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Energy Baseline Methodologies for Industrial Facilities

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Table of Contents

Table of Tables

Table of Figures

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Executive Summary

In order to determine and demonstrate energy performance improvements, an organization must have an established and documented energy baseline (EnB). Industrial facilities face a challenge in that development methodologies for EnBs are neither well-known nor consistently implemented. This paper incorporates several expert viewpoints on establishing an industrial EnB through a straightforward six-step process:

1. Define the boundaries
2. Identify the energy sources
3. Define the baseline period
4. Define relevant variables
5. Determine and calculate energy performance indicators
6. Address baseline adjustments

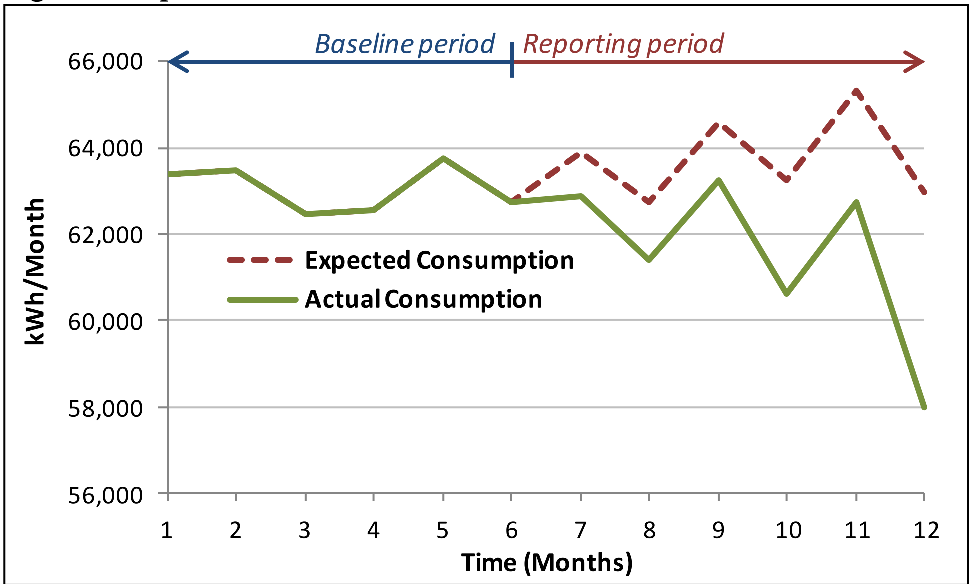
Using these steps, facility energy management staff can determine a suitable EnB from which to monitor and manage improved performance. For ease of use and alignment, this paper utilizes the foundation of the ISO 50001 Energy Management System (EnMS), expressed in terms and definitions found in this paper's appendix.

1. Introduction

To evaluate the effectiveness of a facility's EnMS, organizations need to establish quantitative baselines against which progress can be gauged. Careful choice of baseline methodology minimizes the distortions that would otherwise occur because of subsequent variations in the weather, production mix, and other relevant variables affecting significant energy uses.

Figure 1 illustrates monthly electricity consumption over a one-year period. The first six months are part of the baseline period and represent "business as usual." Improvements made beginning in the seventh month result in decreased electricity consumption relative to the expected – or baseline – consumption that would have occurred in the absence of the improvements. The period during which the improvements are made is referred to as the "reporting period."

Figure 1. Improved Performance over Time Relative to Baseline



To develop a successful EnMS, an organization must define the combination of energy performance criteria – such as minimizing kWh/unit produced while maintaining product quality – that influence its ability to meet its business objectives, such as attaining a larger market share or increasing shareholder value. These energy performance criteria could include the following:

- Energy consumption: How much energy is consumed in a given period (e.g., x kWh)
- Energy efficiency: Ratio of useful work delivered to energy consumed to accomplish a certain task (e.g., x units of work/kWh)
- Energy intensity index: Ratio of actual energy consumed to what would have been expected in the absence of efficiency measures (e.g., 0.92 representing 8% savings)
- Avoided energy use: Cumulative energy saved over a period (e.g., x kWh in a year)
- Peak energy demand: The maximum energy usage in a given time frame (e.g., x KW)
- Total energy cost
- Amount of renewable energy sources used

- Amount of carbon dioxide emitted by energy generation sources
- Ability to meet energy performance forecasts
- Achievement of energy efficiency improvement opportunities
- Performance of Significant Energy Uses

Once an organization defines energy performance, it must determine how it will measure performance changes using one or more energy performance indicators (EnPIs). This may involve tracking currently-available energy-related data such as monthly utility bills and metered or sub-metered consumption. To demonstrate a more detailed level of energy performance, organizations may also combine energy consumption with other relevant variables such as production volume, number of employees, or weather. Organizations can then use regression analysis or other methods to determine whether and how other relevant variables influence energy consumption.

