PROFIenergy

Energy Savings Potential for Production Plants

University of Cologne AIT PROFIenergy Study July 15, 2011

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Summary

Energy-efficient production means more than just the use of variable-speed drives and efficient motors with low energy consumption. The question going forward is how to selectively place complete production lines or portions thereof into an energy saving mode during unproductive times. For example, in every notebook computer the hard drive, screen, or notebook as a whole will be placed in standby mode, depending on the operating situation. This function is a device feature and only requires parameter assignment. This is exactly the approach taken in the PROFIenergy concept, in which standardized control commands are used to place devices and machines into an energy saving mode via PROFINET.

The Initial Situation

In 2009, PI (PROFIBUS & PROFINET International) began work on developing the basic technology of PROFIenergy – the communication profile for operating energy-efficient production plants. The specification was finished in record time, and the first PROFIenergy devices reached the market in 2010. Since then, companies have indicated a strong demand for PROFIenergy products.

PROFIenergy enables the use of *smart energy management* over existing network infrastructures. However, the energy savings actually achieved depends mainly on how OEMs and operators implement the technology into their equipment and concepts. This requires knowledge of the technical and economical trade-offs between energy consumption and equipment operating modes.

Until now, only limited empirical (and hardly any actual) data has been made available on the relationship between energy consumption and equipment operating modes. As such, a detailed measurement study was needed to provide real quantitative data that would support existing qualitative assertions. The Institute for Automation & Industrial IT, at the Cologne University of Applied Sciences, was commissioned to perform this study. The institute is a member of the PI Working Group that developed the PROFIenergy specification and also serves as a PROFINET Competence Center, among other things.

The PROFIenergy Study

The main tasks of the study include:

- Performing the measurements and recording typical load curves
- Analyzing the load curves
- Determining the relevance of idle times for energy savings
- Identifying the potential savings from the use of PROFIenergy

The Task

Measurements for the PROFIenergy study were completed in October 2010 on production lines in Germany at Daimler's Sindelfingen plant and at Volkswagen Commercial Vehicles in Hannover (Porsche Panamera production). Their behavior was analyzed with respect to load curve, load distribution, and pauses in production. More specifically, the influence of different operating modes on energy consumption was analyzed, and production pauses were analyzed with respect to frequency and duration.

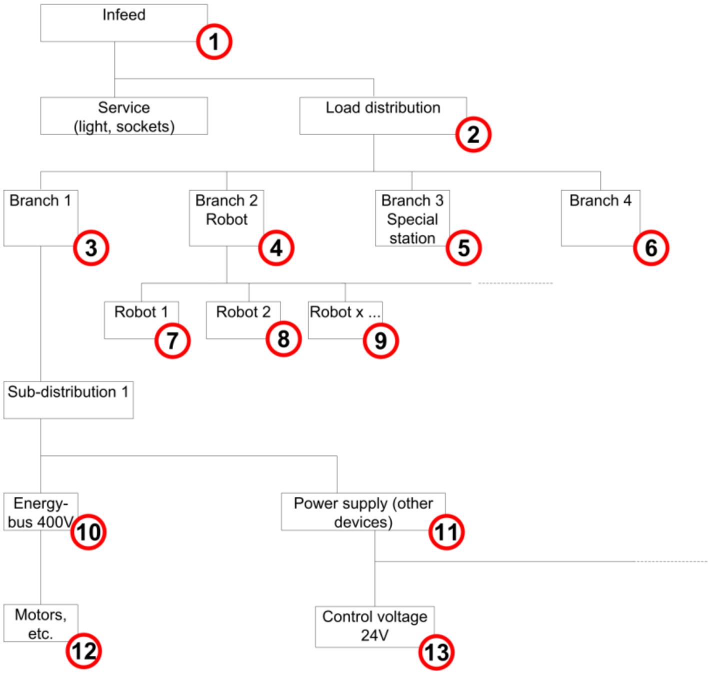

Figure 1 – Typical arrangement of measuring points in a production plant

The Measurement Concept

The power measurements were taken at up to 15 different points within a plant. It was possible to record typical load curves and determine characteristic values at different levels, ranging from the main incoming power supply (‘infeed’) down to individual consumers. See Figure 1.

