Energy Intensity Baselining and Tracking Guidance

2020

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Authors and Acknowledgements

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Preface

The U.S. Department of Energy's (DOE's) Better Buildings, Better Plants Program (Better Plants) is a voluntary energy efficiency leadership initiative for U.S. manufacturers and water/wastewater entities. The program encourages organizations to commit to reducing the energy intensity (EI) of their U.S. operations, typically by 25% over a 10-year period. Companies joining Better Plants are recognized by DOE for their leadership in implementing energy efficiency practices and for reducing their energy intensity. Better Plants Partners (Partners) are assigned 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 that can enable them to reach their goals.

Partners are expected 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 to calculate consumption and intensity changes over time. DOE has developed a free companion Energy Performance Indicator software tool (EnPI) that can be valuable to many types of organizations in the baseline development and tracking process, especially those looking to validate their energy savings.

This guidance document is applicable to companies participating at either the program or the challenge level. The guide is intended primarily to assist companies participating in Better Plants, but the methodologies and guidance within the document are applicable to any organization interested in developing an energy consumption and intensity baseline to track changes to those metrics on an annual basis. Further tailored guidance for wastewater facilities can be found in the DOE's *Energy Data Management Manual for the Wastewater Treatment Sector*.

For more information on the Better Plants program, please visit:
betterbuildingssolutioncenter.energy.gov/better-plants

For more information on the Better Plants Challenge program, please visit:
https://betterbuildingssolutioncenter.energy.gov/better-plants/better-plants-challenge

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Definition of Terms

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

Adjusted Energy	Energy consumption value altered to account for facility closures, facility additions, closures of production lines, weather conditions, etc.
Adjusted R^2	The adjusted R^2 (or R-squared) value is a modification of the R^2 value (definition follows) that adjusts for the number of terms in a model. Although the R^2 value increases when a new term is added to a model, the adjusted R^2 value increases only if the new term improves the model more than would be expected by chance. While higher adjusted R^2 values usually imply a better model, see page 24 for guidance on selecting the most appropriate model.
Baseline Adjustment	Modification to baseline energy consumption data to account for facility closures, facility additions, closures of production lines, etc.
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 (page 18) provides additional information on selecting a baseline year.
Cooling Degree Day (CDD)	A unit used to relate a given day's temperature profile to the energy demands of cooling a building or facility. A cooling degree day (CDD) can calculated by subtracting a reference temperature (such as 65°F) from a day's mean temperature (such as 80°F) at a given location. Monthly CDDs are the sum of CDDs within a given month.
Energy Intensity (EI)	Energy Intensity (EI) relates the energy consumed over time with respect to a defined physical unit of output(s) for a 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 EI, energy consumption, improvement in EI, etc.
Energy Performance Indicator	A quantitative value or measure, as defined by the partner, 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. EI can be an energy performance indicator, but the term energy performance indicator covers a broader set of metrics.
Energy Intensity Improvement	The percent change in EI over time that is used by Better Plants to capture improvement in energy efficiency.
Heating Degree Day (HDD)	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 (or Relevant Variable)	An input value that affects the output, or dependent variable(s) in a regression analysis. Example independent variables in a regression include production, heating degree days, cooling degree days, etc.
Modeled Energy	Predicted energy consumption using a model developed from regression analysis.

New Energy Savings for Reporting Year	An estimate of the energy savings generated since the previous reporting year.
Normalization	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 actual energy consumption using regression analysis for variables such as weather, variations in production level, feedstock quality, etc.
***p*-value**	A regression model has two measures known as *p*-values that help determine the validity of a given model. A **variable *p*-value** indicates that a model is improved by including the variable in the regression. A **model *p*-value** indicates that a model is a better predictor than an intercept-only model. A valid regression model should have a model *p*-value < 0.1 and all variable *p*-values < 0.2 with at least one < 0.1.
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 that energy to the site.[1] For the Better Buildings, Better Plants Program, DOE requires energy data be reported in terms of primary energy for electricity and imported derived energy sources. For electricity, a 3.0 multiplier is used to convert from site to primary energy consumption. See “Primary Versus Site Energy” on page 6 for further information.
R^2	R^2 (or R-squared) is a statistical measure of the goodness of fit of a regression model. Higher R^2 values indicate a larger portion of the variance of the dependent variables is accounted for by the model and that the independent variables explain the model with more confidence. See page 24 for additional guidance on R-squared.
Reporting Year/Period	The reporting period is the most recent 12 months of data used to determine the reporting year energy performance for annual reporting. The starting and ending months of the reporting period time span must be consistent with the baseline period. For example, if the baseline period covers October through September for Year 0, then subsequent reporting years must also cover October through September.
Total Energy Savings Since Baseline Year	An estimate of energy savings resulting from actions taken since the baseline year. This value is the difference between the organization-wide energy use in the baseline year and the current reporting year. Adjustments made for weather, operational changes, facility closures/additions, etc., are considered when calculating this value.
Site Energy	Site energy is the energy directly consumed by the company.[1] 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, the Better Buildings, Better Plants Program uses a multiplier of 3.0 for conversion to primary energy consumption. See “Primary Versus Site Energy” on page 6 for further information.
Statistical Validity	The degree to which an observed result, such as a difference between two measurements, can be relied upon and not attributable to random errors in sampling or 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.

[1] U.S. DOE Energy Information Administration Glossary: https://www.eia.gov/tools/glossary/

Using This Guide

Partners with the Better Buildings, Better Plants Program (Better Plants) are required to submit a report to DOE once per year. New Better Plants partners must submit their first annual report within one year after joining the program. The reporting form is available through the Better Plants section of the Better Buildings Solutions Center[2]. The data will be used to document progress made by program 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 values required for the Better Plants annual reporting form. Figure 1 relates the various input fields on the form to the steps provided on the following pages.

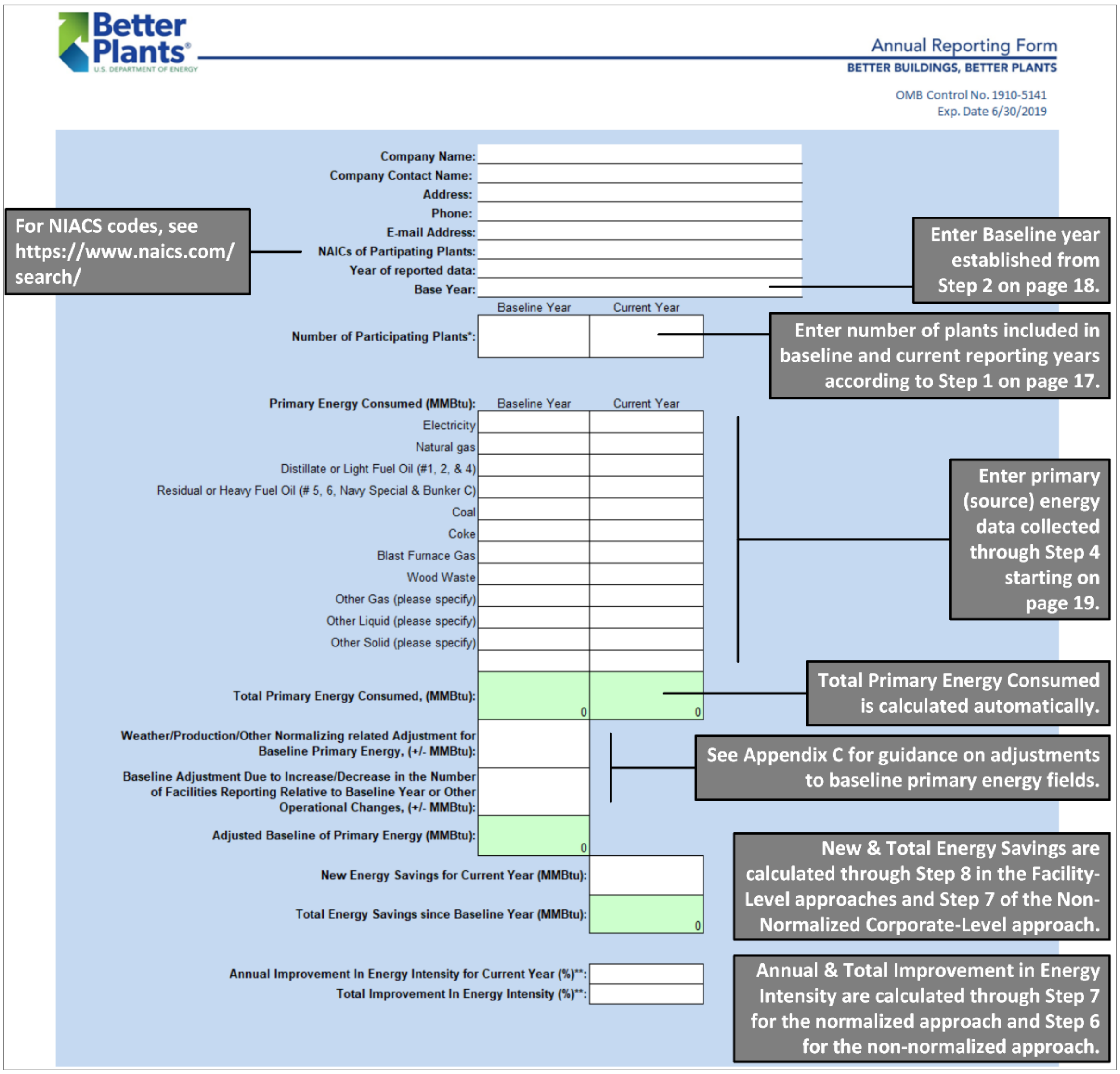

Figure 1: Better Plants annual reporting form.

[2] https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/BBBP%20Pledge%20Annual%20Reporting%20Form.xls

Introduction

Each company joining the U.S. Department of Energy's (DOE's) Better Buildings, Better Plants Program (Better Plants) commits to establishing an **energy consumption** and **energy intensity** (EI) baseline and to tracking its **energy performance** over a 10-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 operations. Energy consumption is calculated by fuel type in terms of **primary energy** (also known as source energy). EI is broadly defined as the amount of energy consumed per unit of output produced. For this guidance document and for the program, the term energy performance represents an evaluation of a facility's capacity to use energy efficiently. Metrics used to assess a facility's energy performance can include EI, energy consumption, improvements in EI, etc.

Establishing an energy 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 for ISO 50001 certification.

Although basic energy data can be collected through utility bills, most manufacturers will have to perform additional analyses to develop accurate and robust energy baselines and tracking systems. Energy is consumed in many ways within the manufacturing sector and can come from multiple 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. Since Better Plants asks companies to account for all their U.S.-based operations, mergers, acquisitions, and divestitures can also have significant implications for a company's energy metrics.

This document aims to demystify the sometimes complex baselining process. It devotes special attention to the task of normalizing and adjusting energy consumption to account for external factors, such as weather and production changes. A key recommendation is that companies use **regression analysis** to normalize their energy consumption data whenever possible. Regression analysis is a statistical technique that estimates the dependence of a variable (i.e., energy use in the context of Better Plants) on one or more **independent variables** such as ambient temperature, while controlling for the influence of other variables at the same time.[3] A properly developed 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.

DOE has developed a companion Energy Performance Indicator software tool (EnPI) to simplify the baselining process. This tool can run regression models, calculate changes in EI at the facility level, and automatically compile facility-level data into a corporate-wide metric. Note that although the relevant equations used to calculate EI are provided in this document, the EnPI tool will automatically perform most calculations for the user. Additionally, Better Plants Partners (Partners) can call on their Technical Account Manager (TAM) to help them establish a baseline and assist with the necessary calculations to track progress.

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

Energy Performance Indicator (EnPI) Tools

Two versions of the EnPI tool are available at no cost through DOE. Key differences between the tools are highlighted in Table 1. Both versions are available through the Better Plants Solution Center at: betterbuildingsinitiative.energy.gov/better-plants/better-plants-solutions.

The **EnPI Lite tool** is an online, regression-based calculator for facility-level energy performance modeling for the 50001 Ready program. The tool can analyze data directly from DOE's *Energy Footprint Tool* or the U.S. Environmental Protection Agency's (EPA's) *ENERGY STAR Portfolio Manager* and therefore may integrate well with existing facility programs.

The **EnPI tool** is an Excel-macro suite that enables more detailed analysis at both the facility and corporate levels. The tool has added functionality compared to EnPI Lite version including corporate "roll-up" of energy savings and an additional regression method (chaining). Both tools are designed to accommodate multiple users including Better Plants Partners and non-production facilities such as data centers and commercial buildings.

Table 1: EnPI and EnPI Lite Tool Comparison

	EnPI Lite	EnPI
Platform	Online	Excel Add-On
Ease of Use	Easy	Moderate
Energy Intensity Approach	✗	✓
Regression Based Approach (# of methods)	✓ (2)	✓ (3)
Corporate Roll-Up	✗	✓
SEnPI Calculation	✗	✓
Energy Footprint Tool and ENERGY STAR Portfolio Manager Compatible	✓	✗

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

Although 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 because 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 EI. Although regression analysis is recommended, DOE recognizes this approach may not be appropriate for all companies, especially those with a complicated product mix, a large number of facilities, or insufficient access to data. In addition to the regression-based methodology, this document provides two alternate approaches to calculating EI improvement, along with general guidelines and minimum requirements that allow for the development of adequate metrics.

The three approaches are summarized below and are 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 uses regression analysis to provide normalized facility-level energy consumption and annual and total changes in energy intensity that account for the effects of variables such as changes in production and weather. This provides facility and corporate energy managers with a better understanding of how they use energy and whether their energy management efforts are succeeding. Facility-level EI 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 the regression approach is that normalization can separate changes in energy consumption due to energy efficiency improvements from changes caused by variation in weather or factors related to production. The regression approach, therefore, offers a truer representation of EI at a facility.
- ***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 EI 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. Like the regression-based approach, a major advantage of this approach is the ability to roll up plant-level metrics into a coherent and valid corporate-level metric even when facilities produce different products. The major disadvantage of the facility-level approach is the inability to distinguish between energy reductions due to energy saving activities and reductions due to factors such as production changes or weather.
- ***Corporate-Level Approach***: This is the most basic approach and is generally acceptable only when facility-level data are not available. This approach requires that a company use a uniform production unit as its EI 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 data over time to account for significant changes to their corporate boundaries and/or 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. Note that although this document attempts to cover common issues that will arise while tracking energy performance data, it is not possible to cover all issues 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 preceding three approaches but is focused primarily on the regression-based approach because of the importance and relative complexity of this approach. Also, 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 2.

Steps 1, 2, and 4 are generally the same across all three methodologies. Steps 6–8 are common across the regression-based and facility-level approaches. 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.

Table 2: Steps for Baseline Development and Energy Performance Tracking

	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 independent variables affecting energy usage at each facility	Decide on the energy intensity (EI) denominator for each facility, usually units of output	Decide on the corporate-wide EI denominator—usually a standard unit of output, revenue, or financial metric
4	Gather data on energy consumption and independent variables for each facility	Gather data on energy consumption and units of output for each facility	Gather data on energy consumption and the variable being used as the corporate-wide EI denominator
5	Use regression analysis to normalize each facility's data	Calculate EI for the baseline year and the reporting year for each facility	Calculate EI for the baseline year and reporting year across the corporation
6	Calculate the change in EI from the baseline year for each facility	Calculate the change in EI from the baseline year for each facility	Calculate the change in EI from the baseline year for the corporation
7	Aggregate the data on EI change from each facility to the corporate level	Aggregate the data on EI 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	———

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 following example, 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 EI change that is less favorable compared with a non-regression comparison but almost always will provide a more accurate and defensible accounting of changes in energy performance.

Example 1: Use of Regression Analysis

Acme Flooring has a facility located in Minneapolis, Minnesota, that manufactures kitchen tiles. In 2018, the baseline year, the weather in Minneapolis was very moderate compared with 2020. Note that the 2018 and 2020 production levels were roughly the same.

The company's comparison of 2018 and 2020 total energy consumption and intensity for the Minneapolis plant shows that the total energy consumption increased based on the raw energy data. The plant consumed 859,662 million British thermal units (MMBtu) of primary energy in 2018 and 874,929 MMBtu in 2020. A comparison of the energy intensities for 2018 and 2020 also shows an increase from 19.98 MMBtu/ton of tile to 20.12 MMBtu/ton of tile, a 0.7% increase in EI.

However, 2020 was a much colder year than 2018. As a result, the plant consumed significantly more energy in the form of natural gas for facility heating relative to 2018. A regression analysis of monthly energy data for the baseline period shows that energy use had a statistically significant relationship with both production and heating demand; therefore, these factors could be used to normalize energy consumption. When the plant normalizes its energy consumption to account for the effects of heating demand on energy consumption, the calculations show that intensity has decreased by 1.9% in 2020 compared with the baseline year.

Table 3: Comparison of Normalized and Non-normalized Improvement

Variable	2018	2020
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 EI	19.98 MMBtu/ton	20.12 MMBtu/ton
Non-normalized Total Improvement in EI	--	**- 0.70%**
Normalized Total Improvement in EI using Regression Analysis	--	**+ 1.90%**

Data Collection

To baseline and track energy consumption, facilities must gather energy data for each year within the program scope. Reported consumption must include a breakdown of energy consumption by fuel type. The Better Plants Reporting Form (page vi) specifies the energy types that will be tracked including electricity, natural gas, distillates, coal, coke, and other fuels. 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, but are encouraged to do so.

