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APPLICATION NOTE
ENERGY MANAGEMENT

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Disclaimer

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SUMMARY

There is no commonly agreed definition of Energy Management (EM) and numerous definitions can be found. For the sake of this application note, we will define EM as the practice of making informed decisions, based on structural insights into energy consumption and its impact on an organization. EM entails proactive and conscious management of an organization's energy consumption, as opposed to an ad hoc, passive approach. Energy in this case includes the typical utilities, often referred to as WAGES (Water, Air, Gas, Electricity and Steam). The goal of energy management is similar to the Trias Energetica concept and aims to reduce energy waste, increase energy-efficiency of remaining energy consumers and increase the share of renewable energy.

While energy management may be new to many organizations, the concepts behind it are not. They are in fact similar to those of other management systems. Starting with an initial audit and analysis of the current state, KPIs are defined, targets are set and results are ultimately reviewed. An existing management system, such as one following the ISO55001 standard on Asset Management can be an ideal starting point for energy management.

These days companies are confronted with ever more reasons to implement energy management: from legislative issues and stakeholder pressure to corporate vision and global competition. Energy costs money and represents risk and therefore needs to be properly managed.

Probably the biggest problem regarding energy consumption and its related costs is the so-called invisible nature of energy. Since electricity and gas always seem to be available yet usually not physically visible, people tend not to think about it and take energy for granted. This in turn explains the common lack of even a basic insight into the various streams of energy and their related costs. Logically, a lack of insight also leads to a lack of priority and/or commitment and to a lack of resources dedicated to addressing the issue.

Nevertheless, more and more companies (especially multinationals in energy-intensive industries) have taken to implementing the international ISO50001 standard for energy management. In a similar manner to other quality system standards, this standard is aimed at structurally embedding energy management within the entire organization. It requires the definition of management's responsibility with respect to energy management. It requires the development and implementation of a company-wide energy policy and an energy plan for continuous improvement. This plan must then be implemented, progress must be checked and/or reviewed periodically and the plan must be adjusted where necessary; all in line with the typical Deming circle (Plan—Do—Check—Act)[1] that is common in most quality systems. While all of these elements can be integrated into an existing management system, many organizations choose to apply for separate ISO50001 certification.

While a certified energy management system certainly has value, it may be overkill for many organizations. A simplified and pragmatic approach may even lead to quicker results and higher levels of enthusiasm among the staff. Management commitment however is a must, since resources will be needed to gain insight into the energy streams and to implement optimization projects. Understanding where, when, how much, why and at what cost energy is being consumed will require many people in various departments and functions to work together. Luckily, there is generally a great deal of information already available. This information is in the form energy invoices and contracts, quarter hour consumption data, machine lists, lighting layouts, et cetera. Based on this information, an energy team should be able to draw up an energy map, define relevant KPIs and identify opportunities for lowering energy consumption. By understanding and improving the company's energy consumption profile, the team can also work on optimizing the company's energy contract. By applying a systematic (Plan—Do—Check—Act) approach, the team will be able to implement an appropriate and structured energy management system that is focused on results, rather than on paperwork.

GLOSSARY

CAPEX
Capital Expenditures

CSR
Corporate Social Responsibility

EEG
Erneuerbare-Energien-Gesetz (German Renewable Energy Act)

EHS
Energy, Health and Safety
Similar: HSE (Health, Safety and Environment), HSSE (Health, Safety, Sustainability, Environment)

EM
Energy Management

EnMS
Energy Management System

EnPIs
Energy Performance Indicators

GRI
Global Reporting Initiative

HACCP
Hazard Analysis and Critical Control Points

KPIs
Key Performance Indicators

LCC
Life Cycle Cost

LEAN
Lean is not an acronym. The core idea is to maximize customer value while minimizing waste. Simply put, lean means creating more value for customers with fewer resources. A lean organization understands customer values and focuses its key processes to continuously increase it. The ultimate goal is to provide perfect value to the customer through a perfect value creation process that has zero waste.

NGO
Non-Governmental Organization

NPV
Net Present Value

OPEX
Operational Expenditure

RE
Renewable Energy

WAGES
Water, (Compressed) Air, Gas, Electricity and Steam

INTRODUCTION

DEFINITION: WHAT IS ENERGY MANAGEMENT?

Before answering this question, it is important to define the term energy, in order to avoid confusion. For this application note, we will refer to the often used acronym WAGES, which stands for Water, (Compressed) Air, Gas, Electricity and Steam. One can argue that water is not a form of energy, but like the other components that make up WAGES, water is one element of the typical utility offering which provide services used in industrial installations. Water is used as an energy carrier, in the form of hot water, steam or ice water. In addition, there is a strong water-energy nexus: a lot of water is needed to produce electricity, and a lot of electricity is needed to provide water. These are reasons enough to include water in the definition of energy.

Energy management in turn is the practice of making informed decisions, based on structural insights into energy consumption and its impact on the organization. Energy management requires permanent and detailed insight into energy consumption, analysis of the related risks, translation into risk management and identification of opportunities. All of this must be in line with corporate strategy. The risks associated with a lack of energy management may include costs, availability, reliability and corporate image. Opportunities from improved EM will come from reduced energy losses, profit margin control (through more accurate cost calculation and optimized price setting), innovation, revenue increase, reliability improvement, and communication. Techniques for energy management will include energy monitoring, energy efficiency measures and demand side management.

TRIAS ENERGETICA

One of the most widely referenced concepts in energy management is the Trias Energetica (Fig.1). This three-step approach was originally conceived in 1979 at the Technical University Delft (TU Delft) as a guideline for the sustainable design of buildings, and was introduced internationally in 1996[2]. The first step in sustainable design is to reduce waste, for instance by providing insulation. The second step is to maximize the production of renewable energy (RE). Finally, the third step is to maximize the efficiency of those fossil fuel consuming systems which are needed to cover the remaining energy needs.

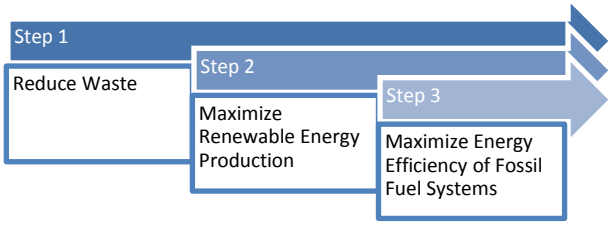

Figure 1—Trias Energetica.