Energy baselines are valued by many entities:

- **Facilities** use EnBs to measure energy performance changes, to indicate savings awareness programs, or to trigger investigations into energy performance deviations.
- **Corporate offices** use EnBs to provide enterprise-wide visibility of facility performance and to indicate corporate energy program effectiveness.
- **Energy Program Administrators** use EnBs to show energy performance improvements to meet requirements of incentive programs, legal requirements, or mandatory regulations.
- **Certification Bodies** use EnBs to determine attainment of standards compliance.

Measuring energy performance of large energy efficiency measures that can be isolated or modeled entails the establishment of system-specific baselines and EnPIs. However, tracking energy performance from multiple small to large energy efficiency measures, seeking to demonstrate the effects of an Operations and Maintenance (O&M) initiative, or utilizing an organizational EnMS requires a facility-wide baseline. ISO 50001 codifies and standardizes organizational approaches and requires an organization-wide baseline from which to monitor progress toward energy goals.

Baseline vs. Benchmark

The terms baseline and benchmark are often used interchangeably; however, subtle but important distinctions exist between the two terms.

A baseline is a set of critical observations or data used as a basis for comparison or control.

A benchmark is a point of reference that serves as a standard by which others can be measured.

For example, a facility wanting to demonstrate energy improvements could use energy values from the previous time frame as the baseline from which to show improvement. If the facility wanted to compare actual results with another facility, it would compare to a benchmark. It could also use its best energy performance in one month as a benchmark that it would strive to meet again.

Defining baselines and associated performance-evaluation methods is not always straightforward. The methods have to discriminate changes in consumption caused by energy-efficiency measures from changes caused by relevant variables such as the weather, daylight availability, production output, and product mix. These factors can cause variations that mask the effects one is trying to detect and quantify. Simple baseline development approaches usually have some degree of inaccuracy that can make them misleading, while rigorous and reliable approaches are sometimes more complex than the natural comfort level of most facility managers.

It is important to note that while some relevant variables can be controlled – such as production – others cannot be controlled – such as the weather. For example, in a mine the quality of the ore impacts the amount of energy necessary to process it, and cannot be controlled except by selecting where to excavate. Conversely, the amount of ore to produce can be controlled and may be determined by its quality.

Finally, variations in the complexity of baseline characteristics should not be treated as a hurdle that leads to inaction. On the contrary, energy management best practices dictate initiating momentum in whatever form that takes. Waiting for the ideal opportunity to proceed is counterproductive. The energy team should proceed with a simpler approach to initiate the energy management process and then later enhance metering, calculations, or other areas as the team gains experience, organizational credibility, or other skills.

The objective of this paper is to provide a clear and concise methodology to establish an industrial facility EnB. The methodology reflects the input of numerous individuals experienced in this area. The methodology should direct facility energy management staff to ask the right questions to establish their own baselines.

2. Baseline Establishment Challenges

Baseline establishment is not straightforward; several challenges are common to all organizations. A company can also be challenged when it follows a baseline development approach inappropriate to its organization's size, production profile, culture, or geography. Table 1 presents a series of questions for facility staff to assess complexity and to identify an appropriate route to determine its baseline. While no specific formula exists to determine a facility's complexity, more affirmative than negative responses to the questions in Table 1 would tend to indicate a more complex facility. The list can guide facility energy management staff toward understanding their organization's degree of complexity and determine whether they will be able to establish their facility's baseline themselves, if they will require some assistance on parts of the effort, or if they will require a third party to establish their baseline.

Table 1. Business Challenges for Baselines

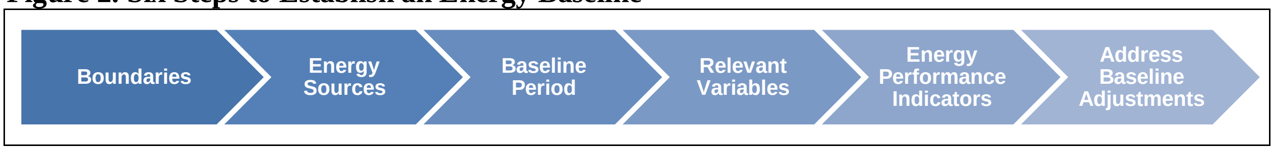
Is energy data not aligned to business units, production areas, or other divisions?
Does weather impact energy performance?
Do business cycles have variability, such as seasonality?
Does the facility manufacture more than one product line?
Does the facility have complex operations requirements?

