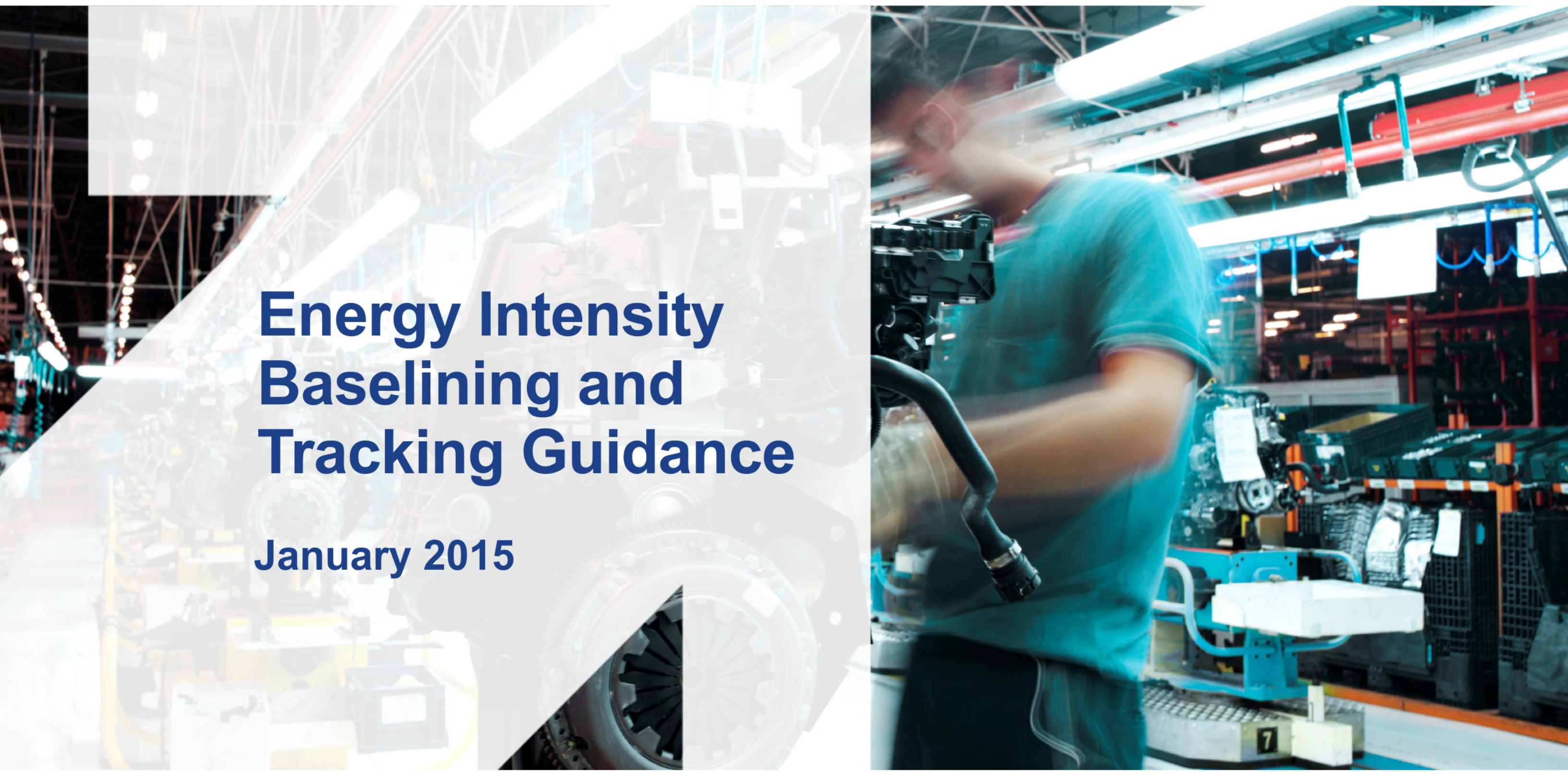
Better Plants®
U.S. DEPARTMENT OF ENERGY



Energy Intensity Baselining and Tracking Guidance

January 2015

Preface

The U.S. Department of Energy's (DOE) Better Buildings, Better Plants Program (Better Plants) is a voluntary energy efficiency leadership initiative for U.S. manufacturers. The program encourages companies to commit to reduce the energy intensity of their U.S. manufacturing operations, usually by 25% over a ten-year period. Companies joining Better Plants are recognized by DOE for their leadership in implementing energy management practices and reducing their energy intensity. Better Plants Partners (Partners) receive access to a Technical Account Manager (TAM) who can help companies establish energy intensity baselines, develop energy management plans, and identify key resources and incentives from DOE, other federal agencies, states, utilities, and other organizations.

Partners are required to report their progress to DOE once a year. This involves establishing an energy intensity baseline upon joining the program, then tracking progress over time. The ***Energy Intensity Baselining and Tracking Guidance for the Better Buildings, Better Plants Program*** helps companies meet the program's reporting requirements by describing the steps necessary to develop an energy consumption and energy intensity baseline and calculating consumption and intensity changes over time. DOE has developed a free companion energy performance software tool (EnPI tool) that can be valuable to many types of organizations in the baseline development and tracking process, especially those looking to validate their measure of energy intensity with statistical analysis.

Partners may also join the Better Buildings, Better Plants Challenge, the industrial component of the Better Buildings Challenge, a closely related voluntary leadership initiative within DOE. These Challenge Partners lead by example, creating on-line narratives that describe key energy-savings best practices. From a data perspective, a key distinction is that Challenge Partners make their energy performance data public through a DOE web site, whereas data from individual Program Partners is not released. The energy intensity baselining and tracking methodologies are the same for each initiative, however. As a result, this document is applicable to companies participating in either the Program or the Challenge.

This document is intended primarily to assist manufacturing companies participating in Better Plants, but the methodologies and guidance within it should be applicable to any organization interested in developing an energy consumption and intensity baseline, and tracking changes to those metrics on an annual basis.

For more information on Better Plants, please visit: energy.gov/eere/amo/better-plants.

For more information on the Better Buildings Challenge program, please visit: energy.gov/betterbuildingschallenge.

Contents

List of Examples

List of Equations

Definitions of Terms

The following definitions apply to the energy performance calculation methodologies specific to Better Plants. Certain terms may have different definitions in other methodologies or contexts.

Adjustment	Modification to the energy consumption data to account for facility closures, facility additions, the closure of production lines, etc.
Adjusted Energy	Energy consumption value altered to account for facility closures, facility additions, the closure of production lines, etc.
Adjusted R^2	Adjusted R^2 (or R-squared) is a modification of R^2 (definition shown below) that adjusts for the number of terms in a model. The R^2 value increases when a new term is added to a model, but the adjusted R^2 value only increases if the new term improves the model more than would be expected by chance.
Baseline Year/Period	The baseline year (also known as baseline period, or year 0) is the first 12 months of energy and production data, as selected by the company, and serves as the point of comparison for annual tracking and reporting purposes. Step 2 (p. 6) provides additional information.
Cooling Degree Day	A unit used to relate a given day's temperature to the energy demands of cooling a building or facility. A cooling degree day (CDD) is calculated by subtracting a reference temperature (such as 65° Fahrenheit) from a day's mean temperature (such as 80° Fahrenheit) at a given location. Monthly CDDs are the sum of CDDs within a given month.
Energy Intensity	Energy intensity relates the energy consumed over time with respect to a defined physical unit of output(s) for the facility or company.
Energy Performance	An evaluation of a facility's capacity to use energy efficiently. Metrics used to determine a facility's energy performance can include energy intensity, energy consumption, improvement in energy intensity, etc.
Energy Performance Indicator	A quantitative value or measure, as defined by the company, used to gauge effectiveness of a facility or company's energy management efforts. For example, an energy performance indicator may be a comparison of modeled to actual annual energy consumption. Energy intensity can be an energy performance indicator, but the term energy performance indicator covers a broader set of metrics.
Energy Intensity Improvement	A representation of the change in energy intensity or performance over time expressed as a percentage.
Heating Degree Day	A unit used to relate a given day's temperature to the energy demands of heating a building or facility. A heating degree day (HDD) is calculated by subtracting a day's mean temperature (such as 35° Fahrenheit) for a given location from the reference temperature (such as 65° Fahrenheit). Monthly HDDs are the sum of HDDs within a given month.

Independent Variable	An input value that can affect the output, or dependent variable(s) in a regression analysis. When performing a regression analysis to predict energy performance, examples of independent variables include production, HDDs, and CDDs.
Modeled Energy	The predicted energy consumption using a model developed through regression analysis.
New Energy Savings for Current Year	An estimate of the energy savings generated since the previous reporting year.
Normalize	Data normalization is a statistical technique for removing biases associated with independent variables on dependent variables in order to reflect a true picture of how a system behaves under different conditions. Within this document, the term is used to describe the process of adjusting the actual energy consumption using regression analysis for variables such as weather, variations in production level, feedstock quality, etc.
p-value	The probability that a derived value is not correlated to another value. This statistic is used to determine the significance of a modeled result. A low p-value represents a high correlation between two variables.
Primary Energy	Primary energy (also known as source energy) is the energy consumed by a company (the site energy) plus the energy required to produce and deliver the energy products to the company's sites.[1] For Better Plants, DOE requires that energy data be reported in terms of primary energy for electricity and imported derived energy sources. For electricity, the program uses a multiplier of 3.0 for conversion from site to primary energy consumption. See Step 4 for further information (page 8).
R^2	A statistical measure of how well the variations of a dependent variable are explained by the regression model. A high R^2 (or R-squared) indicates the model is an accurate prediction of energy consumption for that variable. See page 17 for additional guidance on R-squared.
Reporting Year/Period	Reporting period is the most recent 12 months of data used to determine the Current Year energy performance for annual reporting. The starting and ending months for the reporting period time span must be consistent with the baseline period time span. For example, if the baseline period covers October through September for year 0, then subsequent reporting years must also cover October through September.

[1] U.S. DOE Energy Information Administration - www.eia.gov/consumption/commercial/terminology.cfm#P

Total Energy Savings since Baseline Year
An estimate of the energy savings resulting from the actions taken since the baseline year. This value is the difference between the organization-wide energy use in the baseline and current reporting year. Adjustments made for weather, operation changes, facility closures, additions of facilities, etc. are taken into consideration when calculating this value.

Site Energy
Site energy is the energy directly consumed by the company.[2] It does not take into account the energy required to produce and deliver the energy to the company's sites, in contrast with primary energy. For electricity, Better Plants uses a multiplier of 3.0 for conversion from site to primary energy consumption. See Step 4 for further information (page 8).

Statistical Validity
The degree to which an observed result, such as a difference between two measurements, can be relied upon and not attributed to random error in sampling or in measurement. An energy model is considered statistically valid if it has a high probability of predicting the expected energy consumption, with high R^2 and low p-value being two indications of validity.

[2] U.S. DOE Energy Information Administration - www.eia.gov/consumption/commercial/terminology.cfm#P

Using this Guide

Better Plants Partners are required to submit a report to DOE once a year, with the first annual report required within one year of joining the program. The reporting form is available through an online module on the Better Plants section of the DOE Energy Resource Center[3]. The data will be used to document progress made by Partners toward achieving their energy intensity improvement goal, and serves as the basis for DOE's recognition efforts.

This document provides guidance on setting a baseline and calculating the values required for the Better Plants annual reporting form. Figure 1 below relates the various input fields on the form to the steps provided on the following pages.

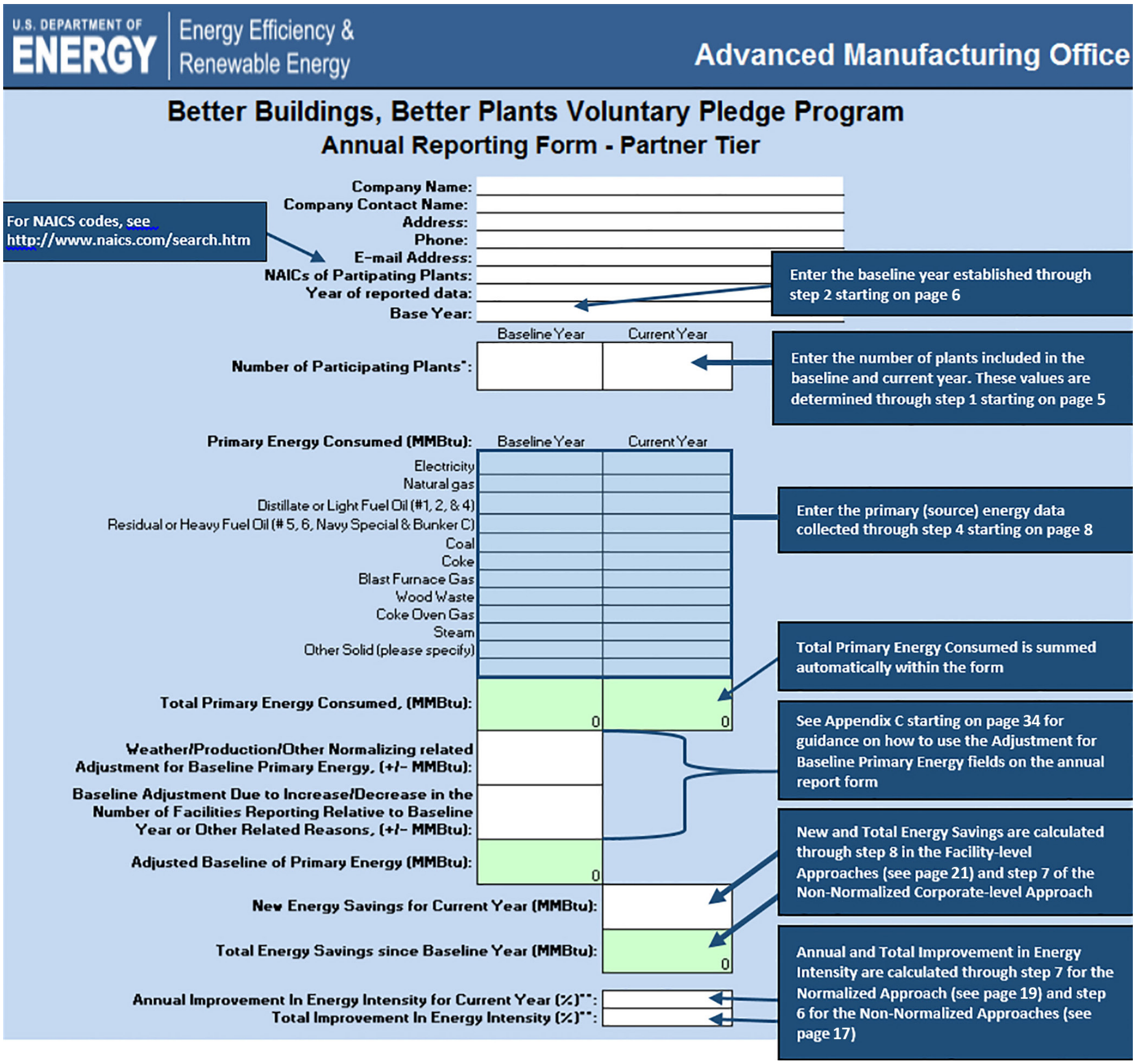


Figure 1: Better Plants Annual Report Form

[3] ecenter.ee.doe.gov/Pages/default.aspx

Introduction

Each company joining Better Plants commits to establishing an energy consumption and **energy intensity** baseline, and to tracking its **energy performance** over a ten-year period against that baseline. The baseline must reflect a company's energy consumption over a 12-month period, covering all its U.S.-based manufacturing operations. Energy consumption is calculated by fuel type in terms of **primary energy** (also known as source energy). Energy intensity is broadly defined as the amount of energy consumed per unit of output produced. For this document and the program, the term energy performance represents an evaluation of a facility's capacity to use energy efficiently. Metrics used to determine a facility's energy performance can include energy intensity, energy consumption, improvements in energy intensity, etc.

Aside from being a requirement of Better Plants, establishing a baseline and tracking system is a critical first step in effectively managing energy use. Developing a baseline can help a company understand energy use within the corporation and give it a point of comparison to evaluate future efforts to improve energy performance. It can also support efforts to validate a company's energy management activities, improve comparative analyses when using benchmarks, and help in predicting future energy needs. In addition, a company that **normalizes** its performance data can determine highly defensible measures of energy savings generated through implemented energy efficiency projects. Establishing a baseline and tracking energy performance is also a requirement of both ISO 50001 and DOE's Superior Energy Performance™ program (see Appendix B).