While the concept of the Trias Energetica is widely accepted for designing new buildings, it is difficult to implement in a context of existing (aging) industrial installations. The top priority should remain a reduction of the energy demand by eliminating energy waste. In an industrial context, we might think of the reduction of steam and compressed air leaks, or avoiding unnecessary lighting, et cetera. The second step—a switch to RE—would require significant investments, and would be unlikely to cover all energy needs. Proper EM management (Fig.2) will focus on energy efficiency first, before turning to renewables, unless the RE options are clearly more cost effective. After all, the more you reduce energy demand, the greater the impact of your investment in renewable energy will be.

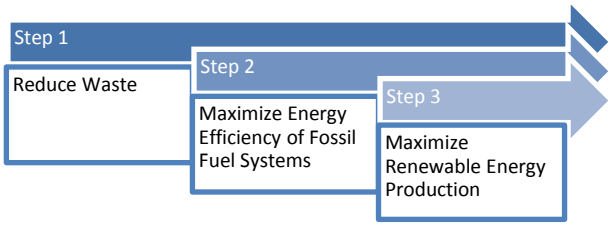

Figure 2—Energy Management.

Gaining Insight

As previously mentioned, EM means making informed decisions. And in order to be informed, one needs insight. Unfortunately, for many companies, energy consumption is a blind spot. While management often knows exactly how much raw material and how many man-minutes go into each specific product, energy somehow seems to be the odd one out. In many cases, the cost of energy consumption is considered a general overhead cost or, at best, is a linearly assigned cost per volume produced, without taking differences in processes into account.

A first step in gaining insight is to perform an energy audit. This will usually help in identifying energy waste as well as the main energy consumers. Such an energy audit will most likely generate some quick wins, and will help assign priorities for energy efficiency improvements. However, an energy audit has its limitations: it is a time-specific snapshot of the situation, which may not be representative of year-round operations. Energy consumption may be heavily impacted by weather conditions, rendering an energy-audit in winter more or less useless for analyzing summer conditions. Production volumes may likewise vary with seasons and consumption may be dependent on raw material quality, et cetera. Therefore, an energy audit does not constitute energy management; it is merely appropriate preparation for energy management.

Once a company has gone through an energy audit and the main consumers have been identified, it becomes possible to specify appropriate KPIs and to start monitoring energy consumption for frequent follow-up. While this can be done manually, by jotting down meter data in an excel file on a regular basis, companies will benefit from installing an automated energy management system (EnMS). Such a system will reduce the time spent in gathering data, will avoid mistakes and will allow context-specific analysis in relation to production data. An EnMS can provide automated reporting as well as alarms when abnormal consumption occurs. Nevertheless, energy monitoring still does not constitute EM: a report or an alarm has no value if no one has been assigned the responsibility to act upon it.

Energy management entails the adoption of a structural approach to gain insight—through audits and monitoring—and to use these insights to assign responsibilities and to take actions that are in line with the corporate strategy. The most commonly used standard for energy management today is ISO50001.

Standards: ISO50001 (Energy Management) versus ISO55001 (Asset Management)

Throughout the world, companies apply international standards, such as ISO9001, 14001, et cetera to structurally organize the management of complex operational challenges. The recently (2014) released ISO55000, 55001 and 55002 standards deal with asset management by specifying how organizations should manage their assets to achieve their strategic goals and balance the associated performance, risks and costs. As mentioned in the GPG Application Note *Asset and Energy Management*[3], energy consumption is one of many parameters (similar to reliability, environmental safety, et cetera) for which demands are defined in asset management. The ISO55001 standard does not go into specifics of how to execute energy management. It does however clarify how decisions regarding energy management cannot be taken without impacting other requirements or demands on assets.

CONTEXT: WHY DOES ENERGY MANAGEMENT MATTER?

I. COMPLIANCE WITH LEGISLATION

For many companies, an imperative reason to implement a form of energy management is because they are obliged to do so, due to local, national or international regulation.

EU ENERGY EFFICIENCY DIRECTIVE[4]

On 25 October 2012, the European Commission adopted the Energy Efficiency Directive, which established a set of binding measures to help the EU reach its 20% energy efficiency target by 2020. Under the Directive, all EU countries are required to use energy more efficiently at all stages of the energy chain; from its production to its final consumption. EU countries were required to transpose the Directive's provisions into their national laws by 5 June 2014. This has—once again—led to variations in interpretation and implementation across the different member states: ESOS[5] in the UK, EBO[6] in Flanders, Belgium, et cetera.

The most important issue however remains valid across Europe: all large companies—according to the European definition, every business with at least 250 employees or annual revenues of €50 million or €43 million annual balance sheet—must undergo an energy audit by 5 December 2015 and at least every four years thereafter. Companies that achieve ISO50001 certification will be exempt from the subsequent audits.

EU ETS

The largest energy consuming companies, which participate in the Emissions Trading Scheme (ETS), have been dealing with energy management for a long time. Energy not only represents a significant part of their cost structure, but also requires emission rights, for which they must monitor and report energy consumption.

ENVIRONMENTAL

In many countries, energy assessments are part of environmental legislation. When applying for a building and/or environmental permit for a new installation, companies need to forecast expected energy consumption, and must comply with energy efficiency best practices.

II. STAKEHOLDER PRESSURE

A secondary, semi-voluntary reason for companies to implement energy management is stakeholder pressure.

CLIENTS

As consumers are becoming more conscious of environmental challenges, and more demanding in terms of sustainability, businesses are starting to respond by evaluating both their own environmental impact as well as the impact of their supply chain. Aside from the small, true pioneers in sustainable business, the multinationals—under intense NGO scrutiny—have taken the lead in calculating their environmental footprint and in setting targets for improvement. Next, they have engaged their suppliers, and a trickle-down effect is now engaging businesses large and small across the world. Initiatives such as the Carbon Disclosure Project[7] and the CO2-Prestatieladder[8] (in the Netherlands) are pushing companies to calculate their carbon footprint and to implement emission reduction strategies.

EMPLOYEES

In today's race to attract talent, companies are realizing that potential employees are not just looking for high salaries, but also for meaning and status. Companies that have a green or sustainable image are considered more attractive employers. Businesses that actively engage their employees in sustainability initiatives enjoy higher levels of personal engagement and loyalty from those employees.

SHAREHOLDERS

Shareholders are pushing businesses towards higher levels of Corporate Social Responsibility (CSR) and are requiring more non-financial reporting, as set out by the Global Reporting Initiative (GRI)[9]. An important aspect of such reporting considers energy consumption and related carbon emissions. Businesses report on how they manage and plan to reduce carbon emissions.

