WHITEPAPER

How can you improve operational performance by tracking and analyzing energy data?

Authored by:

-

Wen Jian Lee
Offer Manager, Industry Solutions, AVEVA

Tony Hunt
MSc, CEM, CPQ, Global Marketing Manager, AVEVA

Vivek A Pinto
Marketing Manager, AVEVA

Executive summary

The manufacturing plant is a heavy energy consumer – energy overheads are always the largest or second largest factory operating expenses. Energy losses and optimization can be strategically managed by using modern technologies such as big data management, manufacturing intelligence and advanced analytics to measure, visualize and analyze energy data in a business context. This forms the foundation for the continuous improvement process. Understanding and correlating energy data with operations data can bring in required changes, enabling factories to advance operational performance, control costs and stay competitive.

Introduction

The manufacturing world constantly faces pressure from tight margins, stringent regulations and capital expenditure constraints, as well as the constant need for variety and rapid response to consumer demands. To stay competitive, manufacturers look to optimize their total operating costs across quality, compliance, asset performance and sustainability.

Because energy costs are the largest operating expense for most manufacturers, improving energy efficiency can result in significant reductions in operating costs.

3 Steps to energy savings

Manufacturers are taking steps to improve energy efficiency, yet the level of success they achieve is heavily dependent on the knowledge, expertize and tools they have in this area.

There are normally three steps that manufacturers take in achieving energy savings:

1. **Upgrade to energy efficient devices** - Upgrading devices such as lighting and soft starters, as well as adopting LED lighting and variable speed/frequency drives is often the most direct way to gain some energy savings. This is a low hanging fruit and can be assessed quickly with ROI calculations and can be executed without too many technology barriers.
2. **Focus on equipment with high energy consumption** - In a manufacturing plant, there are various equipments with high energy consumption such as air compressors, boilers, chillers, cooling towers, heaters, big motors etc. Comprehensive time-based and condition-based maintenance, not only ensures smooth operation and extends the equipment lifespan, but also prevents additional energy wastage to overcome roughness or counterproductive forces due to lack of lubrication or wearing out the hardware. The ROI of replacing equipment with an energy efficient version or for complementary energy saving technologies to decrease the energy consumption of a functional asset can be validated with limited effort.
3. **Continuous improvement on energy efficiency** - Just like continuous improvement on Overall Equipment Effectiveness (OEE), energy efficiency can be greatly improved through optimizing energy consumption related to the production processes, operational activities or behaviour. Such optimization requires tools correlating energy data with production or manufacturing execution data. This empowers process engineers and operational teams to visualize energy KPI's and analyze energy consumption, variation and patterns in context of production events and results.

Although upgrading lighting and drives, and maintaining the equipment that have high energy consumption can help in saving some amounts of energy, the core energy usage in a plant is consumed by production processes when the actual main activities of the plant are running. We can see parallels in a home environment – we can change our home lighting to LED light, install energy saving air conditioner and washing machine models and maintain/service them regularly.

With strong awareness on conservation, people are turning towards making their homes smart. Through home-controllers, that increase savings by controlling lighting, window shades, HVAC, water supply and various home appliances, there is a constant monitoring maintained with these reliable devices that also calculate and log the energy trends of all connected devices. These devices can be accessed online from anywhere, thus providing homeowners visibility and control over their home environment. When we gain visibility on energy usage related to our household operations, or production operations in the case of the manufacturing industry, we can uncover energy saving opportunities. The journey to understand, analyse and enhance energy efficiency begins here.

Can you correlate energy data with production operations?

Transforming energy data into relevant production contexts, monitoring and analysing energy consumption is the significance of continuous improvement in energy efficiency. This is challenging because it can be difficult for manufacturers to correlate energy data with production data. To illustrate the point - energy meters along production lines are not necessarily installed and as such the granularity of energy consumption does not allow it to be correlated to the production process. Also, energy metering data is often collected into an independent software system, not related to production. Moreover, energy data may only be collected in short intervals, which is not precise enough when production batches are relatively small in duration, thus the error in correlating the energy data with the batch production data could be significant.

