APPLICATION NOTE

# Energy Management in SMEs

European Copper Institute
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# Summary

**SMEs can benefit greatly from energy management.** Even for non-energy intensive SMEs, the savings potential compared to business-as-usual can be substantial. Energy management does not always need to lead to ISO certification, since this can be a high bar for a small organisation. SMEs could choose to follow the main principles of energy management systems, but **implement them more pragmatically**, without actually going for accreditation. Sadly, there is no standard for "energy management light", tailored to SMEs, but there is a wide selection of literature on the subject.

A major evolution in **energy monitoring technology** has brought energy management within the reach of SMEs. In the past, installing metering systems was often complex, and processing the resulting data was time consuming. More recently, markets have welcomed easy-to-install, plug-and-play energy monitoring systems that provide data in an aggregated format, such as energy performance indicators.

Assistance does not come from technology alone. **External consultants** can be called in at various stages of the energy management process or during implementation of energy efficiency measures to complement the SME's own workforce.

Compared to energy audits, **energy management penetrates deeper** into the tissue of an organisation, leading to long-lasting results. Not only can it bring changes in workforce behaviour and install a culture of continuous improvement, it can also establish energy efficiency as a major criterion informing future equipment replacement and facility investment decisions.

Perhaps the most essential condition to be met before any kind of energy efficiency oriented system can be elevated to being called *energy management*, is the **involvement of the company's higher management**. This is necessary for the energy impact on the organisation to be assessed in terms of costs and risks, to make investment decisions, and to steer measures designed to create a behavioural shift. Equally important is assembling **a carefully constituted Energy Team**. A major task of this team is to ensure that energy management will become – and remain – integral to the overall corporate strategy. Even in small companies it is important to compose a team of people to ensure that the energy management culture penetrates every functional division of the organisation. It can sometimes be a good idea to also include external consultants in the team.

Continuous improvement is a key concept in energy management. It is sometimes formalised into the Plan – Do – Check – Act (PDCA) cycle but does not always need to be formalised. Once it becomes part of a company mindset, these cycles will take place spontaneously way for many tasks. The advantage for an SME of applying the continuous improvement principle is that you can start small and humble, reflecting the size of the organisation, and develop energy management step-by-step. The continuous improvement principle also ensures that you are never "ready". The principle, however, can also have a downside. If energy management remains limited to those changes that can be achieved one small step at a time, the organisation risks missing out on important savings opportunities that could make the difference. Some opportunities require just a substantial one-off investment to result in a constant harvest of benefits for years to come. These opportunities risk being neglected because of rigid interpretation of the continuous improvement principle.

Continuous improvement is a key concept in energy management.

An important aspect of pragmatic energy management is **finding the right balance between result management and method management**. Result management aims for direct, rapid achievements, bypassing unessential formalities and paperwork. Method management wants to ensure enduring change, and requires a more formal approach by creating methods designed to bring results regardless of the people using them. Without method management, you will not range much further than a one-shot energy audit, returning to business-as-usual all too quickly. Without result management, the whole undertaking risks being abandoned for lack of motivation before any results are harvested.

In the spirit of result management, it is crucial to see the first outcomes early in the process. This can be achieved by conducting a series of **walk-around energy surveys** and by implementing the resulting quick-win solutions.

Taking the walk-around surveys as a starting point, actions to **achieve deeper insight** into the organisation's energy use should be pursued, without which the optimisation process is impossible. For many SMEs, this can be a difficult exercise, but external help can come from monitoring systems, energy audit consultants or energy service companies. At this point, the energy team should identify key performance indicators (KPIs).

The **in-depth energy audit** is at the core of any energy management. It should be repeated at regular intervals, but the first audit will be the most difficult and time consuming. Follow-up audits can profit from the structure and results of former audits and can mainly focus on what has changed in the intervening period. The in-depth audit thoroughly assesses every area of significant energy use (SEU) to look for potential energy efficiency measures that go beyond the obvious. It is exactly these kinds of measure that could make a difference to a company's competitive and environmental position. All kinds of action are possible, leading to changes in infrastructure, equipment, energy carriers, control systems and their settings, operational procedures or staff behaviour. They will range from minor changes requiring only limited resources, to large scale projects demanding substantial investment and which need to be planned years in advance. The following are a few major categories of measures that can make a substantial difference:

The in-depth audit looks for potential energy efficiency measures that go beyond the obvious.

- **Reducing waste**, including re-evaluating heating and cooling settings, insulating pipework, improving compressed air system efficiency, installing variable speed drives (VSDs) on motorized systems, recuperating waste heat, and optimizing equipment control systems and lighting controls
- Making or adapting **equipment replacement plans** to take energy efficiency into consideration
- Including energy efficiency as a criterion in **facility investment plans**
- **Choosing the right energy carrier**: setting time aside to scrutinize the choice of energy carrier in every project involving investment in energy-using equipment. With technology evolving, increasing decarbonisation of grid electricity and government incentives for decarbonisation, electricity has often become the most advantageous energy carrier in cases once dominated by fossil fuels
- Investigating options for **on-site renewable energy generation**

For every potential energy efficiency measure, an estimation is made of the **technical and financial feasibility** and of the potential energy and cost savings. For substantial investment projects, a more detailed analysis covering energy savings, financial implications and risk factors should be undertaken.