Line-side analyzers were used to continuously measure and record all relevant values of the supply system including voltage, current, phase offsets and other power parameters. This was performed over a 7-day period at 1 second measurement intervals. At the same time, synchronous data (regarding equipment status and operating mode) was acquired from the PLC log. This synchronization ensured that the values obtained at the individual measuring points could be correctly attributed for subsequent analysis (see Figure 2).

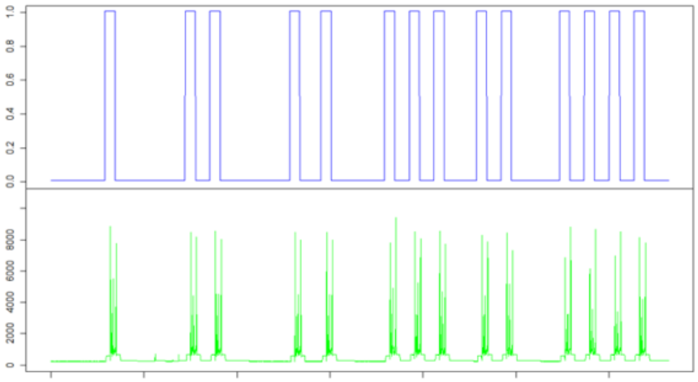

Figure 2 – Example of a recording of the operating mode (PLC signal, top) and load curve (bottom) for a robot system in a production plant

Based on these measurements it was possible to perform a detailed analysis of operating modes and the related energy consumption of plant units. This analysis covered the following points:

- Typical energy consumption of individual plant units
- Typical reduction of energy consumption during idle times
- Characteristic duration of idle times
- Relevance of pauses (planned, unplanned, operational, model-related)
- Relevance of plant concept (effect on energy savings potential)

Figure 4 – Arrangement of current (*I*) transformers / flexible current transducers for high power ratings (background); and split-core transformers for lower power ratings (foreground)

Figure 3 – Measuring setup of PROFIenergy

Results

The load curves typically exhibit regularly recurring profiles that are the result of the discrete production steps occurring in production. Yet, not all production equipment is active at every point in time.

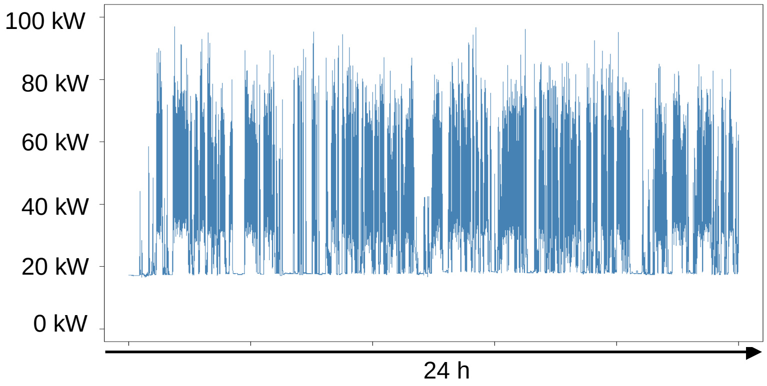

Figure 5 – Load curve for a sample 24 hour period

A noticeable feature of the load curves is the high load peaks, which can be seen in the example measurement results in Figure 5. These were obtained over 24 hours in a typical plant segment. While the load level during operation is around 80 kW, the base load is only around 17 kW. At first glance, this does not seem particularly relevant to the search for potential savings by reducing energy consumption during idle times. After all, the base load appears to be less than 20% of the upper load level – a misinterpretation that is easy to make. Here, one must not allow the high peak load to conceal the fact that the actual consumption value (that is, what is actually paid for) is the mean value of the load profile, which in this example is around 32 kW. The base load during a standstill is therefore more than 50% of the energy consumption during productive operation and provides significant opportunity for savings if handled appropriately.

In addition to this relative evaluation, attention must also be paid to the absolute order of magnitude of this energy consumption. To wit, if we compare this energy consumption to the typical energy consumption of a private household, the order of magnitude is staggering. The base load measured during a standstill is equivalent to the average energy consumption of approximately 50 households (based on 350 watts/household).