For purposes of the Better Plants program, energy consumption is the total of all energy sources entering the facility boundary or withdrawn from facility inventory or stockpile, excluding feedstocks and 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 (MMBtu), based on the fuel's Higher Heating Value or HHV (see Appendix B for HHVs of common fuels). 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 reported in terms of MMBtu. Facility-level consumption, production data, and independent variable data must be collected on a monthly basis (at minimum) to allow for the development of a regression model. Energy consumption for each energy source must be collected separately, ideally from utility bills. 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 but will require more granularity to attribute activity/production to each submeter. For additional information on submetering, see *Metering Best Practices: A Guide to Achieving Utility Resource Efficiency*[4].

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 to generate[5] (i.e., primary energy). For Better Plants annual reporting, primary energy consumption of grid electricity involves converting kilowatt-hours to million British thermal units (1 kWh = 3,412 Btu = 0.003412 MMBtu) and then multiplying by 3. If data exists to document the actual fuel mix and transmission and distribution losses of electricity for a facility, a company may opt to use a different multiplier so long as it uses the same multiplier consistently across all the years of program participation. Companies using this approach and having facilities spread across the country should note that the electricity source multiplier will vary by region. For the consumption of primary fuel sources like natural gas or coal not already in energy units, the HHV of the fuel is used to convert mass or volume consumption to energy. Any distribution and transportation energy or losses (e.g., energy used to compress natural gas delivered in a pipeline) should not be included.

The rationale for using primary energy is that it ensures 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 that the full benefits of technologies like combined heat and power (CHP) and on-site solar energy that reduce losses within the transmission grid and in the conversion of fuels are captured.

[4] https://www.energy.gov/sites/prod/files/2015/04/f21/mbpg2015.pdf

[5] U.S. DOE Building Energy Data Book. ieer.org/resource/energy-issues/2011-buildings-energy-data-book/

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 B provides primary energy multipliers for these and other commonly used energy sources 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. Again, 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 10 years. As with the conversion of purchased electricity to primary energy, the intent of the conversion is to ensure a consistent yearly accounting of the energy embedded in each delivered unit of energy.

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

Electricity

Combined Heat and Power (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 with 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.

When deploying CHP equipment, a company will see a decrease in electricity purchases from the electric grid but will also see an increase in input fuel (such as natural gas) consumption. If a CHP system is within the facility's boundary, 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 tracked as described in other sections of this guide. Any exported energy (electricity, steam, etc.) should be accounted for as an energy credit so long as it less than the amount or resource purchased. See the following section on "On-site Electricity Generation" 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. For example, a CHP system with an overall thermal efficiency of 80% would have a 1.25 site-to-primary multiplier.

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 with electricity purchased from the grid provided it has not been intermingled with other sources of electricity. Steam from a neighboring CHP facility can also be purchased. An

[6] Definition of CHP from DOE, 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, and E. Wong, ICF International; L. Schwartz and D. Lamont, Regulatory Assistance Project; T. Woolf, Synapse Energy Economics; and J. Selecky, Brubaker & Associates.

[8] U.S. DOE and U.S. EPA. *Combined Heat and Power: A Clean Energy Solution*. August 2012.

alternative to the program default site-to-primary energy multipliers can be used for imported electricity and steam provided calculations are well 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.

On-site electricity generation (non-CHP, non-renewable) – Electricity generated on-site (non-CHP) from primary fuels may be consumed at the facility or exported. On-site generated electricity that is consumed on-site is accounted for by the primary fuel used to generate the electricity. On-site 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 vi), 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). If the on-site electricity generation system uses by-product fuels or an exothermic reaction, the company may opt to include or exclude the electricity generated. The maximum amount of allowable electricity export for reporting is equal to the quantity of electricity delivered to the facility. Some special considerations apply to biomass (see details on starting on page 12).

Renewable electricity – Renewable electricity is defined as electricity generated without fossil 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, biogas, etc. In general, renewable electricity generated and consumed on-site 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 on-site generated renewable energy is exported, a credit using a 3.0 multiplier should be used. Special considerations for facilities that use biogas fuels are given in starting on page 10.

Properly accounting for electricity generated from renewables is extremely important when baselining and tracking energy. For sites with renewable sources of energy, the variable nature of renewables and the interchange between the electric grid 3.0 site-to-source multiplier and the renewable energy 1.0 multiplier can cause a facility's source energy consumption to change substantially without any relationship to changes in site energy usage patterns.

Power Purchase Agreements (PPAs) and Renewable Energy Certificates (RECs) – A PPA is an agreement between a power producer and a consumer to purchase electricity and RECs. They are an effective way to offset a facility's carbon footprint without having to invest the large upfront capital needed to install a clean power or energy efficiency solution within the boundary of an organization's facilities.

Two primary types of PPAs exist, and their structure dictates how they are included for baseline data collection. *Physical PPAs* (P-PPAs) directly deliver electricity to a facility from on- or off-site green power generators (solar, wind, etc.). If the P-PPA generator is on-site and the facility retains the RECs, a 1.0 multiplier should be used for metered renewable energy use. If off-site (e.g., a wind farm 10 miles away with direct power lines to the facility), then information from the P-PPA partner about delivery losses should be used to estimate a primary use multiplier. In general, if the facility does not retain the RECs for a green power project, the P-PPA should be treated as a *Virtual PPA* (see below).

Virtual PPAs are an agreement to purchase a certain amount of renewable energy that is delivered to the grid and not directly to the facility. Facilities using a virtual PPA still purchase all their power from the utility, so no additional metering is necessary for data collection and the standard 3.0 multiplier should be used.

Similarly, companies that have purchased RECs to offset fossil fuel-based energy consumption should not include these certificates in their energy consumption baselines. Although these RECs can be counted for other DOE, EPA, or state energy efficiency/environmental programs, the Better Plants program scope concerns power delivered (e.g., electricity) to the facility boundary. For the Better Plants Program in general, any renewable electricity that is delivered to the grid cannot be given a 1.0 multiplier when consumed.

Demand Response Programs – The two common ways to reduce energy intensity (EI) are energy efficiency and demand response (DR). Energy efficiency refers to permanent changes in usage due to things like upgrading equipment or streamlining processes. Efficiency programs translate directly into a reduction in energy consumption. DR refers to price or incentive-based programs that encourage temporary changes in electrical use by consumers in advance of peak demand to prevent electric grid instability. A facility can implement DR in two ways: by shifting load or shedding load. A *load shifting* DR plan will transfer electricity consumption from the DR period to off-peak hours (see Figure 2). Load shifting does not save energy but may result in cost savings due to cheaper energy prices in off-peak hours. *Load shedding* DR reduces demand during the DR period but does not transfer that consumption to off-peak hours. In this implementation, DR will result in quantifiable energy and cost savings.

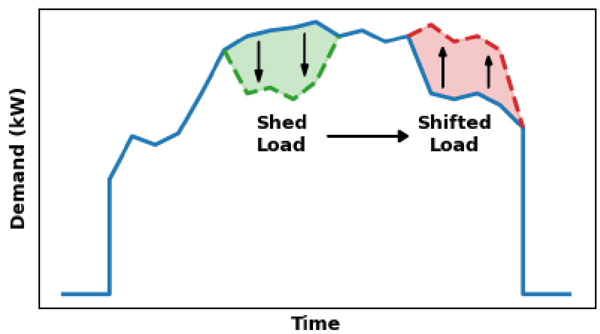

Figure 2: Demand response sheds load during certain times. If shed load is shifted, there are no energy savings.

In general, DR programs are not included when collecting data for Better Plants EI analysis if load shedding times are very short (e.g., 15 or 30 minutes) or if load is shifted to off-peak hours. Facilities that implement substantial load shedding as part of their DR program for longer periods should work with their TAM to capture those savings. The Better Plants program encourages Partners to participate in DR as it benefits the electric grid and research has shown DR to reduce energy consumption over time when coupled with energy education and energy efficiency programs.[9] Rebate structures for DR programs can also be compelling for many facilities.

For energy baseline development and tracking, the general equation for reported electricity is therefore:

Equation 1: Reported Electricity

$$\begin{aligned} Electricity_{Reported} &= 3.0 \times Electricity_{Purchased} + CHP\ Multiplier \times Electricity_{Offsite\ CHP} \\ &+ 1.0 \times Electricity_{Onsite\ Renewable} + P\text{-}PPA\ Multiplier \times Electricity_{P\text{-}PPA} \\ &- 3.0 \times Electricity_{sold} \end{aligned}$$

[9] National Action Plan for Energy Efficiency (2010). *Coordination of Energy Efficiency and Demand Response*. Prepared by C. Goldman (Lawrence Berkeley National Laboratory), M. Reid (E Source), R. Levy, and A. Silverstein.

Example 2: 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 Table 4.

Table 4: Acme Rochester, Minnesota, August Electricity Consumption

	Source	Site Consumption (kWh)	Site-to-Primary Multiplier	Primary Consumption (kWh)	Primary Consumption (MMBtu)
1	Local Utility	3,529,906	3.0	10,585,719	36,106
2	Neighboring Plant CHP	1,825,814	2.0 (CHP System Efficiency 50%)	3,651,627	12,450
3	On-site Solar Panels	365,163	1.0	365,163	1,245

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

$$\begin{aligned} Electricity_{Reported} &= 3.0 \times 3{,}529{,}906\ kWh + 2.0 \times 1{,}825{,}814\ kWh + 1.0 \times 365{,}163\ kWh \\ &= 14{,}606{,}509\ kWh \times 0.00341\ MMBtu/kWh \\ &= 49{,}808\ MMBtu \end{aligned}$$

Exothermic Processes and Waste Heat Recovery

An exothermic process releases energy to its surroundings in the form of light and/or heat. Energy recovered from process waste heat or from an exothermic process should be treated as a by-product fuel, and therefore may be included or excluded from energy consumption data using the same criteria as for by-product fuels.

On-site Generated By-Products Used as Fuel

Facilities that generate by-products used as a fuel source (e.g., hydrogen from ethylene production, blast furnace waste gas, etc.) may choose to include or exclude the energy produced in their models. If included, an estimate of the heat content and metering of the fuel are required. If metering of the fuel cannot be done or is cost prohibitive, metering of the electricity generated is acceptable. See the following Biogas section for more information.

Biogas[10]

Facilities that use anaerobic digestion to breakdown biodegradable material in the absence of oxygen can use the resulting biogas to replace or supplement other purchased energy sources such as natural gas. For example, a wastewater treatment plant can use on-site CHP to generate electricity with biogas as the fuel and use waste heat recovery for digester heating. Food processing facilities, paper mills, and coking plants may also be able to take advantage of biogas in similar manners with on-site digesters.

[10] Information and Figures 2–3 adapted from: P. Lemar (ORNL) and A. de Fontaine (DOE). "*Energy Data Management Manual for the Wastewater Treatment Sector.*" Technical Report, DOE/EE-1700. Oak Ridge National Laboratory. 2017.

A facility's previous use of biogas can influence how biogas recovery affects EI. Unrecovered or flared biogas represents a significant opportunity to reduce fuel use and substitute electricity generated on-site for grid-supplied electricity at a lower site-to-source multiplier. If a facility is already using biogas, no fuel source will be displaced, and energy performance metrics will be driven by the electric efficiency of the CHP system relative to the grid. This is beneficial only when a CHP system can generate biogas electricity more efficiently than grid purchased electricity.

Figure 3 shows three prevailing ways to account for the use of biogas use at a facility:

(A) *Treat Biogas as Free Energy:*
Biogas is excluded from a facility's energy performance metrics, and any resulting displacement of grid-purchased electricity is counted as a reduction in energy consumption. Although this approach has the greatest potential to reduce EI, it is not consistent with strong energy management principles. Burning biogas as a fuel source has environmental considerations and failure to meter or track use can obscure inefficient usage, underlying issues, and generation capacity.

(B) *Measure and Track Energy Content at CHP Input:*
Biogas energy content is directly measured as is enters the CHP unit, essentially treating it as another fuel source. This method is consistent with strong energy management principles because tracking energy content is inclusive of electricity and heat generation. However, measuring flow rate and heat content can be difficult, and direct metering can discourage biogas use in a quest for greater resource conservation.

(C) *Measure and Track Electricity and Waste Heat Recovery:*
Electricity and waste heat recovery (when possible) are measured. This method is equivalent to treating biogas-derived energy as a renewable energy source like solar or wind. Accounting for biogas use this way creates resource recovery incentives and represents a middle ground between options (A) and (B).

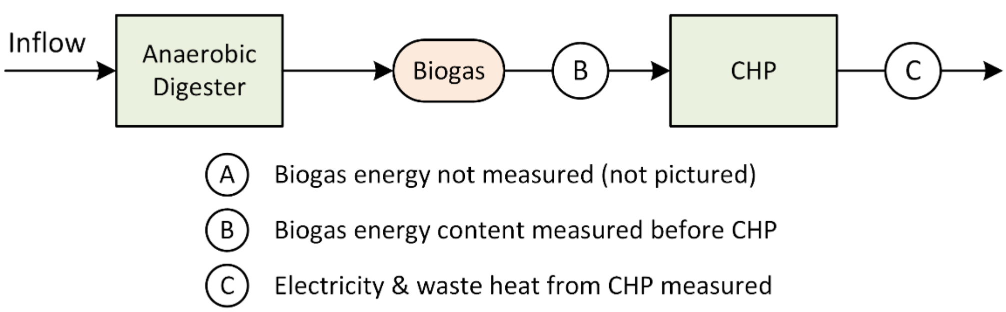

Figure 3: Options for measuring recovered energy from biogas.[10]

DOE recommends using option (C), accounting for electricity and heat output from the biogas CHP system in energy performance calculations. As seen in Figure 4, this option allows facilities to earn credit for their biogas use while not overestimating its effects.

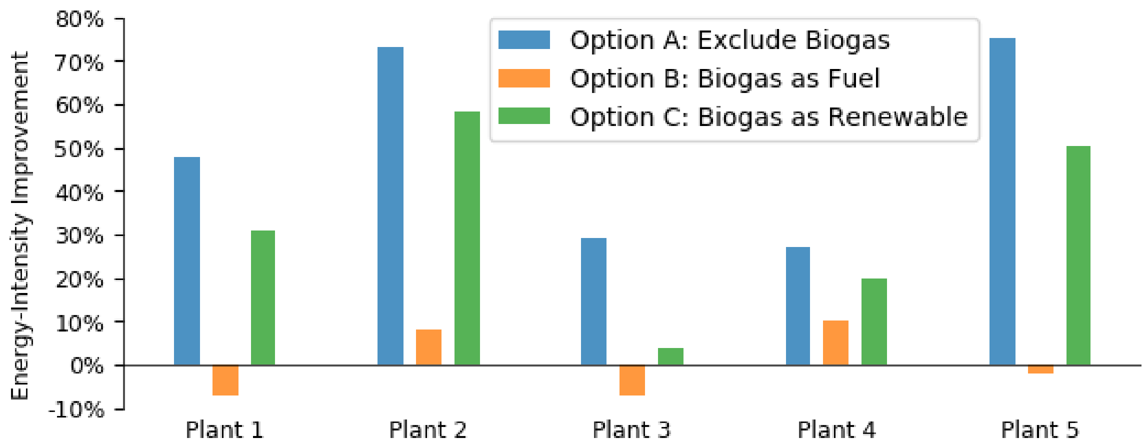

Figure 4: Impact of biogas accounting options on EI improvement at five wastewater treatment plants.[10]

Some facilities may use blending equipment to combine biogas with natural gas in order to maintain constant heat and/or power output of gas-fed equipment. This process allows companies to maximize their biogas use without affecting production. Facilities that combine biogas with natural gas must be careful not to double count their resource consumption when using option (C). Natural gas use in the CHP system will be captured by metering electricity and heat generated and therefore must be subtracted from other natural gas use.

Facilities like paper mills or wastewater treatment plants may have significant amounts of biogas available for electricity generation. In some cases, simply using biogas in a CHP system may cause Partners to reach their Better Plants pledge goal. Because Better Plants seeks to encourage continuous energy savings and establish long-term efficiency goals, partners that reach their goal from a single project or source are strongly encouraged to repledge to the program. Repledging will involve creating a new energy baseline using the techniques in this document from data after biogas implementation and identifying other energy savings opportunities.

Biomass

Biomass fuels are made up of organic materials from renewable sources like saw dust, manure, or certain dedicated crops. The use of biomass as a fuel source is increasing in the United States as companies seek to reduce greenhouse gas emissions. However, biomass fuels typically contain more moisture than fossil fuels, resulting in lower combustion efficiencies. A conversion from fossil to biomass fuel can therefore decrease the efficiency of equipment such as boilers and potentially have negative impacts on EI even though carbon emissions have been reduced.

The effect of moisture on biomass fuel heating values is given in Equation 2, where HHV_d is the dry higher heating value and M is the decimal wet mass fraction of the biomass fuel.[11] As seen, greater moister content decreases the HHV of a given biomass fuel, which could decrease the overall heating value of a biomass fuel mixture. In addition, water content may reduce the efficiency of the boiler system itself.

Equation 2: Effect of Moisture Content on Biomass Higher Heating Values

$$\boldsymbol{HHV = HHV_d \times (1 - M)}$$

[11] B. Boundy, S. Diegel, L. Write, and S. Davis. "*Biomass Energy Data Book,*" 4th Edition. Technical Report ORNL/TM 2011/4446. Oak Ridge National Laboratory, 2011.