Basic energy data can be collected through utility bills, but most manufacturers will have to perform additional analyses to develop accurate and robust energy baselines and tracking systems. Energy is consumed in many different ways within the manufacturing sector, and can come from many different sources. Energy is sometimes generated and sold to other parties, or captured and reused on-site. External events can exert a significant impact on a facility or company's energy use independent of any purposeful efforts to improve energy efficiency. Operational changes, such as production shifts, which may be inevitable for some companies over the 10-year period covered by the program, can also make a big difference in energy use. Additionally, since Better Plants asks companies to account for all their U.S.-based manufacturing operations, mergers, acquisitions, and divestitures, can have significant implications for a company's energy metrics.

This document aims to demystify a sometimes complex process. It devotes special attention to the task of normalizing and adjusting energy consumption data to account for external factors, such as weather and production changes. A key recommendation is that companies should use regression analysis to normalize their energy consumption data whenever possible. Regression analysis is a statistical technique that estimates the dependence of a variable (typically energy consumption for energy use and intensity tracking) on one or more **independent variables**, such as ambient temperature, while controlling for the influence of other variables at the same time.[4] A properly used regression analysis can provide a reliable estimate of energy savings resulting from energy improvement strategies and projects by accounting for the effects of variables such as annual production levels and weather.

[4] Reference: Regression for M&V: Reference Guide. Bonneville Power Administration, September 2011.

DOE has developed a companion energy performance software tool (EnPI tool), which further simplifies the process (see text box). This tool can run regression models, calculate change in energy intensity at the facility level, and automatically compile the facility-level data into a corporate-wide metric. It is important to note that while the relevant equations used to calculate energy intensity are provided in this document, the EnPI tool will perform most of the calculations for the user. Additionally, Partners can call on their Technical Account Managers (TAMs) to help them establish a baseline and assist with the necessary calculations to track progress.

Energy Performance Indicator (EnPI) Tool

The Department of Energy provides a software tool that can assist facility and corporate managers as they establish a baseline and track annual progress of intensity improvement, energy savings, Superior Energy Performance™ (SEP™) SEnPIs, and other EnPIs. The EnPI tool is designed to accommodate multiple users including Better Plants partners, SEP™ participants, and non-production facilities such as data centers and commercial buildings. The tool, as well as an on-line tutorial, is available here: ecenter.ee.doe.gov/EM/tools/Pages/EnPI.aspx.

Users enter their utility, production, weather, and other data needed to develop a baseline and track changes to that baseline over time. The tool allows users to perform regression analyses on their data and determine the relevant variables that affect the energy consumption at their facilities, normalize their energy data, calculate annual improvement in energy intensity, and calculate total improvement in energy intensity since the baseline year. Additionally, the tool performs validity checks and clearly identifies the models with the highest degree of **statistical validity**.

While a key feature of the tool is its ability to run regression models, companies using non-normalized energy data will also see value in the tool as it automatically rolls plant-level data up to a corporate metric, and provides the outputs needed to complete the Better Plants annual reporting form.

DOE provides flexibility to Partners in how they calculate and track energy intensity. While the use of regression analysis is recommended, DOE recognizes this approach may not be appropriate for all companies, especially those that have a complicated product mix, a very large number of facilities, or insufficient access to data. In addition to the regression-based methodology, this document provides two alternate approaches to calculating energy intensity improvement that Partners can use, along with general guidelines and minimum requirements that allow for the development of adequate metrics.

The three approaches are summarized below, and listed in descending order of rigor and accuracy:

- Regression-based Approach – This is the most rigorous approach and can provide the most accurate results when applied effectively. This approach utilizes regression analysis to provide normalized facility-level energy consumption and annual and total changes in energy intensities that account for the effects of variables such as changes in production and weather. This provides facility and corporate energy managers with a better window into how they use energy at the facility, and whether their energy management efforts are succeeding. Facility-level energy intensity improvement metrics are then compiled at the corporate level. The corporate "roll up" is performed by calculating a weighted average of the facility-level improvement rates (in percentage terms). The corporate metric is represented as a "unitless" percent change. An important advantage of this approach is that companies can track energy intensity at the facility level and roll those numbers up into an understandable and statistically valid corporate-wide metric, even when different products (steel, tile, automobiles, etc.) are made at different facilities.

- Facility-level Approach – This approach is simpler than the Regression-based Approach since it does not require the use of regression analysis to normalize for independent variables such as weather and production. Under this approach, facility-level energy intensity metrics are usually calculated as a ratio of energy consumed per unit of output. The facility level improvement metrics are then rolled up to the corporate level using the same weighted average method employed in the Regression-based Approach. Also similar to the Regression-based

Approach, a major advantage of this approach is the ability to roll up disparate plant-level metrics into a coherent and valid corporate-level metric. A disadvantage is the inability to distinguish between energy reductions due to improvement activities and reductions due to factors such as production volume changes and weather.

- Corporate-level Approach – This is the most basic approach, and generally is only acceptable when facility-level data are not readily available. This approach requires that the company use a uniform production unit as its energy intensity denominator across all facilities, or default to a non-production metric, such as revenue. A major disadvantage of this approach is that it does not allow for any visibility into facility-level performance, which can impede a corporate energy manager's ability to allocate resources, reward high performing facilities, and hold non-performing facilities accountable.

Partners should strive to refine and continually improve their methodologies. Companies may need to make **adjustments** to their baseline over time to account for significant changes to their corporate boundaries, significant production increases or decreases, and/or changes to their product mixes. For example, companies may need to make facility-level adjustments to account for significant changes in output mix, and corporate-level adjustments to account for facilities that are bought, built, closed or sold over the 10-year period covering their participation in the program. It is important to note that while this document attempts to cover a number of issues that will arise in tracking energy performance data, it is not possible to cover them all in a single document. Partners should consult with DOE or their TAM when unique issues arise that are not covered in this document.

This document describes each of the three approaches summarized above, but spends the greatest amount of time describing the regression approach. This is due to the importance and relative complexity of this approach, as well as the fact that the other approaches can often be understood as more basic variations of the Regression-based Approach. The steps needed for each approach are shown in Table 1.

Table 1: Steps to Developing a Baseline and Tracking Energy Performance

	Regression-based Approach	Facility-level Approach	Corporate-level Approach
1	Define the boundary	Define the boundary	Define the boundary
2	Choose a baseline year	Choose a baseline year	Choose a baseline year
3	Determine relevant variables affecting energy consumption at each facility	Decide on the energy intensity denominator for each facility, usually units of output	Decide on the corporate-wide energy intensity denominator, which will usually be either a standard unit of output, revenue, or some other financial metric
4	Gather data on energy consumption and relevant variables for each facility	Gather data on energy consumption and units of output for each facility	Gather data on energy consumption and whatever is being used as the corporate-wide energy intensity denominator—usually units of output, revenue, or some other financial metric
5	Use regression analysis to normalize each facility's data	Calculate energy intensity for the baseline year and the current year for each facility	Calculate energy intensity for the baseline year and the current year across the corporation
6	Calculate the change in energy intensity from the baseline year for each facility	Calculate the change in energy intensity from the baseline year for each facility	Calculate the change in energy intensity from the baseline year for the corporation
7	Aggregate the data on energy intensity change from each facility to the corporate level	Aggregate the data on energy intensity change from each facility to the corporate level	Calculate total and new energy savings
8	Calculate total and new energy savings	Calculate total and new energy savings	

Steps 1, 2 and 4 are generally the same across all three approaches. Steps 6, 7, and 8 are common across the Regression-based and Facility-level Approaches, while the math for steps 6 and 7 for the Corporate-level Approach is essentially the same as what is needed for steps 6 and 8 in the Facility-level and Regression-based Approaches.

The following example illustrates the use of regression analysis to normalize the energy consumption in a facility for variables such as production and weather. This is the first of several examples included in this document using a fictitious company, Acme Flooring, to illustrate the steps required for tracking energy performance against a baseline. For the example below, the use of regression analysis results in better energy performance improvement than would have been the case in the absence of regression analysis, but this will not always be the case. Using regression analysis may result in an energy intensity change that is less favorable compared to a non-regression comparison, but almost always will provide a more accurate accounting of changes in energy performance.

Example 1: Use of Regression Analysis

Acme Flooring has a facility located in Minneapolis, Minnesota. The Minneapolis plant manufactures kitchen tiles. In 2010, Acme Flooring's baseline year, the weather in Minneapolis was very moderate compared to 2012. The 2010 and 2012 production levels were roughly the same.

When Acme Flooring compares the 2010 and 2012 total energy consumption and intensity for the Minneapolis Plant, the total energy consumption has increased based on the raw, non-normalized energy data. In 2010, the plant consumed 859,662 MMBtu of primary energy and in 2012, the plant consumed 874,929 MMBtu of primary energy. A comparison of the energy intensities for 2010 and 2012 shows an increase from 19.98 MMBtu/ton of tile to 20.12 MMBtu/ton of tile, a 0.7% worsening of energy intensity.

However, 2012 was a much colder year than 2010. As a result, the plant consumed significantly more energy in the form of natural gas to heat the facility that year relative to 2010, in response to the higher number of heating degree days (HDDs). A regression analysis of monthly energy data for the baseline period showed that energy use had a statistically significant relationship with both production and HDDs, and therefore these factors could be used to normalize energy consumption. When the plant normalizes its energy consumption to account for the effects of HDDs on energy consumption, the calculations show that intensity has improved by 1.9% in 2012 compared to the baseline year.

Table 2: Comparison of Normalized to Non-normalized Improvement

	2010	2012
Non-normalized Energy Consumption	859,662 MMBtu	874,929 MMBtu
Production	43,026 tons	43,483 tons
Total Heating Degree Days	3,680	4,352
Non-normalized Energy Intensity	19.98 MMBtu/ton	20.12 MMBtu/ton
Non-normalized Total Improvement in EI	—	-0.70%
Normalized Total Improvement in EI	—	1.90%

Developing a Baseline and Tracking Energy Performance

Regression-based Approach

The Regression-based Approach requires the following eight steps:

1. Define the boundary
2. Choose a baseline year
3. Determine relevant variables for each facility
4. Gather data on energy consumption and relevant variables for each facility
5. Use regression analysis to normalize each facility's data
6. Calculate the change in energy intensity from the baseline year for each facility
7. Aggregate the data on energy intensity change to the corporate level
8. Calculate total and new energy savings

Steps 1-3 need to be performed when a company develops its baseline. Steps 4-8 need to be performed for each annual report. DOE's EnPI tool can be used to perform all the necessary calculations for steps 5-8 and assists in entering relevant data following step 4.

Step 1. Define the Boundary

When a company joins Better Plants, it indicates which operations are included under its energy savings commitment. For new Partners, all U.S.-based manufacturing facilities must be included, and companies are encouraged to include their commercial buildings, warehouses, distribution centers, and other non-manufacturing space as well. Partners should not report energy or production data from facilities outside the United States.

In addition to determining which facilities are included in the program, each facility within the company's program commitment will need a defined boundary that establishes "what is in and what is out" of the tracking and reporting requirements for those facilities. Companies are only required to include within their boundaries operations and activities they have direct financial or operational control over; activities outside the entity's control (e.g., suppliers, product distributors) should not be included.

Setting the boundary draws a "fence line" around the activities and operations that are included for that facility. For the purposes of Better Plants, any non-feedstock energy, including renewable sources of energy, coming across the fence line into the facility is part of the reported energy intensity. Any non-product energy exported from the facility to outside the fence line (e.g., exported electricity from a cogeneration facility) counts as a credit that can be deducted from the company's reported energy consumption when calculating its energy intensity improvement. If a facility primarily produces energy products (e.g., a petroleum refinery that produces output like fuel oil), this "product energy" should be counted as a product not as exported energy. Step 4 provides additional information on these topics.

Minimal sources of energy, that represent less than 5% of total energy consumption within the facility, may be omitted from the calculation of total facility consumption. If an energy source is purchased in bulk, stored, and then used over time (e.g. propane), annual consumption of any source equal to or over 5% of the total annual energy consumption must be estimated on a monthly basis and included in consumption data and energy intensity calculations. Energy consumption for transportation should be excluded in most cases. Companies that use fuel to test transportation equipment, such as engines, however, should include the fuel use in their energy intensity calculations whenever the annual amount is over 5% of a facility's total annual energy consumption.

Example 2: Defining a Corporate Boundary

Acme Flooring has seven properties. Five are located within the U.S., one is located in Canada, and one located in Mexico. The corporate headquarters is in Ohio and consists of three buildings. The primary function and location of each property is shown in the table below.

Table 3: Acme Flooring's Facilities

	Country	City, State	Number of Buildings	Function	Included in Pledge Boundaries
1	USA	Cleveland, Ohio	3	Headquarters/Office buildings	Optional
2	USA	Ashland, Ohio	2	Manufacture porcelain and ceramic tile flooring	Yes
3	USA	Duluth, Minnesota	4	Warehouse	Optional
4	USA	Minneapolis, Minnesota	3	Manufacture ceramic tile flooring	Yes
5	USA	Rochester, Minnesota	3	Manufacture ceramic tile flooring	Yes
6	Canada	La Plaine, Quebec	5	Manufacture ceramic tile flooring	No
7	Mexico	Veracruz, Veracruz	2	Manufacture vinyl sheet flooring	No

Acme Flooring must exclude the facilities located in Canada and Mexico, but has the option of including or excluding the corporate headquarters complex and the warehouse, since these are non-manufacturing facilities. Acme decides to include the headquarters and warehouse since these facilities make up a significant percentage of the company's overall energy footprint. As shown later, these two facilities will use square feet of floor space as the denominator in their energy intensity ratio.

Step 2. Choose a Baseline Year

Companies joining Better Plants must establish a baseline year (year 0) for tracking energy performance. The baseline year should usually be the most recent calendar or fiscal year before joining the program, or the year the company joins. Partners can set the baseline year up to three years prior to joining the program to capture recent energy savings accomplishments, or if an earlier baseline aligns with existing greenhouse gas or other corporate sustainability targets. Also, a recent major event such as a large acquisition, closure of significant facilities or an extended production stoppage may justify selecting a baseline year other than the most recent year. In all cases, the Partner's commitment shall be interpreted as striving for a 25% energy intensity improvement within 10 years after the end of the base year. For example, a company joining Better Plants in 2012 and setting calendar year 2011 as its baseline year is striving for a 25% improvement in energy intensity for the calendar year ending December 2021. Likewise, a company which joined the program in 2011 and set calendar year 2009 as its baseline year is striving for a 25% improvement in energy intensity for the calendar year ending December 2019 (Year 0 = 2009, Year 1 = 2010, and Year 10 = 2019).

Example 3: Selecting a Baseline Year

Acme Flooring signed the Better Plants Pledge in January 2012, and at first considered 2011 for its baseline year. Final production data issued in March 2012 showed a substantial drop in production in 2011. After discussion with DOE, the company opted to use 2010 as its baseline year since it is more reflective of normal business conditions for the company.

Step 3. Determine Relevant Variables, Including Units of Output, for each Facility

Many variables can affect the monthly or even daily energy consumption of a facility and an organization. Examples of variables that can cause an increase or decrease in energy consumption include production level variability, product type variability, weather, and feedstock quality. The specific variables depend on facility location, processes, and outputs. To accurately track the energy performance of a facility over time, the energy consumption should be normalized for these variables.

The Regression-based Approach uses regression analysis to do this (more details on regression analysis are included in Step 5 starting on page 24). Essentially, regression analysis aims to ensure that **reporting period** energy consumption and baseline year consumption are normalized so that the two periods correspond to consistent conditions (e.g., constant weather and production levels). Prior to regression analysis, variables should be identified using best technical judgment based on observations and other data. For many facilities, the variables that cause the greatest impact on energy intensity will be production levels and weather. Facility managers will need to identify additional variables based on knowledge of their manufacturing processes. DOE's EnPI tool helps automate this process by allowing a facility to evaluate all possible variables for a given year and determine which are statistically significant without having to manually perform multiple iterations. Statistical significance and model validity are discussed in Step 5.

Tips for Selecting Variables

Any knowledge of how a given variable may impact a fuel source should be considered when developing regression models. For example, if a plant manager knows that high humidity affects natural gas consumption, some measure of humidity should be included as one of the variables in the natural gas model.

Use of software tools (such as the EnPI tool) may develop a number of statistically valid models for a given fuel source. However, the model with the best "statistical validity" may not always be the best model to select. Each valid model should be reviewed for technical soundness and the most appropriate overall model should be used. As examples, if any of the following situations occur, consider selecting a different model:

- A variable is included in the model that is illogical. For example, natural gas is not used for cooling a facility but CDDs is included as a variable in the model.
- A coefficient for one of the variables is negative. For example, if the coefficient for production is -3, this indicates that energy use is decreasing as production increases.
- The intercept is negative. This indicates that the facility is consuming energy when the variables are all set to zero. If this does not make sense for a facility, select an alternative model.