Load Distribution and Energy Flow within the Plants

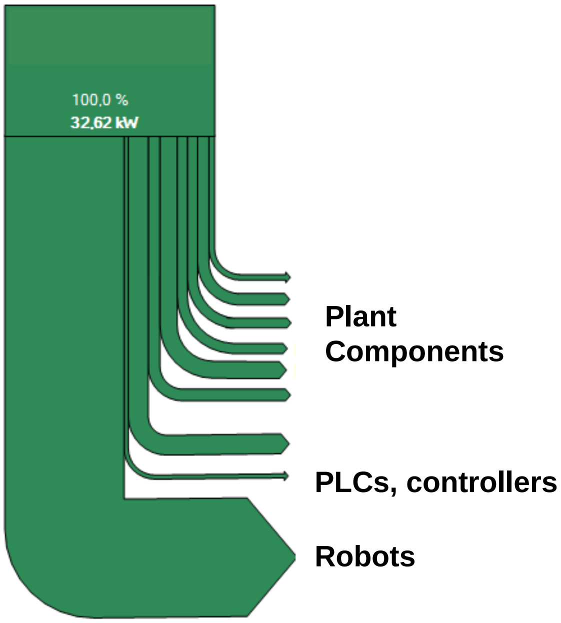

Figure 6 – Energy usage by consumer

Another important aspect of the study was the analysis of the load dispersal. Due to the tiered distribution of measuring points (extending from the incoming power supply down to the terminal level) it was possible to analyze energy consumers separately.

Robot systems are a prominent feature in automotive production. Between 30-60% of the total energy consumed can be attributed to them (Figure 6). Robot systems are also predominant energy consumers during idle times. A robot typically consumes up to 300 watts during idle time.

On the other hand, controllers typically account for only 2-3% of the overall energy demand.

Analysis of Idle Times

Idle times come in four different flavors:

1) Planned (breaks, weekends)
2) Unplanned (faults)
3) Operational (maintenance)
4) Model-related (mixed production)

Brief standstills are often an indicator of opportunities for optimization, especially with respect to equipment synchronization and/or material availability. Longer periods typically only occur during planned pauses, planned shutdowns and when there are complications in production. But, the nontrivial question remains: is the duration of the idle time significant?

The results of the study show that not only planned but also unplanned idle times are relevant for the use of PROFIenergy. Here, idle times were classified according to their duration, and the cumulative duration of all the individual events was calculated (total time of all standstills occurring in one class).

Idle times of short duration occur relatively frequently, but are typically not candidates for a switchover to energy saving mode because of the time required to restart the equipment from standby.

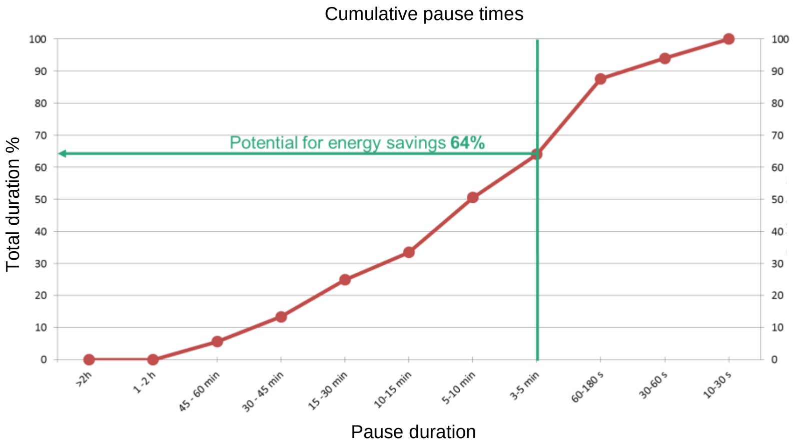

Figure 8 – Duration, frequency, and accumulation of pause times

Based on previous estimations, it can be assumed that for many plant components, a transition to energy saving modes is appropriate for idle times lasting 5 minutes or more. If this approach is taken, one can conclude for the plant example in Figure 7 that 64% of the cumulative idle times last more than 5 minutes and thus offer significant potential for the use of PROFIenergy.