For example, a cement plant uses a pecan shell and coal mixture to fire their process kiln. Nut shells typically have an HHV between 15–20 btu/lb and a moisture content of 5%–15%, below that of the approximately 25 btu/lb of coal. The moisture and lower heating value of the fuel mixture mean that although the plant may use less coal, they are burning more total fuel. Similar conditions can be seen in foundries when furnaces use coke as a biomass fuel.

DOE does not wish to discourage companies from using biomass fuels. However, accounting for changes in EI is very important when some or all a facility's fuel sources are converted from fossil fuels to biomass. Because of the variety of biomass fuel types, all possible situations cannot be addressed in this guide. The basic principle, however, is that companies may adjust their baseline energy consumption to counteract the energy penalty they incur when increasing amounts of biomass are substituted for 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 reporting 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[12].

Example 3: Energy Accounting with Biomass Adjustments

The Acme Flooring Duluth facility has a boiler system that burned 100% coal during its baseline year (2018). In 2020, the Duluth facility began 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 take the following steps:

1. Determine coal consumption and quantity of steam generated by the boiler in the baseline year.
2. Estimate consumption of the fuel mixture (coal plus biomass) that would have been needed to generate the 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.

Biomass adjustments should always be made to the baseline year and reported in the baseline adjustment entry box in the Better Plants annual reporting form.

Energy Generated from Waste Incineration

Facilities that use waste incineration to generate energy resources (e.g., hot water, electricity, etc.) should include this energy stream in their annual reports if it accounts for more than 5% of total energy consumption. The principles outlined in the preceding section on biogas consumption also apply to energy resources generated using waste incineration. Please consult with your TAM for specific details on accounting for energy generation from waste incineration at your facilities.

Energy as a Product

Energy delivered away from the facility boundaries is accounted for as either an energy export or an energy product. For reporting purposes, the maximum allowable energy export is limited to the quantity of energy delivered to the facility boundary. Note that this ensures that a facility cannot be counted as a negative consumer of an energy type.

[12] https://info.ornl.gov/sites/publications/files/Pub33120.pdf

Energy exports are converted to primary energy using the same site-to-source multiplier as the energy type that was delivered (e.g., 3.0 for electricity).

Some facilities (e.g., wastewater treatment plants, paper mills) may be able to generate a surplus of on-site generated energy to sell. When a facility reaches net-zero primary energy status, any excess energy delivered to another entity is accounted for as an energy product. In other words, whenever exported energy is greater than the total energy entering the boundary or generated onsite combined, the net amount of energy leaving the facility is treated as a product. Energy products are included as relevant independent variables in consumption models and use the same primary energy multiplier as the on-site-generated energy type (e.g., 1.0 for on-site solar panels).

As an example, consider a facility that purchases 25 GWh of electricity from the grid and produces 100 GWh of electricity from an on-site wind farm. The facility consumes 50 GWh and exports a total 75 GWh of electricity. This facility could claim a maximum of 25 GWh of energy export with the remaining 50 GWh counted as an energy product. Although this facility would be a net-zero energy consumer, its reported primary energy is reported as:

$$\text{Primary Electric Energy} = \underbrace{(3 \times 25\ \text{GWh})}_{\text{Grid}} + \underbrace{(1 \times 100\ \text{GWh})}_{\text{Wind}} - \underbrace{(3 \times 25\ \text{GWh})}_{\text{Export}} - \underbrace{(1 \times 50\ \text{GWh})}_{\text{Product}} = 50\ \text{GWh}$$

For more information and accounting guidelines on energy products see the *SEP™ Measurement and Verification Protocol for Industry*[13].

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 reporting to Better Plants, feedstock energy should be excluded from energy consumption data and therefore will not factor into a partner's energy intensity metrics.

Calendarization

In most cases, different utility companies will have different billing structures. For example, the electric utility may bill on the 5th of each month while the gas utility bills on the 15th on the month. Some utilities may even have inconsistent periods with each bill having a random number of days.

Calendarization is the process of allocating data to a consistent and appropriate use period. This is done for reporting purposes so that there can be a fair comparison of utility data for each year and resource. The standard way to calendarize utility data is to divide consumption for each utility by the number of days on the bill. Usage is then allocated to each month based on this daily use ratio and the number of billing days in each month. For example, consider adjusting a utility metered on the 15th of the month to align with monthly production data collected on the 1st of the month. For January usage that means there are 14 days of utility consumption on December's bill and 17 days on January's bill. This leads to the following calendarization equation:

$$Calendarized\ January\ Usage = \frac{14}{31} \times December\ Bill + \frac{17}{31} \times January\ Bill$$

Facilities metering internal variables (production, steam, etc.) should make sure their utility data matches their internal data collection, so that peaks in facility activity correspond to peaks in energy consumption. If using regression analysis, calendarization may be necessary to align weather data (heating degree days [HDDs] and cooling degree days [CDDs]) to utility bills. This can be done by using daily or hourly data and allocating values to the

[13] *Superior Energy Performance 50001™ Measurement and Verification Protocol*, October 29, 2019.

appropriate billing period. In general, however, it is only necessary to calendarize when data sets are off by more than five days or billing periods end in the middle of the month.

Independent Variables and Units of Output for Each Facility

In addition to energy consumption data, monthly output data and data for other independent variables identified in Step 3 of the regression approach must be collected for the baseline and reporting year. If weather is identified as a variable that may affect energy consumption at a facility, the company should obtain climate data for a location near the facility. Example variables include average monthly temperature, average humidity, and/or monthly CDDs and HDDs. CDD and HDD data are available through several online sources, such as the National Oceanic and Atmospheric Administration[14]. Data for these variables are used to determine the normalized energy consumption for calculating total improvement in EI.

Selecting the proper independent variables for facilities with on-site energy generation is critical for energy modeling. For example, common independent variables like cooling degree days (CDDs) sometimes correlate well with solar energy production as cold weather tends to follow a decrease in solar radiation and higher wind speeds, but this relationship does not always exist. For PV electricity generation, solar insolation values are a good choice for an independent variable while average wind speed (or even wind speed cubed) is a good choice for wind electricity. If these variables are included, renewable energy and related variables should be zeroed prior to the equipment installation date as there is no energy conversion device onsite before that point. Note that valid models may only be possible if the model year is the same as the year the energy generating equipment is installed.

Units of output data for each facility should also be collected. Example units of output include work hours, raw material input, sales dollars, etc. 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 milk, square feet of ceramic tile, number of sedans). 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 end, 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 new standard unit 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 8 on page 31. For more information on developing a new model, see the “Need for a New Model” section on page 25.

Use of Revenue in Determining Energy Intensity

An option for companies with complex mixes of products is the use of a financial measure as a measure of production (e.g., revenue or value added). A significant issue with this option is that often there is no direct relationship between energy consumption and revenue, leading to less accurate measurements of the impact of energy efficiency improvements. Relatedly, many of the core energy needs of facilities are revenue independent. Increased sales or product price fluctuations may also artificially impact the EI metric.

Energy intensity tracked with financial units (e.g., British thermal units/dollars of revenue) will vary as prices change. Companies using this type of output unit must normalize their figures based on an economic deflator or a price

[14] https://www.cpc.ncep.noaa.gov/products/analysis_monitoring/cdus/degree_days/

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.

The following is a recommended method and guidance for possible indices that can be used when tracking energy using financial metrics. Companies may elect to use other industry-specific indices so long as they are externally generated and publicly 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: To transform a series into real terms, two items are needed: the nominal data and an appropriate price index. Nominal data is simply the data measured in current dollars gathered by a client. The appropriate price index can come from any number of sources. Among the more prominent price indices are the Consumer Price Index (CPI), Producer Price Index (PPI), Personal Consumption Expenditure (PCE) Index, and the Gross Domestic Product deflator (see Figure 5). The Producer Price Index is likely the most relevant for Better Plants Partners as it reflects changes in prices received by domestic manufacturers for their products.

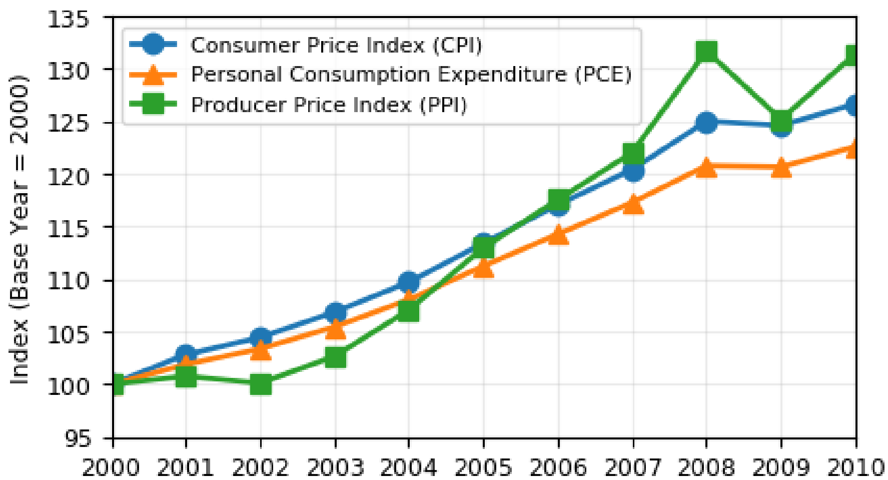

Figure 5: Common price indices for inflation adjustment.[15]

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. Price indices are generally 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 converted to decimal form by dividing by 100. 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 3: Using Price Index to Calculate Real Value

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

[15] Data from the Federal Reserve Economic Data (FRED) tool by the Federal Reserve Bank of St. Louis, Economic Research Division. https://fred.stlouisfed.org/

Developing a Baseline and Tracking Energy Performance

The following section outlines the three main methods for baselining and tracking energy performance of a corporation's facilities: the regression-based approach, facility-level approach, and corporate-level approach.

Regression-Based Approach

The regression-based approach requires the following the eight steps, outlined in Table 2:

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

Steps 1–3 are completed when a company develops its baseline model, usually during the first year of Better Plants participation. 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 the number of plants and facilities that are included under its energy savings commitment. Generally, all U.S.-based industrial facilities should be included, and companies are encouraged to include commercial buildings, warehouses, distribution centers, and other non-manufacturing space as well. While Partners should not report energy or production data from facilities outside the United States, they are still encouraged to track and utilize regression analysis to monitor energy usage at those facilities.

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 (i.e., where you pay the electric bill); 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 EI. Any nonproduct 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 EI improvement. It is possible for a facility that produces a substantial amount of energy to reach net-zero primary energy status. When this situation arises, the Partner should contact their TAM to discuss the proper accounting guidelines. 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 as discussed in the previous section.

Small plants or facilities, that represent less than 5% of total corporate energy consumption, may be omitted from the calculation of total corporate 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 be included in consumption data and EI calculations. Generally, energy consumption for transportation should be excluded. Partners that use fuel to test transportation equipment, such as engines, however, should include the fuel use in their EI calculations whenever the annual amount is more than 5% of a facility's total annual energy consumption.

Example 4: Defining a Corporate Boundary

Acme Flooring has seven properties: five are located within the United States, one in Canada, and one in Mexico. The corporate headquarters is in Ohio and consists of three office buildings. The primary function and location of each property is shown in Table 5.

Table 5: Acme Flooring Facilities

	Country	City, State	Number of Buildings	Function	Included in Boundary?
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 their warehouse since these are non-manufacturing facilities within the US. 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 EI 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 is usually the most recent calendar or fiscal year before joining the program, or the year the company joins. Partners can select the baseline year up to three years before joining the program to capture recent energy saving accomplishments. Partners may select a baseline year outside of the three-year window if it will align with existing corporate energy or sustainability goals with the understanding that they will repledge to Better Plants with a full 10-year pledge once the current goal is achieved (See "Achieving Goals and Updating Pledge" on page 41 for more information). A recent major event such as a large acquisition, closure of significant facilities, or an extended production stoppage may also justify selecting a baseline year other than the most recent year. In all other cases, the Partner's commitment shall be interpreted as striving for a 25% EI improvement within 10 years after the end of the selected baseline year.

For example, a company joining Better Plants in 2020 and setting calendar year 2019 as its baseline year is striving for a 25% improvement in EI for the calendar year ending December 2029. Likewise, a company that joined the program in 2019 and set calendar year 2017 as its baseline year is striving for a 25% improvement in EI for the calendar year ending December 2027 (Year 0 = 2017, Year 1 = 2018, and Year 10 = 2027).

> *Example 5: Selecting a Baseline Year*
>
> Acme Flooring signed the Better Plants Pledge in January 2020 and initially considered 2019 for its baseline year. Final production data in March 2020 showed a substantial drop in production in 2019. After discussion with DOE, the company opted to use 2018 as its baseline year since it is more reflective of normal business conditions for the company.

Step 3: Determine Independent Variables Affecting Energy Consumption at Each Facility

Many variables can affect the monthly or even daily energy consumption of a facility. Examples of variables that can cause an increase or decrease in energy consumption include production level variability, product type variability, factors of production, weather, and feedstock/raw material 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 the independent variables that are most relevant to the facility. Note that these variables do not have to be the same for every facility in the corporate pledge.

The regression-based approach uses regression analysis to normalize consumption (see Step 5 starting on page 20 for more information). Essentially, regression analysis aims to ensure that reporting period and baseline year consumption are normalized so that the two periods correspond to consistent conditions (e.g., comparable weather and production levels). Before regression analysis, potentially relevant independent 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 EI will be production levels and weather. Facility managers will need to identify additional variables based on knowledge of their manufacturing processes and work with their TAM to find sources for this data if not already available. 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 also discussed in Step 5.

> *Tips for Selecting Independent Variables*
>
> Knowledge of how variables affect fuel or electricity consumption should be considered when developing regression models. For example, if a plant manager knows that high humidity affects natural gas usage, some measure of humidity should be included as an independent variable in the natural gas model.
>
> Another way to identify model variables is to compare two months in the same year with similar production levels or the same month from the previous year. By determining and/or explaining differences in energy consumption between months, variables for the regression can be determined.

Step 4: Gather Data on Energy Consumption and Independent Variables for Each Facility

Each facility in a company's pledge scope must gather energy consumption data for the selected baseline year and for each subsequent year for annual reporting to DOE. The data collection guidelines and adjustments from the previous section (see page 6) should be used for each fuel type with sources converted to primary energy using appropriate multipliers. Data for other independent variables including production levels and weather degree days should also be collected.

Example 6: Determining Relevant Independent 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 2020 energy consumption to its baseline year in 2018. 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 heating, ventilation, and air-conditioning loads vary 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 an independent variable and collects data on the tons of tile produced each month for 2018 through 2020.

In Rochester, Minnesota, winter temperatures drop well below freezing and in the summer rise above 80 degrees Fahrenheit. Knowing that temperatures fluctuate throughout the year and that plant air is conditioned between 65 and 75 degrees Fahrenheit year-round, the Rochester facility decides to include both HDDs and CDDs as independent variables in its modeling and collects the monthly degree day data between 2018 and 2020. Because plant heating uses natural gas, HDD is taken as the only weather variable in the natural gas model. Similarly, CDD is taken as the only weather variable in the electrical consumption model as the plant is cooled by electric-powered air conditioners.

The final variable that Rochester considers is number of employee hours worked each month. Between 2018 and 2020, 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 these two should be considered.

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

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.[16] 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 for the effects of variables such as annual production levels and weather. The equations used in

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

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.[17]

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

$$Energy\ Consumption = m_1x_1 + m_2x_2 + m_3x_3 + b$$

In the preceding equation, m_i are constant coefficients, x_i are independent variables, and b represents energy use when all independent variables are zero. Examples of independent variables include production, HDDs, and CDDs. Determining the independent 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.

Tips for Finding the Best Regression Models

Use of software tools (such as the EnPI tool) may develop several 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. For example, if any of the following situations occur, consider selecting a different model:

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

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 the facility uses 3 MMBtu to produce one unit of product and the space heating system requires 1 MMBtu for each HDD. In addition, the energy use for production is not dependent on the HDDs and the facility does not consume energy when production and HDDs are zero. The linear model for this scenario becomes:

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

Continuing the example, assume that production doubles in the third reporting year (RY3) and the number of HDDs is similar to the baseline year. The modeled energy consumption associated with production would approximately 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 implements efficiency upgrades to the production line or throughout the plant that result in energy savings and the HDDs remain unchanged, the actual energy consumption would be less than the modeled energy consumption. The difference between the actual and modeled energy consumption for the facility

[17] Although 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.

represents the energy performance improvement between the baseline year and third reporting year. Figure 6 shows a comparison of the actual to modeled energy consumption for this facility in the third reporting year.