Example 4: Determining Relevant Variables

The Acme Rochester plant is preparing to submit its energy data to the corporate office for Acme's first annual Better Plants report. The annual report will compare Acme's 2012 energy consumption to its baseline year 2010. Acme is normalizing the energy consumption at its plants to provide a more accurate record of its performance.

The Rochester plant needs to determine which factors it will consider when adjusting its energy consumption. Plant managers first make a list of all the factors they think could possibly impact the plant's energy consumption:

1. Production (tons of tile)
2. CDDs
3. HDDs
4. Employee hours

Facility personnel know through experience that the production lines operate more efficiently when the facility is running at full output. Conversely, at times of reduced production, energy efficiency suffers since the lighting and HVAC loads vary very little, and other equipment, such as the boilers and compressed air system, consume less energy, but not in proportion to the drop in production. Therefore, Rochester decides to include tons of tiles as a relevant variable and collects data on the tons of tile produced each month for 2010 through 2012.

In Rochester, Minnesota, the temperatures drop well below freezing in the winter and rise above 80 degrees Fahrenheit in the summer. Knowing the temperatures fluctuate throughout the year, and that the plant is cooled and heated to keep the indoor temperature between 65 and 75 degrees Fahrenheit, Rochester decides to include both heating and cooling degree days as relevant variables and collects the monthly CDD and HDD values for 2010 through 2012. Since the fuel source for heating is natural gas, facility personnel correctly decided to use HDD as a variable for the natural gas model only. Similarly, since the facility is cooled by electrically-powered air conditioning systems, CDDs are used as a variable for the electricity model only.

The final variable that Rochester considers is number of employee hours worked each month. Between 2010 and 2012, the number of employee hours was dependent on the production demand, meaning when production doubles, the number of employee hours worked also doubles. Since the variables are highly correlated with one another, only one of the two needs to be considered.

Personnel at the Rochester facility thus conclude that production, HDDs, and CDDs are the relevant variables to include in their regression models.

Step 4. Gather Data on Energy Consumption, Units of Output, and Relevant Variables for each Facility

Each facility needs to gather energy data for the baseline year selected, and then for each subsequent year for annual reporting to DOE. The energy consumption reported must include a breakdown of energy consumption by fuel type .The Better Plants Reporting Form (page vii) specifies the energy types that will be tracked, which include electricity, natural gas, distillate or light fuel oil (#1, 2, & 4), residual or heavy fuel oil (#5, 6, navy special & bunker C), coal, coke, purchased blast furnace gas, purchased wood waste, other gas, other liquid fuel, and other solid fuel. Companies are not required to include consumption of fuels that are byproducts of the manufacturing process, such as wood waste or other forms of biomass.

For purposes of the program, energy consumption is the total of all energy sources entering the facility or withdrawn from facility inventory or stockpile, excluding feedstocks and excluding energy sources passed through the facility to an outside party. Fossil fuels and biomass are valued in terms of their energy content, in million British thermal units (MMBtus), based on the fuels' higher heating values

(HHV). Electricity and other derived energy sources are valued in terms of the primary energy required to generate, transmit, and distribute the energy delivered to the participating facility, and all energy sources are also reported in terms of MMBtus. Facility level consumption, production data, and relevant variable data must be collected on a monthly basis (at a minimum) to allow for the development of the regression model. Energy consumption for each energy source must be collected separately. In addition, if submeters are used to measure energy consumption for different areas within a facility, modeling each submeter separately by counting each as a separate energy source may simplify the regression analysis. For additional information on submetering, see page 23.

Primary versus Site Energy

Energy consumption data reported to DOE must be in terms of primary energy as specified in Section 106 of the Energy Policy Act of 2005. The delivery of electricity includes inherent energy losses in the conversion of fuel (like coal or natural gas) to electricity, plus losses in transmission and distribution. Although there are regional and other variations, on average each unit of electricity that reaches the end-user (i.e. **site energy**) requires approximately three times more energy[5] to generate it (i.e. primary energy). For Better Plants annual reporting, primary energy consumption of purchased electricity involves converting kilowatt-hours to MMBtu (1 kWh = 3412 Btu = 0.003412 MMBtu) and then multiplying by 3.0. If data exists to document the actual fuel mix and transmission and distribution losses of electricity for its facilities, a company may opt to use a different multiplier, so long as it uses the same multiplier consistently across all the years it participates in the program. Companies using this approach and having facilities in multiple regions of the country should note that the electricity source multiplier will vary by region. For purchased primary fuel sources like natural gas or coal, the HHV of the fuel is used, and any distribution and transportation energy or losses (e.g., energy used to compress natural gas delivered in pipeline) should not be included. The rationale for using primary energy is that it ensures that the total energy required to generate, transmit, and distribute electricity from the power generation source to the end user is factored into a company's energy consumption metrics. In addition, calculating savings in terms of primary energy ensures the full benefits of technologies like combined heat and power (CHP) and on-site solar energy that reduce losses within the transmission lines and in the conversion of fuels are captured.

Primary energy accounting should also be used for purchased energy streams such as steam, chilled water, or compressed air that are generated outside the boundary of the facility. Appendix A provides primary energy multipliers for these most commonly used energy sources. This appendix provides default multipliers based on national averages or typical conversion factors. The multipliers represent the input unit of energy required at the fuel production site to produce each unit of energy delivered to each individual facility. Alternatively, a company may convert to primary energy using its existing energy accounting system or other proven methodology. Since primary energy conversion factors can vary by region, companies can use different site to primary conversion factors at different facilities, provided each factor stays consistent throughout the ten years. As with the conversion of purchased electricity to primary energy, the intent of the conversions is to ensure a consistent yearly accounting of the energy embedded in each delivered unit of energy.

Other Adjustments to Energy Accounting

Other adjustments to the energy accounting may be needed to develop a sound baseline. Energy accounting for annual reporting of CHP, onsite electricity generation, and electricity generated from renewable sources, is described below.

[5] U.S. DOE Buildings Energy Data Book - buildingsdatabook.eren.doe.gov/TableView.aspx?table=6.2.4

Electricity

CHP – CHP, also known as cogeneration, is the production of electricity and a form of useful thermal energy (such as heat or steam) used for industrial, commercial, heating, or cooling purposes.[6] Instead of purchasing electricity from the local utility and burning fuel in an on-site furnace or boiler to produce needed thermal energy, an industrial (or commercial) user can use CHP to provide both energy services in one energy efficient step.[7] CHP systems typically achieve total system efficiencies of 60%-80% compared to only about 45%-50% for conventional separate heat and power generation by avoiding line losses and capturing much of the heat energy normally wasted in power generation to provide heating and cooling to factories and businesses.[8] One common application of CHP is using a prime mover (e.g., combustion turbine) to generate electricity and using the prime mover's waste heat for heating. Another common CHP application is generating high pressure steam in a boiler, generating electricity with a backpressure steam turbine, and then using the exiting lower pressure steam for process heating.

A company installing and deploying CHP equipment onsite will see a decrease in electricity purchases from the electric grid, but will see an increase in the input fuel (such as natural gas) consumption.

If a CHP system is within the facility's boundary, all of the energy generated (electricity and heat) is accounted for by the fuel going into the CHP system, and this fuel (whether fossil, biomass, by-product, etc.) should be accounted for as described in other sections of this guidance. Any exported energy (electricity, steam, etc.) should be accounted for as an energy credit. See **Onsite electricity generation** below for guidance on accounting for exported electricity. Exported thermal energy should use a site-to-primary multiplier equivalent to the inverse of the overall efficiency of the CHP system.

Electricity purchased 'over-the-fence' from a neighboring facility's CHP operations will likely have a lower primary energy multiplier and fewer CO_2 emissions compared to electricity purchased from the grid. Steam from a neighboring CHP facility can also be purchased. An alternative to the program default site-to-primary energy multipliers can be used for imported electricity and steam; provided calculations are documented, based on sound engineering principles and the electric and thermal efficiency of the CHP system, and are used consistently over time. As an example, a Partner's neighboring facility has a natural gas-fueled CHP system with an electric efficiency of 35% and an overall efficiency of 75%, with the CHP waste heat used to generate steam at that facility. The Partner imports some of the electricity from this neighboring CHP system. In this case, since the system has an overall efficiency of 75%, a site-to-primary multiplier of 1.33 (multiplier = 1 / 0.75), is reasonable.

Onsite electricity generation (non-CHP) – Electricity generated onsite (non-CHP) from primary fuels may be consumed at the facility or exported. Onsite generated electricity that is consumed onsite is accounted for by the primary fuel used to generate the electricity. Onsite generated electricity that is exported is considered a credit, i.e. it can be subtracted from the facility's total energy consumption. For Better Plants annual reporting, the amount of sold electricity is provided as a negative value in the "other" row (see form on page 7), using a site-to-primary multiplier of 3.0 (since this exported electricity is replacing electricity that other utility customers would purchase from the grid). A facility

[6] Definition of CHP from Department of Energy, Energy Information Administration. www.eia.doe.gov/glossary/

[7] State and Local Energy Efficiency Action Network. 2013. *Guide to the Successful Implementation of State Combined Heat and Power Policies*. Prepared by B. Hedman, A. Hampson, J. Rackley, E. Wong. ICF International; L. Schwartz and D. Lamont, Regulatory Assistance Project; T. Woolf, Synapse Energy Economics; J. Selecky, Brubaker & Associates.

[8] U.S. DOE, U.S. EPA. Combined Heat and Power: A Clean Energy Solution. August 2012. www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_clean_energy_solution.pdf

that is a net exporter of electricity should enter zero for total electricity on the Better Plants annual report form. That is, total reported electricity cannot be a negative number. If the onsite electricity generation system uses by-product fuels or an exothermic reaction, the company may opt to include or exclude the electricity generated. Some special considerations apply to biomass (see details on page 23).

"Renewable electricity" is defined as electricity generated without using either fossil fuels or biomass fuels. Although biomass is often considered renewable, for Better Plants reporting purposes, it should be treated separately as some special considerations apply. Renewable electricity may be derived from wind, photovoltaic cells, hydro, tidal, etc. Renewable electricity generated and consumed onsite should be accounted for using a 1.0 primary multiplier, assuming meters are in place that can track the renewable electricity separate from the grid-purchased electricity. If onsite generated renewable energy is exported, a credit using a 3.0 multiplier should be used.

For energy baseline development and tracking, the general equation for these other adjustments is:

Equation 1: Reported Electricity

$$\text{Electricity}_{\text{Reported}} = (\text{Electricity}_{\text{Purchased}} \times 3.0) + (\text{Electricity}_{\text{Offsite CHP}} \times \text{CHP multiplier}) + (\text{Electricity}_{\text{Onsite Renewable}} \times 1.0) - (\text{Electricity}_{\text{Sold}} \times 3.0)$$

Renewable energy credits (RECs) purchased by companies to offset fossil fuel-based energy consumption do not factor into the calculation of energy consumption or change in energy intensity for Better Plants reporting.

Energy as a feedstock

Some industries use fuel as raw material inputs (i.e., a feedstock) for their products. For example, chemical facilities convert natural gas into ammonia, methanol, and many other products. For energy accounting purposes in the program, feedstock energy should be excluded from the energy consumption data.

Onsite generated byproducts used as a fuel

If a facility generates a byproduct that is used as a fuel (e.g., sawdust from a sawmill operation), the Partner may choose to include or exclude energy produced by the byproduct.

Exothermic processes

Energy recovered from waste heat from a process or from an exothermic reaction should be treated like a byproduct fuel, and therefore may be included or excluded from the energy consumption data.

Example 5: Calculating Primary Energy Consumption in MMBtu

Acme's Rochester, Minnesota plant purchases electricity from a neighboring plant's CHP system as well as from its local utility, and has a solar photovoltaic system which produces electricity used by the plant. The electricity production from each of these systems for the month of August is shown in the table below.

Table 4: Acme Rochester August Electricity Consumption

Electricity Source	Site Energy Consumption in August (kWh)	Site to Primary Multiplier	Primary Energy Consumption in August (kWh)	Primary Energy Consumption in August (MMBtu)
Local utility company	3,529,906	3.0	10,589,719	36,106
Neighboring plant's CHP system	1,825,814	CHP multiplier = 2.0 for this system	3,651,627	12,450
Solar panels onsite	365,163	1.0	365,163	1,245

The total primary electricity consumption for the Rochester, Minnesota plant for the month of August is:

$\text{Electricity}_{\text{Reported}}$ (kWh) = (3,529,906 kWh* 3.0) + (1,825,814 kWh* 2.0) + (365,163 kWh * 1.0) =14,606,509 kWh

$\text{Electricity}_{\text{Reported}}$ (MMBtu) = 14,606,509 kWh * 0.00341 MMBtu/kWh = 49,808 MMBtu

Biomass

The use of biomass as a fuel source is increasing in the U.S. as companies seek to reduce greenhouse gas emissions. However, biomass fuels typically contain more moisture than fossil fuels, resulting in lower boiler efficiencies. So a conversion from fossil to biomass fuel can decrease the efficiency of a boiler and can potentially have a negative impact on energy intensity even though carbon emissions will be reduced.

DOE does not wish to discourage companies from using biomass fuels. It is important, however, for a company converting all or a portion of its fuel sources from fossil fuel to biomass to account for this change when reporting energy consumption and changes in energy intensity. Due to the variety of biomass fuel types, all possible situations cannot be addressed in this guidance. The basic principle, however, is that companies may adjust their baseline energy consumption to counteract the energy penalty they incur when using increasing amounts of biomass in substitute of natural gas or other fossil fuels. To do this, baseline year data should be adjusted to assume the same percentage (based on heating value) of biomass was burned as the current year (replacing some of the fossil fuel that was burned during the baseline year) for the energy use(s) consuming the biomass fuel (e.g., a boiler system). If the moisture content of biomass changes over time, similar adjustments should be made. A useful table of heat content ranges for common biomass fuels is contained in Appendix A of the Biomass Energy Data Book published by Oak Ridge National Laboratory[9].

[9] cta.ornl.gov/bedb/appendix_a/Heat_Content_Ranges_for_Various_Biomass_Fuels.pdf

Example 6: Energy Accounting with Biomass Adjustments

The Acme Flooring Duluth facility has a boiler system burning 100% coal during its baseline year, 2010. In 2012, the Duluth facility begins using a fuel mixture consisting of 10% biomass and 90% coal, with the biomass being purchased from outside the facility boundary. Burning the biomass reduces the boiler efficiency. To account for this, the Duluth facility will need to:

1. Determine the coal consumption and the amount of steam generated by that boiler in the baseline year
2. Estimate the consumption of the fuel mixture (coal plus biomass) that would have been needed to generate this baseline year amount of steam with the 90% coal/10% biomass fuel mix
3. Estimate the baseline consumption adjustment, which equals the hypothetical estimated fuel mixture consumption value for the baseline year minus the actual coal consumption value for the baseline year.

Units of output and relevant variables for each facility

In addition to energy consumption data, monthly output data and data for other relevant variables identified in step 3 must be collected for the baseline and **reporting year**. If weather is identified as a variable that may affect the energy consumption at a facility, the company must obtain the monthly CDDs and HDDs for the baseline year at a location near the facility. CDD and HDD data are available through several online sources, such as the National Oceanic and Atmospheric Administration[10]. Data for these variables are used to determine the normalized energy consumption in order to calculate total improvement in energy intensity.

Units of output data for each facility must be collected. Production is the most common unit of output. If a facility produces multiple types of product, each product should be collected separately in a separate unit (e.g., tons of cheese, square feet of ceramic tile, sedans, etc.). Data for each unit of output would then be included as separate independent variables when developing the regression model. Over the course of the Better Plants commitment, manufacture of certain products may cease and new product lines may be introduced. In such situations, the production units will no longer be able to be treated as separate units of output, and the regression model will no longer be valid. If the product mix for a facility changes drastically, companies should try to develop a "standard unit of output" and begin using a new model to normalize the energy consumption for the facility. The "standard unit of output" would be included as a variable in the model instead of separate units of output. For more information on how to develop a standard unit of output, see Table 7 on page 23. For more information on how to develop a new model, see page 18.

Step 5. Use Regression Analysis to Normalize each Facility's Data

Regression analysis is a statistical technique that estimates the dependence of a variable (energy consumption, for the purpose of this document) on one or more independent variables, such as production levels or ambient temperature, while controlling for the influence of other variables at the same time.[11] Regression is commonly used for estimating energy savings through the measurement and verification of energy projects and programs, and has proven to be reliable when the input data includes variation in operating conditions. A properly used regression analysis can provide a reliable estimate of energy savings resulting from energy improvement strategies and projects by accounting

[10] www.ncdc.noaa.gov/oa/documentlibrary/hcs/hcs.html

[11] Reference: *Regression for M&V: Reference Guide.* Bonneville Power Administration, May 2012.

for the effects of variables such as annual production levels and weather. The equations used in regression analyses at times can be complicated. Companies do not need to perform these calculations manually, but instead can use tools such as DOE's EnPI tool to calculate metrics required for the annual report form[12].