A very straightforward facility may produce a single product with little month-to-month variation in production volume. At the other end of the spectrum, a complex facility may have varying product throughputs that each distinctly influences energy consumption, as well as complications such as time delays between production data and energy data.

3. Baseline Establishment in Depth

Establishing an EnB requires a series of activities that fit within an organization's EnMS. This includes an energy management planning process of analyzing past activity and data and a description of future efforts and goals. It also includes assembling a collaborative team to provide input on energy consumption, energy uses, relevant variables, seasonal or recurring business cycles, and one-time events that occurred in the past or that are anticipated to occur in coming months or years. These activities and the outputs are typically part of an energy management plan. The time required to establish an EnB varies with facility complexity as well as with the ease of access to energy data. The baseline establishment process can be expressed in six steps, as illustrated in Figure 2.

Figure 2. Six Steps to Establish an Energy Baseline



3.1 Define the Boundaries

The organization's energy management plan should detail which operational activities and facilities are within the boundaries. Baseline results can be undermined by complications of inappropriate boundary characteristics. The three primary boundary characteristic types include physical, system-related, and organizational.

- **Physical:** This common boundary type typically pertains to a facility building or fence line within which energy use is measured. It can also be broader than a single location to include a group of facilities. For example, a product may be manufactured in one facility and shipped to another site for assembly, packaging, or distribution. In this case, rather than just tracking energy used at a single location, the energy team may want to track all energy uses across facilities from component manufacture to final product assembly and distribution.
- **System-related:** When a system constitutes a significant portion of a facility's energy consumption and the system's performance can be seen as a proxy for the facility's performance, an organization may focus on that single system. In addition, a system-related boundary may be required if metering or other data are limited.

Boundaries & Influences

As an organization increases its understanding of relevant variables, it can begin to see its system's interactive effects – in other words, how one system's energy use can affect another system's energy use.

For example, installation of a more efficient lighting system may result in less heat produced; if the organization predominantly heats its facility, then it may have to provide additional heat to make up for that lighting system improvement. Similarly, a system such as an industrial heat pump can actively harness waste energy for re-use elsewhere in the facility or outside of the facility's boundaries.

Understanding these systems can be important to understanding their roles in influencing energy consumption – either increasing it or, more typically, decreasing it. In addition, understanding the usage of the waste heat as an energy source is important when establishing boundaries.

- **Organizational:** An organizational boundary may be appropriate when energy performance is measured for a business unit. This boundary can be established around systems within a facility or between facilities. For example, large companies may define boundaries around a business unit that manufactures a common product. A bottling company with plants worldwide may include all of a product line's locations and exclude other product line information. This boundary is useful when a facility's business units have varying objectives.

Evolving business requirements constitute an important consideration when determining boundaries. Physical changes or business events can occur that influence the appropriateness of boundaries. For example, a facility expansion or partial shut-down could warrant a change in the boundaries in which energy is managed and data are collected. Anticipating these situations is helpful to ensure an appropriate baseline and meaningful demonstrated energy performance.

In some cases combining two or more boundary characteristics is appropriate. In addition, when establishing a baseline, subsequent baseline establishment steps may reveal a necessity to revisit and revise boundaries. For example, a lack of appropriate data may make one baseline suboptimal or unviable. Any boundary change typically has a major impact on energy performance determination and, thus, should be a relatively rare occurrence that results from in-depth analysis and discussion between organization management and the energy team.

Within the boundaries, an energy team can decide to include or exclude energy generated locally. Depending on how the organization views energy performance, a business may decide to exclude these energy sources because they do not tie to actual energy efficiency at the energy end-use, or to include them because they are part of the overall energy cost for the entire facility.

Organizations might also focus solely on systems that consume a significant amount of energy. This prioritization can motivate the organization to focus on areas that produce near-term results, with a plan to later focus on less-significant energy consumers.

Case in Point

For its finished goods, a food processing facility has an on-site cold storage facility that is operated by an outside contractor. To demonstrate its energy performance, facility staff may decide it is best to exclude the cold storage facility from its boundary.

A municipal water system may decide that, due to the significant energy used by a large number of pumps in a high number of distribution zones, it will include its water treatment plant and distribution system within its analysis boundary and regard them as a single system from which to manage energy.

3.2 Identify the Energy Sources

The next step is to identify all energy flowing across the defined boundary and to determine how energy is categorized, measured, and collected. Energy sources fall into two primary categories:

- **Electricity:** Electrical energy typically comes from an electric utility and is often measured in kWh. However, it can also come from on-site renewable generation sources such as solar or wind, as well as from combined heat and power (CHP) systems.
- **Fuel:** A number of potential fuel sources exist, including natural gas, petroleum products, coal, and biomass. Fuel sources entering a facility can be used directly in combustion processes to produce thermal energy (often measured in units of therms) or they can be used to generate both electricity and thermal energy, such as in a CHP system. Thermal energy sources may also be supplied from an outside provider in the form of steam or chilled water.