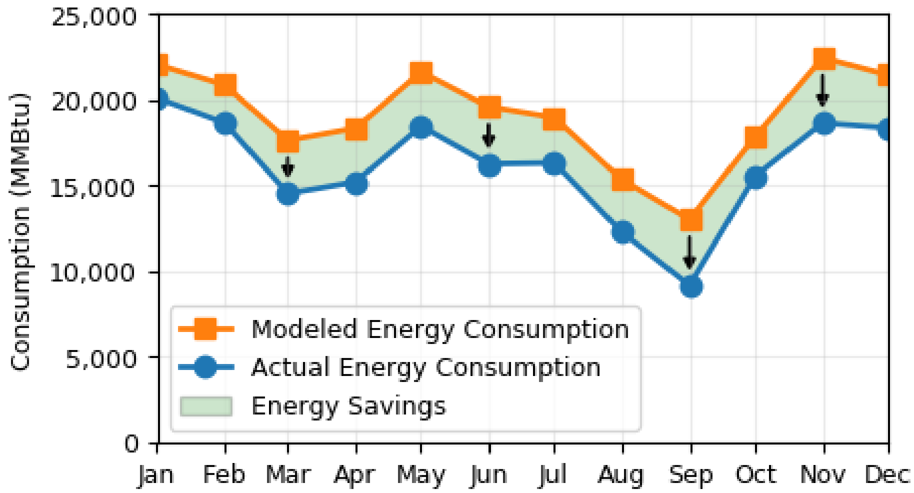

Figure 6: Reporting Year 3 (RY3) model shows an improvement in energy efficiency.

In Figure 6, the upper line (orange) represents the energy the plant would have used in RY3 if the plant was operating the way it did in the baseline year, but at RY3 production levels and weather conditions. The lower line (blue), shows the actual RY3 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 RY3. The difference between these two models represents the magnitude of the improvement.

Three primary methods exist for calculating energy performance using regression analysis. [18] The most common is forecasting, the method used in the preceding example. Details for each method are given subsequently, and Table 6 summarizes which periods are used to determine energy savings for each method. Figure 7provides a graphical representation of energy saving calculations with each method.

- **Forecasting** uses baseline period energy consumption to develop a linear model from which reporting period energy consumption can be estimated assuming no operational changes or efficiency measures have occurred. If the modeled energy consumption in the reporting period is higher than the actual energy consumption, then the facility 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 easily to analyzing EI improvements for several years into the future.
- **Backcasting** uses the reporting period energy consumption to develop a linear model that 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 can be used to normalize data from future reporting years. The year after the first year the model is used, the method becomes the chaining method described subsequently because the model is now applied both forward and backward in time.

[18] *Superior Energy Performance™ Measurement and Verification Protocol for Industry*, November 19, 2017.

- **Chaining** uses an intermediate year to create a model when a statistically valid model cannot be found from either the reporting or baseline period data (i.e., p-values and R-squared values are not acceptable). A chaining model will be evaluated at both baseline and reporting year conditions to calculate total improvement provided the model is valid according to the second validation check described on page 24 and assuming facility conditions are unchanged. This method is particularly helpful when a plant has undergone a significant change in production such that current production compared to the baseline year is outside of the 3 standard deviation limits for a valid model.

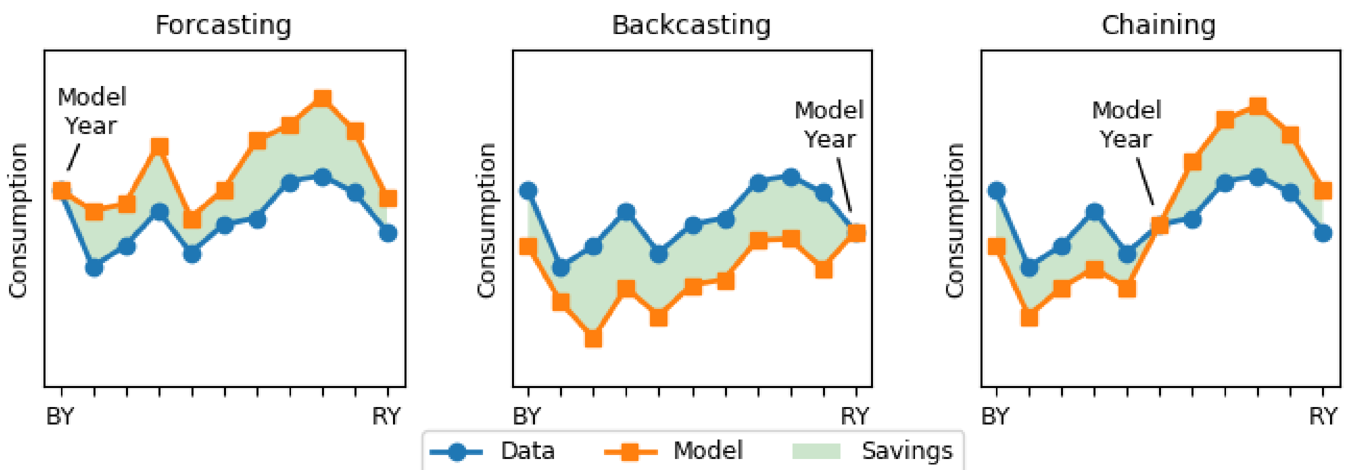

Figure 7: Savings are calculated differently for each of the three methods used in regression modeling.

To calculate changes in EI 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 periods. Note that the EnPI tool also supports data sets with weekly or daily intervals if available. DOE recommends Partners base their models on 12 months of data. Expanding the time frame beyond 12 months can improve the model accuracy but complicates the calculation of energy savings.

Typically, a Partner must develop a separate regression model for each fuel source consumed by the facility. In some cases, a variable might be included with only one fuel source. For example, in a facility where a substantial amount of the energy is used to cool a facility, CDDs may be important only 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. This is particularly true when multiple fuels are used in a single boiler, those fuels can be added on a BTU basis and used to model the steam fuel used by the boiler.

Table 6: Model Year and Normalized Year for Regression Modeling

	Forecast	Backcast	Chaining
Model Year (Used to Determine Model)	Baseline Year	Reporting Year	Any Year Between the Baseline and Reporting Year
Normalized Year(s)	Reporting Year	Baseline Year	Baseline and Reporting Year

A Partner may find that different regression methods are more appropriate for different facilities within its scope. 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 14-2014 – Measurement of Energy, Demand, and Water Savings,* and Bonneville Power Administration's *Regression for M&V: Reference Guide*. Note that use of regression may not be advisable for all situations, such as when limited data exist for independent variables. Better Plants technical account managers can help evaluate plant data and independent variables to determine if regression techniques are appropriate for a given facility.

Model Validity

To determine whether a regression model is valid, several statistical measures can be 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 and EnPI follow the Super Energy Performance (SEP) model validity tests as outlined in Sections 3.4.5 and 3.4.6 of the *Superior Energy Performance 50001™ Measurement and Verification Protocol.* Validation checks are explained further in the following call-out.

Validation Checks for Model Validity

Better Plants recommends two validation checks that can be done to ensure a model is valid for a given data set. These checks confirm that a model will 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 R-squared value for the regression must be at least 0.50

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

For additional information on model validity, see the *Superior Energy Performance 50001™ Measurement and Verification Protocol*.

Need for a New Model and the Banking Approach

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 passes the preceding validations checks, when a facility begins producing a new product, etc. In many cases, changes to the production level will cause validation check 2 to fail. In these situations, 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). If the new model is valid, it can be used as outlined in the previous sections.

If no new valid model can be developed, an "intermediate baseline year" can be established for the first year in which operating conditions match current conditions. A new model will need to be developed using either data from the current reporting year or the first year the operating conditions match current conditions. Savings for this new baseline year will be taken as zero as no data for comparison is available. Total improvements in EI from the original model (from baseline year to previous year) can then be **banked** and added to total improvements from the new model starting from the new baseline year.[19]

An example of banked savings is shown Figure 8, where a major production change occurred in year 6 such that no valid model could be found for all years in the data set. Savings from Baseline Period 1 (BP1) are fixed after year 5 (banked), and a new baseline model is developed from year 6 data. Savings from year 7 onward are calculated using the new model and added to the fixed savings from BP1. Although 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.

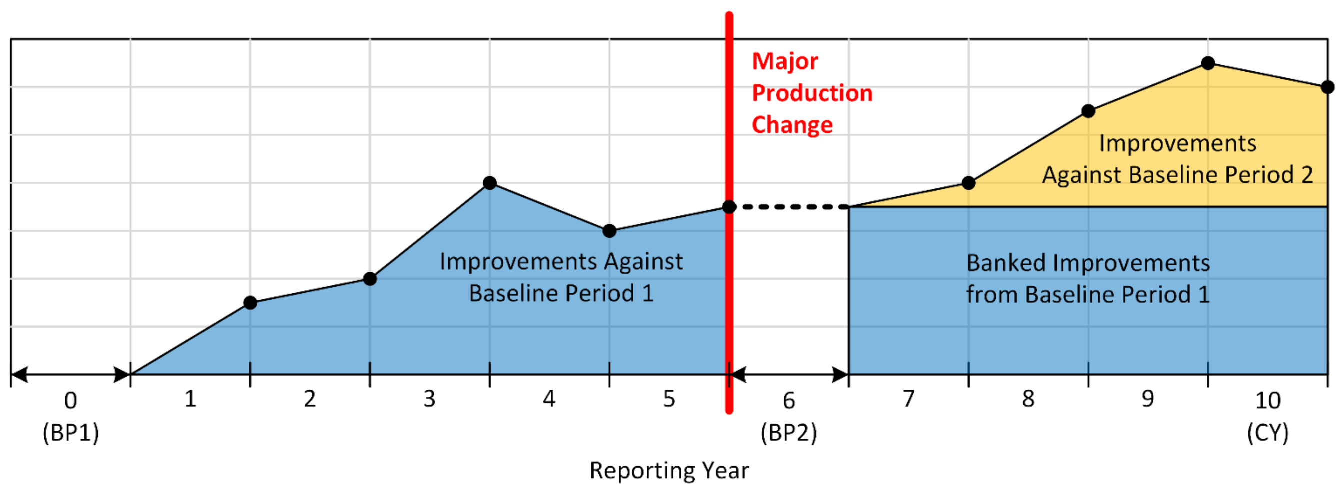

Figure 8: Facility baseline year reset can accommodate large changes in production.

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

The next step for regression-based modeling is to calculate the total improvement in EI. The equation used for this calculation varies depending on which regression method is used. The following box lists the equations used to calculate the *Total Improvement in EI Since Baseline Year* for the forecasting, chaining, and backcasting regression methods. In the following equations, EC represents the actual energy use, $\overline{EC}$ represents the modeled energy use,

[19] Companies using the facility-level approach may also use the banking method. In some cases, operations may change so significantly at an individual plant that reporting year energy intensity can no longer be usefully compared with 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.

BY represents the baseline year, and RY represents the current reporting year. DOE's EnPI tool will perform these calculations for the user.

Equation 4: Calculating Total Improvement in Energy Intensity

Forecasting (Model Year = Baseline Year)

$$Total\ Improvement\ in\ Energy\ Intensity_{RY} = \left(1 - \frac{EC_{RY}}{\overline{EC}_{RY}}\right) \times 100$$

Chaining (Baseline Year < Model Year < Reporting Year)

$$Total\ Improvement\ in\ Energy\ Intensity_{CY} = \left(1 - \frac{\overline{EC}_{BY} \times EC_{RY}}{EC_{BY} \times \overline{EC}_{RY}}\right) \times 100$$

Backcasting (Model Year = Reporting Year)

$$Total\ Improvement\ in\ Energy\ Intensity_{CY} = \left(1 - \frac{\overline{EC}_{BY}}{EC_{BY}}\right) \times 100$$

Example 7 illustrates the calculation for *Total Improvement in EI* for a case using forecasting as the regression method. Organizations calculating total improvement in EI without modeled values (i.e., using non-normalized energy data) should refer to Example 13.

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

Forecasting was selected as the regression method for Acme's Rochester, Minnesota, facility. For 2020, the modeled energy consumption for the facility is calculated to be 921,189 MMBtu while the actual energy consumption was 843,772 MMBtu. Using the actual and modeled energy consumption, the total improvement in EI since baseline year is calculated to be

$$Total\ Improvement\ in\ Energy\ Intensity_{CY} = \left(1 - \frac{EC_{RY}}{\overline{EC}_{RY}}\right) \times 100$$
$$= \left(1 - \frac{843{,}772\ MMBtu}{921{,}189\ MMBtu}\right) = \mathbf{+8.40\%}$$

The positive total improvement indicates the Rochester facility performed more efficiently in 2020 than its baseline year of 2018.

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 facility's EI improvements based on energy consumption for the baseline year. The equation for aggregating the facility-level EI improvements to determine the corporate total improvement in EI is shown in Equation 4.

Equation 5: Corporate Total Improvement in Energy Intensity

$$Total\ Improvement\ in\ Energy\ Intensity_{Corp} = \frac{\sum_{i=1}^{n} TEI_i \times EC_i}{\sum_{i=1}^{n} EC_i} \times 100$$

In Equation 5, TEI_i represents facility total improvement in EI, EC_i represents facility modeled *baseline* energy consumption, and n represents the number of facilities within the company pledge. 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 EI*. See Appendix C for additional information on corporate-level adjustments.

Example 8: Calculating Corporate-Level Total Change in Energy Intensity

In Example 7, Acme Flooring calculated the total change in EI for its Rochester facility for 2020. Knowing the energy consumption and total change in EI for each facility, the total corporate-level change in EI can be determined. The 2020 Total Improvement in EI and baseline total modeled primary energy consumption values for all six Acme Flooring facilities are shown in Table 7.

Table 7: 2020 Annual Improvements and Total Energy Consumption for Acme Flooring

	Plant	2020 Total Improvement in EI	Baseline Total Modeled Primary Energy Consumption (MMBtu)
1	Cleveland, OH	7.34%	120,300
2	Ashland, OH	11.95%	340,000
3	Duluth, MN	2.78%	320,100
4	Minneapolis, MN	1.90%	859,660
5	Rochester, MN	8.40%	843,772
6	Hastings, MN	9.65%	765,000
		TOTAL	**3,248,832**

For Acme Flooring, the corporate total change in EI is calculated using Equation 5:

$$Total\ Improvement\ in\ Energy\ Intensity_{corp} =$$

$$\frac{7.34\% \times 120{,}300 + 11.95\% \times 340{,}000 + 2.78\% \times 320{,}100 + 1.90\% \times 859{,}600 + 8.40\% \times 843{,}772 + 9.65\% \times 765{,}000}{3{,}248{,}832} \times 100$$

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

Annual Improvement in Energy Intensity

After the *Total Improvement in EI* is determined, the *Annual Change in EI* for the Reporting Year is calculated. This is done by subtracting the previous year's corporate total improvement in EI from the current reporting year's corporate total improvement in EI. Equation 6 gives the formula for this calculation.

Equation 6: Annual Improvement in Energy Intensity

$$\begin{aligned} &Annual\ Improvement\ in\ Energy\ Intensity_{Reporting\ Year} \\ &\quad = Total\ Improvement\ in\ Energy\ Intensity_{Reporting\ Year} \\ &\quad - Total\ Improvement\ in\ Energy\ Intensity_{Previous\ Year} \end{aligned}$$

For a Partner selecting a baseline year that is two or more years earlier than the reporting year, a previous report will not be available to draw on for the first annual report; therefore, there will not be a reported "Total Improvement in EI for Previous Year" to use in Equation 6. For this situation, the Partner will use unreported data from the previous year to determine the *Total Improvement in EI* for the Previous Year. For example, if a Partner joined the program in 2020 and set calendar year 2017 as its base year, the Partner's first annual report, covering calendar year 2020, will need to draw on internal (unreported to DOE) energy data for 2019 when calculating EI using Equation 6. If the baseline year and reporting year are consecutive years, then the annual improvement should equal total improvement for the first year.

Example 9: Calculating Corporate-Level Annual Improvement in Energy Intensity

In 2020, Acme Flooring reported a total improvement in EI since its baseline year (2018) of 6.75%. For 2021, the company's total improvement in EI since its baseline year is 11.20%. On its 2021 report, Acme Flooring will report an annual improvement in EI of:

$$11.20\% - 6.75\% = \mathbf{+4.45\%}$$

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

Step 8. Calculate Total and New Energy Savings

The final calculations required for the Better Plants annual reporting form are the "*Total Energy Savings since Baseline Year*" and "*New Energy Savings for the Reporting Year*." The calculation for the "*Total Energy Savings since Baseline Year*" is shown 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

$$\begin{aligned} &Total\ Energy\ Savings\ since\ Baseline\ Year\ (MMBtu) \\ &\quad = Total\ Primary\ Energy\ Consumed_{Baseline\ Year} \\ &\quad + Adjustment\ for\ Baseline\ Primary\ Energy_{Reporting\ Year} \\ &\quad - Total\ Primary\ Energy\ Consumed_{Reporting\ Year} \end{aligned}$$

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 Reporting Year*" represents an estimate of the energy savings accumulated since the previous reporting year and is calculated as shown in Equation 8.

As with the previous calculation, Partners may need to use unreported data if filing their first report with a selected baseline year two or more years before joining the program. Therefore, a Partner with 2018 as a baseline year would need unreported data for 2019 to determine the *New Energy Savings for Reporting Year* in 2020.

Equation 8: New Energy Savings for Reporting Year

$$\begin{aligned} &New\ Energy\ Savings\ for\ Reporting\ Year\ (MMBtu) \\ &\quad = Total\ Primary\ Energy\ Consumed_{Previous\ Year} \\ &\quad + Adjustment\ for\ Baseline\ Primary\ Energy_{Reporting\ Year} \\ &\quad - Total\ Primary\ Energy\ Consumed_{Reporting\ Year} \end{aligned}$$

--- *OR* ---

$$\begin{aligned} &New\ Energy\ Savings\ for\ Reporting\ Year\ (MMBtu) \\ &\quad = Total\ Energy\ Savings\ since\ Baseline\ Year_{Reporting\ Year} \\ &\quad - Total\ Energy\ Savings\ since\ Baseline\ Year_{Previous\ Year} \end{aligned}$$

Facility-Level Energy Intensity Approach

Although the regression-based approach is highly recommended by Better Plants and will generally provide the most accurate results for companies participating in the Better Plants program, it may not be feasible for all companies. This section presents two options for the next best method known as the facility-level energy intensity approach: Classic Energy Intensity (CEI) analysis and Modified Energy Intensity (MEI) analysis.