When regression analysis is used to determine a facility's energy performance, the first step is to develop a linear model which can be used to determine the "modeled" energy use. The linear model is often shown in the following form.

$$Energy\ Consumption = m_1 x_1 + m_2 x_2 + m_3 x_3 + b$$

In the equation above, ***m*** represents a constant multiplier, ***x*** represents an independent variable, and ***b*** represents the energy use when the independent variables are set to zero. Examples of independent variables include production, HDDs, and CDDs. Determining the relevant variables requires a basic understanding of the facility and its operation, and may require modeling different variable combinations to determine the best model.

Once developed, this linear equation determines the **modeled energy** consumption for a given year using a known set of conditions (production, HDDs, CDDs, etc.). By comparing the actual energy consumption to the modeled energy consumption, a company can estimate the energy performance improvements of a facility.

For example, consider a simple scenario in which a facility produces one type of product in a geographic region that requires space heating but not cooling. In the baseline year (2009), the facility uses three MMBtu to produce one unit of product and the space heating system requires one MMBtu for each HDD. In addition, the energy use for production is not dependent on HDDs and the facility does not consume energy when the production and HDDs are set to zero. The linear model for this scenario becomes:

$$Energy\ Consumption = (3 \times Production) + (1 \times HDD)$$

A plot showing the measured energy consumption for the baseline year is shown in Figure 2.

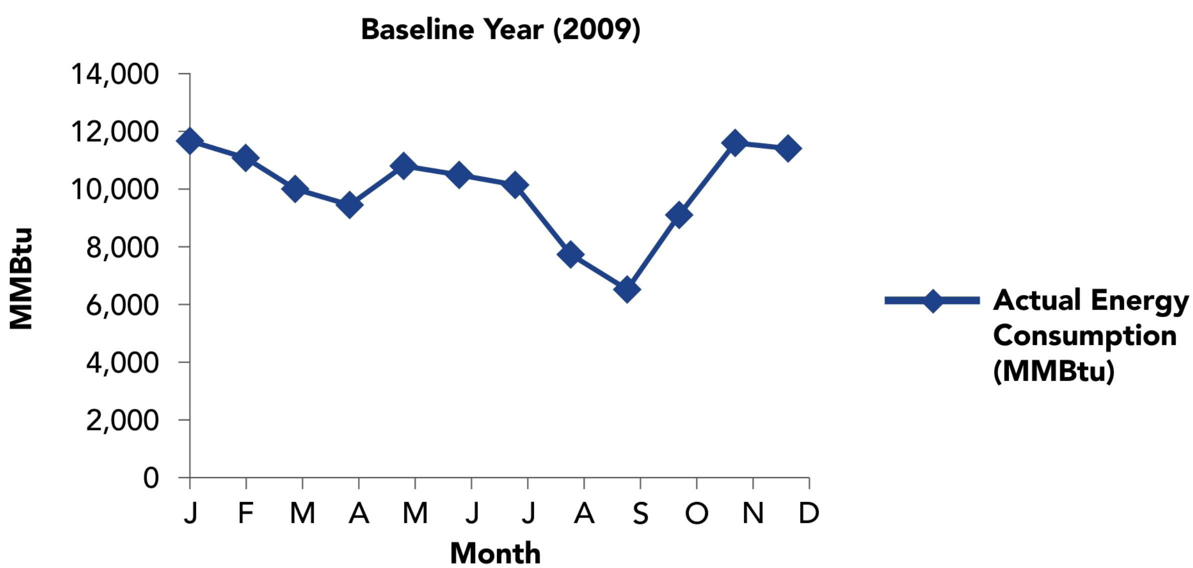


Figure 2: Development of a regression model

[12] While this document and the DOE EnPI tool focus on energy analysis through linear regression, companies may encounter cases that are better addressed through non-linear regression analyses.

Continuing with this example, assume the production doubles in the third reporting year and the number of HDDs is similar to the baseline year. The modeled energy consumption associated with production would double for the third year based on the model developed using the baseline year data. This example assumes no changes to the operating efficiency or other parameters for the facility.

However, if the facility makes energy efficiency upgrades that result in energy savings and the HDDs remain unchanged, the actual energy consumption will be less than the modeled energy consumption. The difference between the actual and modeled energy consumption for the facility represents the energy performance improvement between the baseline year and third reporting year. The following plot shows a comparison of the actual to modeled energy consumption for this facility in the third reporting year.

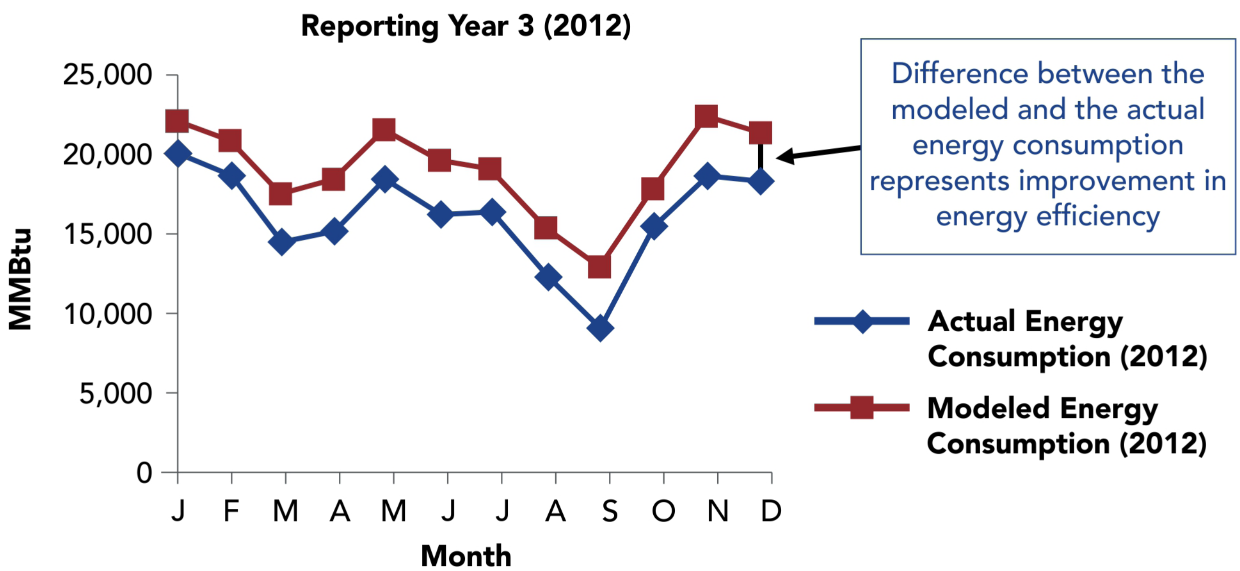


Figure 3: Using a linear model to determine improvement in energy performance

The upper line (red) represents the energy the plant would have used in 2012 if the plant was operating the way it did in 2009, but at 2012 production levels and weather conditions. The lower line (blue), shows the actual 2012 consumption. Since the actual energy consumption is lower than the modeled energy consumption, the facility's energy performance has improved between the baseline year and reporting year 3. The difference between these two represents the magnitude of the improvement.

In the example above, the forecasting method, which is the most common method, was used to determine the energy performance of the facility. Three primary methods exist for using regression analysis to calculate the energy performance of a facility[13].

Forecast: Forecasting uses the **baseline period** energy consumption to develop a model which is used to determine the modeled reporting period energy consumption using the known reporting period production levels and external factors. If the modeled energy consumption in the reporting year is higher than the actual energy consumption, then the facility's energy performance has improved.

The forecast method is the most commonly used regression methodology, which is used when the first year of collected data serves as the baseline year and the data can produce a statistically significant model. This method is good starting point for Better Plants companies since it lends itself to analyzing energy intensity improvements for several years into the future.

[13] Source: *Superior Energy Performance™ Measurement and Verification Protocol for Industry,* November 19, 2012.

Backcast: Backcasting uses the reporting period energy consumption to develop a linear model which is used to determine the expected baseline period consumption considering current conditions. If the modeled energy consumption in the baseline year is lower than the actual energy consumption in the baseline year, then the facility can conclude that their energy performance has improved.

The backcast method is useful when the reporting period data can produce a statistically significant model. This method normalizes energy consumption for prior years, and then in the future can be used to normalize future reporting years. The year after the first year the model is used, the method becomes the chaining method (described below), because the model is now applied both forward and backward in time.

Chaining: If a statistically valid model cannot be found using the reporting or baseline period data (i.e. p-values and r-squared values are not acceptable), a middle year between the baseline year and the reporting period can be used to create a model. The model developed for a middle year will be evaluated at both the baseline conditions and reporting period conditions to calculate a total improvement, provided the model is valid, according to the second validation check (described on page 17) for both the baseline and reporting periods. In this case, the middle year model is used to predict the energy consumption at both the baseline and reporting period conditions assuming the facility conditions are unchanged. DOE recommends partners base their models on twelve months of data. Expanding the time frame can improve the model year accuracy, but complicates the calculation of energy savings. Models developed using DOE's EnPI tool use twelve months of data.

Table 5 summarizes the model and normalized years to be used for each of these three types of regression methods.

Table 5: Model Year and Normalized Years for Regression Methods

	Forecast	Backcast	Chaining
Model Year (used to determine linear model)	Baseline Year	Current Year	12-month mid-period
Normalized Year(s)	Current Year	Baseline Year	Baseline Year & Current Year

To calculate changes in energy intensity by any of these methods, the data used to create the model (production, HDDs, CDDs, etc.) must be available for the baseline, model, and reporting period.

Typically, the Partner must develop a separate regression model for each fuel source consumed by the facility. In some cases, a variable might only be included with one fuel source. For example, for a facility where a substantial amount of the energy is used to cool a facility, CDD may only be important to electricity use, since most cooling systems are electric based. However, in some cases it may be best to develop a model with a variable that is the sum of multiple fuels. As an example, if the input fuel source to a boiler system changes throughout the year, developing a model that includes a variable that sums the total consumption of those fuels may be appropriate.

A Partner may find that different regression methods are most appropriate for different facilities within its scope boundary. The Partner is not confined to forcing one regression method onto all facilities or energy sources. The company can use forecasting at one facility, backcasting at another, and chaining at a third. DOE's EnPI tool can take the facility-level outputs and roll them into a corporate wide performance improvement metric, even when different regression methods are used at the facility level, and when no regression model is used at one or more facilities.

DOE recommends that users possess a basic understanding of statistical methods before applying regression techniques. Sources for additional information include *ASHRAE Guideline 14-2002 – Measurement of Energy and Demand Savings; International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings, Volume 1*; and Bonneville Power Administration's *Regression for M&V: Reference Guide*. Use of regression may not be advisable for all situations, such as when limited data exist for relevant variables.

Model Validity

To determine if a regression model is valid, several statistical measures are calculated. For example, the DOE EnPI tool generates *model p-values, variable p-values, and R^2-values* as tests of model validity. Better Plants follows the SEP™ tests for model validity, as given in Sections 3.4.5 and 3.4.6 of the Superior Energy Performance™ Measurement and Verification Protocol for Industry. The validation checks are explained further in the following text box.

Model Validity

Better Plants recommends two validation checks which can be done to ensure a model is valid for a given data set. These checks ensure the model can accurately predict the energy consumption for a given reporting period given a set of conditions. DOE's EnPI tool performs these checks automatically for users.

Validation Check 1 – Regression Statistics for the Model Year
For a model to be valid, the regression statistics for the model must meet the following criteria:

1. The p-value for the overall model fit must be less than 0.10
2. All independent variables included in the model must have a p-value of less than 0.20
3. At least one of the independent variables in the model must have a p-value of less than 0.10
4. The adjusted R^2 for the regression must be at least 0.50

The DOE EnPI tool produces two R^2 values. The R^2 value increases when a new term is added to a model, but the adjusted R^2 value only increases if the new term improves the model more than would be expected by chance. The adjusted R^2 value is used to rank possible models from most to least predictable since the value only increases if the variables included in the model improve the predictability of the model.

Validation Check 2 – Variable Relevance in the Model and Reporting Periods
For the model to be valid for calculating normalized energy consumption for surrounding reporting periods, the average of the independent variables used to calculate the normalized consumption from the model must fall within either:

1. The range of observed data that went into the model, OR
2. Three standard deviations from the mean of the data that went into the model

These validation checks are adopted from the SEP™ program. For additional information on model validity, see the SEP™ M&V Protocol.

Step 6. Calculate the Change in Energy Intensity from the Baseline Year for each Facility

The next step is to calculate the total improvement in energy intensity. The equation used for this calculation varies depending on which regression method analysis is used. The box below lists the equations used to calculate the *total improvement in energy intensity since baseline year* for forecasting, chaining, or backcasting regression methods. In the equations below, ***EC*** represents the actual energy use, $\widehat{EC}$ represents the modeled energy use, ***BY*** represents the baseline year, and ***CY*** represents the current year. DOE's EnPI tool will perform these calculations for the user.

Equation 2: Forecasting to determine Total Improvement in Energy Intensity

Forecasting (baseline year is selected as the model year)

$$\text{Total Improvement in Energy Intensity}_{CY} = \left(1 - \frac{EC_{CY}}{\widehat{EC}_{CY}}\right) \times 100\%$$

Equation 3: Chaining to determine Total Improvement in Energy Intensity

Chaining (a middle year between the baseline and current year is selected as the model year)

$$\text{Total Improvement in Energy Intensity}_{CY} = \left(1 - \frac{\widehat{EC}_{BY} \times EC_{CY}}{EC_{BY} \times \widehat{EC}_{CY}}\right) \times 100\%$$

Equation 4: Backcasting to determine Total Improvement in Energy Intensity

Backcasting (the current reporting year is selected as the model year)

$$\text{Total Improvement in Energy Intensity}_{CY} = \left(1 - \frac{\widehat{EC}_{BY}}{EC_{BY}}\right) \times 100\%$$

Example 7 illustrates the calculation for *total improvement in energy intensity* for a case using forecasting as the regression method. Organizations calculating total improvement in energy intensity without modeled values, i.e., using non-normalized energy data, should refer to Example 12.

Example 7: Calculating Total Change in Energy Intensity Using Modeled Values

Forecasting was selected as the regression method for the Rochester, Minnesota facility. The modeled 2012 energy consumption for the Rochester, Minnesota facility is calculated to be 921,189 MMBtu and the actual energy consumption for 2012 is calculated to be 843,772 MMBtu. Using the actual and modeled energy consumption, the *total improvement in energy intensity since baseline year* is calculated to be:

$$\text{Total Improvement in Energy Intensity}_{CY} = \left(1 - \frac{EC_{CY}}{\widehat{EC}_{CY}}\right) \times 100\% = \left(1 - \frac{843{,}772}{921{,}189}\right) \times 100\%$$

$$= 8.40\%$$

The positive *Total Improvement* indicates the Rochester facility performed more efficiently in 2012 than its baseline year of 2010.

Need for a New Model

Over the Better Plants participation period, circumstances may result in the need to develop a new model. This situation can occur when an existing model no longer meets the model validity criteria, when a facility begins producing a new product, or for some other situation. In many cases, changes to the production level will cause Validation Check 2 (see Model Validity text box on page 27) not to be met. If this situation occurs, the best solution may be to develop a new model that meets all validation checks for all years (e.g., pick a year near the mid-point and use the chaining method). The DOE EnPI tool can be very helpful in evaluating models. If the new model is valid, it can be used. If no new valid model can be developed, an "intermediate baseline year" can be established for the first year for which operating conditions match current conditions. A new model will then need to be developed either using data from the current year or the first year the operating conditions match current conditions. Then, total improvements in energy intensity from the original model (from baseline year to previous year) can be banked and summed with total improvements from the new model (forward from previous year).[14] While imperfect, this method will provide a good estimate of energy improvement during the duration of the pledge while ensuring a valid model is used for the remainder of the partner's commitment period. A diagram depicting this calculation is shown in Figure 4.