The process of creating an energy map or diagram of the facility that shows its boundary and the energy flows across the boundary is often very helpful in identifying energy sources and associated EnPIs.

After identifying energy sources, the EnB development process must address how energy consumption data will be measured and collected. Utility billing records identify energy quantity consumed over a billing period which can be converted to average energy consumption per day, for example to average kWh or therms per day. These daily rates can be collected for the baseline period and applied to the baseline analysis. Knowing the billing period is important to facilitate pairing energy consumption with other baseline calculation factors.

Utilities often collect hourly or fifteen-minute interval data for their large customers. In some cases, these data are available through a direct meter connection (sometimes referred to as “pulse outputs”) or after the fact as electronic files. Shorter time intervals are desirable as greater granularity better enables analysis. However, facilities with limited granularity can still estimate energy use with a reasonable degree of confidence.

To support complex baseline analysis, companies may need to align energy use to specific operational activities. This requires individual measurement of energy sources after the utility meter, a practice called submetering.

Case in Point

Pulp and paper mills typically use many forms of energy. These often include purchased electricity as well as electricity generated on-site from waste wood chips. Mills may vary the ratio between purchased and self-generated electricity depending on the real-time cost of purchased energy as well as the availability of waste wood chips.

A small manufacturing facility produces two products on two separate production lines. One product – and thus one production line – is significantly more energy-intensive. To enable identification of two EnPIs, the facility installed a submeter for each production line on the breaker panel serving the two lines.

3.3 Define the Baseline Period

Performance improvement tracking results are affected by two characteristics: the period duration and the specific historical time frame. The baseline period options can be limited by available data. For example, facility staff may prefer to work with a longer baseline, but due to limited data availability it may only be able to use the previous three months.

3.3.1 Baseline Duration

The baseline duration should be based on business condition information together with statistical methods such as regression analysis to determine the best fit among variables over time.

Baseline duration can range from less than one year to multiple years:

- **Less than One Year:** An EnB duration of less than one year can be appropriate in operations where energy consumption is steady throughout the year. Short baseline durations may also be necessary for situations with insufficient reliable or available historical data, or when changes occur to the company's culture, policies, or processes.
- **One Year:** The most common EnB duration is one year, because it often aligns with energy management business objectives such as reducing energy consumption from a previous year. The one-year period could be a calendar year or a fiscal year depending on the organization's budgeting or other needs. A one-year duration may be appropriate for seasonal operations, such as for food processors that produce based on a growing season or for textile manufacturers that produce prior to a school year.
- **More than One Year:** Seasonality and business trends can combine to make a multi-year EnB optimal. Specifically, custom multi-year EnB periods are useful for extremely short annual production cycles where a business manufactures for a few months each year and then is relatively dormant for the remainder of the year. For example, a winery might want to track energy performance only during the crush and fermentation periods of each year over multiple years.

3.3.2 Baseline Time Frame

Three potential EnB time frames are as follows:

- **Immediately Preceding:** This is the typical time frame used in most instances. Facilities already making changes that will improve energy performance should choose an EnB time frame immediately preceding the reporting period; this will ease identification and quantification of improvements. If the immediately-preceding period does not have reliable data, facility staff should choose the most recent period with reliable data.
- **Prior Event:** Tying an EnB time frame to a prior event is appropriate for organizations undergoing a recent significant change such as a major acquisition or facility enlargement.
- **Fixed Time Frame:** Using a fixed reference year for the EnB time frame is common when demonstrating improvements across a group, such as for multi-site corporations, government programs, or industry organizations.

Case in Point

A small toy manufacturer had only five months of monthly production data. As a result, its EnB period had to extend into its reporting period. To correctly account for this situation, its EnB model included an indicator variable to designate the overlapping months.

To show progress across all of its facilities, a multi-site corporation chooses a single, common year as its EnB time frame. It chooses the year 2007, as it was the most recent year to reflect operating parameters prior to corporate energy reduction efforts.