SOCIETY

Finally, society in general, and the business' neighborhood in particular, are important stakeholders as well. Businesses wish to be regarded as good neighbors, even if only to avoid complaints. By setting an example for efficient energy management, businesses can engage their neighbors and push other businesses to clean up their act as well.

III. CORPORATE VISION/MISSION

A third, and very effective driver for energy management, is corporate vision. If corporate management believes in the need for sustainability and proper energy management, the results can be fast and significant. By creating a vision which includes sustainability and energy management, and by defining a mission to achieve ambitious, related goals, businesses can truly be transformed.

Management can focus on an overall CSR strategy, install a culture of transparency, initiate true innovation and enable effective risk management.

IV. COST CONTROL/COMPETITIVENESS

Finally, the one driver that tends to convince everyone regarding energy management is money. Energy is an expense for virtually every company. In order to control costs, a business must understand its consumption, and aim to reduce the related costs. This cost of energy is determined by:

$$Invoice = volume \times unit\ price + taxes\ and\ other\ fees$$

The cost can thus be reduced by consuming less, and by paying less per unit consumed, thanks to an optimized consumption profile. Therefore, it is important to understand how energy is consumed, and how the price for energy is determined. Unfortunately, too many companies understand neither parameter.

If companies wish to increase their competitiveness, they will need to regard energy as a raw material, just like any other. Businesses will need to apply operational excellence and LEAN[10] concepts to energy consumption. Through activity-based costing, they will be able to optimize energy consumption and increase competitiveness.

CHALLENGES

LACK OF INSIGHT

Probably the biggest problem regarding energy consumption and its related costs is the so-called invisible nature of energy. Contrary to, for instance, raw materials and personnel, electricity and gas are always available yet usually not physically visible. As a result, people tend not to think about it, and take energy for granted.

In most companies, energy contracts are negotiated by the purchasing department. Most of the time, volumes are estimated based on historical consumption and production forecasts. However, a true understanding of that historical consumption volume and profile is often lacking. The purchasing department may not even be aware that the consumption profile, with a base load consumption and peak demand, is a significant parameter used by the energy supplier in determining the unit price. The more unpredictable the profile, the more expensive the energy.

In the production departments, the focus is on production and quality; all else is secondary. There is often no incentive at all to reduce energy consumption or to lower peak demand, since production has not been informed of the energy contract conditions. In fact, there may even be reluctance to change anything, out of fear of disrupting production or affecting quality. “We’ve always done it this way” and “If it isn’t broken, don’t fix it” are widely accepted concepts.

Finally, the accounting department receives an invoice without really being able to check its accuracy. Unless there is a sudden and significant difference in cost compared to other months, the invoice will be paid without further questions.

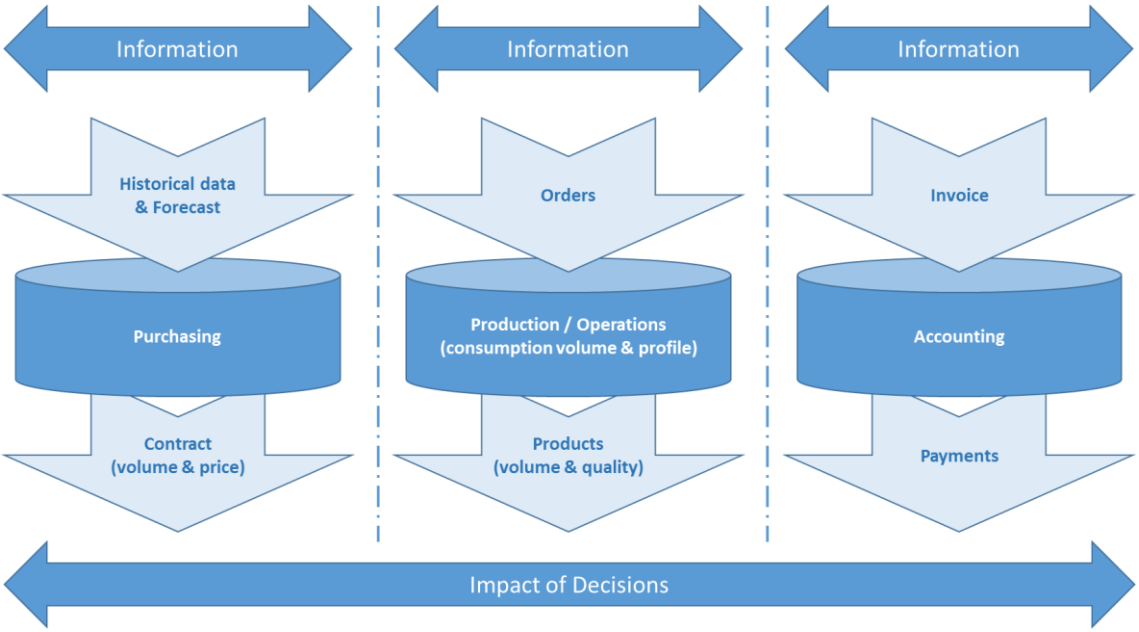

Figure 3—Silo thinking versus company-wide impact.

The disconnect between the different departments in the company—purchasing, production and accounting—is responsible for large amounts of money being wasted through energy costs. This is sometimes called silo thinking (Fig. 3). In many cases, management has even actively contributed to this problem. By splitting CAPEX (Capital Expenditure) and OPEX (Operational Expenditure) budget responsibilities, they have forced people into silo-thinking, whereby increasing OPEX costs were disregarded in favor of lower CAPEX costs.

Unfortunately, the recurring OPEX costs often represent a much larger share of the Life Cycle Cost (LCC) of an investment. For electric motors for instance, the CAPEX is usually only about 2~3% of the LCC, whereas energy consumption amounts to 95%! Clearly, investment decisions should be made based on a proper LCC, which includes OPEX costs such as energy and maintenance. More information on LCC can be found in the GPG Application Note *Life Cycle Costing—The basics*.[11]

LACK OF PRIORITY/COMMITMENT

Another reason why companies may not be paying much attention to energy consumption, is its share in the overall cost structure. While there are industries where energy represents 30% or even more than 50% of the total production cost, for many others energy is just one of many costs, representing perhaps no more than 5% or 10%. As a result, management may not consider it a very important KPI. If no one is given specific responsibilities regarding energy management, and without clear management commitment, it is very unlikely that anyone in the organization will voluntarily take on this task. In fact, many will actively avoid the issue because of conflicting interests, such as the CAPEX/OPEX split budgets trap, as mentioned above.