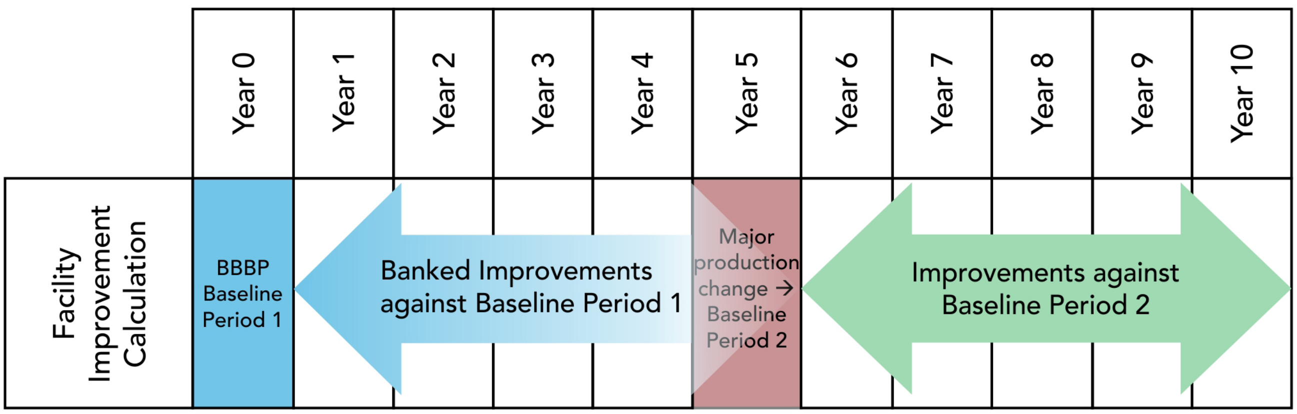


Figure 4: Facility Resets Baseline Year due to Production Shifts, No Change in Pledge Timeline.

Step 7. Aggregate the Data on Energy Intensity Change to the Corporate Level

Percentage changes at the corporate level are a weighted average of the individual facilities' energy intensity improvements based on energy consumption for the baseline year. The equation for aggregating the facility-level energy intensity improvements to determine the corporate total improvement in energy intensity is shown below.

Equation 5: Corporate Total Improvement in Energy Intensity

$$\textit{Total Improvement in Energy Intensity}_{Corporate} = \frac{\sum((ei_{Plant\ 1} \times ec_{Plant\ 1}) + (ei_{Plant\ 2} \times ec_{Plant\ 2}) + \cdots + (ei_{Plant\ n} \times ec_{Plant\ n}))}{\sum(ec_{Plant\ 1} + ec_{Plant\ 2} + \cdots + ec_{Plant\ n})} \times 100\%$$

[14] Companies using the facility-level approach may also use the banking method, if needed. In some cases, operations may change so significantly at an individual plant that current year energy intensity can no longer be usefully compared to baseline year energy intensity. In these cases, in consultation with DOE, companies can set an intermediate baseline year, bank prior year improvements made against the original baseline year, and sum those with improvements made against the new baseline year.

In equation 5, ***ei*** represents facility total improvement in energy intensity, ***ec*** represents facility modeled baseline energy consumption, and ***n*** represents the number of facilities. DOE's EnPI tool performs this calculation. If corporate level adjustments are required for the addition or closure of a plant, the adjustments should be made before calculating the *Corporate Total Improvement in Energy Intensity*. See Appendix C for additional information on corporate-level adjustments.

Example 8: Calculating Total Change in Energy Intensity at the Corporate Level

In Example 7, Acme Flooring calculated the total change in energy intensity for its Rochester facility for 2012. Knowing the energy consumption and total change in energy intensity for each facility, the total corporate-level change in energy intensity can be determined. The 2012 Total Improvement in Energy Intensity and baseline total modeled primary energy consumption values for all six Acme Flooring facilities are shown in the table below.

Table 6: 2012 Annual Improvements and Total Energy Consumption for Acme Flooring

	Plant	2012 Total Improvement in Energy Intensity	Baseline Total Modeled Primary Energy Consumption (MMBtu)
1	Cleveland, Ohio	7.34%	120,300
2	Ashland, Ohio	11.95%	340,000
3	Duluth, Minnesota	2.78%	320,100
4	Minneapolis, Minnesota	1.90%	859,660
5	Rochester, Minnesota	8.40%	843,772
6	Hastings, Minnesota	9.65%	765,000
		Total	**3,248,832**

For Acme Flooring, the corporate total change in energy intensity is calculated using Equation 5.

$$\textit{Total Improvement in Energy Intensity}_{Corporate}$$

$$= \frac{(7.34\% \times 120{,}300) + (11.95\% \times 340{,}000) + (2.78\% \times 320{,}100) + (1.90\% \times 859{,}660) + (8.40\% \times 843{,}772) + (9.65\% \times 765{,}000)}{(3{,}248{,}832)} \times 100$$

$$= \frac{219{,}390 \text{ MMBtu}}{3{,}248{,}832 \text{ MMBtu}} \times 100 = 6.75\%$$

Annual Improvement in Energy Intensity

After the *Total Improvement in Energy Intensity* is determined, calculate the *Annual Change in Energy Intensity for the Current Year*. This is done by subtracting the previous year's corporate total improvement in energy intensity from the current year's corporate total improvement in energy intensity. The following equation shows the calculation.

Equation 6: Annual Improvement in Energy Intensity

$$\text{Annual Improvement in Energy Intensity}_{\text{Current Year}}$$
$$= \text{Total Improvement in Energy Intensity}_{\text{Current Year}}$$
$$- \text{Total Improvement in Energy Intensity}_{\text{Previous Year}}$$

For a Partner selecting a baseline year that is two or more years earlier than the reporting year, the Partner will not have a previous report to draw upon when submitting its first annual report, and therefore no reported "Total Improvement in Energy Intensity for Previous Year" to use in Equation 6. In this situation, the Partner will use unreported data from the previous year to determine the *Total Improvement in Energy Intensity* for the Previous Year. For example, if a Partner joined the program in 2012 and set calendar year 2009 as its base year, the Partner's first annual report, covering calendar year 2012, will need to draw upon internal (unreported to DOE) energy data for 2011 when calculating energy intensity using Equation 6. If the baseline year and current year are consecutive years, then the annual improvement should equal total improvement for the first year.

Example 9: Calculating Annual Improvement in Energy Intensity

In 2012, Acme Flooring reported a total improvement in energy intensity since its baseline year (2010) of 6.75%. For 2013, the company's total improvement in energy intensity since its baseline year is 11.20%. On its 2013 report, Acme Flooring will report an annual improvement in energy intensity of:

$$11.20\% - 6.75\% = 4.45\%$$

The percentage is positive, indicating an improvement in energy performance from the previous year to the current year.

Step 8. Calculate Total and New Energy Savings

The final calculations required for the Better Plants annual report form are the "*Total Energy Savings since Baseline Year*" and "*New Energy Savings for the Current Year*." The calculation for the "*Total Energy Savings since Baseline Year*" is shown below in Equation 7. This corporate-level value is calculated automatically on the Better Plants annual report form. Additional guidance on how to calculate Adjustments is provided in Appendix C.

Equation 7: Total Energy Savings since Baseline Year

Total Energy Savings since Baseline Year (MMBtu)

$$= \text{Total Primary Energy Consumed}_{\text{Baseline Year}}$$
$$+ \text{Adjustment for Baseline Primary Energy}_{\text{Current Year}}$$
$$- \text{Total Primary Energy Consumed}_{\text{Current Year}}$$

The Total Energy Savings value represents an estimate of the energy savings resulting from the cumulative actions taken since the baseline year. "*New Energy Savings for Current Year*" represents an estimate of the energy savings accumulated since the previous reporting year and is calculated as shown below in Equation 8. This calculation is a part of DOE's EnPI tool.

Similar to how partners calculate annual percent improvement, the company may need to use unreported data if it is filing its first report and selected a baseline year two or more years back from when it joined the program. Therefore, for the previous example, the Partner needs energy data for the unreported year of 2011 to determine the *New Energy Savings for Current Year*.

Equation 8: New Energy Savings for Current Year

New Energy Savings for Current Year (MMBtu)

$$= \text{Total Primary Energy Consumed}_{\text{Previous Year}} + \text{Adjustment for Baseline Primary Energy}_{\text{Current Year}} - \text{Total Primary Energy Consumed}_{\text{Current Year}}$$

or

New Energy Savings for Current Year (MMBtu)

$$= \text{Total Energy Savings since Baseline Year}_{\text{Current Year}} - \text{Total Energy Savings since Baseline Year}_{\text{Previous Year}}$$

Facility-level Approach

The Regression-based Approach described above will generally provide the most accurate results for companies participating in Better Plants. This approach may not work for all companies, however. In those cases, the next best option is to use the Facility-level Approach.

Methodology

The Facility-level Approach is very similar to the Regression-based Approach, except regression analyses are not performed, and there is therefore no need to collect data on additional variables outside of production and energy use. Steps that make up the Facility-level Approach are:

1. Define the boundary
2. Choose a baseline year
3. Decide on the energy intensity denominator for each facility
4. Gather data on energy consumption and units of output for each facility
5. Calculate energy intensity for the baseline year and the current year for each facility
6. Calculate the change in energy intensity from the baseline year for each facility
7. Aggregate the data on energy intensity change to the corporate level
8. Calculate total and annual energy savings

Data Needs

For the Facility-level Approach, energy intensity is defined as the amount of energy consumption over a given time period per unit of output. Fewer data sets need to be collected for the Facility-level Approach than the Regression-based Approach. Only total primary energy consumption and total units of output for each facility are needed. Data on relevant variables that could affect energy consumption such as temperature, humidity, etc. do not need to be collected. Additionally, annual energy consumption and production data are sufficient for this approach, whereas monthly data are needed for the regression-based approach. While primarily designed for determining energy performance through regression analysis, the DOE EnPI tool is also useful for the Facility-level approach.

As shown in Equation 9, energy intensity is typically a ratio of actual energy consumed per year (the numerator) divided by a physical unit of output being produced (the denominator).

Equation 9: Facility-Level Energy Intensity

$$\text{Energy Intensity} = \text{Total Energy Consumption} / \text{Total Units of Output}$$

In Equation 9, "total units of output" should be the factor having the largest impact on energy consumption in the facility. Typically, this denominator will be the production for a facility. When a facility makes multiple products within a plant, and has a submetering system in place, DOE recommends tracking the energy consumption to produce each product separately, especially if it is known that the energy intensity varies greatly from product to product. This allows for a more accurate calculation of the energy intensity improvement from year to year.

When this is possible, energy intensity change at the facility is calculated by taking a weighted average of each product line's percent change, similar to how facility-level changes at each facility are rolled up into a corporate wide metric in step 7. In this case, the weighting is the baseline energy use (in absolute terms) of the individual product lines. See Example 10 for an illustration on how to aggregate the *Improvement in Energy Intensity* for multiple products with submetering in place to determine the plant-level *Total Improvement in Energy Intensity*.

Effective energy management requires measuring and monitoring energy consumption at critical points throughout a facility. This will be especially true for companies seeking to track energy consumption by product groups. Companies without existing submetering in place will want to consider installing submeters to collect energy consumption information for key production lines or processes. This may involve installing electrical submeters at key electrical panels, sub-panels, or circuits within a panel. Installing submeters on key steam distribution or compressed air distribution lines may be necessary as well. DOE's Federal Energy Management Program has published Metering Best Practices: A Guide to Achieving Utility Resource Efficiency[15] for organizations looking for an introduction to metering and submetering technologies. The guide also includes several case studies.

When submetering is not in place, only one unit of output can be selected for the "total units of output." If multiple dissimilar products are produced within a given facility, different approaches can be used to develop an energy intensity metric for that facility. A company without a submetering system in place should consider developing a "standard unit of output." Essentially, a "standard unit of output" is one unit that represents the breadth of products produced at the facility. For example, if a facility produces multiple types of flooring but cannot determine the energy consumption associated with the production of each type, the facility could select "square feet of flooring" as the standard unit of output when calculating the energy intensity for the facility. This approach is most appropriate when the relative energy intensity of the different product types does not vary significantly.

When energy intensity varies significantly among products produced, and the facility lacks a submetering system, engineering judgment can be applied to estimate the relative energy intensities of the different product types. From there, the company can create a "standard unit of output" with an energy intensity equivalent to a weighted average of the estimated intensities of the individual products being produced. If estimating the relative energy intensities of the different products cannot be done, other denominators, such as revenue, value added, or square feet of floor space, may be acceptable.

Table 7 shown below lists the different methods for selecting a "standard unit of output" in order of expected accuracy.

[15] www1.eere.energy.gov/femp/pdfs/mbpg.pdf

Table 7: Methods for Grouping Multiple Different Products at a Facility

Method Type	Data Needs	Method for grouping products
Product Line Approach	Annual submetered energy data for each production line and total annual number of units produced per production line	Calculate the energy intensity metric for each production line separately. This approach may require extensive submetering but often leads to the most accurate calculation. After calculating the energy intensity and *total improvement in energy* for each product line, aggregate the *total improvement in energy intensity* for each production line using Equation 5 to determine the facility-level *total improvement in energy intensity*.
Standard Unit of Output: Energy Intensity	Annual total energy consumption for the facility, annual number of units produced per production line and the relative energy intensity for each production line at the facility	Develop a “standard unit of output” based on relative energy consumption needed to develop each product (i.e. relative energy intensity). First estimate the approximate percent of total energy consumption required to produce each product (e.g. product 1 requires 80%, product 2 requires 20%). Using the estimated percentages, determine the weighted energy intensity for each product (e.g. 0.8 MMBtu/unit and 0.2 MMBtu/unit). Note: Relative to the Product Line Approach, this method does not require submetered data, but does require the relative energy intensity of each production line. This approach is typically the second most accurate method; however, it requires an estimation of the relative energy needs of each process.
Standard Unit of Output: Other	Annual total energy consumption for the facility and total annual number of units produced per production line	Develop a “standard unit of output” based on a metric other than energy intensity, such as the mass or area of output. Company accounting staff may have an equivalent metric suitable for this approach. The ratio of annual energy consumption to mass or area (or other selected metric) would be used in place of the energy intensity in Equation 5. This is the recommended method when submetered energy data is not available and the relative energy intensities of each product are not known, since the energy consumption often has a higher correlation to mass or area than revenue or labor hours.
Non-output-based Approach	Annual total energy consumption for the facility and annual revenue or labor hours for the facility	Use an alternative unit of output other than production, such as revenue, labor hours, etc. The ratio of annual energy consumption to annual revenue or labor hours would be used in place of the energy intensity in Equation 5. See Example 12 for additional information on how to use this approach. A benefit of this approach is that the necessary data is often easy to obtain. However, it is the least accurate of the approaches since the revenue or labor hours may not be directly correlated to the energy consumption of the facility.

Once the energy intensity for each production line or the entire facility is determined, the *Total Improvement in Energy Intensity* should be calculated using Equation 10 shown below. Equation 10 can be used to calculate the Total Improvement for each production line or the entire facility depending on the method used to group the production data (see Table 7).

Equation 10: Facility-Level Total Improvement in Energy Intensity

Total Improvement in Energy Intensity (%)

$$= \frac{\text{Energy Intensity}_{\text{Baseline Year}} - \text{Energy Intensity}_{\text{Current Year}}}{\text{Energy Intensity}_{\text{Baseline Year}}} \times 100$$

Improvements in energy intensity should be a positive percentage. If the energy intensity worsens, the Total Improvement in Energy Intensity will be a negative value.

Example 10: Calculating Non-normalized Energy Intensity with Submetered data

Acme Flooring's Ashland, Ohio plant manufactures two types of flooring; each type with a different energy intensity metric. If only aggregate energy data for the production of the flooring were available, the Ashland plant could select a single unit of output that represented the breadth of products produced at the plant. For example, 'square feet of flooring' could be used for its unit of output. The plant may also choose other appropriate units, such as mass of shipments or number of tiles. This method could lead to inaccuracies if the energy intensities for the two products are quite different and the relative amount of output for each product changes over time.

However, the Acme Ashland plant has meters on each of its production lines and is able to determine the energy consumption associated with each product. In addition, the Ashland plant would like to understand the differences in energy required to produce each type of flooring. Therefore, the Ashland plant opts to track the energy consumption separately for each type of product. The units of output selected by the Ashland plant are shown in table 8:

Table 8: Units of Output for Acme Flooring Ashland Plant

Submeter	Energy Sources	Unit of Output Selected
Ceramic tile production line	Electricity, Natural Gas	Tons of ceramic tile
Porcelain tile production line	Electricity, Natural Gas	Tons of porcelain tile

After selecting the units of output, Acme calculates the 2011 energy intensity change for its Ashland plant versus its baseline year of 2010. The production lines, baseline energy use, baseline production, 2011 energy use, and 2011 production for the Ashland plant are shown in table 9:

Table 9: Calculation of Energy Intensity for Acme Flooring Ashland Plant

Submeter	2010 (baseline) Primary Energy Consumption (MMBtu)	2010 (baseline) Output	2011 Primary Energy Consumption (MMBtu)	2011 Output
Ceramic tile production line	340,000	18,600 tons of ceramic tile	355,000	19,200 tons of ceramic tile
Porcelain tile production line	300,300	20,500 tons of porcelain tile	320,000	22,200 tons of porcelain tile

For the ceramic tile production line, the energy intensity for 2010 and 2011 are calculated as:

2010 Energy Intensity (Ceramic) = 340,000 MMBtu / 18,600 tons of ceramic tile = 18.28 MMBtu/ton of ceramic tile
2011 Energy Intensity (Ceramic) = 355,000 MMBtu / 19,200 tons of ceramic tile = 18.49 MMBtu/ton of ceramic tile

Ashland then repeats this calculation for the porcelain tile production line.