3.4 Define Relevant Variables

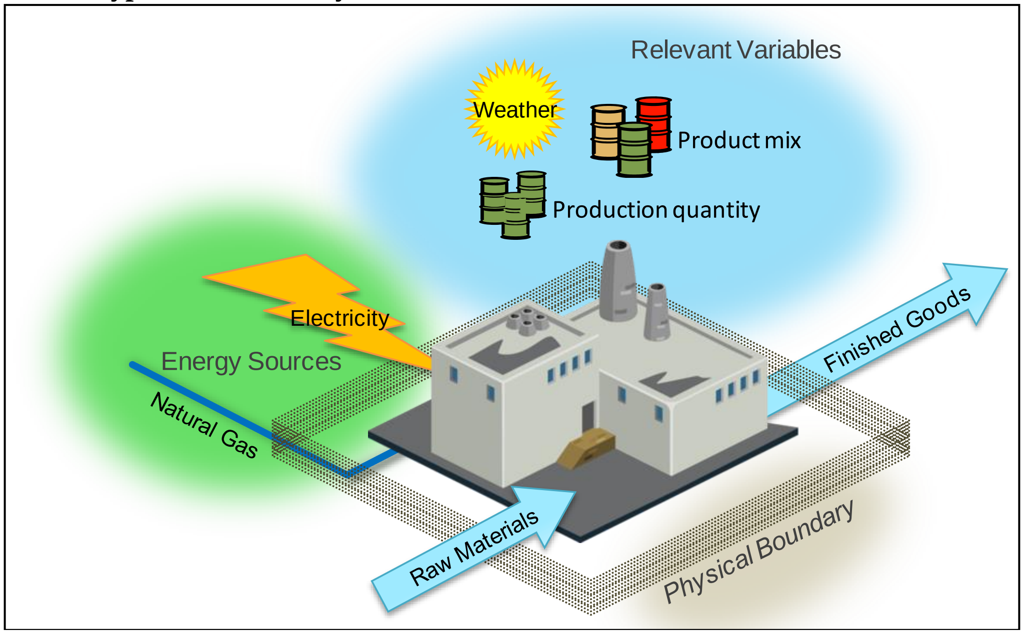
Relevant variables are quantifiable factors that impact facility energy consumption, such as weather conditions, production, and hours of production or operation.

Facilities whose energy consumption is influenced by weather should account for it in their analyses; otherwise the energy team could mistake weather-driven variations for other causes. Obtaining weather data that is appropriate for use in energy performance determination can be challenging. Common difficulties include finding nearby weather measurement locations, finding weather measurement frequencies that align to other energy-related facility data, and finding the appropriate type of weather indicator. For the latter, common options include Heating Degree Days (HDD), Cooling Degree Days (CDD), temperature, and humidity.

In addition, hours of operation or hours of production can influence energy consumption, though neither of these energy influences is typically used as they are usually more consistent or lower in importance than production levels.

Figure 3 illustrates the potential energy consumption influences for a hypothetical facility: production quantity, product mix, and weather. The illustration also shows the facility's energy sources and physical boundaries.

Figure 3. Illustration of the Boundaries, Energy Sources, and Relevant Variables for a Hypothetical Facility



The relationship between energy consumption and its influences can range from a simple linear relationship with one relevant variable to complex, non-linear relationships with several relevant variables. To determine driving factors, organizations could use either of two techniques:

- **Engineering analysis** of an operation's inputs and outputs can expose how relevant variables impact energy consumption. By visually assessing a facility, discussing flows with operations team members, or using more advanced approaches such as energy mapping, the energy team can identify possible energy influences.
- **Statistical analysis** can demonstrate how relevant variables influence energy consumption. Correlation analysis, X-Y scatter plots, and regression analysis can all be used to identify relevant variables and to measure the strength of any statistical relationships.

Though units of raw materials or units of production throughput can be viable energy influences, the most commonly-used relevant variables are units of production output. These may be based on the number of products produced (e.g., number of ladders or cases of paint), mass-based (e.g., kilograms of pet food or tons of rolled steel), or volume-based (e.g., barrels of beer or square feet of fiberboard). The common usage of production output does not imply its appropriateness for all facilities; throughput can be a more appropriate relevant variable to measure and monitor.

Some companies produce a variety of diverse products. If these products have similar energy intensities (energy consumption per unit of output) and units of output, they can be grouped. If these products differ widely in energy intensities or units of output, then the energy data should be tracked separately. If measuring the energy use data separately is not practical or cost-effective, and the data are only available in aggregate, then the energy team may need to find another process to allocate energy use data to product groups.

Aligning the time periods of energy consumption data and relevant variables is vital. If an energy-intensive process occurs days or weeks before or after production measurement, misalignment may occur. In this case, the energy team can make adjustments using time-series offsets. In addition, if energy consumption data are reported monthly but production information is tracked daily, the data may be difficult to align. Obtaining different interval energy information from a utility provider, or pursuing more in-depth solutions such as installation of, or reprogramming, an energy information system (EIS) can correct such a misalignment.