LACK OF RESOURCES

An automatic result of the lack of management commitment is a lack of resources. Too often, energy management is a task that is handed to the head of maintenance, or to the Energy, Health and Safety (EHS) manager, in an addition to their regular responsibilities. Unfortunately, these people often lack the specialized energy expertise and usually they already have too much work with their primary responsibilities. The expectations for energy management may even be in conflict with those of their primary tasks. Add in the lack of empowerment by management, and it becomes unlikely that these energy managers by accident will be able to achieve significant energy savings.

ISO50001

International standards offer a well-structured way for businesses large and small, in a wide variety of industries, to cut through day-to-day complexity and to work towards a common goal. One of the best known standards is the ISO9001 quality standard. While it is entirely possible to include energy management in an existing ISO9001 quality system, more and more companies are opting to implement a dedicated energy management standard. The ISO50001 standard for Energy Management Systems (EnMS), released in June 2011, seems to have gained the most momentum so far. This is due in part to Energiewende-related incentives in Germany[12] and the inclusion of energy management demands in the Energy Efficiency Directive of the European Commission mentioned earlier.

Requirements

General requirements

Given the challenges mentioned earlier, it seems logical that the main requirement of an EnMS is making energy management and energy efficiency part of the organization's culture by structurally embedding it into daily operations. The goal should be to continuously improve; in this case both energy performance as well as the EnMS itself. While there is no obligation to do this in accordance with any quality standard, the ISO50001 standard—probably the best known example of an energy management standard—offers clear guidance in defining and documenting the scope and establishing, documenting, implementing, maintaining and improving the EnMS. The following describes the main elements and requirements of an EnMS in accordance with ISO50001.

Management responsibility

As mentioned earlier, management commitment—or the lack thereof—is often what makes or breaks energy management initiatives. The ISO standard therefore clearly describes management's responsibilities and deliverables, including:

- Defining, establishing, implementing, maintaining, reviewing and improving an energy policy, including its scope, its objectives and targets and its KPIs (EnPIs)
- Forming an Energy Management Team which must include a management representative
- Providing the necessary resources to implement an EnMS and to continuously improve both energy performance and the EnMS itself
- Communicating about the importance of the EnMS to the organization
- Conducting regular Energy Management reviews

Energy policy

The energy policy, as defined by management, must define the organization's commitment to energy performance improvement, and how these will be achieved through actions of continuous improvement. It must ensure that:

- Information and resources are available to achieve objectives and targets
- A framework is available for setting and reviewing energy objectives and targets
- Energy efficiency and design for energy performance improvement are taken into account for investment decisions
- The energy policy is documented, regularly reviewed, updated and communicated throughout the organization

Energy Planning

Once the energy policy has been defined, it must be translated into actions for continuous improvement of energy performance, based on internal and external information and requirements. This includes:

- Reviewing **the organizations activities that can affect energy performance**
- Identifying and implementing appropriate **legal and other requirements** relating to energy use
- Performing regular **energy reviews**:
    - Analyzing past and current energy consumption and estimating future consumption
    - Energy mapping of major energy consuming activities and installations and determining their energy performance
    - Identifying and prioritizing opportunities for improving energy efficiency
- Setting and maintaining an **energy baseline**, against which future energy performance will be measured.
- Identifying, implementing, recording and reviewing appropriate **Energy Performance Indicators** (EnPIs)
- Identifying, implementing and maintaining documented energy **objectives, targets and timeframes**, at relevant functions, levels, processes or facilities throughout the organization. This will include:
    - Assigning responsibilities, time frames and methods of verification

Implementation and Operation

The organization will use the energy plan and its outcomes for implementation and operations. More specifically, it will:

- **Train people**. The organization should provide appropriate training to ensure company-wide awareness of:
    - The importance of conformity with the energy policy and the EnMS
    - Individual roles and responsibilities regarding the EnMS
    - The benefits of improved energy performance
    - Individual impact on energy consumption
- **Communicate**. It should communicate internally (and optionally externally) with regards to energy performance and the EnMS and provide ways for stakeholders to participate in improving the EnMS
- **Document.** The organization should establish, implement and maintain information, documenting the core elements of the EnMS (as described above) and their interaction. It will implement proper document control procedures, including approval, review and update, identification of changes and revisions, et cetera
- **Set operational criteria**. The company will identify and plan operations and maintenance activities which significantly affect energy use. It will set, follow and communicate about operational criteria to ensure best practices related to energy use.
- **Consider improvement opportunities**. The organization will consider energy performance improvement when designing new, modified or renovated facilities, systems and processes. Suppliers will be informed that energy performance will be a criteria in evaluating services, products and equipment.

Checking

The ISO standard follows the typical Plan—Do—Check—Act cycle. Monitoring and verification of progress is therefore an intrinsic part of the quality process. In the EnMS, the organization will need to ensure that the key operational characteristics, which determine its energy performance, are properly and regularly monitored, measured and analyzed. An energy measurement plan must be defined and implemented to include at least these characteristics:

- Significant energy uses, their relevant variables and appropriate EnPIs
- The effectiveness of the action plans in achieving objectives and targets
- Evaluation of actual versus expected consumption

The organization shall monitor progress, evaluate compliance with legal and other requirements, audit the implementation of the EnMS, and take corrective/preventive action to address non-compliance.

MANAGEMENT REVIEW

At planned intervals, management will review the EnMS and its progress, and will provide feedback to the organization on its performance and the required actions.

CERTIFICATION

Companies that choose to implement a standardized quality system, such as the ISO50001 for energy management, usually have this system certified, in order to prove that their management system actually meets the requirements of the chosen standard. The certification of the energy management system ensures that a process of continuous improvement is in place. In the case of ISO50001 this translates into continuous efforts towards energy savings.

Organizations may also need the certification for legal or financial reasons or because of the marketing value of such a certificate. The EU Energy Efficiency Directive is pushing large companies towards implementing an Energy Management System, such as ISO50001 or similar, by turning it into an alternative for a mandatory energy-audit every four years. In Germany, such a system is a prerequisite to receive tax/EEG[13] surcharge reductions on the energy invoice.

For certification according to ISO50001, companies can turn to the traditional ISO certifying companies.

Some companies however believe in the concepts of ISO50001, but see no value in an additional certification. If these organizations employ other quality systems, such as ISO9001, ISO14001, HACCP[14] for food-related activities, et cetera, they may choose to implement the main elements of ISO50001 into their existing systems.[15]

Even if a company does not have a formalized or certified quality system, the concepts of a proper energy management system can still be implemented, as long as there is true management commitment and ownership. If management communicates clearly regarding goals and processes; if it actively monitors progress and reviews results; and if feedback and guidance is regularly provided, then energy management can be turned into a success story.