2010 Energy Intensity (Porcelain) = 300,300 MMBtu/20,500 tons of porcelain tile = 14.65 MMBtu/ton of porcelain tile
2011 Energy Intensity (Porcelain) = 320,000 MMBtu/22,200 tons of porcelain tile = 14.41 MMBtu/ton of porcelain tile

Example 10 continued on the next page…

Example 10 continued…

Using the energy intensities calculated above, the Ashland plant next calculates 2011 total improvement in energy intensity by aggregating **energy intensity improvements** for the porcelain and ceramic production lines. First, the 2011 energy intensity improvement for each production line is calculated using equation 10.

Ceramic Tiles:

$$\text{2011 Total Improvement in Energy Intensity (\%)}_{Ceramic} = \frac{\text{Energy Intensity}_{2010} - \text{Energy Intensity}_{2011}}{\text{Energy Intensity}_{2010}} \times 100$$

2011 Total Improvement in Energy Intensity $(\%)_{Ceramic}$ = 18.28 – 18.49 / 18.28 ×100 = –1.15%

The negative total improvement in energy intensity represents worsening energy intensity. Acme repeats this calculation for Ashland's porcelain tile production line and determines the 2011 improvement to be 1.60%. Using these values, Acme calculates the 2011 total improvement in energy intensity for the Ashland plant using equation 5:

$$\text{2011 Total Improvement in Energy Intensity}_{Ashland} = \frac{((ei_{ceramic} \times ec_{ceramic}) + (ei_{Porcelain} \times ec_{Porcelain}))}{(ec_{ceramic} + ec_{Porcelain})} \times 100$$

where ***ei*** represents the total improvement in energy intensity for a given production line and ***ec*** represents the baseline energy consumption for the given line. Using the equation above, the total improvement in energy intensity for the Ashland plant is calculated as:

$$\text{2011 Total Improvement in Energy Intensity}_{Ashland} = \frac{((-1.15\% \times 340{,}000) + (1.60\% \times 300{,}300))}{(340{,}000+300{,}300)} \times 100$$

2011 Total Improvement in Energy $\text{Intensity}_{Ashland}$ = 0.14%

Since the total improvement in energy intensity is positive, as a whole, the Ashland facility improved its energy performance. However, based on the calculations for each production line, Acme sees that the energy performance of its ceramic tile production line worsened and the energy performance of its porcelain tile production line improved.

Adjustments may need to be made to account for significant changes at the facility level. Examples of scenarios in which facility-level adjustments may be necessary include:

- A facility makes more than one product and decides to close one production line.
- A facility is closed for an extended (but temporary) period of time.
- A facility consists of multiple buildings and the Partner closes one of the buildings.
- A facility converts a large office space to manufacturing use.

Adjustments for facility-level changes should be made prior to calculating plant level *Total Improvement in Energy Intensity* and corporate level *Total Energy Savings since Baseline Year*. Example 11 shown below illustrates how to make an adjustment for a production line closure prior to calculating the *Total Improvement in Energy Intensity*.

Example 11: Closing a Production Line

The following example illustrates how to calculate plant-level energy intensity improvements while adjusting for production line closures.

At the beginning of 2012, the Ashland facility shut down its porcelain tile production line due to limited market demand. Because of this market shift, production on other lines and at other facilities did not change. The energy consumption for its porcelain and ceramic tile production lines for 2010, 2011, and 2012 are shown below.

Table 10: Ashland Plant Energy Consumption and Production

	2010		2011		2012	
Type of tile produced	porcelain	ceramic	porcelain	ceramic	porcelain	ceramic
Tons of tile produced	20,500	18,600	22,200	19,200	0	21,000
Total Primary Energy Consumption for the production of tiles (MMBtu)	300,300	340,000	320,000	355,000	0	338,000
Total Energy Consumption (MMBtu)	640,300		675,000		338,000	

An adjustment must be made to the baseline year energy consumption value before Acme Flooring can calculate Ashland's *Total Improvement in Energy Intensity* and *Total Energy Savings since Baseline* year for 2012. The adjustment for this example is the energy consumption for porcelain tile production in 2010, which is 300,300 MMBtu.

When calculating the 2012 total improvement, Ashland should only include the ceramic tile production line since the porcelain production line was closed in 2012.

2011 Total Improvement in Energy Intensity (%)

$$= \frac{\text{Adjusted Energy Intensity}_{\text{Baseline year}} - \text{Energy Intensity}_{\text{Current Year}}}{\text{Adjusted Energy Intensity}_{\text{Baseline year}}} \times 100$$

$$\text{2011 Total Improvement in Energy Intensity (\%)} = \frac{340{,}000/18{,}600 - 338{,}000/21{,}000}{340{,}000/18{,}600} \times 100$$

The 2012 Total Improvement in Energy Intensity for the Ashland plant is 11.95%.

Then the total energy savings since baseline year for 2012 is:

Total energy savings since baseline year2012

$= \text{Total Primary Energy Consumed}_{\text{Baseline}}$
$+ \text{Adjustment for Baseline Primary Energy}_{\text{Production Closures}}$
$- \text{Total Primary Energy Consumed}_{2012}$

Total energy savings since baseline year$_{2012}$ = 640,300 + (–300,300) – 338,000 = 2,000 MMBtu

Corporate-level Approach

Methodology

The Corporate-level Approach is similar to the Facility-level Approach, except that all facilities within the Program are treated as one composite facility. In Step 4, energy consumption data and production data (unit of output) are gathered and summed for all facilities, and Step 7 of the Facility-level Approach does not apply. All facilities must be using the same denominator when calculating energy intensity to use the Corporate-level Approach. As with the Facility-level Approach, the Corporate-level Approach draws heavily from the steps described in the Regression-based Approach, and the DOE EnPI tool can greatly simplify the calculation process. The steps for the corporate-level approach are:

1. Define the boundary
2. Choose a baseline year
3. Decide on the corporate-wide energy intensity denominator
4. Gather data on energy consumption and the corporate-wide energy intensity denominator—usually units of output, revenue, or some other financial metric
5. Calculate energy intensity for the baseline year and the current year
6. Calculate the change in energy intensity from the baseline year
7. Calculate total and new energy savings

Data Needs

If all facilities are using the same unit of output, then the Facility-level Approach and Corporate-level Approaches are mathematically the same. In this case, DOE still recommends that companies track energy consumption and energy intensity at their individual facilities. This allows companies to benchmark facilities against one another and determine which facilities are improving at the fastest rates or which facilities require closer monitoring of their energy performance.

Use of Revenue in Determining Energy Intensity

An option for companies with complex mixes of products is the use of a financial measure such as revenue or value added as the energy intensity denominator. A significant issue with this option is the lack of a direct relationship between energy consumption and revenue in many cases, leading to less accurate measurements of the impact of energy improvement actions on energy intensity. Also, product price fluctuations may impact the energy intensity metric in ways that are unrelated to energy efficiency actions. Companies using a financial measure to calculate energy intensity must normalize their figures based on an economic deflator or a price index such as the U.S. Bureau of Labor Statistics' Consumer Price Index (CPI). In general, use of financial measures should be used only if other measures of intensity are impractical, and after consultation with DOE. Companies participating in DOE's SEP™ program may not use a financial unit of output.

The following is a recommended method and guidance for possible indices that can be used when determining energy intensity using financial metrics. The company may elect to use other industry-specific indices as long as they are externally generated and publically available. Regardless of the index selected, it should be used consistently for each annual report while involved in the program.

Changing Nominal to Real Value[16]: To transform a series into real terms, two items are needed: the nominal data and an appropriate price index. The nominal data series is simply the data measured in current dollars. The appropriate price index can come from any number of sources. Among the more prominent price indices are the Consumer Price Index (CPI), the Producer Price Index (PPI), the Personal Consumption Expenditure (PCE) index and the GDP deflator (see Figure 5).

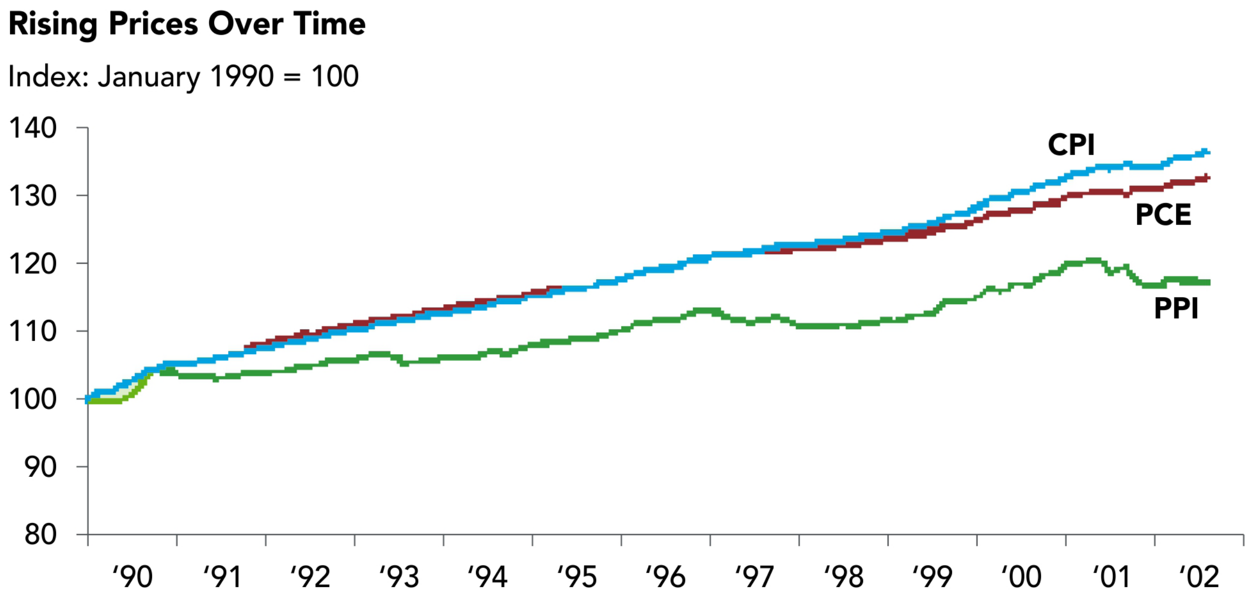


Figure 5: Example Price Indices (source: Federal Reserve Bank of Dallas)

Common price indices measure the value of a set of goods in a certain time period, relative to the value of the same set in a base period. They are calculated by dividing the value of the set of goods in the year of interest by the value in the base year. By convention, this ratio is then multiplied by 100. Generally speaking, price indices are set to 100 in a given base year for convenience and reference. To use a price index to deflate a nominal series, the index must be divided by 100 (decimal form). The formula for obtaining a real series is given by dividing nominal values by the price index (decimal form) for that same time period.

Equation 11: Real Value

Real Value = (Nominal Value) / (Index Value (decimal form))

[16] From the Federal Reserve Bank of Dallas website, www.dallasfed.org/research/basics/nominal.cfm

Example 12: Calculating Total Improvement in Energy Intensity using Revenue

Consider a company which has a baseline year of 2005 and is determining its Total Improvement in Energy Intensity for 2009 using revenue as the output. The company's nominal revenue and primary energy consumption for 2005 through 2009 are shown in Table 11. Also shown are the consumer price index (CPI) values for 2005 through 2009 and the ratio of each year's CPI to the 2005 CPI.

Table 11: Nominal Revenue

Year	Primary Energy Consumption (MMBtu)	Nominal Revenue	CPI	Ratio of CPI for the current year to the 2005 CPI*
2005	253,000	$ 20,500	195.3	1.000
2006	255,000	$ 23,500	201.6	1.032
2007	261,300	$ 26,400	207.3	1.061
2008	258,600	$ 28,000	215.3	1.102
2009	252,500	$ 28,400	214.5	1.098

* Rounded

The real revenue for each year is calculated using equation 11.

$$\text{Real Value} = \frac{\text{Nominal Value}}{\text{Index Value (decimal form)}}$$

$$\text{Real Value}_{2009} = \frac{\text{Nominal Value}}{\text{Index Value (decimal form)}} = \frac{\$28{,}400}{1.098} = \$25{,}858$$

Next, the energy intensity for 2005 and 2009 is calculated using equation 9.

$$\text{Energy Intensity}_{2005} = \frac{\text{Total Energy Consumption}}{\text{Total Units of Output}} = \frac{253{,}000}{\$20{,}500} = 12.341$$

$$\text{Energy Intensity}_{2009} = \frac{252{,}500}{\$28{,}400} = 9.767$$

Finally, equation 10 is used to calculate the corporate total improvement in energy intensity for 2009.

$$\text{Total Improvement in Energy Intensity (\%)}_{2009}$$

$$= \frac{\text{Energy Intensity}_{\text{Baseline Year}} - \text{Energy Intensity}_{\text{Current Year}}}{\text{Energy Intensity}_{\text{Baseline Year}}} \times 100$$

$$\text{Total Improvement in Energy Intensity (\%)}_{2009} = \frac{12.341 - 9.767}{12.341} \times 100 = 20.86\%$$

Table 12 shown below provides a summary of the real revenue, energy intensity, and total improvement for 2005 through 2009.

Table 12: Nominal Revenue

Year	Primary Energy Consumption (MMBtu)	Nominal Revenue	Ratio of CPI for the current year to the 2005 CPI*	Real Revenue	Energy Intensity (MMBtu/$)	Total Improvement in Energy Intensity
2005	253,000	$ 20,500	1.000	$20,500	12.341	--
2006	255,000	$ 23,500	1.032	$22,766	11.201	9.24%
2007	261,300	$ 26,400	1.061	$24,872	10.508	14.86%
2008	258,600	$ 28,000	1.102	$25,399	10.182	17.50%
2009	252,500	$ 28,400	1.098	$25,858	9.757	20.86%

Appendix A. Unit Conversion Factors and Primary Energy Multipliers for Other Energy Sources

Table 13: Site to Primary Energy Conversion Factors

Energy Source	Delivery Measurement Units	Unit Conversion Factor		Production energy conversion multiplier formula	Production energy conversion default factor	Electric Energy Primary Conversion Multiplier
Steam	Pounds	Per steam tables[17] (temperature and pressure must be known)	BTU/lb	1/Combustion system efficiency (applicable for non-electric boilers)	1.33 (applicable for non-electric boilers)	1.0 for fired boilers 3.0 for electric boilers
Hot water	Hot water volume (gallons/ year) multiplied by temperature difference between pre-heated and delivered hot water	8.34	Btu/gal°F	1/combustion system efficiency (applicable for non-electric boilers)	1.33 (applicable for non-electric boilers)	1.0 for fired boilers 3.0 for electric boilers
Chilled Water	Cooling demand in ton-hours/ year	12,000	Btu/ton-hour	1/Coefficient of Performance (COP)	1.25 Absorption chiller default 0.83 Engine-driven compressor default	1.0 1.0
Chilled Water	Chilled water volume (gallons/ year) Multiplied by temperature difference between the pre-chilled and chilled water	8.34	Btu/(gal°F)		.24 Electric-driven compressor	3.0
Compressed Air[18]	Volume (ft^3) at 100 psi, for motor driven compressors	10.93	Btu/ft^3	1	1	3
Solar	kWh	3412	Btu/kWh	1	1	1
Wind	kWh	3412	Btu/kWh	1	1	1

Source: Superior Energy Performance™ Measurement and Verification Protocol for Industry, November 19, 2012

[17] Values taken from steam tables should subtract out the enthalpy (Btu/lb) of water at inlet conditions

[18] Compressed air default value assumes a motor driven compressor at 100 psi only. The value of compressed air as an energy source under other conditions can be calculated using site-specific conditions of delivered pressure, the efficiency of the compression equipment for the compression ratio needed at the delivered pressure, the altitude, the efficiency of the part load control mechanisms and controls, and the efficiency of the motor(s), engines or turbines driving the compression equipment

Appendix B. ISO 50001 and Superior Energy Performance™

ISO 50001 Overview

The ISO 50001 energy management standard is an international framework for industrial facilities, commercial facilities or entire organizations to manage energy, including all aspects of procurement and use.[19] The standard provides organizations and companies with technical and management strategies to increase energy efficiency, reduce costs, and improve environmental performance. ISO 50001 was published as an International Standard in June 2011 and is now available from the American National Standards Institute (ANSI) for purchase[20].