Case in Point

In some industries, such as pulp and paper, energy consumption is driven by one thing: production. But in most industries several factors drive energy consumption, and identifying the most relevant variables may be time-consuming. Regression analysis for energy consumption at one wastewater treatment facility was unsuccessful because consistent flow rates resulted in weak statistical relationships with relevant variables.

In winery operations, fermentation tanks tend to consume significant amounts of energy, but production data may only exist for barrels of wine shipped three months after fermentation, resulting in a time delay between energy data and production data. To address this, the winery may install flow meters to measure gallons of wine coming out of the fermentation tanks, and focus on production throughput rather than production output as its relevant variable.

3.5 Determine and Calculate Energy Performance Indicators

EnPIs should provide relevant energy performance information to enable various groups within an organization to understand its energy performance and to take actions to improve it. This may mean that energy performance is represented by more than one EnPI.

EnPIs have been historically expressed as energy consumed per unit of output or of another relevant metric. Though this can be sufficient for some facilities, problems may arise when production changes dramatically. In addition, other relevant variables often exist, requiring multivariate analysis to determine the EnPI, and thus making EnPI expression in terms of a single relevant variable difficult or impossible. In those cases, one technique often employed is to express energy performance as the ratio of actual energy consumed to expected energy consumption (see sidebar “Performance Indices”).

Having precise EnPIs can be important to accurately connect operational improvements to energy performance improvements, but facilities have seen the positive impact of tracking even very basic information, such as energy consumption (e.g., kWh). Often tracking simple, easy-to-obtain information can lead facility staff to solve operational issues and answer questions. Having organizations utilize the most precise analysis feasible is important, as they will gain greater usefulness from the resulting information and potentially have a more effective EnMS.

Case in Point

A sporting goods manufacturer that fabricates multiple products in a single facility needed to decide which product to use in its EnPI. It settled upon the product for which it had the most consistent production quantities and the most historical data. This metric was built into its monthly energy model so that its EnPI is calculated automatically each month.

Energy consumption at a platinum mine varied with tons of rock processed as well as with the grade of the rock. With these two relevant variables, the mine established a multi-variable model to indicate performance. To demonstrate to stakeholders that it is improving energy performance, the mine reports how much energy is saved compared to what is expected. It also reports an Energy Intensity Coefficient, showing expected energy usage from the multi-variable model divided by the actual energy used at the meter.

3.6 Address Baseline Adjustments

Organizational change is common, and when an organization anticipates a change that could impact baseline validity, it should plan for possible baseline adjustments. These adjustments could come in multiple forms:

- **Energy Source Change:** When an organization changes source fuels for its operation, it may make sense to modify what is tracked or the weighting of how energy sources fit into the EnB, for example if an organization installs a CHP system.
- **Operational Change:** When an organization makes significant operational changes, it may need to change its EnB time frame. For example, if an organization expands its facility, changes its mixes of distinct product throughputs, or changes a major energy-consuming piece of equipment, the organization may consider initiating the EnB time frame to the point immediately following that change.
- **Business Change:** Business changes such as acquiring a facility or a new asset may point to the need for an EnB adjustment.
- **Energy Management System Change:** Changes to an organization's calculation methodology or improvements to data collection may make an EnB adjustment desirable if it enables better resolution for tracking performance improvements.

An organization should define intervals at which it reviews the key characteristics of its operations that determine energy performance, regardless of whether any of the changes above have occurred. The organization should consider these adjustments and make changes with appropriate stakeholder input and approval. However, the organization may not be able to adjust EnBs due to requirements from stakeholders or from programs to which the organization subscribes.

Case in Point

A manufacturer of renewable energy technologies made significant changes to its production inputs not long after it established its EnB. While its overall energy use was largely unchanged, its production quantity was significantly impacted. The result was *that the manufacturer was forced to re-establish its EnB because the existing energy model could no longer estimate electricity consumption with the same level of accuracy as before the change.*

If an organization commits to improve on energy intensity from 2009 levels, a core operations change may make an EnB adjustment preferable; however, the organization's previous commitments may not allow this.

4. Baseline Selection

Table 2 presents three approaches for selecting an EnB and shows that facilities can have characteristics in different levels of complexity. For example, a facility could have "simple" boundaries, "complex" energy sources and energy influences, and "moderate" baseline period and anticipated adjustments.

Table 2. Energy Baseline Selection

Approach	Boundaries	Energy Sources	Baseline Period	Energy Influences	Anticipated Adjustments
Simple	Single facility, clear boundaries	Single source	Consistent operation each period	Single product group influences energy use	No factors that require adjustments
Moderate	Multiple facilities, moderately clear boundaries	More than one source (electricity and gas)	Production varies over the year, seasonally based	Single product group, weather, seasonal shutdown	Single factor that may result in baseline revision
Complex	Multiple facilities, multiple operations	Multiple energy sources, cogeneration, energy used as a raw material	Production constantly changes, both product output and energy intensity	Complex energy influences, varying energy intensities, weather influences, raw material variations	Major factors that require adjustments, process design changes, new products

Organizations that follow a more thorough process should document the information leading to their EnB selection in their energy management plans. As an organization makes changes over time, the documentation will help it to diagnose whether to make revisions to its EnB.