ENERGY MANAGEMENT IN PRACTICE

PRAGMATIC APPROACH

While the ISO50001 standard represents a solid, well-structured approach towards energy management, it is not necessarily the best solution for every single organization. Some businesses already have other quality systems, such as ISO9001, ISO14001, HACCP, et cetera. Without additional advantages (for instance marketing value) some of these companies may baulk at implementing yet another certified quality system. These companies can still benefit from energy management by incorporating all of the concepts of ISO50001 into their existing system.

Even those companies that do not have an existing quality system, and that consider most quality standards too much of an administrative burden, can implement energy management in their own, simplified and pragmatic way.

By identifying the impact of energy on the organization, especially in terms of costs and risks, essential management attention is guaranteed. Whatever opportunities have surfaced, they are likely to require resources for which management approval is needed. Aside from possible waste-eliminating quick wins, most energy management measures require not only investments, but some change management in the organization as well. Change, in turn, is usually met with resistance and is doomed to failure without management commitment. Again, management commitment is an essential requirement for energy management!

Based on the acquired insights, the stakeholders, both internally and externally, can be identified and an Energy Team can be formed. This team should ideally consist of internal staff, supported by external expertise where needed. Together with management, this energy team must ensure that the entire energy management concept is in line with the overall corporate strategy.

GAINING INSIGHT

The number one priority in getting started with energy management is to gain insight into the impact of energy on the organization. After all, without insight, it is impossible to implement effective optimization. Proper insight means being able to determine:

- Where energy is being consumed: locations, installations, components, et cetera
- When energy is being consumed: permanent base load, production time, peak demand, day vs. night, et cetera
- How much energy is being consumed: per location, per shift, per product, per item of volume, et cetera
- Why energy is being consumed: identify waste, analyze settings, et cetera
- How much does this energy cost: contracts, invoices, calculations and forecasts, et cetera
- What technical or operational options are available to reduce consumption

For many companies, these questions are (very) hard to answer. In some cases, they will need to enlist the help of a specialist, such as an energy consultant. In other cases, businesses just need some help in getting started with some guidelines and check lists. The GPG Application Note Energy Efficiency Self-Assessment in Industry[16] offers a good overview of how to get an internal team get started on this.

ANALYZE CURRENT LEVEL OF INSIGHT

A good starting point is those types of information that are readily available within the company, or which can easily be requested from the energy supplier:

- Energy invoices:
    - Total energy cost/year and energy's proportional share in the OPEX structure of the company
    - Variations in monthly consumption and link with weather, seasonality in production, et cetera
    - Penalties for excessive peak demand and unfavorable power factor (cos ϕ)
- Energy contract:
    - Energy commodity price: compare to current market prices
    - Contractual volumes and peak load: compare to actual of past years
- Quarter hour consumption data (can be requested from the electricity supplier):
    - Permanent and/or variations in base load outside of working hours: where is energy consumed, and is this consumption necessary or is it waste?
    - Peak load: how high is peak load, why does it occur and can it be reduced?
    - Why are there significant differences in energy consumption across different shifts or products?
- Lists of energy consuming systems
    - Machine lists
    - Lighting layout: Number of light fixtures x power x operating hours/year = consumption
    - Et cetera

By using the available information, a company should be able to draw up an energy map (Fig. 4), identifying its biggest energy consumers, and the most obvious forms of waste. Based on this, priorities—for both energy efficiency measures and for further, more detailed investigation—should be determined.

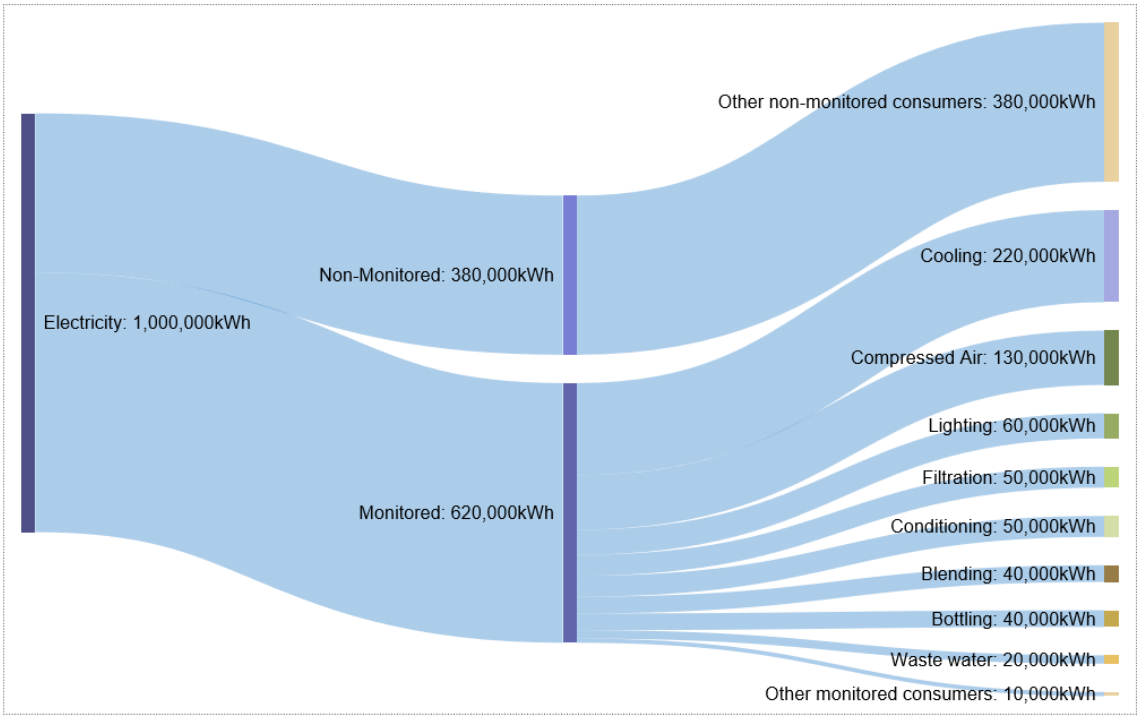

Figure 4 – Sankey diagram showing distribution of energy consumption.