DOE provides a web-based toolkit, the DOE eGuide for ISO 50001[21], to help organizations implement an energy management system consistent with ISO 50001. This self-paced module guides organizations throughout the implementation process—from making an initial decision to utilize an energy management system to successfully implementing it. The eGuide includes forms, checklists, templates, and examples for developing and implementing an energy management system. Organizations new to energy management can use the DOE eGuide Lite[22] tool to learn about the basics of better energy management. See www1.eere.energy.gov/energymanagement/ for additional information.

Superior Energy Performance™ Overview[23]

Superior Energy Performance™ (SEP™) is a certification program that provides industrial facilities with a roadmap for achieving continual improvement in energy efficiency while maintaining competitiveness. The program provides a transparent, globally accepted system for validating energy performance improvement and management practices. SEP™ is accredited by the American National Standards Institute (ANSI) and the ANSI-ASQ National Accreditation Board (ANAB).

A central element of SEP™ is implementation of the ISO 50001 energy management standard, with additional requirements to achieve, verify, and document energy performance improvements. All industrial facilities pursuing certification must demonstrate an improvement in energy performance. This program provides companies with a framework for fostering energy-efficiency at the facility level and a methodology for measuring and verifying energy efficiency/performance improvements. The program will emphasize transparency through measurement and verification of energy performance improvement and savings.

SEP™ is facility-focused, whereas Better Plants has a corporate focus. SEP™ will have additional requirements relative to Better Plants, including ISO 50001 certification, reporting, auditing, and the resetting of the baseline every three years due to the SEP™ re-certification process. Requirements and procedures for measurement and verification are detailed in the *Superior Energy Performance™ Measurement and Verification Protocol for Industry*.

For additional information on SEP™, see http://superiorenergyperformance.energy.gov/.

[19] Source: superiorenergyperformance.energy.gov/

[20] webstore.ansi.org/RecordDetail.aspx?sku=ISO+50001%3a2011&source=doe

[21] ecenter.ee.doe.gov/EM/SPM/Pages/Home.aspx

[22] ecenter.ee.doe.gov/EM/SSPM/Pages/home.aspx

[23] Source: *Superior Energy Performance™ Certification Framework*

Energy Performance Indicators

A Better Plants Partner participating in SEP must also define its energy intensity through an SEP™ Energy Performance Indicator (SEnPI) calculation. SEnPI is the ratio of reporting-period energy consumption to baseline consumption, where one or both of these consumption quantities are adjusted for consistent conditions. Baseline consumption represents the consumption that would have occurred during the reporting period in the absence of energy performance improvements. For the calculation of the SEnPI, the reporting-period and/or baseline consumption must be adjusted so that they represent consistent production levels and other external conditions. Thus, the SEnPI is the ratio of normalized reporting-period energy consumption to normalized baseline-period energy consumption. The **energy performance improvement** is defined in the *Superior Energy Performance™ Measurement and Verification Protocol for Industry* (M&V protocol) as one minus this ratio (or 100% minus the ratio expressed as a percent). Thus,

Equation 12: Superior Energy Performance™ Energy Indicator

Total Improvement in Energy Intensity (%)

$$\text{SEnPI} = \frac{\text{Normalized Reporting Period Energy Consumption}}{\text{Normalized Baseline Energy Consumption}}$$

(Note: The reporting period and baseline consumption must be in consistent units, and one or both is adjusted so that they correspond to consistent conditions.)

and

Equation 13: SEP™ Energy Performance Improvement

$$\text{Energy Performance Improvement (\%)} = (1 - \text{SEnPI}) \times 100$$

with the *Reporting Period Energy Consumption and Baseline Energy Consumption* defined within Table 3.2 of the M&V protocol.

The SEnPI is a slightly different metric than what Partners calculate through the Regression-based Approach described in this document. But the same principles apply in terms of using regression analysis to arrive at a more accurate measure of energy efficiency improvement while controlling for factors, such as weather and production. Partners participating in SEP™ can use their plant-level SEnPIs and roll those up to the corporate level for Better Plants, provided the SEP™ and Better Plants baseline years are aligned.

If using SEnPI, please refer to the guidance provided in section 3.1 of the M&V protocol, which is available at http://superiorenergyperformance.energy.gov/

Appendix C. Accounting for Changes to Better Plants Pledge Scope

The facilities operated by a Partner and included in the pledge scope may change over the 10-year time period covered by the program. If facilities are removed from a pledge scope, they will no longer be a part of the Partner's annual reporting. If facilities are added to the scope, Partners should incorporate them into the program commitment.

The guidelines for handling changes to the pledge scope were designed to: 1) encourage the inclusion of all new facilities in the corporate-wide commitment, 2) reward Partners appropriately for building energy-efficient new construction, and 3) clarify the accounting for facilities closed or divested during program participation. To the extent possible, program guidelines are consistent with other protocols for tracking energy and greenhouse gas emissions savings, including EPA Climate Leaders, World Resources Institute, and ENERGY STAR Leaders.

Scenarios such as the addition or closure of an existing facility will often require an adjustment to the baseline energy consumption. Exceptions may be made for facilities added or eliminated within a given year that, when combined, account for less than 5% of the total baseline year energy consumption. The energy accounting procedure for acquired facilities will depend on whether the facility is new construction or an existing facility. When an adjustment is required, it should be made prior to calculating *Total Improvement in Energy Intensity* and *Total Energy Savings since Baseline Year*, unless otherwise noted. Note: facilities should only be included in these calculations if a full reporting year of data is available for those facilities.

The section below includes guidelines that apply to changes to the pledge scope after the baseline year. The approach taken to account for the closure or addition of a facility depends on whether the plant uses regression analysis to normalize the energy consumption for a given facility. Adding a facility to the scope can be slightly more complex when using the Regression-based Approach if sufficient baseline year data does not exist to create a valid regression model. Steps to overcoming this challenge are described later in this section.

Adding a New Facility

Scenario

A company constructing a new facility after the baseline year should include this new facility in reports to DOE once a full year of reporting data is available. For example, if a Partner has a baseline year of 2008 and builds a new plant in middle of 2009, the new plant should be included in the 2010 annual report form. If the new facility, combined with any other U.S. based facilities excluded from the pledge, makes up less than 5% of the Partners total baseline energy consumption, the Partner may choose to exclude the new facility from the annual report form.

Accounting Guidelines

First, adjust the baseline energy consumption to account for the addition of the new facility. This is accomplished by adding the energy consumption corresponding to the first full reporting year that the new facility is fully operational to the corporate baseline energy consumption.

The method for calculating *Total Improvement in Energy Intensity* depends on which approach the Partner selects for calculating energy metrics for the Better Plants annual report (Regression-based Approach, Facility-level Approach, or Corporate-level Approach), as described below.

Regression-based Approach

If the company decides to use the Regression-based Approach, a facility that produces a similar product in a similar geographic region is needed for comparison. A model must be developed based on either the similar facility's baseline period or the new facility's first reporting year. If a model is developed based off the similar facility's baseline period, forecasting is used to calculate the **energy performance indicators** for the new facility's first year in which 12 months of energy, production, and other relevant variables are available. If a model is developed based on the first 12 month period in which energy, production, and other relevant variables are available for the new facility, the model should be applied to the similar facility's baseline period using backcasting.

For the second report (2 years after the baseline), create a new model using the first 12 months in which energy data is available for the new facility. Add the total improvement from the second report to the total improvement calculated for the first year after the baseline period.

If the company does not have similar facilities making similar products, the facility's energy and relevant variable data (e.g. production, weather, etc.) for the first full reporting year of operation can be used to develop a regression model (even though the year is different) and to determine the *Total Improvement in Energy Intensity*.

Facility-level Approach

The improvement in energy intensity for the first 12 months of operation should be calculated by comparing the energy intensity of the new facility to the average baseline energy intensity of similar facilities. Two facilities are considered similar if they produce the same or similar products, are located in the same geographic region and are similar sizes. After the first full reporting year of operation, the total improvement can be calculated by comparing the new facility's energy intensity for that year to the energy intensity of a similar plant corresponding to the baseline year. An average energy intensity from multiple similar plants can also be used for the baseline energy intensity in the improvement in energy intensity calculation.

For the second full year the new facility is in operation, calculate the annual improvement by comparing the new facility's second year energy intensity to the new facility's first year energy intensity. Add the annual improvement to the total improvement for the previous year to calculate the *Total improvement in Energy Intensity* for the second year.

As with the Regression-based Approach, if the company does not have similar facilities making similar products, the energy intensity for the new facility's energy and production data for the first full reporting year of operation must be used as the baseline data (even though the year is different) when calculating *Total Improvement in Energy Intensity*.

Corporate-level Approach

If the Partner decides to use the Corporate-level approach, the energy consumption for the new facility is added to the numerator when calculating energy intensity for the first reporting period. The unit of output for the facility, which will be the same unit of output used for all the Partner's facilities included in the pledge, should be added to the denominator.

Example 13 starting on page 56 considers an adjustment for the construction of a new facility.

Adding an Existing Facility

Scenario

An acquired *existing* facility will require an adjustment to the company's baseline. An example of an addition of an existing facility is a Partner purchasing a facility that is fully operational upon purchase, needing no major renovations, and transitioning to the Partner with minimal interruption in production.

Accounting Guidelines

If possible, the company should obtain historical energy data for the acquired facility dating back to the company's baseline year, or as far back as possible up to the baseline year. The historical data corresponding to the Partner's baseline year is used to determine the baseline model or calculate the baseline energy intensity, depending on the approach the Partner uses to calculate the *Total Improvement in Energy Intensity*.

Prior to calculating the *Total Energy Savings since Baseline Year*, an adjustment is required to the Partner's corporate baseline energy consumption. The Partner must add the acquired facility's energy consumption to the corporate baseline energy consumption for either the baseline period, or a reporting year between the Partner's baseline period and the acquired facility's first reporting year.

If historical data are not available, the company should treat the facility as a newly constructed facility and use the methodology described in the previous section to calculate the *Total Improvement in Energy Intensity and Total Energy Savings since Baseline Year*.

Closing or Selling Facilities

Scenario

A facility that is sold, closed, or otherwise removed from the corporate boundary will necessitate an adjustment to the baseline to remove the facility from the baseline year. If all production for the affected facility is shifted to another facility that produces a similar product, an adjustment does not need to be made to the baseline year for the closed facility.

Accounting Guidelines

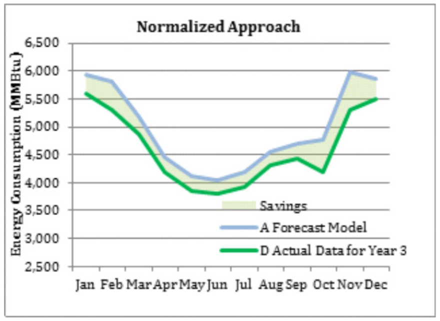
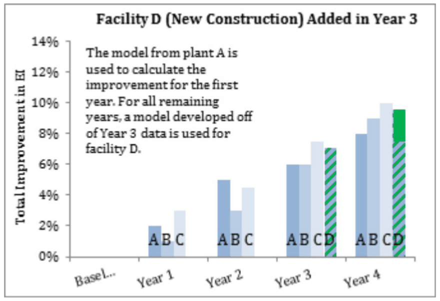
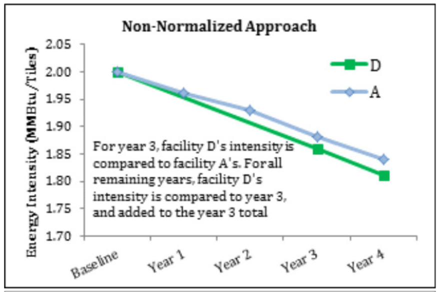
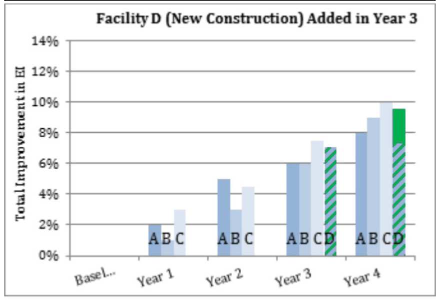
If a facility is closed or sold, the Partner should exclude the facility from its calculations completely, including removing it from both the baseline energy consumption and reporting year energy consumption values. This means the facility will not factor into calculations for new and total energy savings and annual and cumulative percent improvement. Companies should exclude plants from their calculations that are sold in the middle of a reporting year. For example, if a Partner reports along a calendar year and a facility is closed in June 2011, the facility should be excluded from the 2011 Better Plants annual report calculations since fewer than 12 months of data are available. This guidance applies to all methods of energy performance tracking – Regression-based, Facility-level, and the Corporate-level approach.

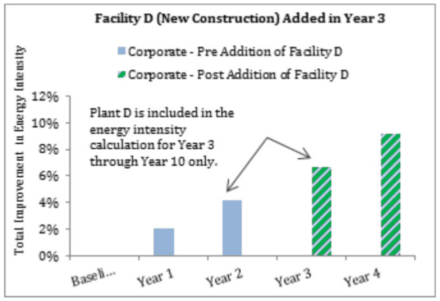
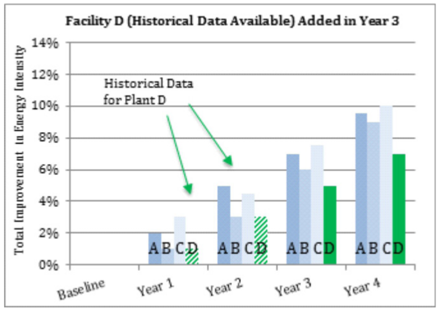
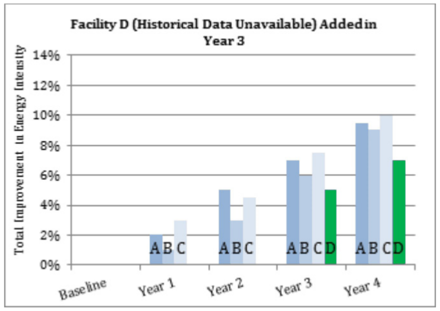
Other Pledge Scope Changes

Other significant corporate level scope changes may arise for Partners. As part of reporting energy information to DOE every year, Partners should notify DOE of such changes and report energy information accordingly using the text box on the annual report form labeled "*Please describe any methods undertaken to normalize energy intensity data or adjust baseline data to account for economic and other factors that affect energy use*." If a Partner experiences any significant scope changes that are not addressed by the guidelines above, the Partner should contact DOE for guidance.

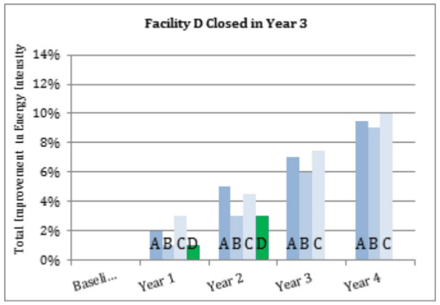
The following table summarizes the different scenarios described above, and explains the values that should be entered in the *Adjustment for Baseline Primary Energy* input box on the annual report form, along with a description of how to calculate the *Total Improvement in Energy Intensity*.

Table 14: Scope Changes Requiring a Baseline Adjustment

SCENARIO	ADJUSTMENT TO CORPORATE BASELINE ENERGY CONSUMPTION	METHOD FOR CALCULATING TOTAL IMPROVEMENT IN ENERGY INTENSITY	EXAMPLE
New Construction (Regression-based Approach): A newly built facility is added to the pledge scope and the Partner uses regression analysis to calculate the percent improvement in energy intensity.	Add the new facility's energy consumption for the first full reporting year for which data are available to the corporate baseline energy consumption.	Use a model from a facility producing the same product and located in the same geographic region to compare actual energy consumption to modeled energy consumption, OR Follow the guidance for the Facility-level approach for the initial year (see below). After the initial year, percent improvement calculated against the facility baseline will be added to the improvement from the initial year.	 
New Construction (Facility-level Approach): A newly built facility is added to the pledge scope and the Partner uses the Facility-level Approach to calculate total improvement in energy intensity.	Add the new facility's energy consumption for the first full reporting year for which data are available to the corporate baseline energy consumption.	Compare the energy intensity (EI) of the new facility to the average baseline (EI) of facilities within the pledge scope that produce similar products. For subsequent years, compare the performance of the new facility to the first full year the new facility was included in the pledge. Add the new EI improvement to the total EI improvement calculated for the first year.	 