5. Baseline Utilization Recommendations

Facility staff should use its EnB and related information in a manner to best measure and support energy performance improvements. Table 3 provides summary recommendations that can lead to optimal EnB data utilization.

Table 3. Baseline Utilization Recommendations

Commit to long-term use of an EnB to avoid having to track multiple EnBs
Review energy performance at the same frequency as other operation information
Present energy performance data in ways similar to other operation information
Make energy performance data easily accessible
Support energy performance data with visual indicators
Involve management in review of energy performance data
Review EnB at regular intervals to maintain validity

1. **Commit to Long-Term Use of an EnB:** Making a long-term commitment to measurement from a specific EnB is important for an organization. Baseline revisions may eventually require tracking multiple EnBs, which should be avoided if possible due to increased complexity.
2. **Frequency of Energy Performance Data Review:** To manage operations, organizations review data such as production volume at appropriate frequencies. To increase systematic use of energy performance data, the energy team should review it at the same frequency. For example, if facility staff tracks production volume weekly, then the team should review energy performance at the same time each week. Successful organizations treat energy as any other manageable aspect of their operations and review it with the same regularity.
3. **Types of Presentation of Energy Performance Data:** Organizations present operational information to employees using a variety of methods, including email, bulletin boards, and intranet websites. The energy team should share performance information using similar methods to increase the organization's visibility of energy performance.
4. **Ease of Access to Energy Performance Data:** When obtaining energy performance information is difficult, the additional effort necessary to acquire the data can make it a lower priority. For example, when organizations must contact their utility providers or information technology departments each time they want energy performance data, they will often monitor this information less frequently. Ideally their energy data is within a system already utilized by the organization.
5. **Energy Performance Data using Visual Indicators:** Organizations have numerous priorities, and energy performance is rarely the top priority. Using visual indicators such as energy dashboards provides an easy way to quickly convey important energy metrics. Control bands or other signals can be used to indicate whether energy performance is outside of an expected range and to enable easier management of energy. Including targets can also help give a visual sense of progress toward energy reduction goals.
6. **Management Integration into Performance Review:** The organization should involve executive management in the energy management process. Management should be aware of actual energy performance, reviewing regular performance reports, and asking

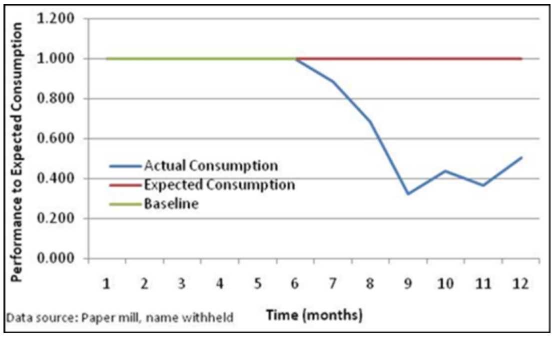
performance-related questions of the energy management team. In addition to general awareness, management should have a clear expectation that it will hold the energy management team accountable for performance and that performance drops will necessitate a response.

7. **Review Baseline for Maintained Validity:** At the programmatic level, organizations should regularly review the EnB to ensure it accurately reflects operations. Ideally, the review would occur in the scope of an annual energy program review prior to the establishment of the following year's program goals. The review of the baseline does not have to be onerous, but should involve two straightforward perspectives similar to those in the initial baseline establishment:
   - **Physical:** The energy team and management can discuss completed projects or other operational changes to identify needs to revise the baseline.
   - **Data:** Facility staff can conduct regression analysis with more recent, updated data and ensure that the baseline approach is still appropriate.

Performance Indices

When a facility uses a multi-variable model to demonstrate performance, expressing the result in a single EnPI can be difficult or impossible. In this case, facilities often employ the technique of expressing energy performance as the ratio of actual energy consumed to expected energy consumption. Starting from a baseline of 100%, any result below 100% is considered a positive movement, where the facility is using less energy than anticipated; a result above 100% is considered negative, where the facility is using more energy than anticipated.

The figure below shows monthly energy consumption as an index value relative to "business as usual" energy consumption—in other words, how much would have been used in the absence of energy efficiency improvements. From this baseline energy intensity index, improvements take place starting at month six (6) that decrease the energy consumption from the expected levels, illustrated by the falling line.