The energy team should start to identify appropriate EnPIs already at this point, and to analyze them within the proper context. After all, if EnPIs are not well thought out, they will lead to inaccurate cost structure analyses and, at times, bad decisions. A food company, for instance, might produce just one type of product, but in various different forms and packaging. An EnPI of energy per unit or volume produced seems logical, but

if there are significant differences in the way the various end products are produced, a single EnPI may not be accurate. Clearly, frozen vegetables will have a different energy need than canned vegetables stored at ambient temperature.

On the other hand, accurate, effective EnPIs can help identify quick wins, which are crucial for energy management to gain momentum within the organization. An EnPI for steam or compressed air consumption can quickly help identify abnormal consumption due to leaks. At the same time, focusing solely on quick wins runs counter to permanent optimization. Proper insight must give an overview of various improvement measures and must allow for developing a plan whereby opportunities with both short and longer pay back times can be included.

Define bottlenecks and blind spots

Despite all good intentions, the process described above often fails to uncover sufficient detail and information to enable proper energy management. An energy map with 40% other (i.e. unidentified) consumers obviously still needs a lot of work. This in itself is not a problem. Energy management is a process of continuous improvement, not just of the energy performance, but of the EnMS itself as well. The most important is to identify bottlenecks and blind spots that need to be investigated further.

In order to gain the required additional insight, companies can implement a temporary measurement campaign or they can choose to invest in additional, permanent monitoring. In the case of temporary measurements, it is of course crucial that these are representative of a normal operating situation.

Set up of structural energy monitoring and reporting

If energy management is to succeed within the organization, it must be structurally organized. This means setting up procedures and assigning responsibilities. It must be clear who has to do what and when or how often.

Purpose and goal

Depending on the purpose of energy management, or the goals to be achieved, different people will need to be involved. If the #1 goal is to reduce energy-related costs, obviously the purchasing department must be involved to ensure optimization of the energy contract. If the purpose is to reduce energy consumption (regardless of cost) the input of the purchasing department may not be necessary. Yet if the purpose is reduction of energy-related CO2 emissions, the purchasing department must again be involved to ensure the purchase of renewable energy. Start by defining the goals, together with management.

Assign responsibilities

As a function of the goals, identify which departments or functions can have an impact on the targets, and assign the appropriate person to the energy team. Next, determine how interaction between these different departments can affect the targets. For instance, if the production department manages to reduce peak demand, the purchasing department may be able to negotiate a better energy tariff.

Next, have the energy team determine appropriate KPIs for the organization. These can include kWh/volume or weight produced, kWh/shift, volume of steam or compressed air/1000 units produced, et cetera. Once the KPIs have been identified, it is important to determine how the data will be gathered (automated, or manually), how often, and how it will be reported and to whom.

Selecting an Energy Management System

Once there is consensus regarding the KPIs and responsibilities, it is necessary to decide how to organize all of the various facets. In some organizations, it may suffice to have somebody manually jot down meter readings once a month, while other organizations may need to automate peak shaving. For some companies, a monthly

excel dashboard may offer a good starting point, while other organizations may need to integrate energy management into an existing SCADA-system. Once again, the choice should be made, based on the goals for energy management.

Implement continuous energy management improvement/PDCA-cycle

With the overall structure in place, it is time to start the process of continuous improvement, a.k.a. the Deming Circle or the PDCA (Plan—Do—Check—Act) cycle (Fig.5).

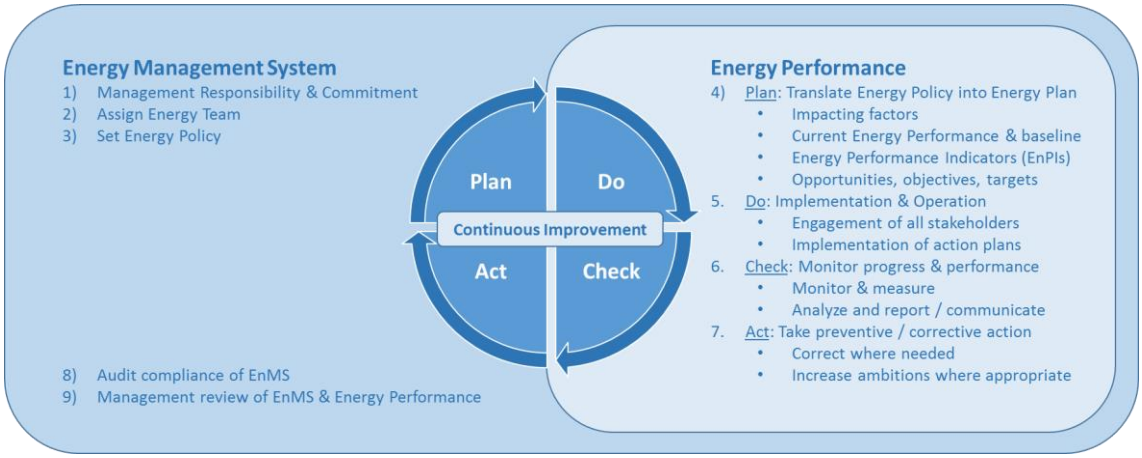

Figure 5—Continuous improvement of Energy Performance and Energy Management System.

Plan

The first part of the Deming cycle deals with establishing a baseline from which to start, and defining objectives or targets. The objectives can be related to energy performance or to the performance of the energy management system itself. In other words, the objective may be to reduce specific energy consumption by a certain percentage, but it could also be an objective to gain additional insight and to reduce the proportion of other (i.e. unidentified) consumers from 40 to 10%, over a certain time period. With the objectives in place, action plans can be established.

Do

The logical next step is to get everybody involved in implementing the action plans. Once again, management commitment is crucial in getting the necessary involvement of all stakeholders.

Check

Throughout the process, it is important to check the progress in a consistent and structured way, and to report on it in compliance with the procedures of the EnMs.

Act

The 4th step in the Deming circle is to take action based on the analysis of the progress so far. If procedures are not followed, or if stakeholders are not fulfilling their roles, corrective action is needed. If targets are not being achieved, the reasons must be identified and acted upon. And finally, if targets are easily achieved, more ambitious target should be defined. By doing this, a new plan is defined, and the Deming circle has started its continuous improvement process all over again.

FOCUS ON RESULTS, NOT PAPERWORK

Unlike a certified quality system, such as ISO50001, the pragmatic approach described above doesn't require a great deal of paperwork. The main point is to make clear what is expected and to assign appropriate responsibilities to get results. With the right expertise and some common sense, big results can be achieved.

