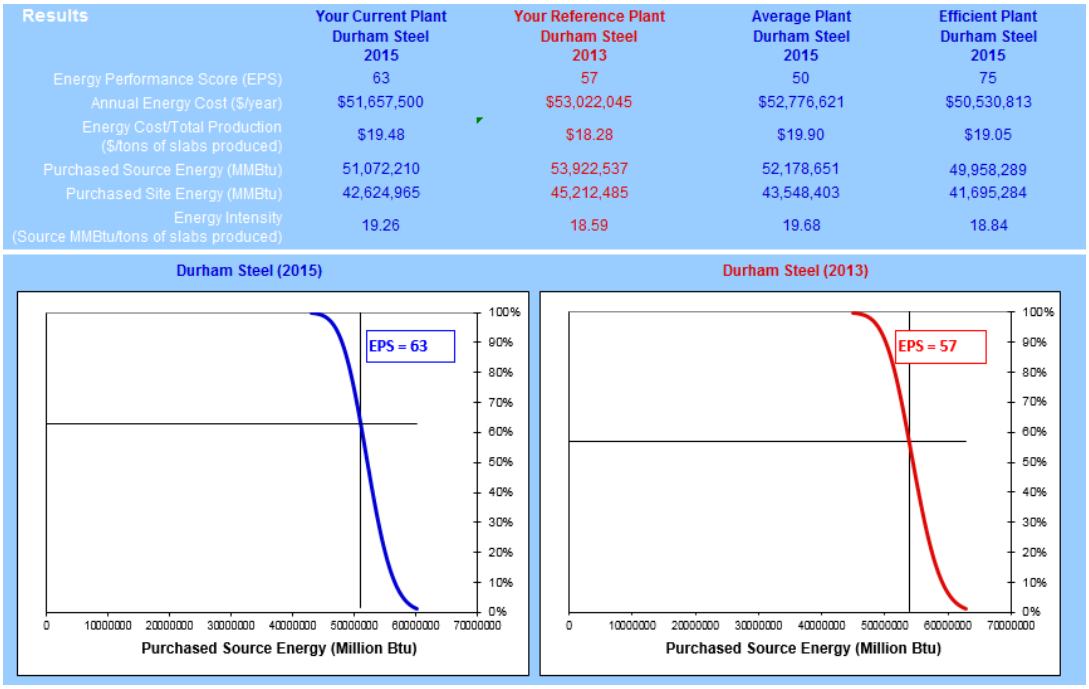
* See description of Steel Product Details on the Instructions worksheet, under Plant Characteristics
** See description on the Instructions worksheet, under Plant Characteristics.

Energy Consumption

		Electricity [2]	Gas [3]	Miscl. Fuels [4]	COG [5]	Coal [6]	Coke [7]
	Select Units	MWh	MMBtu	MMBtu	MMBtu	MMBtu	MMBtu
Durham Steel 2015	Annual Purchases & Transfers	1,065,980	13,276,000	-2,461,329	6,750,090	3,123,080	18,300,000
	Annual Cost ($)	10,659,800	33,190,000	Enter cost	Enter cost	7,807,700	Enter cost
Durham Steel 2013	Annual Purchases & Transfers	1,106,732	12,580,981	-2,200,419	6,504,844	4,200,909	20,350,000
	Annual Cost ($)	11,067,320	31,452,453	Enter cost	Enter cost	10,502,273	Enter cost

[1] Entering cost data is optional and does not impact the computation of the Energy Performance Score.
[2] Subtract out any electricity used in the coke plant or sinter plant, used in oxygen production, or transferred out of the plant.
[3] Subtract out any natural gas used in the coke plant or sinter plant.
[4] Subtract out any miscellaneous fuels that are used in the coke plant or sinter plant, or transferred out of the plant. This would include subtracting out recovered blast furnace gas that is used in the coke plant or sinter plant, or transferred out of the plant. Other examples include propane, diesel, fuel oil, tar, and steam.
[5] Enter the total COG that is available to the plant, including that which is flared. I.e., total COG produced, less COG used in the coke oven or sinter plant, or transferred out. This is an adjustment agreed to by the industry even though it is not strictly a measure of energy consumption.
[6] Coal injected into the blast furnace, which excludes coking coal.
[7] Coke charged to the blast furnace, regardless of source.