Methodology

The process for the facility-level approach is similar to the regression-based approach except that regression is not performed and the only data required are annual production and energy consumption. The steps of the facility-level approach are as follows:

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

These steps are the same for both facility-level methodologies described in this section.

Energy Intensity

Both CEI and MEI analysis require the calculation of a facility's EI, which is the ratio of total annual energy consumed to a physical unit of production. EI is defined in Equation 9 where "*Total Units of Output*" should be the factor, usually production, having the largest impact on energy consumption at a facility. Compared with the regression approach, less data is required to compute EI as additional variables that affect consumption (e.g., temperature and humidity) are not considered. Only total primary energy consumption and total units of output for each facility are required. Additionally, annual data is sufficient to compute EI, whereas monthly data is required when modeling using the regression-based approach.

Equation 9: Facility-Level Energy Intensity

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

When a facility makes multiple products within a plant and has a submetering system in place, DOE recommends tracking the energy consumption for each product separately, especially if it is known that EI varies greatly from product to product. This allows for more accurate calculation of EI improvement from year to year.

When individual product tracking is possible, changes in EI at the facility are calculated by taking a weighted average of each product line's percent change, similar to how facility-level changes are rolled up into a corporate-wide metric in Step 7 of the regression-based approach. In this case, the weighting is the baseline energy use (in absolute terms) of the individual product lines. Example 10 shows how to aggregate *Improvement in EI* for multiple products with submetering to find plant-level *Total Improvement in EI* using the CEI method.

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 submeters at key locations such as electrical panels, natural gas headers, steam distribution junctions, etc. Installing submeters on key steam distribution or compressed air distribution lines may also be necessary. DOE's Federal Energy Management Program has published *Metering Best Practices: A Guide to Achieving Utility Resource Efficiency*[20] for organizations looking for an introduction to metering and submetering technologies and planning. The guide also includes several case studies.

When submetering is not available, only a single unit of output can be selected for the "*Total Units of Output.*" Different approaches can be used to develop an EI metric if multiple dissimilar products are produced within a given facility. A company without a submetering system should consider developing a "standard unit of output," essentially a single 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 its standard unit of output when calculating the facility EI. This approach is most appropriate when the relative EI of each product type is similar.

If EI 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, a company can create a "standard unit of output" with an EI 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 8 lists the different methods for selecting a "standard unit of output" in order of expected accuracy.

Classic Energy Intensity Method

Once the EI for each production line or the entire facility is determined, the next step is to calculate the *Total Improvement in Classic Energy Intensity (CEI)* for each production line or the entire facility depending on the method used to group the production data (see Table 8). Equation 10 gives the formula for calculating the CEI.

Equation 10: Facility-Level Total Improvement in Classic Energy Intensity

$$Total\ Improvement\ in\ Classic\ Energy\ Intensity = \left(1 - \frac{Energy\ Intensity_{Reporting\ Year}}{Energy\ Intensity_{Baseline\ Year}}\right) \times 100$$

Improvements in EI should be a positive percentage. If the EI worsens, the Total Improvement in CEI will be a negative value.

Example 10 shows how to calculate *Total Improvement in CEI* for a company that has submetering of two production lines.

[20] https://www.energy.gov/sites/prod/files/2015/04/f21/mbpg2015.pdf

Table 8: Methods for Grouping Multiple Different Products into a Standard Unit of Output

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: Unlike the product line approach, this method does not require submetered data but does require at least an estimate of the relative energy intensity for each production line. This approach is typically the second most accurate method.
Standard Unit of Output: Other	Annual facility total energy consumption 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 because 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.	Uses 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 13 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 all the approaches since the revenue or labor hours may not always be directly correlated to energy consumption by the facility. In addition, when revenue is used, the time frame corresponding to the revenue may not line up with the time frame corresponding to the energy consumption.

Example 10: Calculating Energy Intensity Improvement Using Classic Energy Intensity

Acme Flooring's Ashland, Ohio, plant manufactures two types of flooring, each with a different EI metric. If only aggregate energy data for flooring production 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 plant opts to track the energy consumption separately for each type of product. The units of output selected by the plant are shown in Table 9:

Table 9: Units of Output Selected for Acme Flooring Ashland Plant

Submeter	Energy Sources	Unit of Output
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 2019 CEI change for its Ashland plant versus its baseline year of 2018. The production lines, baseline energy use, baseline production, 2019 energy use, and 2019 production for the Ashland plant are shown in Table 10:

Table 10: Calculation of EI for Acme Flooring Ashland Plant

Submeter	2018 (Baseline) Primary Energy Consumption (MMBtu)	2018 Output (tons)	2019 Primary Energy Consumption (MMBtu)	2019 Output (tons)
Ceramic Tile Production Line	340,000	18,600	355,000	19,200
Porcelain Tile Production Line	300,300	20,500	320,000	22,200

For the ceramic tile production line, the CEI for 2018 and 2019 are calculated as:

$$\text{2018 Classic Energy Intensity (Ceramic)} = 340{,}000\ MMBtu/18{,}600\ tons = 18.28\ MMBtu/ton$$

$$\text{2019 Classic Energy Intensity (Ceramic)} = 355{,}000\ MMBtu/19{,}200\ tons = 18.49\ MMBtu/ton$$

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

$$\text{2018 Classic Energy Intensity (Porcelain)} = 300{,}300\ MMBtu/20{,}500\ tons = 14.65\ MMBtu/ton$$

$$\text{2019 Classic Energy Intensity (Porcelain)} = 320{,}000\ MMBtu/22{,}200\ tons = 14.41\ MMBtu/ton$$

Using the energy intensities calculated above, the Ashland plant next calculates 2019 total improvement in EI by aggregating EI improvements for the porcelain and ceramic production lines. First, the 2019 EI improvement for each production line is calculated using Equation 10.

Example 10 continued on next page…

Example 10 continued…

Ceramic Tiles:

$$2019 \text{ Total Improvement in Classic Energy Intensity} = \left(1 - \frac{Energy\ Intensity_{2019}}{Energy\ Intensity_{2018}}\right) \times 100$$
$$= \frac{18.28 - 18.49}{18.28} = \mathbf{-1.15\%}$$

The negative total improvement in EI represents worsening EI. Acme repeats this calculation for Ashland's porcelain tile production line and determines the 2019 improvement to be **+1.60%**. Using these values, Acme calculates the *2019 Total Improvement in CEI* for the Ashland plant using Equation 5:

$$2019 \text{ Ashland Plant Total Improvement in Classic Energy Intensity} = \frac{\sum_{i=1}^{n}(TEI_i \times EC_i)}{\sum_{i=1}^{n} EC_i} \times 100\,,$$

where TEI_i represents the total improvement in EI for a given production line and EC_i represents the baseline energy consumption for the given line. Using the equation above, the total improvement in EI for the Ashland plant is calculated as

$$2019 \text{ Ashland Total Improvement in Classic Energy Intensity}$$
$$= \frac{(-1.15\% \times 340{,}000) + (1.60\% \times 300{,}300)}{340{,}000 + 300{,}300} \times 100 = \mathbf{+0.14\%}$$

The Ashland facility has improved its energy performance as the *Total Improvement in EI* is positive. However, based on the calculations for each production line, Acme sees that the energy performance of its ceramic tile production line has worsened and that the energy performance of its porcelain tile production line has improved.

Adjustments may be needed to account for significant changes at the facility level. Examples of scenarios that may require facility-level adjustments 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.
- 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 before calculating the plant-level *Total Improvement in EI* and corporate-level *Total Energy Savings since Baseline Year.* Example 11 illustrates how to make an adjustment for a production line closure before calculating the *Total Improvement in EI*. More information on adjustments follows in the "Special Considerations" beginning on page 38.

Example 11: Calculating Adjustments because of Production Line Closure

At the start of 2020, Acme's Ashland facility shut down its porcelain tile production line because of limited market demand. Because of this market shift, production on other lines and at other facilities did not change. Energy consumption for its porcelain and ceramic tile production lines for 2018, 2019, and 2020 is shown in Table 11.

Table 11: Acme Ashland Plant Energy Consumption and Production

	2018		2019		2020	
Tile Type	Porcelain	Ceramic	Porcelain	Ceramic	Porcelain	Ceramic
Output (tons)	20,500	18,600	22,200	19,200	0	21,000
Primary Energy Consumed for Production (MMBtu)	300,300	340,000	320,000	355,000	0	338,000
Total Primary 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 EI and Total Energy Savings since Baseline year for 2020. The adjustment for this example is the energy consumption for porcelain tile production in 2018, which is 300,300 MMBtu.

When calculating the 2020 total improvement, Ashland should include only the ceramic tile production line since the porcelain production line was closed in 2020. Therefore, the total adjusted improvement in EI of the Ashland facility for any reporting year can be calculated as:

$$2020\ Total\ Improvement\ in\ Classic\ Energy\ Intensity$$
$$= \frac{\left(Adjusted\ Energy\ Intensity_{Baseline\ year} - Energy\ Intensity_{Reporting\ Year}\right)}{Adjusted\ Energy\ Intensity_{Baseline\ year}} \times 100$$
$$= \frac{340{,}000\ MMBtu/18{,}600\ tons - 338{,}000\ MMBtu/21{,}000\ tons}{340{,}000\ MMBtu/18{,}600\ tons} \times 100 = \mathbf{+11.95\%}$$

Then the total energy savings since the baseline year for 2020 is:

$$\begin{aligned} Total\ energy\ savings\ since\ baseline\ year_{2020} &\\ &= Total\ Primary\ Energy\ Consumed_{Baseline} \\ &+ Adjustment\ for\ Baseline\ Primary\ Energy_{Production\ Closures} \\ &- Total\ Primary\ Energy\ Consumed_{2020} \\ &= 640{,}300\ MMBtu + (-300{,}300\ MMBtu) - 338{,}000\ MMBtu = \mathbf{2,000\ MMBtu} \end{aligned}$$

Modified Energy Intensity Method

The CEI method from the previous section considers production as the only factor affecting energy consumption. It also inherently assumes that energy consumption is zero when production is zero. These conditions are rarely valid because of technological and operational considerations including power draw from idling equipment, compressors running because of compressed air leaks, etc.

The Modified Energy Intensity (MEI) approach was developed to bridge the gap between the CEI approach and linear regression modeling.[21] MEI considers not only production but incorporates the concept of baseload energy (consumption not related to production). Thus, MEI can be more accurate than CEI while requiring only one additional data point: the percentage of base energy. Although less accurate than the regression-based approach, the MEI approach is much easier to implement.

Equation 11 shows that *"Total Improvement in MEI"* is a weighted average of the total energy comparison and the CEI metrics[21]. The total energy comparison is a non-normalized metric that uses the actual total energy consumed in the reporting ($\bar{E}_T$) and baseline ($\hat{E}_T$) years. The weights $\%_B$ and $\%_P$ are an estimate of the ratio of facility base load to production energy with $\%_B + \%_P = 1$. If available, submetering is be best option to determine a facility's base load percentage ($\%_B$). Facilities can also estimate $\%_B$ based on Manufacturing Energy Consumption Surveys (MECS) industry end-use energy consumption, data from facilities with similar processes, or based on engineering knowledge of the facility. In essence, the MEI approach is a corporate roll-up of two fictitious facilities. One facility calculates its savings using absolute total energy and one calculates savings using the CEI approach.

Equation 11: Facility-Level Total Improvement in Modified Energy Intensity

$$\begin{aligned}&Total\ Improvement\ in\ Modified\ Energy\ Intensity\\&= \%_B \times \left(1 - \frac{\bar{E}_T}{\hat{E}_T}\right) + \%_P \times \left(1 - \frac{\overline{EI}}{\widehat{EI}}\right)\\&= \%_B \times S_{TEC} + \%_P \times S_{CEI}\end{aligned}$$

Example 12 shows how the facility-level *Total Improvement in EI* can be calculated using the MEI approach.

Example 12: Calculating Energy Intensity Improvement using Modified Energy Intensity

Acme's Ashland plant estimates that 20% of its annual energy consumption is not related to production but is tied to systems like heating, ventilation, air-conditioning, and lighting. Because monthly data is not available, Ashland decides to update their energy savings using the MEI facility-level approach.

From Table 11 and Equation 11, the Ashland plant's *Total Improvement in EI* using the MEI approach is:

$$\begin{aligned}&Total\ Improvement\ in\ Modified\ Energy\ Intensity\\&= 0.2 \times \left(1 - \frac{338{,}000\ MMBtu}{340{,}000\ MMBtu}\right) + 0.8 \times \left(1 - \frac{338{,}000\ MMBtu/21{,}000\ tiles}{340{,}000\ MMBtu/18{,}600\ tiles}\right)\\&= \mathbf{+9.67\%}\end{aligned}$$

[21] W. Guo, T. Wenning, S. Nimbalkar, K. Thirumaran, K. Armstrong, and E. Levine. 2019. "*A New Methodology for Calculating the Energy Performance of Manufacturing Facilities*. Energy Engineering, 116(2): 7-21.

Corporate-Level Energy Intensity Approach

Methodology

The corporate-level EI approach is similar to the facility-level EI approach except that all facilities within a Partner's pledge scope are treated as one composite facility. As in Step 4 of the facility-level approach, energy consumption and production data (unit of output) are gathered and summed for all facilities; however, Step 7 does not apply. All facilities must use the same denominator when calculating EI to use the corporate-level approach, which draws heavily on the steps used in the regression-based approach. An understanding of those steps is recommended before proceeding. The steps for the corporate-level EI approach are as follows:

1. Define the boundary.
2. Choose a baseline year.
3. Decide on the corporate-wide EI denominator.
4. Gather data on energy consumption and whatever is being used as the corporate-wide EI denominator—usually units of output, revenue, or some other financial metric.
5. Calculate EI for the baseline year and the reporting year.
6. Calculate the change in EI 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 EI 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.

Example 13: Calculating Energy Intensity Improvement Using Corporate Approach and Revenue

Consider a company that was unable to find valid regression models for its two facilities. To calculate their energy intensity improvement, they have therefore opted to use the corporate-level energy intensity approach using revenue as the unit of output. The company's nominal revenue and combined primary energy consumption for both facilities for the baseline year (2016) through the current reporting year (2020) are shown in Table 12. Also shown are the CPI values for adjusting for inflation (see Figure 5 on page 16) and the ratio of each year's CPI to the baseline year CPI.

Table 12: Nominal Revenue and Economic Indicators

Year	Primary Energy Consumption (MMBtu)	Nominal Revenue	CPI	CPI Ratio	Real Revenue	Energy Intensity (MMBtu/$)	Total Improvement in Energy Intensity
2016	253,000	$20,500	113.4	1	$20,500	12.341	---
2017	255,000	$23,500	117.1	1.032	$22,770	11.199	9.25%
2018	261,300	$26,400	120.4	1.062	$24,860	10.511	14.83%
2019	258,600	$28,000	125.0	1.102	$25,410	10.177	17.54%
2020	252,500	$28,400	124.6	1.099	$25,840	9.769	20.84%

The real revenue for each year is calculated using Equation 3. For 2020 this calculation is:

$$Real\ Value_{2020} = \frac{Nominal\ Value_{2020}}{Index\ Value_{2020}} = \frac{\$28{,}400}{1.099} = \$25{,}840$$

The corporate level EI for 2016 and 2020 are calculated using Equation 9:

$$Energy\ Intensity_{2016} = \frac{Total\ Energy\ Consumption_{2016}}{Total\ Units\ of\ Output_{2016}} = \frac{253{,}000\ MMBtu}{\$20{,}500} = 12.341\frac{MMBtu}{\$}$$

$$Energy\ Intensity_{2020} = \frac{Total\ Energy\ Consumption_{2020}}{Total\ Units\ of\ Output_{2020}} = \frac{252{,}500\ MMBtu}{\$25{,}840} = 9.772\frac{MMBtu}{\$}$$

Finally, Equation 10 is used to calculate the corporate level total improvement in EI for 2020:

$$Total\ Improvement\ in\ Energy\ Intensity_{2020} = \frac{12.341 - 9.769}{12.341} = \mathbf{+20.84\%}$$

Special Considerations

Over the 10-year Better Plants pledge period, operations at Partner facilities may undergo significant changes. This section seeks to clarify energy accounting practices for several common circumstances. Additional examples can be found in Appendix C.

Internal Changes at a Facility

Rarely will a facility remain unchanged during the Better Plants pledge period. Plants may undergo expansion, consolidation, or change production capabilities. When such changes occur, adjustments to energy models and savings must be made.

Adding a New Product

When a facility adds a new product to its production or makes significant changes to a production line, the appropriate accounting procedure depends on the baseline method used:

- *Regression-Based Approach:*
  Production data from the new line must be used to generate a regression model that includes the new product as an independent variable. After the first full 12-month period with new production, energy savings are calculated as before with the new baseline model.
- *Facility-Level Approach:*
  A facility adding a new product to its production is encouraged to install the proper submetering capabilities to independently track the energy intensity (EI) of the new product. This EI would then be included in the corporate roll-up calculation (Equation 5) as a separate instance/facility. If submetering is not available, a common unit of output must be developed for the facility that includes the new product.
- *Corporate-Level Approach:*
  A new common unit of output must be developed for all facilities in the corporate pledge scope. The new product production then appears as an increase in the output of the facility in the denominator of the corporate-level roll-up equation.