SCENARIO	ADJUSTMENT TO CORPORATE BASELINE ENERGY CONSUMPTION	METHOD FOR CALCULATING TOTAL IMPROVEMENT IN ENERGY INTENSITY	EXAMPLE
New Construction (Corporate-level Approach): A newly built facility is added to the pledge scope and the Partner uses the Corporate-level Approach to calculate total improvement in energy intensity.	An adjustment is required before calculating *Total Energy Savings since Baseline Year* but not before calculating the *Total Improvement in Energy Intensity*. To adjust the baseline for the *Total Energy Savings since Baseline Year* add the new facility's energy consumption for the first full reporting year for which data are available to the corporate baseline energy consumption.	When calculating the corporate energy intensity for the first full year in which the new facility is part of the pledge scope, include the new facility's energy consumption in the numerator and the new facility's output in the denominator. No adjustment is required for the baseline energy intensity when calculating the *Total Improvement in Energy Intensity*.	
Acquisition of an existing "move-in"[24] ready facility and historic data are available: An existing facility is acquired by the Partner and historic energy and production data from the previous owners are available.	Add the energy consumption for the new facility for the 12 months corresponding to the baseline year to the corporate baseline energy consumption. If data for the baseline period are not available, historic data should be collected as near to the baseline period as possible and used for the purposes of baseline year adjustments. This calculation is the same whether or not the facility uses regression analysis to normalize the energy data.	Compare the facility's energy performance for the first full year the facility is part of the pledge scope to the facility's energy performance corresponding to the Partner's baseline year, or as close as possible to the baseline year with available data. This calculation is the same whether or not the facility chooses to use regression analysis to normalize the energy data.	 *Dashed lines indicate historic data and solid fill is partner data.*
Acquisition of an existing "move-in ready" facility and historic data are unavailable: energy and/or production data from the previous owner are not available.	The facility will be treated in the same manner as New Construction.	The facility will be treated in the same manner as New Construction.	

[24] "Move-in ready" refers to a facility in which no changes are needed to the current operations or equipment.

SCENARIO	ADJUSTMENT TO CORPORATE BASELINE ENERGY CONSUMPTION	METHOD FOR CALCULATING TOTAL IMPROVEMENT IN ENERGY INTENSITY	EXAMPLE
Removals: A Partner sells or closes a facility included in the baseline year.	Remove the facility from the baseline year by subtracting the baseline year energy consumption of the closed facility from the corporate baseline energy consumption. This calculation is the same whether or not the facility uses regression analysis to normalize the energy data.	Exclude the facility when calculating total improvement using Equation 5 shown on page 30. This calculation is the same whether or not the facility uses regression analysis to normalize the energy data.	

U.S. DEPARTMENT OF ENERGY

Example 13: Corporate Level Adjustments, Total Energy Savings, and New Energy Savings

The following example discusses two scenarios in which a newly-constructed facility is added to the Acme pledge scope after the baseline year 2010.

Scenario 1

In 2010 and 2011, Acme had within the boundaries of its commitment five facilities located in Ashland, Cleveland, Duluth, Minneapolis and Rochester. In December 2011, Acme builds a new facility in Hastings, Minnesota that produces ceramic tiles. The Hastings plant manager would like to determine the true savings from year-to-year taking into consideration the effects of weather fluctuations. Therefore, Acme decides to use the regression-based approach to determine the *Total Improvement in Energy Intensity and Total Energy Savings since Baseline Year*.

Since Acme has elected to use the regression-based approach to calculate the energy performance for the Hastings facility, Acme needs to select a facility to use for comparison to determine the improvement in energy intensity between 2010 (Acme's baseline year) and 2012 for the Hastings facility. Since the Hastings and Rochester plants are in the same geographic region, produce the same type of product, are similar in size, and have similar energy intensities, Acme elects to compare the new Hastings' facility's 2012 performance to the Rochester plant's baseline performance to determine the *Total Improvement in Energy Intensity* for 2012.

Next, Acme needs to select an approach for calculating the *Total Improvement in Energy Intensity*. The two approaches available to the Hastings plant are:

1. Apply a model to Hastings' 2012 data developed based off of Rochester's baseline year data to determine the modeled and actual energy consumption for 2012 (i.e. forecasting) OR
2. Develop a model using Hasting's 2012 energy, production, and weather data. Apply the model to Rochester's baseline data to determine the modeled consumption if the Rochester plant was performing the same as Hastings did in 2012. Compare the actual to modeled consumption to determine Hastings 2012 *Total Improvement in Energy Intensity and Total Energy Savings since Baseline Year* (i.e. backcasting).

Acme decides to use the first approach (forecasting). Using the model developed based off of Rochester's 2010 energy, production, and weather data, Acme determines the 2012 modeled energy consumption for the Hastings facility to be 824,599 MMBtu. This is calculated using the following equations developed based off Rochester's 2010 energy data:

Modeled Natural Gas (MMBtu) = (9.98×Tons of Tile) × (7.85×HDD) + 13,945

Modeled Electric (MMBtu) = (11.23×Tons of Tile) × (5.65×CDD) + 13,610

The actual consumption for the Hastings facility in 2012 was 745,000 MMBtu. Using the actual and modeled consumption, Acme determines the Total Improvement in Energy Intensity in 2012 for the Hastings facility to be:

$$\textit{Total Improvement in Energy Intensity}_{CY} = (1-\frac{EC_{CY}}{\widehat{EC}_{CY}})\times 100\% = (1-\frac{745{,}000}{824{,}599})\times 100\% = 9.65\%$$

Acme can then use Equation 5 to determine the Corporate Total Improvement in Energy Intensity for all 6 facilities. To use Equation 5, Acme needs the adjusted baseline energy consumption for all 6 facilities along with the 2012 total improvement.

Since Hastings does not have energy data corresponding to 2010 (Acme's baseline year) Hastings uses its 2012 energy consumption in place of the baseline energy consumption for the Corporate Total Improvement in Energy Intensity calculation.

In 2010 and 2011, Acme had within the boundaries of its Pledge five facilities located in Ashland, Cleveland, Duluth, Minneapolis and Rochester. In December 2011, Acme builds a new facility in Hastings, Minnesota that produces ceramic tiles. The Hastings plant manager would like to determine the true savings from year-to-year taking into consideration the effects of weather fluctuations. Therefore, Acme decides to use the regression-based approach to determine the Total Improvement in Energy Intensity and Total Energy Savings since Baseline Year.

Example 13 continued on the next page…

U.S. DEPARTMENT OF ENERGY

Example 13 continued…

Since Acme has elected to use the regression-based approach to calculate the energy performance for the Hastings facility, Acme needs to select a facility to use for comparison to determine the improvement in energy intensity between 2010 (Acme's baseline year) and 2012 for the Hastings facility. Since the Hastings and Rochester plants are in the same geographic region, produce the same type of product, are similar in size, and have similar energy intensities, Acme elects to compare the new Hastings' facility's 2012 performance to the Rochester plant's baseline performance to determine the Total Improvement in Energy Intensity for 2012.

Facility	2012 Total Improvement in Energy Intensity	Baseline Energy Consumption (MMBtu)
Ashland	11.95%	340,000*
Cleveland	7.34%	120,300
Duluth	2.78%	320,100
Minneapolis	1.90%	859,662
Rochester	8.40%	851,150
Hastings	9.65%	745,000

**Ashland uses an adjusted baseline for the 2012 Corporate Total Improvement in Energy Intensity since a production line was closed in 2012. See Example 11 for an explanation of how the adjusted baseline is calculated.*

$$\textit{Total Improvement in Energy Intensity}_{Corporate} = \frac{\sum((ei_{Plant\ 1} \times ec_{Plant\ 1}) + (ei_{Plant\ 2} \times ec_{Plant\ 2}) + \cdots + (ei_{Plant\ n} \times ec_{Plant\ n}))}{\sum(ec_{Plant\ 1} + ec_{Plant\ 2} + \cdots + ec_{Plant\ n})} \times 100\%$$

$$\textit{Total Improvement in Energy Intensity}_{Corporate} = \frac{(11.95\% \times 340{,}000) + (7.24\% \times 120{,}300) + (2.78\% \times 320{,}100) + (1.90\% \times 859{,}662) + (8.40\% \times 851{,}150) + (9.65\% \times 745{,}000)}{340{,}000 + 120{,}300 + 320{,}100 + 859{,}662 + 851{,}150 + 745{,}000} \times 100$$

$$\textit{Total Improvement in Energy Intensity}_{Corporate} = 6.74\%$$

Therefore, with the inclusion of the Hastings facility, the Corporate Total Improvement in Energy Intensity for Acme in 2012 is 6.74%.

Scenario 2

In Scenario 2, Acme attempts to apply the model developed using Rochester's 2010 data to Hasting's 2012 production and weather data. However, due to major differences in the cooling and heating degree days, Acme discovers the model does not pass the second validation check (see page 28 for more information). Therefore, the model developed using Rochester's baseline data cannot be used to model Hasting's 2012 energy consumption. Acme must then use the facility-level approach to calculate the Total Improvement in Energy Intensity.

Example 13 continued on the next page…

Example 13 continued…

To use the non-normalized approach, Acme first calculates the baseline energy intensity for the Rochester facility using equation 9.

$$Energy\ Intensity_{Rochester} = \frac{2010\ Total\ Energy\ Consumption}{2010\ Total\ Units\ of\ Output} = \frac{851{,}150\ MMBtu}{35{,}677\ tons\ of\ tile} = 23.851\ MMbtu/tons\ of\ tile$$

$$Energy\ Intensity_{Hastings} = \frac{2012\ Total\ Energy\ Consumption}{2012\ Total\ Units\ of\ Output} = \frac{745{,}000\ MMBtu}{34{,}500\ tons\ of\ tile} = 21.594\ MMbtu/tons\ of\ tile$$

Using equation 10, Acme determines the 2012 *Total Improvement in Energy Intensity* for the Hastings facility to be:

$$Total\ Improvement\ in\ Energy\ Intensity_{Hastings} = \frac{Energy\ Intensity_{Baseline\ Year} - Energy\ Intesnity_{Current\ Year}}{Energy\ Intensity_{Baseline\ Year}} \times 100$$

$$= \frac{23.857 - 21.594}{23.857} \times 100$$

$$Total\ Improvement\ in\ Energy\ Intensity_{Hastings} = 9.49\%$$

$$Total\ Improvement\ in\ Energy\ Intensity_{Corporate} = \frac{\sum((ei_{Plant\ 1} \times ec_{Plant\ 1}) + (ei_{Plant\ 2} \times ec_{Plant\ 2}) + \cdots + (ei_{Plant\ n} \times ec_{Plant\ n}))}{\sum(ec_{Plant\ 1} + ec_{Plant\ 2} + \cdots + ec_{Plant\ n})} \times 100\%$$

And the 2012 Corporate *Total Improvement in Energy Intensity* is

$$Total\ Improvement\ in\ Energy\ Intensity_{Corporate} = \frac{(11.95\% \times 340{,}000) + (7.24\% \times 120{,}300) + (2.78\% \times 320{,}100) + (1.90\% \times 859{,}662) + (8.40\% \times 851{,}150) + (9.65\% \times 745{,}000)}{340{,}000 + 120{,}300 + 320{,}100 + 859{,}662 + 851{,}150 + 745{,}000} \times 100$$

$$Total\ Improvement\ in\ Energy\ Intensity_{Corporate} = 6.70\%$$

Therefore, using the non-normalized approach to calculate the *Total Improvement in Energy Intensity* for the Hastings facility, the Corporate *Total Improvement in Energy Intensity* for Acme in 2012 is 6.7%.

Appendix D. Better Plants Annual Pledge Reporting Data Review Checklist & Verification

Review Item	Checklist and Additional Notes	Year to Year Fluctuation Tolerance & Follow-up Actions
Reporting and Baseline Year	• Have you confirmed Fiscal Year (FY) and Calendar Year (CY) definitions (July to June, October to September, January to December, etc.) for your company? Some companies submit 2012 reports as their 2011 report due to confusion regarding FY and CY definitions.	• Rule of thumb - Select the full year for which the most months of the fiscal year fall in. • For fiscal years that run from July to June, the latter half of the two years should be used (e.g. for July 2010 through June 2011, select 2011).
Number of Participating Plants (baseline and current year)	• Does the number of participating plants submitted match the expected number of plants committed when the agreement form was signed? • Does the submitted data only represent U.S. plants?	• Provide detailed explanation in the text box on the reporting form if the listed number of plants varies from the previous year. • If plants have been added or dropped, ensure that you are accounting for them consistent with the protocols described in the baseline guidance document (see pages 34-41).
Energy consumption data – source and MMBtus	• Have you provided the primary (or source) energy consumed, by fuel type, for the company, for the baseline and current years? Primary energy use takes into consideration generation, transmission, and distribution losses. Energy consumption data by fuel type needs to be in MMBtus. • Have you used a consistent site-to-source conversion factor (e.g. 3) over time? • Does the un-adjusted baseline energy consumption value reported in the current year match with the previously reported baseline energy consumption value?	• DOE will investigate this field if change is > ±25% w.r.t. baseline year • Follow guidelines provided in this Guidance Document for site-to-source conversions (see page 9).
Adjustment for Baseline Primary Energy, (+/- MMBtu)	• Have you included adjustments to the baseline due to addition or removal of plants from the program and weather interactions, and increases in production separately? • Adjustment box 1 - Weather/Production/Other Normalizing related Adjustment for Baseline Primary Energy • Adjustment box 2 - Baseline Adjustment Due to Increase/Decrease in the Number of Facilities Reporting Relative to Baseline Year or Other Related Reasons	• DOE will investigate this field if adjustment is ≥ ±25% of the baseline energy use
New Energy Savings for Current Year	• Have you checked the report to ensure the "total energy savings since baseline year" and "new energy savings for current report year" are not equal when the reporting year is more than 1 year after the baseline year? If the reporting year is 1 year after the baseline, "new energy savings" should equal "total energy savings." • If the reporting year is more than one year after the baseline, make sure that this number is calculated using the following equation: *New Energy Savings in Current Year = Total Energy Savings since Baseline Year for the Current Year - Total Energy Savings since Baseline Year for the Previous Year* • Investigate if new energy savings for current year ≥ baseline or current year energy use or a significantly positive/negative number.	• DOE will investigate this field if new energy savings ≥ ±15% of the baseline or current energy use • Provide justification for significantly positive/negative number

Total Energy Savings since Baseline Year	• Have you calculated the total energy savings since baseline year using the following equation? *Total Energy Savings since baseline year = Total Primary Energy Use in Baseline Year + (Weather/Production/Other Normalizing related Adjustments to Baseline + Baseline Adjustment Due to Increase/Decrease in the Number of Facilities Reporting) - Total Primary Energy Use in Current Year).* • Check if you are reporting a "total energy savings since baseline year" greater than 30% of the adjusted baseline energy use. This may indicate an error when entering the current year source energy consumption.	• DOE will investigate this field if total energy savings ≥ ±30% of the adjusted baseline energy use. • Provide justification for significantly positive/negative number
Annual Change In Energy Intensity for Current Year (%)	• Have you provided a value for "Annual Change In Energy Intensity"? • Have you ensured that the "annual change in energy intensity" and "total change in energy intensity" are not equal when the reporting year is more than one year after the baseline year? Make sure this number is calculated using the following equation: *Annual Change In Energy Intensity for Current Year (%) = Total Change in EI for current year – Total change in EI for previous year.* If the company is reporting for the first time and current year = baseline year + 1, annual % change for current year must be equal to total change in EI since baseline year. See page 20 in the baseline guidance document for more details.	• DOE will investigate this field if % annual change in energy intensity ≥ 10% or <0% of the previous year energy intensity w.r.t. baseline year [*(previous year EI – current year EI)/baseline year EI*] • Provide justification for significantly positive/negative change
Total Change In Energy Intensity since baseline year (%)	• Have you provided the "Total Change In Energy Intensity Since The Baseline Year"? • Check if you are reporting a "Total Improvement In Energy Intensity" ≥ 25% when the reporting year is 1 or 2 years after the baseline year. • Investigate if "Total Change in Energy Intensity Since Baseline Year" (%) shows no correlation with the % change in total energy savings. • Check for instances when the difference in the ratio of "Total Energy Savings" to "Adjusted baseline energy use" and "total improvement in energy intensity" is greater than 200%. *{[(Total Energy Savings/ Adjusted baseline energy use) - total improvement in energy intensity]/ (Total Energy Savings/ Adjusted baseline energy use)} ≥ 200%.*	• DOE will investigate this field if total improvement in EI ≥ 25% when the reporting year is 1 or 2 years after the baseline year. • Provide justification for a significantly positive/negative number • Does total change in EI (%) show a general correlation with total energy savings? Investigate if the difference in the ratio of "Total Energy Savings" to "Adjusted baseline energy use" and "total improvement in energy intensity" is greater than 200%.

Better Plants®
U.S. DEPARTMENT OF ENERGY