Sometimes this happens even with the most straightforward production data – production volume. Logically, one would expect the energy usage trend should be in line with production volume trend – when production volume goes up by 5%, the energy consumption should go up by around 5% too. But this is not the case in the real world.

Quite often manufacturers find that the energy consumption does not follow a pattern based exactly on production volume. There will be cases where energy consumption goes up by 20% with production volume up 5%, or energy consumption can increase even though the production volume goes down. This means manufacturers can neither justify the energy consumption nor foresee energy consumption trends, hence preventing a proper analysis and creating a challenge to generate clear improvement plans.

Why don't energy consumption trends follow production volume trends? Production volume seems like it would be a good indicator of energy consumption, but there are too many variables that can affect energy consumption. Basically, every single production activity can contribute to energy consumption - from volume, product mix, production method to operator behavior. A few scenarios are as follows:

- **Every product has its own energy consumption properties** – In the first case, production volume in a manufacturing plant drops by 5% this month, yet 80% of the month's volume turns out to be a product with high energy consumption properties. Thus, the energy consumption of this month could be higher than last month despite volume drops.
- **Certain production events or activities can consume more energy although no production output is counted** - Projects such as new equipment/new product introduction and enhanced production recipe or method, involve system tests, commissioning, test runs or test productions. These activities have no impact on the production volume, yet they consume significant amount of energy. Thus, if these projects are running that month, the energy consumption can still go up compared to the previous month, even when production volume stays flat.
- **Methods and behaviours affect energy consumption** - Although the impact may be small in a single event, team methods and behaviours have a cumulative effect as they affect day to day manufacturing operations, which means methods and behaviours that contribute to energy wastage can have a large effect. If not corrected, energy will be wasted, and keeping with this trend, it will keep occurring. The impact accumulates and can be great over a period. Some examples are:
  - Playing safe – Team 'A' operators increase the temperature by 2 degrees above nominal set point, believing this will make the production process and product quality more stable. This makes Team 'A' consume more energy than other teams.
  - Convenience – Team 'A' uses manual labor for the cleaning process, and Team 'B' uses a mechanised and convenient method such as a compressed air gun to clean. This will make the energy consumed by Team 'B' during cleaning much higher than Team 'A'.
  - Practices – Common practice for a three-day machine shut down for maintenance/projects includes full shutdown of all heaters. Yet if the heaters are not involved in maintenance or the project, the user can consider keeping the heaters at production temperature or hibernating temperature during that period, as the energy used to maintain the temperature per hour is much lower than the energy used to heat up per hour. Thus, it all depends on the activities and the duration of the shutdown. Based on different maintenance or project durations, best practices can be derived to achieve optimal energy use over the period.

- **Normalization of energy data** - All energy sources should be considered in energy management, for e.g. Water, Air, Gas, Electricity, Steam (WAGES). It is important to consider all those sources as a whole, so that an improvement project does not improve consumption of one energy type while increasing another one, resulting in a zero net gain, or even worse, additional costs.

These details cannot be extracted from either a Manufacturing Execution System or Energy Management System alone. Manufacturers need the right tool to link up both systems, contextualize the data to ensure the energy data comes with production context, and help correlate the energy usage to production activities.

Uncover improvement opportunities through energy data with production context

Because the core energy utilization in a manufacturing plant is in the production process, most of the improvement opportunities come from there. These opportunities can be uncovered by correlating energy data with production data that channel energy management as a variable cost rather than a fixed cost. Below are some examples of contextualized energy data and the value it can deliver. In all cases, it is important to consider all energy types (WAGES), and as such, one must also consider the conversion of energy units into normalised energy units such Gigajoules (GJ) or British Thermal Units (BTUs).

Energy intensity – energy data per production unit

Energy intensity is energy data divided by production volume, e.g. energy consumption per ton, or energy consumption per item. Energy intensity is the true indicator to evaluate the plant performance. It provides an apple to apple comparison for different periods by taking production volume into account.

For example, Factory A consumed 1000 GJ of energy in January and consumed only 800 GJ of energy in February. Does this mean Factory A is doing better in February? We can only infer that February used less energy but we do not know whether it is an improvement from January. A probable cause for the lesser energy use in February could be because the factory ran for fewer days in that month, or factory had lesser production volume in February etc. This view could be different if the production volume results are considered, for e.g. 750kJ/item for January and 500kJ/item for February. In this case, we can see the factory using energy more efficiently in February as it used less energy to produce every single item.