Expanding/Consolidating Existing Production

When existing production is expanded or consolidated, special care must be taken with the regression-based approach to ensure the validity of the energy model. In general, changes in production levels due to line additions and closures will cause model Validation Check 2 to be violated (see page 24). Either a new model that is valid for all reporting years must be developed, or a banking approach must be employed for previous reporting years.

The facility- and corporate-level approaches require no changes in energy saving calculations when dealing with production expansion or consolidation.

Addition/Closure of a Facility

The facilities operated by a Partner and included in their pledge scope often change over the pledge period. 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 are 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 including EPA Climate Leaders, World Resources Institute, and ENERGY STAR for INDUSTRY partners.

Scenarios such as the addition or closure of an existing facility will often require an adjustment to the baseline year 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 before calculating *Total Improvement in EI* and *Total Energy Savings since Baseline Year,* unless otherwise noted. Note that facilities should be included in these calculations only if a full reporting year of data is available.

Closing or Selling a Facility

When removing a facility, that facility's energy consumption is removed from the baseline year and is excluded from future energy saving calculations. Savings from intermediate years are unchanged as those energy savings have been realized. A facility closed before the end of the current reporting year should be excluded from the reporting year's energy savings calculations. If production from a closed facility is transferred entirely to another plant, no change in baseline energy is required.

Adding a New Facility

The approach taken to account for the addition of a newly constructed facility to the Partner's portfolio depends on the method used to estimate energy savings:

- *Regression-Based Approach:*

  If a company has a similar facility in its portfolio, data from that facility should be used to create a forecast model to calculate energy performance indicators for the new facility's first full reporting year. Two facilities are considered similar if they produce the same or similar products, are in the same geographic region, and are similar in size. For the second reporting period after the addition, a new regression model should be created using the first 12 months of data for the new facility. The total improvement from the second report will be added to the improvement from the first report.

  If the company does not have a similar facility, the new facility's energy and relevant data (e.g., production, weather) for the first full reporting year of operation must be used as the baseline for developing a regression model (even though the year is different) and to determine the baseline EI.

- *Facility-Level Approach:*

  Improvement in EI for the first 12 months of operation should be calculated by comparison with similar facilities or an average EI from multiple similar plants. For the second full year of operation, annual improvement for the new facility is calculated by comparing the second year EI with the first year EI. Total Improvement in EI for the second year is calculated by adding the annual improvement to the total improvement from the first year.

  As with the regression-based approach, if the company does not have similar facilities making similar products, the EI 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 the total improvement in EI.

- *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 EI 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.

Adding an Existing Facility

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 EI, depending on the approach the Partner uses to calculate the *Total Improvement in EI.*

Before 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 facility should be treated as new construction and the methodology described in the previous section used to calculate the *Total Improvement in EI* and *Total Energy Savings since Baseline Year.*

Appendix C provides example scenarios and expanded guidelines for changes to the pledge scope after the baseline year, including for construction of a new facility, acquisition of an old facility, and closure of a facility.

Other Pledge Scope Changes

Other significant corporate-level scope changes may arise for program 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 pledge scope changes that are not addressed by the previous guidelines, the Partner should contact DOE for guidance.

Baseline Shifting

A facility may need to shift its baseline energy consumption because of many special circumstances, for example, if an additional production line is added only a year after a facility's selected baseline year. In this case, the facility may choose to shift their baseline to the first full year after the new line is opened. Another common scenario is a company shifting from a fiscal to calendar year schedule. For these and other baseline shifting situations, the Better Plants Technical Account Manager (TAM) and DOE should be consulted for the best approach.

Switching Modeling Methodologies

DOE strongly encourages the use of the regression-based approach when modeling energy usage. As this approach may not be suitable for all Better Plants Partners, the use of facility- or corporate-level approaches is acceptable.

A partner that chooses facility- or corporate-level analysis to calculate energy savings can transition to regression-based analysis during the pledge period. This change will require finding a valid regression model using the steps outlined in this document and updating savings numbers from previous years accordingly. If no valid model can be found, a banking approach can be used for savings before the methodology switch.

Although the reverse case is possible (i.e., a company moving from regression modeling to a facility- or corporate-level analysis), DOE strongly discourages this option. The regression-based approach provides the most accurate energy savings analysis and therefore should be used whenever possible.

Achieving Goals and Updating Pledge

The purpose of the Better Plants program is to facilitate companies in reaching their pledged energy saving goals. When partners reach their initial goals, DOE is proud to recognize and promote those achievements. These opportunities include being featured on the Solution Center webpage, receiving recognition trophies from DOE leadership, being recognized in person at the Better Buildings/Better Plants Summit by DOE leadership, receiving invitations to special events, and participating in media opportunities.

The Better Plants program also encourages a continuation of an energy saving culture. After partners reach their Better Plants goals, they are encouraged to renew their pledge by setting a new energy goal, adding facilities to their pledge, setting goals for other resources (e.g., water, waste, supply chains), becoming a Better Plants Challenge Partner, etc. Companies are also encouraged to become involved in other DOE efficiency programs such as 50001 Ready.

Companies that are unable to reach their pledged goals should work with their Better Plants TAM and DOE to find solutions or alternative metrics. The Better Plants program can validate models and savings calculations, identify issues, and help create an action plan to help partners reach their goals.

Hiatus from Better Plants Reporting

Should a hiatus from the Better Plants Program become necessary, several possibilities are available to partners. These include keeping the existing pledge intact, keeping the baseline intact but extending the goal date, or fully repledging to the program if events cause substantial permanent changes. If you feel that your company must request a hiatus from Better Plants due to unexpected events, please reach out to your TAM or Better Plants management for specific guidance based on your situation.

Accounting for Unexpected Events

Facilities that are severely damaged from an accident or natural disaster are likely to be taken offline for an extended period. This situation should be treated as a plant closure, with a baseline adjustment made to remove the facility from the pledge scope. After repairs, the plant can be incorporated back into the corporate pledge scope as an existing facility. If the Better Plants Partner is a one-facility company, a long hiatus will be required with a new baseline established after the plant has become fully operational again. A similar approach can be used when dealing with unexpected economic events (e.g., market crashes, embargos, public health crises).

DOE recognizes that unexpected events can greatly affect a corporation’s operations and their ability to reach their energy efficiency goals. Better Plants Partners should always work with their Better Plants TAM and DOE to determine appropriate steps when unexpected events occur.

Appendix A: ISO 50001

The International Organization for Standardization (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.[22] The standard provides organizations and companies with technical and management strategies to increase energy efficiency, reduce costs, and improve energy performance. ISO 50001 was first published as an International Standard in June 2011. A new version was published in 2018 and is available for purchase from the American National Standards Institute (ANSI)[23].

The U.S. Department of Energy's (DOE) 50001 Ready program provides a web-based tool called the 50001 Ready Navigator[24] to help organizations implement an energy management system consistent with ISO 50001. This self-paced, online 50001 Ready Navigator, guides organizations through the implementation process—from generating a corporate policy to performing a management review. The Navigator includes forms, checklists, templates, and examples for developing and implementing an energy management system that is aligned on ISO 50001. See https://betterbuildingssolutioncenter.energy.gov/iso-50001 for additional information on DOE programs for adopting ISO 50001.

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[22] Source: http://superiorenergyperformance.energy.gov/

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

[24] https://navigator.lbl.gov/about

Appendix B: Resource Conversion Factors and Multipliers

MMBtu Conversion Factors and Primary Energy Multipliers for Other Resources

Energy Source	Delivery Measurement	Unit Conversion Factor	Production Energy Conversion Multiplier Formula	Production Energy Default Conversion Factor	Electric Energy Source Conversion Multiplier
Steam	Pounds (lb)	Btu/lb From steam tables[25]	$\frac{1}{\eta_{cmbstn}}$ (Non-elec. BLR)	1.33 (Non-elec. BLR)	1.0 (fired BLR) 3.0 (Elec. BLR)
Hot water	Volume multiplied by inlet-outlet ΔT (gal · °F)	$8.34 \frac{Btu}{gal \cdot °F}$	$\frac{1}{\eta_{cmbstn}}$ (Non-elec. BLR)	1.33 (Non-elec. BLR)	1.0 (fired BLR) 3.0 (Elec. BLR)
Chilled Water	Demand (ton-hr/yr)	$12{,}000 \frac{Btu}{ton\text{-}hr}$	$\frac{1}{COP}$	1.25 (Absorption CHLR) 0.83 (Engine-driven CMPSR)	1.0
	Volume multiplied by inlet-outlet ΔT (gal · °F)	$8.34 \frac{Btu}{gal \cdot °F}$	---	0.24 (Elec.-driven CMPSR)	3.0
Compressed Air[26]	KW/100 CFM at 100 psig (ft^3)	10.93 Btu/ft^3	1.0	1.0	3.0
Solar	kWh	3,412 Btu/kWh	1.0	1.0	1.0
Wind	kWh	3,412 Btu/kWh	1.0	1.0	1.0

Source: *Superior Energy Performance Measurement and Verification Protocol for Industry*, March 8, 2017.

Boiler: BLR
Chiller: CHLR
Compressor: CMPSR
Electricity: Elec.
Combustion Efficiency: η_{cmbstn}
Temperature Difference: ΔT
Coefficient of Performance: COP

[25] Values taken from steam tables should subtract enthalpy (Btu/lb) of the water at inlet conditions. Temperatures and pressure must be known to use steam tables.

[26] 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.

Higher Heating Values for Selection of Common Fuels

Fuel Type	Heating Value (btu/lb)
Solid Fuels	
Typical Bituminous Coal (USA)	12993.76
Typical Anthracite Coal (USA)	12083.36
Typical Lignate Coal (USA)	8806.74
Liquid Fuels	
Fuel Oil #2	20,050
Fuel Oil #6	18,840
Typical Wood	10,595
Gas Fuels	
Methane	23,875
Ethane	22,323
Propane	21,669
Typical Natural Gas (USA)	22,030
Typical Coke Oven Gas	19,185
Typical Blas Furnace Gas	1,080

Appendix C: Scenarios for Changes to Better Plants Pledge Scope

The following scenarios summarize the situations described starting on page 38 and explains the values that should be entered in the *Adjustment for Baseline Primary Energy* input box on the annual report form, along with descriptions of how to calculate the Total Improvement in Energy Intensity (EI). Example 14 shows detailed calculations for a company adding a new facility.

Scenario: New Construction with 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 EI.

Adjustment to Corporate Baseline Energy Consumption

Add the new facility's energy consumption for the first full reporting year for which data are available to the corporate baseline energy consumption.

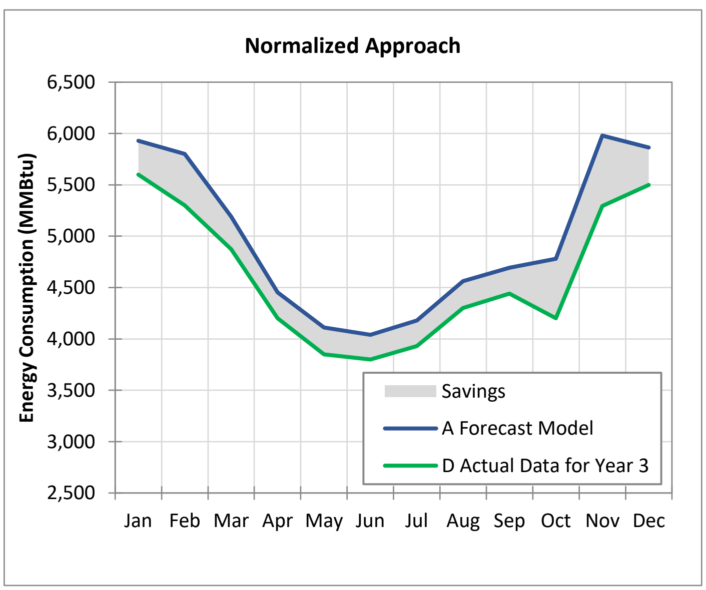
Method for Calculating Total Improvement in EI

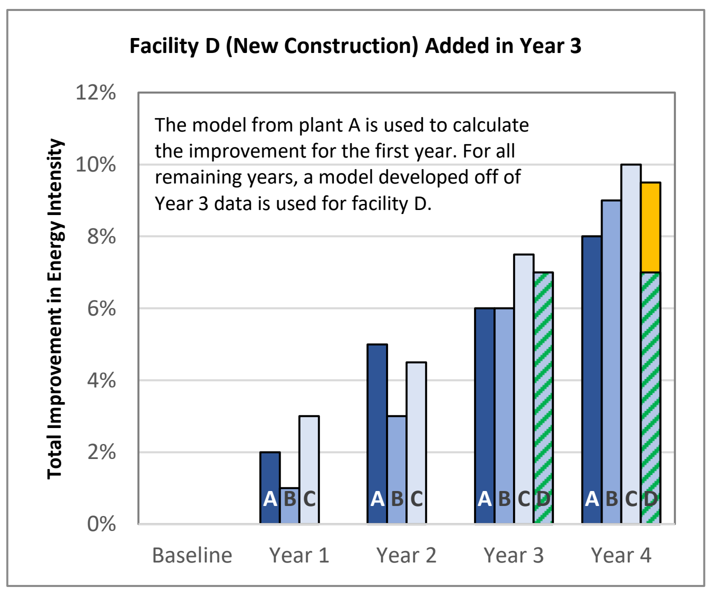
Two methods are available:

1. 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.
2. Follow the guidance for the facility-level approach for the initial year (see next scenario).

After the initial year, percent improvement in EI calculated against the facility baseline will be added to the improvement from the initial year.

Example(s):





Scenario: New Construction with 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 EI.

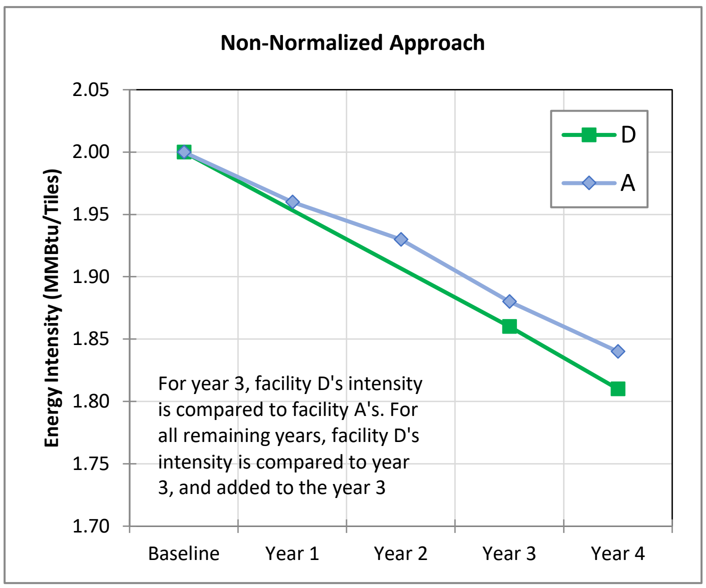
Adjustment to Corporate Baseline Energy Consumption

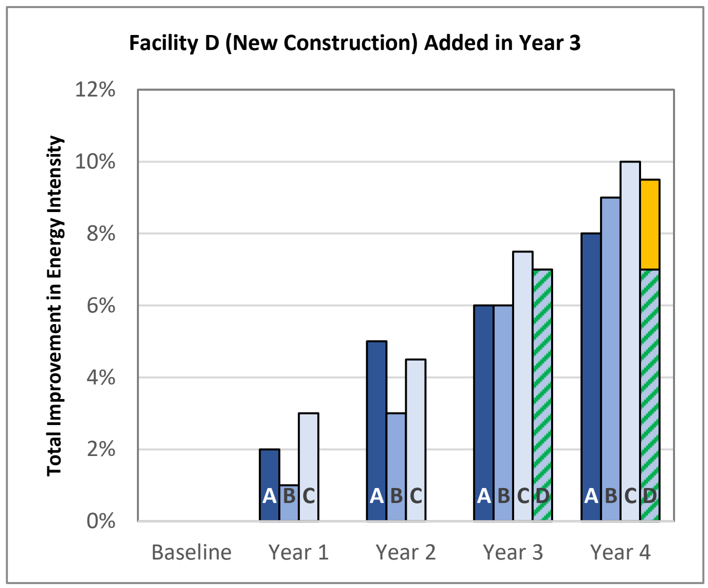
Add the new facility's energy consumption for the first full reporting year for which data are available to the corporate baseline energy consumption.

Method for Calculating Total Improvement in EI

Compare the 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 with 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.

***Example(s)*:**





Scenario: New Construction with 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 EI.