REDUCE WASTE

If you know that 1kW of consumption for an entire year (i.e. 8,760 hours) can cost a company around 800~1000 euro (on average), it becomes clear that eliminating energy waste can generate huge savings. Just by looking around the facilities, most people—even those without specific energy-related expertise—can identify forms of waste. These can include lights which unnecessarily stay on 24/7, steam or compressed air leaks that are clearly visible or audible, temperature or pressure settings that are way beyond the actual system requirements, flow rates that are controlled by throttling valves rather than using a frequency drive on a pump, et cetera. Many of these vampire consumers will be responsible for an important part of a company's base load consumption (Fig.6), i.e. energy that is constantly being consumed, independently of production or other activities.

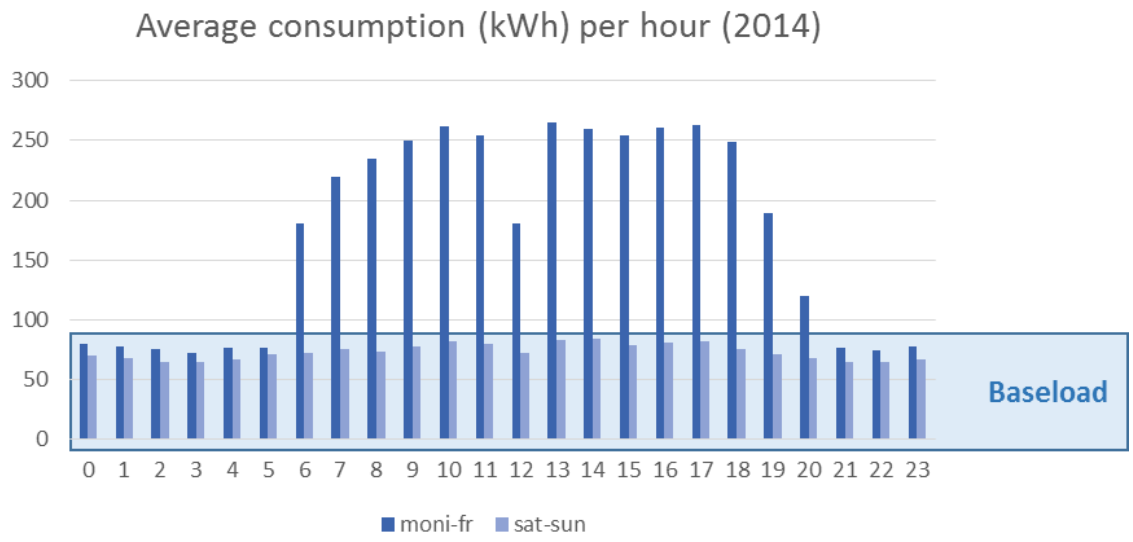

Figure 6—Permanent Base Load during evenings and weekends.

EXAMPLE: COMPRESSED AIR

Compressed air systems are notoriously energy-inefficient, yet are found at most industrial sites. Compressors and networks that are not properly maintained, tend to waste on average 20~30% of their compressed air production. Given that on average just 4~5% of the energy consumed by the compressor is turned into useful compressed air, proper maintenance of these air systems represent huge financial savings. Regular leak detection and repair campaigns usually pay for themselves in a very short time. Other opportunities can often be found in the settings: a reduction of air pressure by 1 bar represents on average a saving of around 7% of energy consumption. Finally, recovering the heat produced by the compressors (and representing around 95% of the energy consumed) can also offer significant savings on other thermal processes. (See also the GPG *Application Note on Compressed Air*[17].)

OPTIMIZE ENERGY CONTRACT

As mentioned earlier, to save money on energy, you can reduce your consumption, and you can reduce the amount paid per unit of energy. In order to do so, you need to understand how your invoice is structured, and which parameters are impacted by your specific profile. In most countries, the total cost of energy is

composed of the actual cost of energy, costs for the use of the distribution grid, and various forms of taxes and charges.

When an energy supplier takes on a customer, it also takes on the risk related to that customer's consumption profile. After all, a supplier must balance the energy demand of its entire customer portfolio with its own energy production and energy purchasing. In case of imbalance, the supplier will face expensive fines. A customer with a very unpredictable and strongly varying consumption profile will therefore represent a much higher risk to the supplier, and as a result, will pay a higher tariff than a customer with a very predictable, stable consumption profile. Contracts often also stipulate contractual peak load limits and penalties for exceeding those limits. In the worst case, an additional tariff increase for a period of twelve months may be charged each time the contractual limit is exceeded! Unfortunately, in many companies, such situations pass unnoticed because of the disconnection between purchasing, operations and accounting.

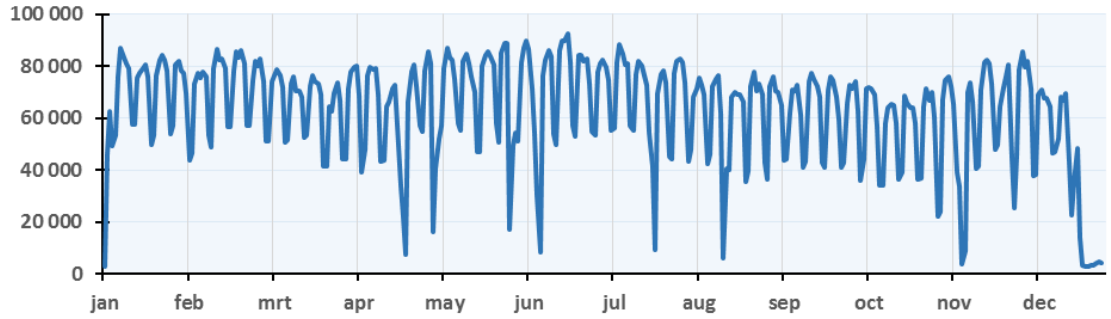

Figure 7—Annual consumption profile.

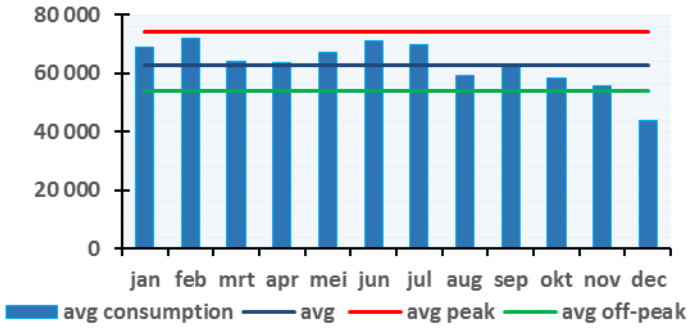

Figure 8—Average monthly consumption and peak load distribution.