Energy data per products

A single production line can produce multiple products. By analyzing energy meters on the production line, we can assess how much energy is consumed by the line, but we cannot get the energy information related to energy consumption per product. Energy data by product can be assessed only when energy data is correlated with production data.

When energy data is correlated with production data, manufacturers can identify energy intensity for all different products. This can help manufacturers to:

- Prevent peak electricity demand by avoiding running products with high energy intensity together. Eventually this can help prevent penalties from the electricity supplier.
- Identify the exact unit energy cost to produce every product. This enables manufacturers to treat energy like a raw material of the product, and consider it during price setting. This can prevent over-pricing which may affect market share, and underpricing which may affect the margin.
- Use the energy intensity of products as indicator for continuous improvement activities, especially to bring down the energy consumption of producing those products that require high energy.

Energy data per production event

Changeover, projects, maintenance, breakdown, start up and even shutdown: all these production events consume energy. With the ability to identify energy consumption for certain production events, continuous improvement can be done to drive the best practices and methods to use energy efficiently. For example:

- Changeover from smaller to bigger sizes consumes more energy. The planning department can minimize the changeover from small to big, and maximize the changeover from big to small. Meanwhile, engineers can focus their analysis on the changeover from small to big, further bringing down the energy consumption.
- Experiment with shutdowns with production temperature, room temperature (full shutdown of heater), or hibernating temperature, and for 1/3/7 days. From these combinations manufacturers can identify which gives the best energy consumption.
- Energy consumption for projects can also be captured. This helps to identify the true project cost and drive correct budgeting, or drive the initiative to use less energy for fixed project budgets.

Energy data per crew

There is a tendency to think every crew consumes the same level of energy, since operators follow a set of Standard Operation Procedures (SOP) which guide their way of running the machines. Yet even with SOP, there is a range to play, and a certain flexibility that makes certain crews' productivity vary with more energy consumption, or vice versa. For example:

An operator who is playing safe increases temperature by 3 degrees (within the specification), thinking this can stabilize the process.

An operator cleaning manually vs. operator using compressed air gun.

Operator who always shuts off the water source when it is not in use vs. operator who always keeps the water source open – thinking it will be needed quite frequently and would be too troublesome to keep shutting it off.

With energy data per crew, benchmarking among different teams can be done. Best practices can be derived on top of SOP to drive better habits for improved energy efficiency.

Energy data per combination of multiple dimensions

By analysing energy data with multiple production contexts, a more detailed analysis can be done and uncover more improvement opportunities. Some examples:

Energy intensity per product, per production line, per operation recipe – with this, different sets of operation recipes (temperature setting, running speed, pressure etc.) can be tested to produce certain products and to help identify the most energy-efficient production method. Of course, product quality should not be compromised in any case.

Energy intensity per production event, per production line, per shift, per crew – with this, manufacturers can see, for example, the electricity intensity in line 1 when production is running during the day shift for different crews. This provides a more detailed perspective and fairer benchmarking among crews.

Energy intensity per product, per crew, per line – with this, manufacturers can assess energy intensity to produce a product by a certain crew for different production lines. This can help evaluate the energy consumption rates for different lines, and identify if maintenance, fix or improvements need to be done on those lines.

Being smart in an energy efficient environment

There are huge opportunities for companies that exploit the intelligence gathered from plant operational data. When the desired data can be correlated to energy the resulting energy performance information will be invaluable to assess energy cost management and sustainability. This can lead to enhanced operational efficiency, reliability and equipment performance.

Becoming energy aware:

The massive amount of data available can threaten to overwhelm an operator trying to make sense of it all. Being aware of the energy data involved and being able to monitor, analyse, track trends and identify opportunities from the data processed, enables users to provide recommendations and take decisions.

Making improvements:

Transforming energy data into actionable metrics and KPIs, that can be tracked by operators, is the next step in an organizations' journey towards energy management. Improving energy performance becomes harder and harder over time, once the low hanging fruits have been addressed.