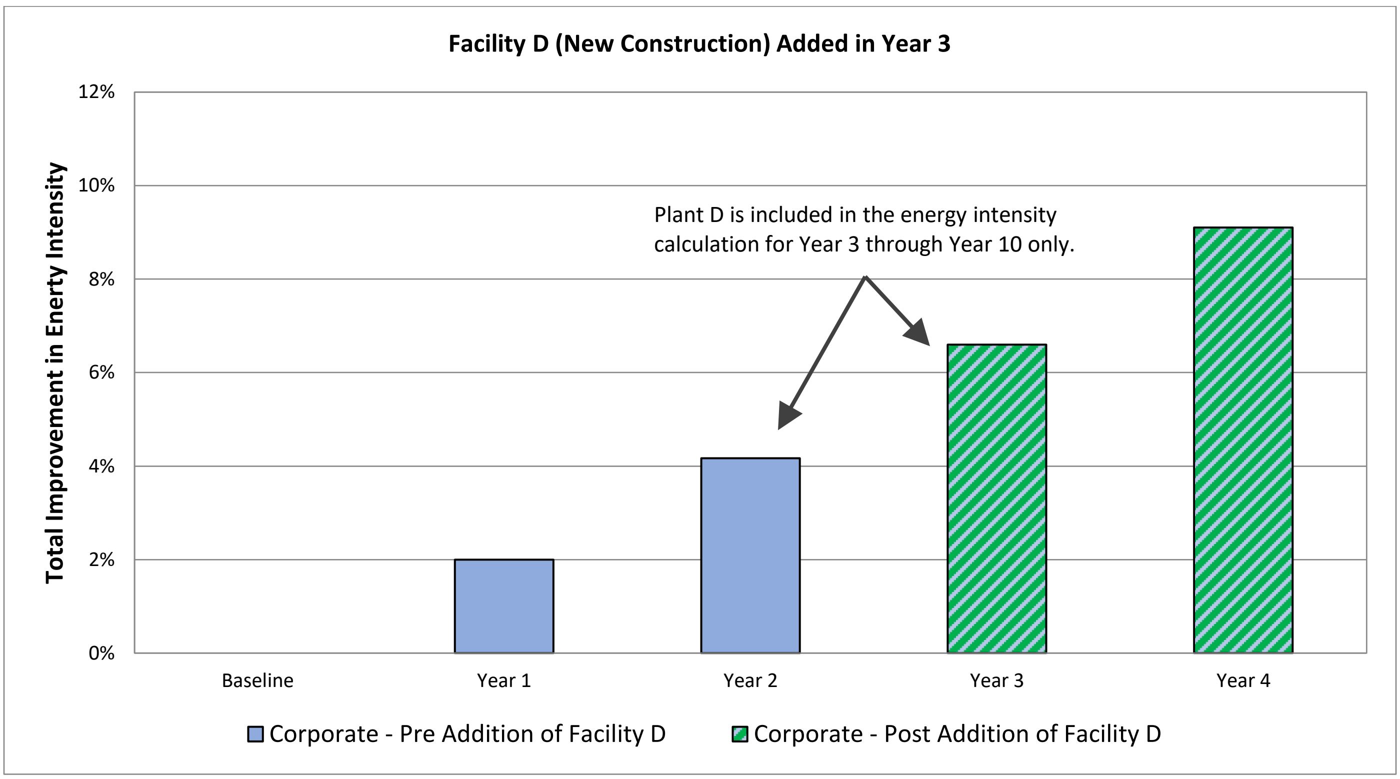
Adjustment to Corporate Baseline Energy Consumption

An adjustment is required before calculating Total Energy Savings since Baseline Year but not before calculating the Total Improvement in EI. 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.

Method for Calculating Total Improvement in EI

When calculating the corporate EI 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 EI when calculating the Total Improvement in EI.

Example(s):



Scenario: Acquisition of an Existing "Move-In Ready" Facility[27] with Historic Data Available

An existing facility is acquired by the Partner, and historic energy and production data from the previous owners are available.

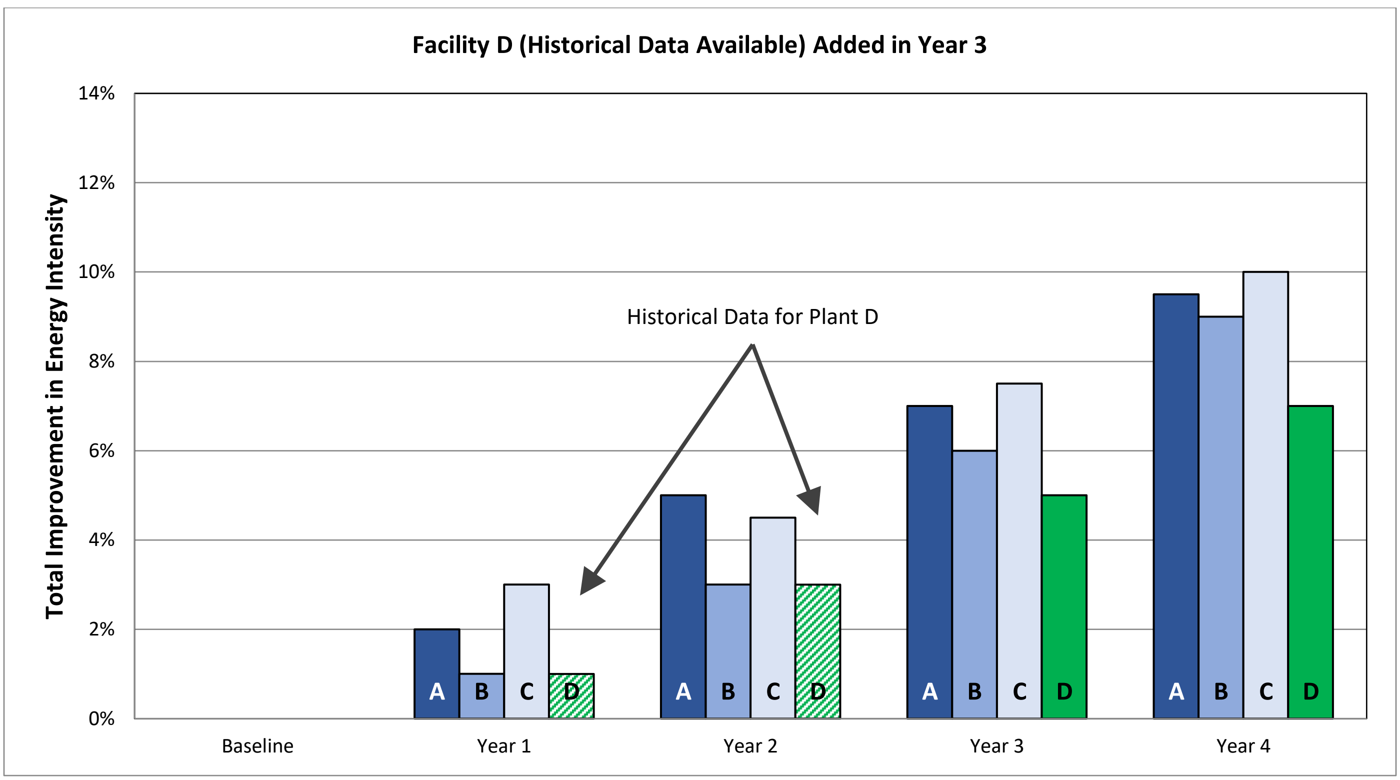
Adjustment to Corporate Baseline Energy Consumption

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 if the facility does not use regression analysis to normalize the energy data.

Method for Calculating Total Improvement in EI

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. Again, this calculation is the same if the facility does not use regression analysis to normalize the energy data.

***Example(s)*:**



Dashed lines indicate historic data, and solid fill is partner data.

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

Scenario: Acquisition of an Existing "Move-In Ready" Facility with No Historic Data

An existing facility is acquired by the Partner, and historic energy and/or production data from the previous owner are not available.

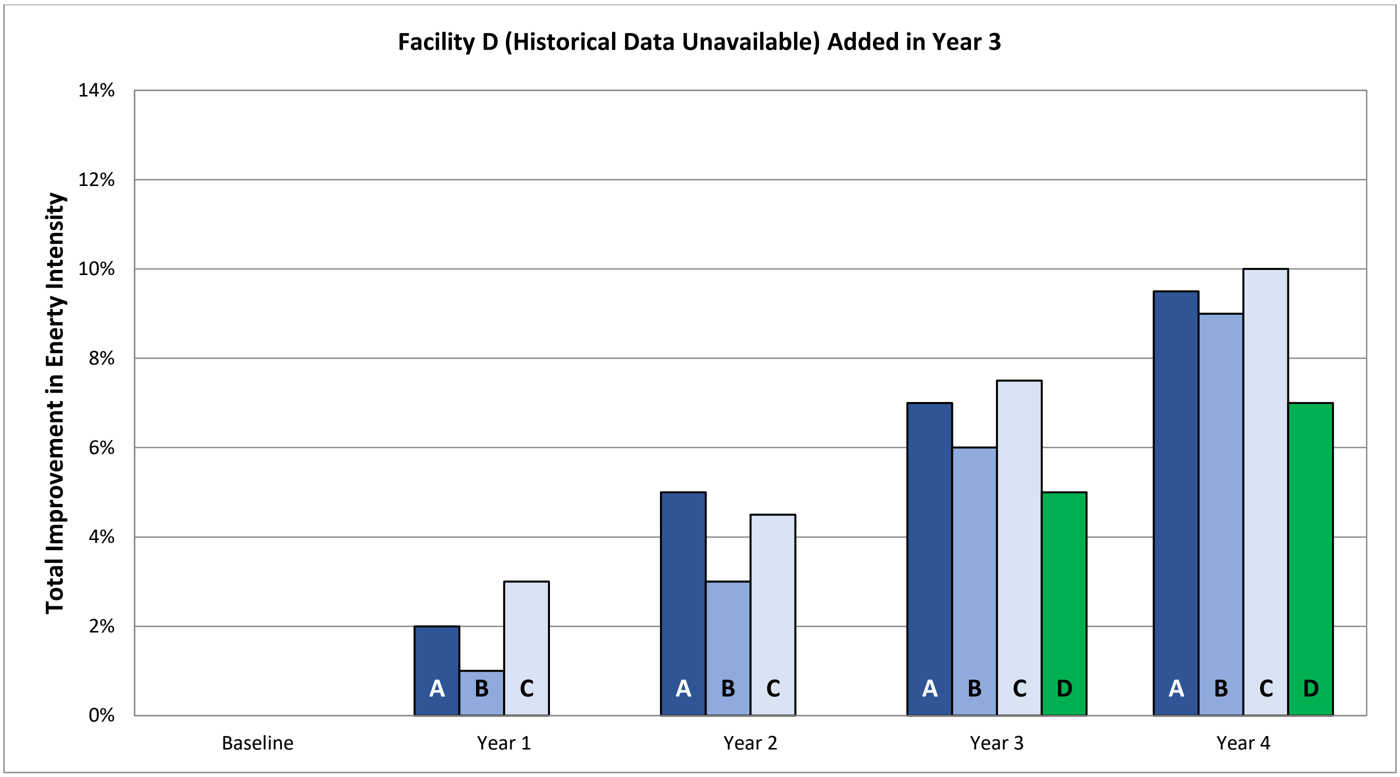
Adjustment to Corporate Baseline Energy Consumption

The facility will be treated in the same manner as new construction.

Method for Calculating Total Improvement in EI

The facility will be treated in the same manner as new construction.

Example(s):



Scenario: Removals

A Partner sells or closes a facility included in the baseline year.

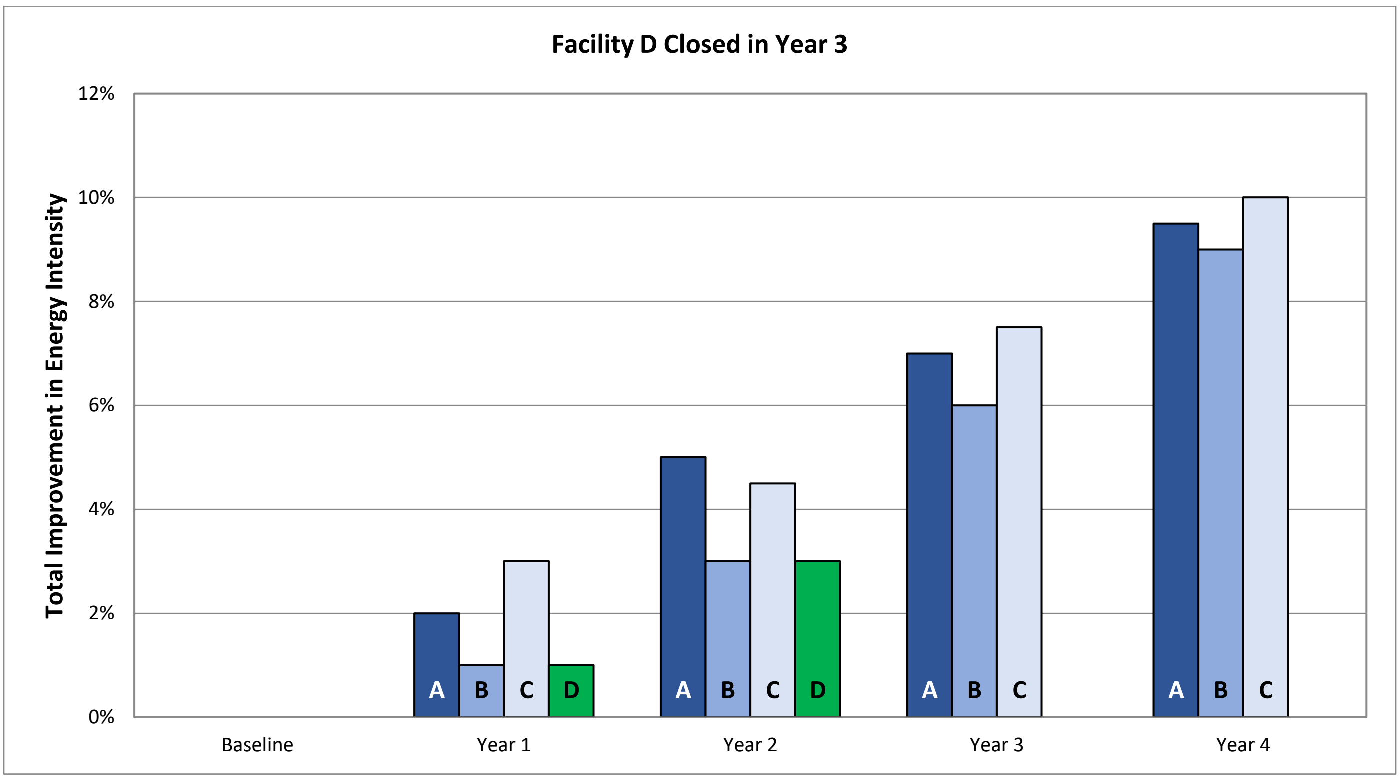
Adjustment to Corporate Baseline Energy Consumption

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 if the facility does not use regression analysis to normalize the energy data.

Method for Calculating Total Improvement in EI

Exclude the facility when calculating total improvement using Equation 5 shown on page 9. This calculation is the same if the facility does not use regression analysis to normalize the energy data.

Example(s):



Scenario: Adjusting for Regulatory Requirements

Occasionally, a Better Plants partner may be required to adopt a more energy intensive technology to meet certain regulatory requirements. Examples may include:

- Replacing one air emissions control device with another that has significantly higher energy consumption, but treats the same source of emissions, for a standard that previously existed but the regulatory body is requiring an alternative control technology. For example, replacing an electrostatic precipitator with a scrubber or thermal oxidizer to meet particulate control levels in air permitting requirements.
- Addition of equipment to further treat emissions or working environment, to meet a standard which has become more stringent or the level of emissions from a process has increased. For example, adding a scrubber to remove mercury emissions from boiler flue gas or an air compressor to filter breathing air in a plant area where increased respiratory protection is required to meet safety requirements.

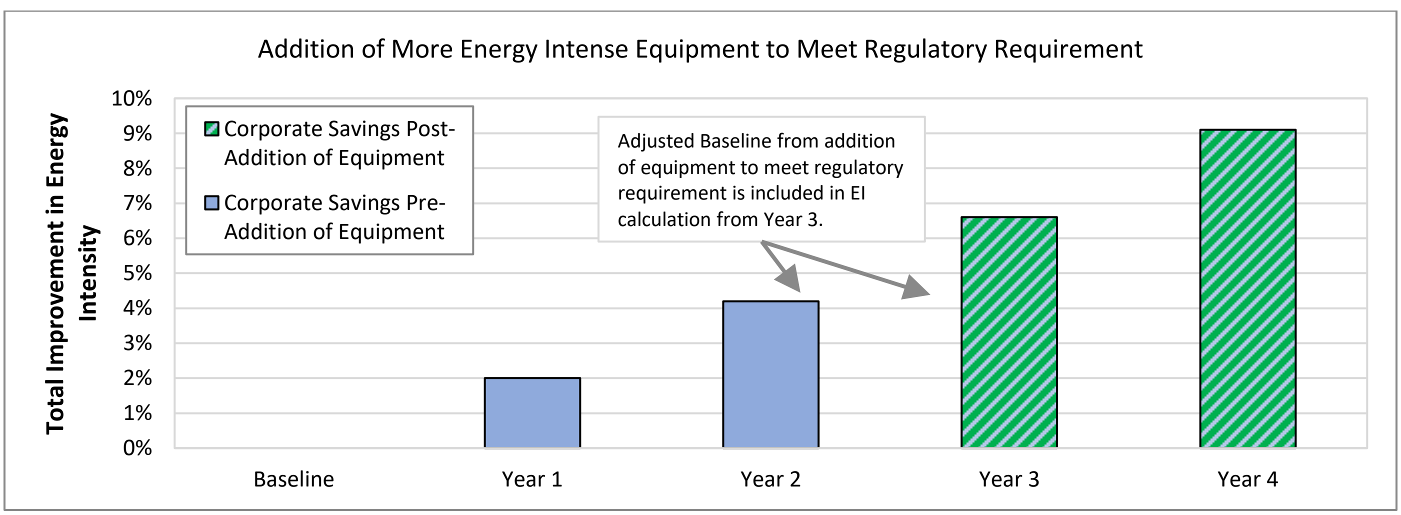
Note that these adjustments would pertain to situations where existing controls either did not exist or were inadequate to meet regulatory requirements. This scenario does not address making an adjustment due to an increase in energy use related to a production increase, nor to increased energy use to control emission which have changed due to a process change spawning from a Partner's decision. This adjustment is intended for situations where a Partner is required to adopt equipment which increases its energy consumption, to meet a regulatory requirement, with no impact on production.