Another component of the invoice is the various transmission and distribution costs. In some countries these costs are invoiced separately by the grid operators, while in other countries they are included in the invoice from the energy supplier. Often, these costs are based both on the amount of energy consumed as well as on the capacity of the connection to the grid. While the energy contract (from the energy supplier) may stipulate a certain peak load per quarter hour, the actual capacity of the connection to the grid may be much larger. Since that connection represents a type of reserved capacity, which could be consumed from a technical perspective, the grid operators will most likely charge for the available capacity, regardless of the contractual volume stipulated in the energy contract. If the connection is significantly over dimensioned, most likely the transformers are also over dimensioned, and not running at optimal efficiency. This represents additional energy losses.

Finally, it is important to review the way energy is being purchased. Many companies have long-term contracts, based on annual volumes, for which the tariffs are locked in through several clicks. These clicks

represent parts of the total annual volume and are reserved at the forward price valid at the moment of clicking. They offer the company more flexibility in its purchasing strategy, as well as the ability to monitor the energy market on the long-term and to spread the risks. For budget-oriented companies, it may be important not to have sudden shifts in energy costs over a fairly long period of time. Longer-term contracts may be a good choice, but these only cover the energy component and do not protect the company from sudden changes in regulation, which may lead to increases in taxes, charges and even distribution costs.

Other companies, which produce energy-intensive commodities for which changes in energy costs are quickly reflected in the sales price, will tend to prefer much more short-term contracts, in order to closely follow market prices.

In some cases, companies can benefit from a combination of both strategies. Stable, year-round base load profiles can be purchased long-term, while more dynamic, and for instance seasonal demand, can be purchased for the short-term requirements. In some cases, a company's own energy production, or flexibility in consumption can even be sold on the energy market at times of peak demand and high prices.

Energy contracts can have a huge impact on a company's cost structure. Understanding the consumption profile can help identify ways to reduce the tariffs, avoid over dimensioning, avoid peak load penalties, optimize purchasing strategies and even valorize a company's own (renewable) energy production and flexibility through demand response or demand side management (see also the GPG Application Notes *Wind Powered Industrial Processes*[18] and *Solar Powered Building Applications*[19]).

Optimize remaining consumption

Once energy waste has been eliminated, an organization needs to look at further optimizing its remaining energy consumption. The distinction is not always clear, but can be simplified by considering the example of a steam network. Eliminating waste means repairing steam leaks and reducing pressure where possible. Optimizing the remaining energy consumption means for instance installing a new, more energy-efficient boiler to produce that steam or even questioning the entire steam system altogether. Is steam needed, or could hot water be used, and if so, how much would be saved and how much would need to be invested to make the required changes?

Optimization projects can vary greatly, ranging from installing frequency drives on compressors and pumps to replacing a steam network with a hot water network. It can also include implementing energy recovery, such as heat recovery on air compressors or kinetic energy recovery on stacker cranes, and replacing 24/7 HID lighting with motion controlled LED-lighting, among many other possibilities.

Usually, these are not quick wins, and often require significant investments. And while a proper Life Cycle Cost (LCC) analysis may identify a project as being cost-effective, and as having a positive Net Present Value (NPV), companies often expect very short (and at times unrealistic) pay back requirements.

Nevertheless, an LCC-analysis remains a very valuable methodology in energy management, because it considers not only investment costs (CAPEX) but also operational costs (OPEX) such as energy consumption and maintenance costs. By performing LCC, it is possible to distinguish between projects that are instantly cost-effective and those that are potentially cost-effective at the end of their life time. In some cases, the potential savings may warrant the immediate and outright replacement of an old, inefficient component. In such a situation, labor costs for installation above and beyond the choice of hardware have to be taken into account. In other cases, the savings only justify the cost for the more efficient (and usually more expensive) replacement option in the case of failure of the original component.

Energy Management is a process of continuous optimization, and by identifying and prioritizing the various opportunities (based on such LCC-analyses), we can integrate the energy management objectives into other fields of operations, such as maintenance and spare parts management.

INTEGRATE ENERGY MANAGEMENT IN OVERALL ORGANIZATIONAL CULTURE

Quality systems such as ISO9001, ISO14001, HACCP, et cetera are based on the premise that everybody in the organization must understand its importance and must participate in implementing the system.

The same goes for energy management, whether it is a certified system or not. And as mentioned many times above, management commitment is essential in order to succeed.

It is therefore highly recommended that a company-wide energy policy is implemented by the management. This policy must:

- Clarify the impact of energy throughout the company
- Assign responsibilities
- Answer questions such as What is my role and What's in it for me
- Encourage cross-functional thinking (as opposed to silo-thinking)
- Set minimum energy-efficiency requirements for new and spare parts
- Require training of appropriate competences and development of awareness
- Communicate progress, results and challenges
- Never stop improving

With proper insight into energy consumption, its impact on the company and the active involvement of all employees, companies will be able to reduce expenses and emissions related to energy consumption. Through energy management, companies will have a positive and sustainable impact on People, Planet and Profit.

CONCLUSION

Energy management matters. For every company, energy represents a cost and a risk. There are various drivers for energy management, both internally (corporate vision, cost control, et cetera) and externally (legislation, stakeholder pressure, competition, et cetera). Most companies cannot imagine running daily operations without proper control over personnel, raw materials, stock management, bookkeeping, business intelligence and marketing. Yet when it comes to energy consumption, there seems to be a black hole which consumes energy and money, without anyone questioning it. Energy, in all its forms (WAGES), should be regarded as a resource, not unlike any other resource used by the organization, and management should strive to achieve at least similar levels of insight and efficiency as it does for those other resources.

Management commitment is essential to successful energy management. Management must believe in the need for, and the opportunities in energy management. Only then will management be willing to make the necessary resources available. In order to structurally embed energy management practices in the organization, and to engage the entire workforce, management must lead by example. It must communicate its commitment, set the policy, implement the plan, review the results and adjust the course where needed.

Whether a company chooses to follow an international standard, such as the ISO50001, or whether it prefers to follow a simplified and more pragmatic approach, does not really matter. There is a great deal of energy-related information available within and throughout each company. The challenge is to get the right people together and to start questioning the status quo.

With the proper insight, companies can lower their consumption and optimize their energy contracts, thus optimizing both parameters of the energy invoice: volume and unit price. The insight gained may even lead to new innovations and can help improve the sustainable image of the company. As a result, energy management may not just lower costs; it may also increase revenue and net gain.

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