Figure 2 Output Section of the Integrated Steel Mill EPI Spreadsheet Tool



Results	Your Current Plant: Durham Steel 2015	Your Reference Plant: Durham Steel 2013	Average Plant: Durham Steel 2015	Efficient Plant: Durham Steel 2015
Energy Performance Score (EPS)	63	57	50	75
Annual Energy Cost ($/year)	$51,657,500	$53,022,045	$52,776,621	$50,530,813
Energy Cost/Total Production ($/tons of slabs produced)	$19.48	$18.28	$19.90	$19.05
Purchased Source Energy (MMBtu)	51,072,210	53,922,537	52,178,651	49,958,289
Purchased Site Energy (MMBtu)	42,624,965	45,212,485	43,548,403	41,695,284
Energy Intensity (Source MMBtu/tons of slabs produced)	19.26	18.59	19.68	18.84

4.3 Use of the ENERGY STAR Integrated Steel Mill EPI

EPIs are developed to provide an industry with a unique metric for evaluating energy performance that will guide plants to take steps to improve energy performance. To promote the use of EPIs, EPA works closely with manufacturers in an industry, through an ENERGY STAR Industrial Focus on energy efficiency, to promote strategic energy management among the companies in the industry. The EPI is an important tool that enables companies to determine how efficiently each of their plants in the industry is using energy and whether better energy performance can be expected. The EPI and the Energy Performance Score also serve as the basis for ENERGY STAR plant certification. Plants that score a 75 or higher become eligible for ENERGY STAR certification.

EPA recommends that companies use the EPIs on a regular basis. At a minimum, it is suggested that corporate energy managers benchmark each plant on an annual basis. A more proactive plan would provide for quarterly use (rolling annual basis) for every plant in a company. EPA suggests that the EPI score be used to set energy efficiency improvement goals at both the plant and corporate levels. The EPIs can also be used to inform new plant designs by establishing energy intensity targets.

The models described in Boyd et al. (2016) are based on the performance of the industry for a specific period of time. One may expect that energy efficiency overall will change as technology, energy management, and business practices change, so the models will need to be updated. EPA plans to update these models every few years, contingent on newer data being made available and industry use of the EPI tools.

4.4 Steps to Compute a Score

The technical process detailed in Boyd et al. (2016) is built into spreadsheet tools available from EPA (http://www.energystar.gov/epis). Anyone can download, open the EPI spreadsheets, and enter, update, and manage data as they choose. The following details each step involved in computing an EPS for a plant.

1. *User enters plant data into the EPI spreadsheet*

   - Complete energy information includes all energy purchases (or transfers) at the plant for a continuous 12-month period. The data do not need to correspond to a single calendar year.
   - The user must enter specific operational characteristic data. These characteristics are those listed above as final and intermediate products, and inputs.

2. *EPI computes the Total Source Energy (TSE) Use*

   - TSE is computed from the metered energy data.
   - The total site energy consumption for each energy type entered by the user is converted into source energy using the source to site conversion factors.
   - TSE is the sum of source energy across all energy types in the plant.
   - TSE per relevant unit of production is also computed.

3. EPI computes the Predicted "Best Practice" TSE

- Predicted "Best Practice" TSE is computed using the methods described by Boyd et al. (2016) for the specific plant.
- The terms in the regression equation are summed to yield a predicted TSE.
- The prediction reflects the expected minimum energy use for the plant, given its specific operational characteristics.

4. EPI compares Actual TSE to Predicted "Best Practice" TSE

- A lookup table maps all possible values of TSE that are lower than the Predicted "Best Practice" TSE to a cumulative percent in the population.
- The table identifies how far the energy use for a plant is from best practice.
- The lookup table returns a score on a scale of 1-to-100.
- The Predicted TSE for a median and 75^{th} percentile plant is computed based on the plant-specific characteristics.
- A score of 75 indicates that the building performs better than 75% of its peers.
- Plants that earn a 75 or higher may be eligible to earn the ENERGY STAR, an energy performance certification offered by U.S. EPA.

5 REFERENCES

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