Adjustment to Baseline Energy Consumption

Remove the energy consumption of the original control equipment from the baseline year by subtracting the baseline year energy consumption of the control technology from the plant baseline energy consumption and add the estimated energy consumption of the new regulatory control equipment. The estimated energy consumption for current and new equipment should be based on baseline year production levels and can be determined on a monthly basis and added for the annual total or developed over an annual basis.

Method for Calculating Total Improvement in EI

If using the corporate approach, the adjusted baseline energy intensity can then be determined by dividing the *adjusted baseline energy use* by the baseline year production. Improvement in EI using the adjusted baseline should be calculated for the first full year that the equipment required for the regulatory change was operated and compared to the adjusted baseline year intensity to determine the Total Improvement in EI.



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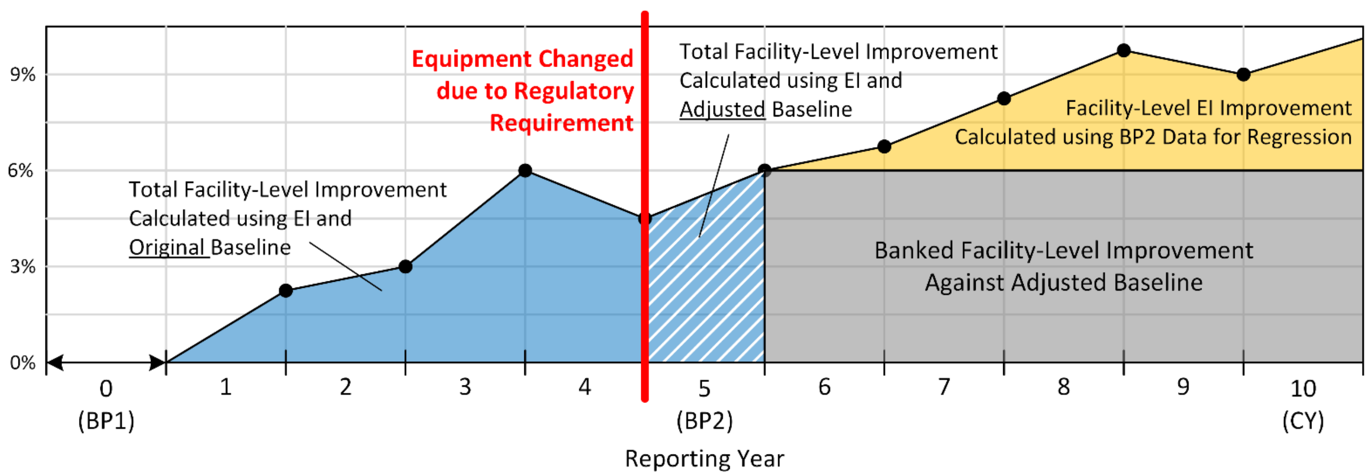
If using the facility-level approach, the adjusted baseline energy intensity for the facility can be determined by dividing the *adjusted baseline energy use* by the baseline year production. Improvement in EI using the adjusted baseline should be calculated for the first full year that the equipment required for the regulatory change was operated and compared to the adjusted baseline year intensity to determine the Total Improvement in EI for that facility. The corporate improvement in EI would then be determined using Equation 4 on page 26.

If using the regression-based approach, determine the Total Improvement in EI using the facility-level approach described above, to calculate the Improvement in EI for the facility affected by the regulatory change. This calculation would compare the adjusted baseline year EI with the EI for the first year the facility operated the equipment required to meet the regulatory change. Note that this uses the facility-level approach and does not apply regression analysis.

For subsequent years, use the regression approach to compare the performance of the affected facility by finding a new model with the first full year the affected facility operated the equipment to meet the regulatory requirement. Add the EI improvement from the regression approach to the total EI improvement calculated through the first full year of equipment operation.

Example:

A facility initially uses Baseline Period 1 (BP1) to track their energy intensity improvement in the Better Plants program. However, the facility incorporated new pollution control equipment at end of Year 4 requiring the original baseline to be adjusted in order to account for the increased energy consumption due to the regulatory requirement. Year 5 savings, the first full year with the new equipment in place, were estimated to be 1.5% (or 6% total) against an adjusted baseline using the method described previously. Regression analysis was performed to determine the Year 10 EI savings of 4.1% using Year 5 as the model year and the new baseline period (BP2). Savings from Year 1-5 were banked and added to the results from the regression analysis. The two EI improvements were added to yield a 10.1% Total Improvement in EI for the affected facility.



Example 14: 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 2018.

Scenario 1:
In 2018 and 2019, Acme had within the boundaries of its Pledge five facilities located in Ashland, Cleveland, Duluth, Minneapolis, and Rochester. In December 2019, 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 EI and Total Energy Savings since the Baseline Year.

Since Acme has elected to use the regression-based approach to calculate the energy performance for the Hastings facility, a facility to use for comparison must be selected to determine improvement in EI between 2018 (Acme's baseline year) and 2020 for the Hastings facility. Acme elects to compare the Hastings facility 2020 performance with its Rochester plant to determine the Total Improvement in EI for 2020 as these facilities are in the same geographic region, produce the same type of product, are similar in size, and have similar EIs.

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

1. Apply a model to 2020 Hastings data developed based off the Rochester facility baseline year to determine the modeled and actual energy consumption for 2020 (i.e., forecasting).
2. Develop a model using 2020 Hastings 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 2020. Compare the actual consumption to modeled consumption to determine Hastings 2020 *Total Improvement in EI* and *Total Energy Savings since Baseline Year* (i.e., backcasting).

Acme decides to use the first approach (forecasting). Using the model developed based off Rochester's 2018 energy, production, and weather data, Acme determines the 2020 modeled energy consumption for the Hastings facility to be 824,599 MMBtu. This is calculated using the following equations developed based off Rochester's 2018 energy data:

$$Modeled\ Natural\ Gas = (9.98 \times\ Tons\ of\ Tile) + (7.85 \times HDD) + 13{,}945$$
$$Modeled\ Electricity = (11.23 \times Tons\ of\ Tile) \times (5.65 \times CDD) + 13{,}610$$

The actual consumption for the Hastings facility in 2020 was 745,000 MMBtu. Using the actual and modeled consumption, Acme determines the Total Improvement in EI in 2020 for the Hastings facility to be

$$Total\ Improvement\ in\ Energy\ Intensity_{CY} = \left(1 - \frac{\overline{EC}_{CY}}{EC_{CY}}\right) \times 100\% = \left(1 - \frac{745{,}000}{824{,}599}\right) \times 100\% = +9.65\%$$

Acme can then use Equation 5 to determine the Corporate Total Improvement in EI for all six facilities. To use this equation, Acme needs the adjusted baseline energy consumption for all six facilities along with the 2020 total improvement.

Since Hastings does not have energy data corresponding to 2018 (Acme's baseline year), Hastings uses its 2020 energy consumption in place of the baseline energy consumption for the Corporate Total Improvement in EI calculation.

Example 14 is continued on the next page…

Example 14 continued…

Table 13: Acme Plant Facilities Improvement in EI and Baseline Consumption

Facility	2020 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 2020 Corporate Total Improvement in EI since a production line was closed in 2020. See Example 11 for an explanation of how the adjusted baseline is calculated.

$$Total\ Improvement\ in\ Energy\ Intensity_{Corp} = \frac{\sum_{i=1}^{n}(TEI_i \times EC_i)}{\sum_{i=1}^{n} EC_i} \times 100$$

$$= \frac{11.95\% \times 340{,}000 + 7.34\% \times 120{,}300 + 2.78\% \times 320{,}100 + 1.90\% \times 859{,}662 + 8.40\% \times 851{,}150 + 9.65\% \times 745{,}000}{340{,}000 + 120{,}300 + 320{,}100 + 859{,}662 + 851{,}150 + 745{,}000} \times 100$$

$$Total\ Improvement\ in\ Energy\ Intensity_{Corp} = \mathbf{+6.74\%}$$

Therefore, with the inclusion of the Hastings facility, the Corporate Total Improvement in EI for Acme in 2020 has improved 6.74%.

Scenario 2:

Acme attempts to apply the model developed using Rochester's 2018 data to Hasting's 2020 production and weather data. However, because of major differences in the cooling and heating degree days, Acme discovers the model does not pass the second validation check (see page 24 for more information). Therefore, the model developed using Rochester's baseline data cannot be used to model Hasting's 2020 energy consumption. Acme must then use the facility-level approach to calculate the Total Improvement in EI.

To use the non-normalized approach, Acme first calculates the baseline EI for the Rochester facility using Equation 9.

$$Energy\ Intensity_{Rochester} = \frac{2018\ Total\ Energy\ Consumption}{2018\ Total\ Units\ of\ Output} = \frac{851{,}150\ MMBtu}{35{,}677\ tons\ of\ tile} = 23.857\frac{MMbtu}{tons\ of\ tile}$$

$$Energy\ Intensity_{Hastings} = \frac{2020\ Total\ Energy\ Consumption}{2020\ Total\ Units\ of\ Output} = \frac{745{,}000\ MMBtu}{34{,}500\ tons\ of\ tile} = 21.594\frac{MMbtu}{tons\ of\ tile}$$

Example 14 is continued on the next page…

Example 14 continued…

Using Equation 10, Acme determines the 2020 Total Improvement in EI for the Hastings facility to be

$$Total\ Improvement\ in\ Energy\ Intensity_{Hastings} = \frac{Energy\ Intensity_{BY} - Energy\ Intensity_{CY}}{Energy\ Intensity_{BY}} \times 100$$

$$= \frac{23.857 - 21.594}{23.857} \times 100 = +9.49\%$$

The 2020 Corporate Total Improvement in EI is therefore

$$Total\ Improvement\ in\ Energy\ Intensity_{Corp} = \frac{\sum_{i=1}^{n}(TEI_i \times EC_i)}{\sum_{i=1}^{n} EC_i} \times 100$$

$$= \frac{11.95\% \times 340{,}000 + 7.34\% \times 120{,}300 + 2.78\% \times 320{,}100 + 1.90\% \times 859{,}662 + 8.40\% \times 851{,}150 + 9.49\% \times 745{,}000}{340{,}000 + 120{,}300 + 320{,}100 + 859{,}662 + 851{,}150 + 745{,}000} \times 100$$

$$Total\ Improvemnt\ in\ Energy\ Intensity_{Corp} = +\mathbf{6.70}\%$$

Therefore, using the non-normalized approach to calculate the Total Improvement in EI for the Hastings facility, the Corporate Total Improvement in EI for Acme in 2020 has improved +6.70%.

Appendix D: Water Intensity Metrics and Savings

The U.S. Department of Energy has expanded the Better Buildings Challenge to include tracking of water consumption[28]. Industrial facilities are beginning to use water more efficiently for multiple reasons, including lower operating costs, water scarcity, and corporate sustainability initiatives. Manufacturing water use is approximately 6% of total U.S. water use, expanding to 31% if agricultural and thermoelectric uses are excluded[29]. As much as 85% of manufacturing water usage is what is normally referred to as non-consumptive, meaning much of the water is returned to the environment after treatment[30]. Reductions in manufacturing water use can therefore have a significant effect on total water consumption in the United States.

More than half of manufacturing water use is derived from surface water sources, and three-quarters is self-supplied. Facilities often do not pay monthly changes for the volume of water drawn from self-supplied sources, leading to a perception that water use is low cost. However, there are associated costs such as energy costs to pump, treat, and maintain water quality. Capturing these costs is important to understanding the true cost of manufacturing water consumption.

Better Plants Water Challenge Partners that choose to participate in the water efficiency initiative are expected to commit to a 20% reduction in water intensity over a 10-year period. Monitoring of water consumption follows many of the principles outlined in this document for energy intensity baselining and tracking. Classic water intensity metrics (i.e., gallons/product) are a good starting point for companies looking to begin evaluating their water intensity. Regression analysis can be performed for water consumption using the EnPI tool and can therefore complement energy saving initiatives already in progress for Better Plants Partners. As with Better Plants, facilities that achieve significant water savings will receive recognition and may even be eligible to apply for special certifications like the U.S. Environmental Protection Agency's WaterSense labeling for their products[31]. More information on water baseline development can be found in the "Developing a Corporate Water Management Strategy for Manufacturers" guidance document.

The Better Plants program has also launched a Water Efficiency In-Plant Training. This training is a three-day workshop to conduct a water use assessment, calculate the true cost of water, and identify water/cost saving opportunities. This training was rolled out in in 2020 to all Better Plants Partners and is an excellent resource for in-person learning and networking.

As part of the In-Plant training, participants will use the new Plant Water Profiler excel tool (PWP). The PWP tool can evaluate a water balance for individual systems accounting for source water intake, recirculation, consumption, and wastewater disposal. The PWP tool can also estimate water losses and the "true cost" savings that can be achieved from improving water use at a facility. The PWP tool is available at no cost through the Better Plants Solution Center at https://betterbuildingssolutioncenter.energy.gov/better-plants/software-tools.

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[28] https://betterbuildingssolutioncenter.energy.gov/sites/default/files/Better-Buildings-Challenge_Water-Savings-Overview.pdf

[29] Maupin, M.A., Kenny, J.F., Hutson, S.S., Lovelace, J.K., Barber, N.L., and Linsey, K.S., 2014, *Estimated use of water in the United States in 2010: U.S. Geological Survey Circular 1405*, p. 56.

[30] Rao, Prakash, *Developing a Corporate Water Management Strategy for Manufacturers*, Lawrence Berkeley National Laboratory, 2016.

[31] https://www.epa.gov/watersense/learn-about-watersense-partnership

Appendix E: Better Plants Pledge Reporting Data Review Checklist

Review Item	Checklist and Additional Notes	Year-to-Year Fluctuation Tolerance and Follow-Up Actions
Reporting and Baseline Year	• Have you confirmed fiscal year and calendar year definitions (July to June, October to September, January to December, etc.) for your company? Some companies submit 2020 reports as their 2019 report because of confusion regarding fiscal year and calendar year 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 2018 through June 2019, select 2019).
Number of Participating Plants (baseline and reporting year)	• Does the number of participating plants submitted match the expected number of plants committed when the agreement form was signed? • Does submitted data represent only 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 consistently with the protocols described in the baseline guidance document (see pages 34–41).
Energy Consumption Data: Source and MMBtu	• Have you provided the primary (or source) energy consumed, by fuel type, for the company, for the baseline and reporting years? Primary energy use takes into consideration generation, transmission, and distribution losses. Energy consumption data by fuel type needs to be in MMBtu. • Have you used a consistent site-to-source conversion factor (e.g., 3) over time? • Does the unadjusted baseline energy consumption value reported in the reporting year match with the previously reported baseline energy consumption value?	• DOE will investigate this field if change is > ±25% with respect to the 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 the 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 Reporting 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 1 year after the baseline, make sure this number is calculated using the following equation: *New Energy Savings in Reporting Year = Total Energy Savings since Baseline Year for the Reporting Year —Total Energy Savings since Baseline Year for the Previous Year* • Investigate whether new energy savings for reporting year ≥ baseline or reporting year energy use or significantly positive/negative.	• DOE will investigate this field if new energy savings ≥ ±15% of the baseline or current energy use • Provide justification for a 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 Reporting 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 reporting year source energy consumption.	• DOE will investigate this field if total energy savings ≥ ±30% of the adjusted baseline energy use. • Provide justification for a significantly positive/negative number.
Annual Change in Energy Intensity (EI) for Reporting Year (%)	• Have you provided a value for "Annual Change in EI"? • Have you ensured that the "annual change in EI" and "total change in EI" are not equal when the reporting year is more than 1 year after the baseline year? Make sure this number is calculated using the following equation: *Annual Change in Energy Intensity for Reporting Year (%) = Total Change in EI for Reporting Year—Total Change in EI for Previous Year* If the company is reporting for the first time and reporting year = baseline year + 1, annual % change for reporting year must be equal to total change in EI since baseline year. See page 27 in the baseline guidance document for more details.	• DOE will investigate this field if % annual change in EI ≥ 10% or <0% of the previous year EI with respect to the baseline year: *(previous year EI – reporting year EI)/baseline year EI* ≥ 10% or <0% • Provide justification for a significantly positive/negative change.
Total Change in EI Since Baseline Year (%)	• Have you provided the "Total Change in EI since the Baseline Year"? • Check if you are reporting a "Total Improvement in EI" ≥ 25% when the reporting year is 1 or 2 years after the baseline year. • Investigate if "Total Change in EI 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 EI" is greater than 200%. *[(Total Energy Savings/Adjusted baseline energy use) - total improvement in EI]/ (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 EI" is greater than 200%.

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