

Energy Efficiency May be Your Factory's Golden Ticket

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Imagine you are Willy Wonka, and it is time to build a new factory. You would like the new factory to be as energy efficient as possible, while still producing as many great tasting Wonka Bars as you can. Food and beverage manufacturing facilities typically are huge energy consumers with annual bills in the realm of 5-10 percent of the facility's construction budget, or in absolute terms, in the multi-million dollar range.

Operational savings are a critical component of the food and beverage industry business model. By diligently estimating projected energy use for the project, identifying areas for energy reduction, and implementing the best return on investment energy efficiency measures, substantial cost reduction can be achieved while maintaining the quantity and quality of the product produced.

What are the special characteristics of food and beverage manufacturing facilities that set them apart from other higher energy use building types?

Unlike general manufacturing and other heavy energy use building types such as data centers, most food and beverage manufacturing plants produce some type of custom product that has a proprietary formula (aka Everlasting Gobstoppers) and hence uses specialized equipment. This specialized nature can make it difficult to identify where to capture energy and energy cost savings.

In addition, engineers, vendors and specialist integrators are in charge of designing different pieces of the processing plant – such as raw product receiving and storage equipment; equipment and utilities for the manufacturing process; packaging, heating, cooling and refrigeration systems; and the basic shell of the manufacturing plant. Any alteration to improve the efficiency of one portion of the plant can affect the performance of the upstream and downstream equipment. Finally these plants are built only every few decades, when company production increases enough to warrant a new facility. This timeline does not allow a lot of space for incremental improvement or test-and-adopt scenarios that are frequently used in commercial building construction.

Given these complexities, what is a good key performance indicator (KPI) to predict and measure energy performance?

From experience, we know that that absolute energy use reduction is not a good performance indicator for food and beverage facilities. Comparing overall energy use to other facilities does not tell the whole story because each facility is so different, and built so far apart in time and technology, that it would be impossible to establish a baseline energy performance standard on top of which energy improvements can be applied. Unfortunately, most green building rating systems and energy benchmarking frameworks (e.g. ENERGY STAR Portfolio Manager) use the traditional absolute energy efficiency achieved by the facility, and in some cases energy use per square foot, to establish energy performance.

We have found that the best KPI for food and beverage manufacturing facilities is energy cost per product: the cost of the energy required to produce one unit of the product, such as energy cost to produce one pound of coffee, or energy cost to produce one packet of cookies.

Energy cost per product is easily measurable and the owner understands it well because it ties back into the high-level cost per product that they track for profitability. In addition, the KPI allows comparison against the energy efficiency of other products within the same facility, against the energy performance of an existing facility and, if data is available, even against the energy performance of a competitor's facility or a competing production technology. This KPI also helps establish energy improvement capital expenditure (CapEx) as a dollar amount saved per product KPI, which allows comparisons against other cost reduction measures across the supply chain such as improvements in transportation or material cost.

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Finally, and most importantly for the purposes of tracking and driving energy performance, this KPI allows the design team to quickly establish a baseline, as the client or owner has already established the cost of what it takes to produce the product (total cost per unit product).

Is there a good methodology one can use to calculate the energy cost per product?

Trying to nail down how much how much energy will be consumed, and how much product will be produced, before the first Everlasting Gobstopper rolls out of the factory may seem like a daunting task, but with a bit of organization and a good project team we can achieve a reliable estimate.

Following is a process that has been used many times to calculate the energy use cost for highly complex food and beverage facilities.



Step 1: Identify the key designers for the different pieces of the project design. Typically, the key players

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that we need information from include the mechanical designer, architect, the process designer for the project, the refrigeration systems designer, the electrical engineer, and the process designer from the vendor side if there are any custom packaged processing equipment, such as Shibuya's aseptic filling system for a beverage manufacturing plant or Zarpac's packaging systems.

Step 2: Obtain and track the energy performance and operation metrics of each system in the project. This may include the energy demand, hours of operation, diversity in load, part load conditions, and system efficiencies for each piece of cooling equipment, fans, motors, process equipment.

Step 3: Collate the demand and performance information collected in Step 2 and calculate the annual energy use for each system, and then combine to calculate the energy use for the entire facility.

- For systems that interact with the environment—such as the chillers and air conditioning equipment for space conditioning—and are affected by weather conditions and people and equipment dynamics in the space, use an hourly simulation energy modeling software such as eQUEST to predict annual energy use.
- For more standalone systems where energy use is driven purely by production schedule and capacity—such as conveyors belts in a packaging line— calculations are usually sufficient to determine the system's annual energy use.

Step 4: Obtain the electric, natural gas, purchased chilled water and steam negotiated utility rates for the project. Convert the annual energy use to annual energy cost, and calculate the energy cost per product using the information collected in Step 3. It might be helpful to use a 20-year averaged energy cost that takes into account energy cost escalation for each utility type. When calculating the energy cost per product make sure to use the anticipated annual production capacity of the facility when it is under full operation.

What is the best way to identify energy reduction strategies that have the most impact on the energy cost per product KPI?

Based on the energy use calculated for the different uses in the plant in Step 3 above, identify energy reduction areas and corresponding energy reduction strategies. It is important to look at both energy use and energy cost impact when identifying which energy reduction strategies to implement.

While natural gas used for process heating, sterilization and emission control is the largest energy use component in many food and beverage manufacturing facilities, in many cases installing energy reduction strategies for natural gas use reduction may not translate into a 1:1 energy cost savings/product. This is because in many cases, natural gas is typically four to five times cheaper than electricity. Reducing

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natural gas use may show substantial energy savings but not a big energy cost savings.

Continuously update the annual energy use/product and annual energy use cost/product throughout the design process to track progress and to ensure that the project stays on track.

What is the most effective way to set up and continuously track all this information?

Given the time sensitivity and complexity of the energy cost per product calculation, it is best to have one entity in charge of managing the overall plant energy performance tracking. There are many designers involved in a food and beverage plant design, and the variables involved in the design evolve constantly. In order to track and affect the overall energy performance of the project effectively, there needs to be a central person to facilitate the process, with oversight to look at all energy related information and bring it together in cohesive manner. This way, there will be a single responsible party in charge of tracking the energy performance goal, updating calculations as the design changes and examining the impact on energy performance KPI.

The above process has helped multiple food manufacturing projects improve energy performance in the range of 10-30 percent compared to industry standards and reduce annual energy cost in the range of 8-25 percent. Given annual energy bills can be in the range of \$12-\$15 million dollars, overall savings may amount to \$14 million - \$60 million over a fifteen year operation period. This number will be even higher if utility rate escalation is taken into account.

Conclusion

In addition to the direct energy cost savings, establishing the energy cost per product KPI early in the design process and continuously tracking improvement during design and construction provides a host of other benefits. The project will be well positioned to achieve USGBC's LEED certification and it will have a well-established energy performance target for the operational phase. In addition, this information can be used to apply for utility incentives, providing additional cost savings to the owner.

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