As such, providing a holistic view of energy and production data for all areas in the plant becomes essential. It is also critical to baseline energy consumption and cost in all related areas so that an improvement in one area does not come at the unforeseen expense of another area.

Maintaining efficiency:

As communication tools evolve, these new technologies are broadening market channels. Plant operations stakeholders are now able to model facilities before performance monitoring and then compare their usage after process, behavior, technology and controls change.

This explores potential scope for continuous improvement and operational excellence, and ensures operations, facility teams and energy managers can cohesively work and sustain a growth environment.

Modernizing to make a difference

Modernization for a plant can be extremely stressful. As smart manufacturing upgrades pick up speed across various industrial segments, enterprises need to analyse tons of data at their disposal. One such plant looked well ahead into the future as it embarked on an automation upgrade to improve access to production data.[1]

A brewery in Namibia needed to focus on the need for more visibility into the various utilities across the facility and subsequent interactions among different production departments. The brewing, packaging and distribution departments focused on their respective functions, but there was no consolidation of utility reports. Utility reports were needed to track consumption of water, electricity, chemicals, thermal energy and solar generation among others.

The beverage producer decided to scale plant-wide monitoring and remove data “silos” via a SCADA system, OPC-based Software Toolbox servers and a historian solution. The historian product handles time-series data, as well as alarm and event data. Before the modernization initiative, operators had been using the historian product for five years and had manually gathered and entered key performance indicators (KPIs) into Excel spreadsheets. Preceding this initiative, the plant had separate physical servers for each application and different operating systems. The brewer used this opportunity to upgrade its systems and link them to an online network while ensuring the data time synchronization happened accurately.

Securing the dashboard that provided daily data in the form of operational sales and KPIs to management, the brewer was now able to plan ahead through a real-time driven advanced planning system. However, the most important part was that the brewer could now find opportunities to reduce costs via power management. This was done by the installation of more than 50 power meters throughout the plant. The brewery now had improved decision-making capabilities regarding the plant requirements, and this was seen when the BioMass boiler requirement was reduced from 8MW to 5MW using historical thermal energy data.

Major takeaways for the brewery from this modernization process included better loss control by being able to view consumption data in conjunction with production information. Also, a more accurate calculation and reconciliation of project KPIs and ROIs was achieved. Plant personnel were now able to view daily, weekly and monthly consumption information on the same platform. Immediate total estimated savings from this project were in excess of USD 150,000.

Successes like this event are going to be evident in the coming months and years as plants modernise and come up to speed with the digitization process sweeping various industry platforms. Open standards, scalability, easy customization and integration make it a highly viable business proposition when it comes to monitoring and building decisions around energy performance.

Implementing energy efficiency is just a part of the overall target of achieving energy performance. Keeping in mind the continuous improvement required to drive plant energy performance, the ISO 50001 international standard helps raise the bar here. This process helps in reviewing energy performance while establishing an energy baseline across various time periods. ISO 50001 is a streamlined approach to energy management that can help uncover untapped energy efficiency potential. This standard targets the management level by alerting them on the immediate and long-term gains that a plant’s operations can achieve. Leveraging this standard, a clear understanding of the energy performance indicators can be brought on to monitor performance while helping establish objectives, targets and action plans. Keeping in mind existing business practices, management and technical aspects of energy management can now be seamlessly integrated into the system.

[1] Brewer Scales Smart Manufacturing Platforms for Next Decade; Automation0 World; Grant Gerke,Automation World Contributing Writer, November 13, 2017

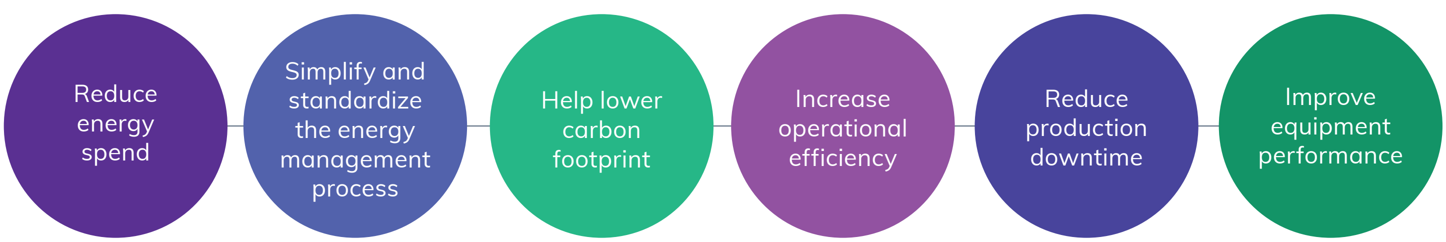
Energy as a real-time cost of operations