An even more pronounced result can be seen in the curve for another plant example in Figure 8 in which the relevant portion of the exploitable idle times accounts for 90% of the cumulative idle times.

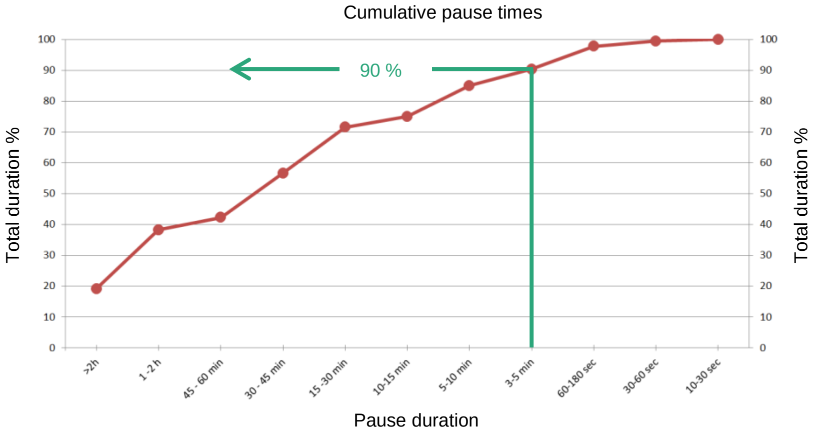

Figure 7 – Duration, frequency, and accumulation of pause times

The Potential for Energy and Cost Savings

Planned idle times account for a significant portion of the operating hours, depending on the workers’ shifts. Based on this study, it can be assumed for typical automotive manufacturing lines with a 2-shift operation that they will consume about half (47%) of their total energy consumption during idle times. Only 53% of the energy consumption is used for productive operation.

Most of today's manufacturing environments have only a ‘hard’ on/off switch option. Experience dictates that problems can occur when restarting switched-off equipment. Borne out of the fear of start-up problems, operators often do not turn off production equipment even during lengthy standstills. Since PROFIenergy is a module that sits on top of PROFINET, and is integrated deep within components, these fears are alleviated.

Of course, not all of the energy consumed during idle times can be saved. The PROFIenergy concept does not switch-off equipment entirely but rather places it in an energy-saving mode; this mode can differ depending on the component.

It is safe to assume that the use of PROFIenergy can save approximately 70% of the energy consumed during exploitable idle times. With that in mind, and based on the results of this study What does that mean in the grand scheme of things? **The result is a savings of 33% of the total energy consumption of a plant.**

In summary:

→ Half of the total energy consumption occurs during idle times
→ One-third of the total energy consumption can be saved by using PROFIenergy

Based on the energy consumption of a typical production line of 210,000 kWh per year, this yields a potential savings on the order of 7,000 € per year (based on 0.10 € per kWh).

The Prerequisites

To fully exploit the savings potential, the use of PROFIenergy-capable control components alone is not enough. Changes to plant concepts are also needed to enable devices or plant units to be placed selectively in energy-saving modes. In so doing, there must not be any impairment of safety-related functions in standby mode for safety-related applications.

For machine and plant manufacturers, this opens up new opportunities for gaining a competitive advantage. But this will only be the case, if purchase decisions for new equipment take into account energy consumption costs in addition to investment costs. Plant owners must clearly define their requirements to plant manufacturers so that PROFIenergy can be included in the design plans for equipment from the outset.

Summary

The current results of the PROFIenergy study confirm significant potential energy savings during pauses and idle periods of up to 50% or more and a savings potential on the order of 33% of the total energy demand. In addition to the direct benefits associated with improved energy efficiency (electric, pneumatic, thermal energy, associated costs), there are indirect benefits, resulting from extended service life of operating equipment.

The new opportunities made possible by PROFIenergy will change how plants are operated, assuming that these opportunities are considered during the engineering and development of plants and their concepts.

PROFIenergy is both the basis for and the driver behind this development work.

Imprint
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