Additional Utilization Considerations

A change that does not improve production and/or energy efficiency, but lowers energy costs, may still make business sense. For example, total energy cost may be a main priority at a refrigerated warehouse with high demand charges. Decreasing demand leads to slightly decreased overall efficiency, but also to decreased total energy costs due to reduced demand charges. If the EnB accounts only for efficiency and not for total cost, then the facility would appear to be underperforming. The energy team should anticipate this and alter the baseline development approach to account for this broader view of including cost as part of the EnPIs.

Additionally, considering long-term commitments to measurement from a specific EnB is important; it may eventually require an organization to track multiple EnBs, which should be avoided if possible.

Finally, documenting how the EnB is used by the organization to help inform changes and improvements over time is also important.

Case in Point

The owners of a stone quarry with production of about 200,000 tons per year decided to embark on an EnMS, which required development of an EnB.

EnB development at the quarry began with the determination that the boundary should include both the quarry and the kilns, even though they are physically separated from each other by about ¼ mile.

The quarry used coal and coke to fuel its kilns and electricity for crushing, conveying, dust collection, and blowers. However, electricity constituted the only energy source with which the quarry's operators were immediately concerned for the EnB.

The quarry began its EnMS in mid-2011. Thus, its baseline period ended at that time. The operators had daily historic data available on a significant number of inputs and outputs going back as far as the beginning of 2010. As a result, the quarry's EnB extended eighteen months from the beginning of 2010 to mid-2011, providing almost 550 data points for each relevant variable.

Relevant variables were easily recognized at the quarry and included the following:

- *Tons of rock crushed per day*
- *Crusher operating hours per day*
- *Kiln operating hours per day*
- *Hydrator operating hours per day*
- *Heating degree days*
- *Cooling degree days*

Since the quarry's electricity use was more greatly affected by tons of rock than by the other relevant variables, the operators identified tons of rock crushed per day as the quarry's EnPI.

After about two years, the EnB was adjusted because the quarry's operators had found that although daily data were readily available for each of the relevant variables, daily data entry was too time-consuming. As a result, data entry had fallen far behind. Therefore, the operators reevaluated the baseline using monthly data from the same baseline period; the result is an equally robust model that requires less time for data entry. The downside is that potential problems will not show themselves as easily or quickly.

6. Conclusions

The approach presented in this report is designed to help all types of facilities – from simple to complex – to develop EnBs and to get started right away in using energy data to support their EnMSs. The straightforward methodology is scalable so that initial efforts can be iteratively adapted to increase sophistication as energy managers become more confident and gain more information. Moreover, the approach applies to programs set by utilities, government agencies, and corporate offices to increase energy management adoption and ultimately improve energy performance.

If an energy team sees the process as too complex, it should move forward employing a simpler approach to initiate the energy management process. Later, the team can employ more advanced techniques as it gains experience, organizational credibility, or other skills. For some complex facilities and circumstances, bringing in a specialist to assist the facility may make sense in order to more efficiently use time and resources.

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Appendix – Terms and Definitions

Baseline: Quantitative reference(s) providing a basis for comparison of energy performance (NOTE 1: An EnB reflects a specified period of time. NOTE 2: An EnB can be normalized using variables affecting energy use and/or consumption such as production level, degree days (outdoor temperature), etc. NOTE 3: EnB is also used for calculation of energy savings, as a reference before and after implementation of energy performance improvement actions.)

Consumption: Quantity of energy applied

Energy Performance: Measurable results related to energy efficiency, use, and consumption (NOTE 1: In the context of energy management systems, results can be measured against the organization's energy policy, objectives, targets, and other energy performance requirements; NOTE 2: Energy performance is one component of the performance of the energy management system.)

Energy Performance Indicator (EnPI): Quantitative value or measure of energy performance as defined by the organization (NOTE: EnPIs could be expressed as a simple metric, ratio, or as a more complex model.)

Use: Manner or kind of application of energy (NOTE: Examples are ventilation, lighting, heating, cooling, transportation, processes, and production lines.)

Northwest Energy Efficiency Alliance

The Northwest Energy Efficiency Alliance is a non-profit organization working to maximize energy efficiency to meet our future energy needs. NEEA is supported by and works in collaboration with Bonneville Power Administration, Energy Trust of Oregon and more than 100 Northwest utilities on behalf of more than 12 million energy consumers. NEEA uses the market power of the region to accelerate the innovation and adoption of energy-efficient products, services and practices. Since its inception in 1997, NEEA initiatives have saved enough energy to power more than 450,000 homes each year. Energy efficiency can satisfy more than half of our new demand for energy, saving us money, and keeping the Northwest a healthy and vibrant place to live.

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