As technologies mature and innovative solutions become the norm, companies are always on the lookout for what works best for them. From an age of multiple 'silos' collecting energy data and stored in different places, there is now a great opportunity to consolidate and standardize the data and have a central energy performance repository. A dynamic energy performance solution can be a dedicated function for energy managers to optimize their operations and save money while collecting the data that already exists, upgrade equipment and go beyond legacy systems. There is a need for a strong partner for the industry who can understand interoperability and data acquisition. This partner will be able to turn this understanding into a strategic initiative that can increase visibility and data accuracy around the plant operations.

As soon as an organization places measuring devices across the plant, real-time energy attributes are created leading to operational intelligence that can enable decision-making and the way forward in optimizing operations. Investment in systems that can monitor and target energy can be the base for performance improvement.

F&B manufacturing plants have a very good reason to monitor and target their energy performance across operations. Depending on the manufacturing processes and how energy intensive the business is, it is possible to reduce energy bills by approximately 30%. The enormity of the energy savings can be gauged through the research done by the Carbon Trust[2] who estimate that the food and drink industry consumes nearly 37TWh – enough energy to power 125,000 homes for nearly 15 years – and emits around 11 million tonnes of carbon dioxide into the atmosphere. Keeping these metrics in mind, there is no doubt that the company CFO and energy managers would find it ideal to have the industry and power solutions combined to provide a world-class solution for them to obtain best-in-class continuous improvement in energy performance. It's all about making energy a real visible business driver in the context of production.

To summarize, deriving a strong energy performance from an industrial plant can help:



[2] Energy saving: a measure of success; Food Processing; John Grenville, 29 July 2017

Consumers in general are more aware now than ever. People want to buy from sustainable and responsible corporations, and being an energy efficient organization would add brand value. They are determined to ensure that companies they patronise are environmental friendly and have sustainable operations. Countries are wizening up and realising that economic success and environmental responsibility are tightly linked. Countries now have stringent emission norms in place and regulatory guidelines when it comes to emission data from factories.

It's all about being smart with the information you have. Adoption of energy efficient food processing equipment is a critical part of the organizations' journey to realise a viable way to adopt an efficient approach in food production processes. Energy saving strategies make things viable not only for the factories but also for the end consumers – in the long run the reduced production costs could be passed on to the consumer.

Finally, it all comes to the level of investment that can be placed in process innovation and equipment upgrade. It is this crucial link that can establish an understanding of how energy is used in a plant across processes and equipment. Further providing ammunition to develop an accurate modeling of energy flows and identifying the most cost effective ways to reduce energy waste. Information is where the opportunities remain and powering this with accurate energy intelligence can enable plants to take on a whole new digitized world with confidence.

About the authors

Wen Jian Lee is the Offer Manager, Industry Solutions at AVEVA. Wen Jian brings in significant experience in product/solution lifecycle management, leveraging the same in the Food & Beverage and Life Sciences business. He combines this experience with leadership in product marketing, operational excellence, process control and management among other responsibilities that he handles.

Tony Hunt, MSc, CEM, CPQ, works for AVEVA as a global marketing manager specializing in bringing Power Management applications to companies who operate facilities in a variety of segments including data centers, healthcare and infrastructure. He is a Certified Energy Manager and a Certified Power Quality Professional with over 16 years experience in the field of Energy and Power Management. Tony helped develop and deploy power management software modules designed to integrate into Building Management Systems and Process SCADA Systems and he remains an instrumental contributor to AVEVA's integrated power management software strategy.

Vivek A Pinto is a Marketing Manager at AVEVA, focusing on branding and communication projects across the software portfolio. Vivek works with regional marketing teams in developing campaign promotions and messaging besides managing creatives for various strategic initiatives.