**To assess the profitability** of energy efficiency measures, a payback time is often relied upon, despite it being a sub-optimal evaluation criterion. Life cycle costing (LCC), net present value (NPV) and internal rate of return (IRR) are better instruments to assess the profitability of energy efficiency investments.

**Quantifying the anticipated energy savings** is arguably the most complex part of any investment decision involving energy efficiency measures. Energy use is typically the result of many factors, including local conditions, the quality of implementation and commissioning, and operational and maintenance practices. These factors can vary from year to year, making it difficult to assess any expected savings. Because of this uncertainty and complexity, decisions to implement energy efficiency measures are often either postponed or avoided. Having an energy management system in place has the advantage that the organisation will have already gained some insight into the energy streams in its facility and how they can be measured. However, if the organisation lacks the necessary resources or focus to forecast energy savings, outsourcing this element can be a good solution.

Since the future is never entirely predictable, investment always involves risk. Whether this risk needs to be assessed in a formal manner depends on the size and the time horizon of the investment. For more substantial investments with a longer time horizon, a formal risk assessment is highly recommended and will often be critical to gaining access to external financing. This risk assessment can also be outsourced to external consultants if the organisation lacks resources or the necessary focus.

# Why energy management in SMEs?

## USEFUL FOR SMALLER ORGANISATIONS

Contrary to general perception, energy management can be highly beneficial for most SMEs, even those whose operations are not energy-intensive, for the following reasons:

1. **Potential savings are substantial.**
   a. Even in non-energy-intensive SMEs, energy is a major expense *(Bröckl, 2014 – p.23)*.
   b. In an energy-intensive enterprise, the greatest energy use is in production processes where it easily draws attention. In non-energy-intensive companies, and most SMEs fall into this category, most of the energy is consumed by support processes (for example, ventilation, space heating, and lighting), with the risk of it going unnoticed or being taken for granted *(Thollander, 2020 – chapter 1.4)*.
   c. An increasing number of medium-sized companies operate in the global marketplace. International competitors often benefit from lower energy costs compared to those in the EU, while installations in emerging economies are often newer and therefore highly energy efficient. Sustained energy efficiency improvements through energy management can lead to competitive advantages in such markets.
   d. In the context of the European Green Deal, the EU continues to support energy efficiency, particularly focusing on SMEs. Among national governments, there is a tendency to couple financial incentives with sustained energy management. With energy management in place, SMEs can draw maximum benefit from EU and national policies.

2. **Energy management need not be highly complex.**
   a. New scalable energy monitoring technologies have entered the market in recent years, making it easier to map energy use and keep track of energy performance indicators, even for small organisations.
   b. Energy management does not necessarily mean ISO 50001 compliance. SMEs can follow the standard's main principles but implement them pragmatically, without actually going for accreditation.
   c. Outsourcing can be a good way to counter a lack of time and focus within an organisation. Various types of external consultants can be called in during the different phases of energy management and energy efficiency investment projects. An energy service company (ESCO) can take over the entire process, from the energy audit to the implementation of energy efficiency measures, including financing and risk management. In an energy efficiency network, a group of SMEs rolls out an energy management process together, sharing the cost of a full time 'in-sourced' energy efficiency coordinator.

## FROM ENERGY AUDIT TO ENERGY MANAGEMENT

An energy audit can be a good initial step towards improving energy efficiency at an SME but does not by itself constitute effective energy management. Often, an audit is followed up only with easy-to-implement, low-investment energy efficiency measures. Sometimes the response is even worse and the mandatory energy audit is used for nothing more than verifying compliance with energy efficiency regulations. In both cases, measures that go beyond the quick wins are postponed and disappear from view over the years and, before long, energy use returns to pre-audit levels. Even where energy audits are repeated at regular intervals, some of the economic energy savings potential will remain untapped *(Barckhausen, 2019 – p.13, figure 1.3)*.

Compared to energy efficiency audits alone, implementing some kind of additional energy management practice can bring the following advantages:

- It can generate changes in behaviour and operation necessary to support energy efficiency measures;
- The company will not only witness energy savings in the year immediately following the audit, but will continue to strive for energy excellence in years to come;
- Energy efficiency will automatically become a major criterion in future equipment purchases and investment in facilities;
- Working with a cross-disciplinary energy team stimulates a systems approach towards energy efficiency, leading to additional savings opportunities;
- Energy management instils a culture of continuous improvement in the company, which is likely to have positive effects on productivity and product quality.

An energy audit can be a good initial step towards improving energy efficiency at an SME but does not by itself constitute effective energy management.

# Energy management tailored to SMEs

ISO 50001 provides a solid and structured approach towards energy management *(Figure 1)*, but comes with an administrative burden considered to be too heavy for most SMEs. The exceptions to this observation are highly energy intensive medium-sized companies that could benefit from policy programmes backed up by financial incentives, or operating in sectors where ISO accreditations have a high marketing value. Other SMEs may find that seeking to achieve ISO 50001 accreditation is too ambitious.

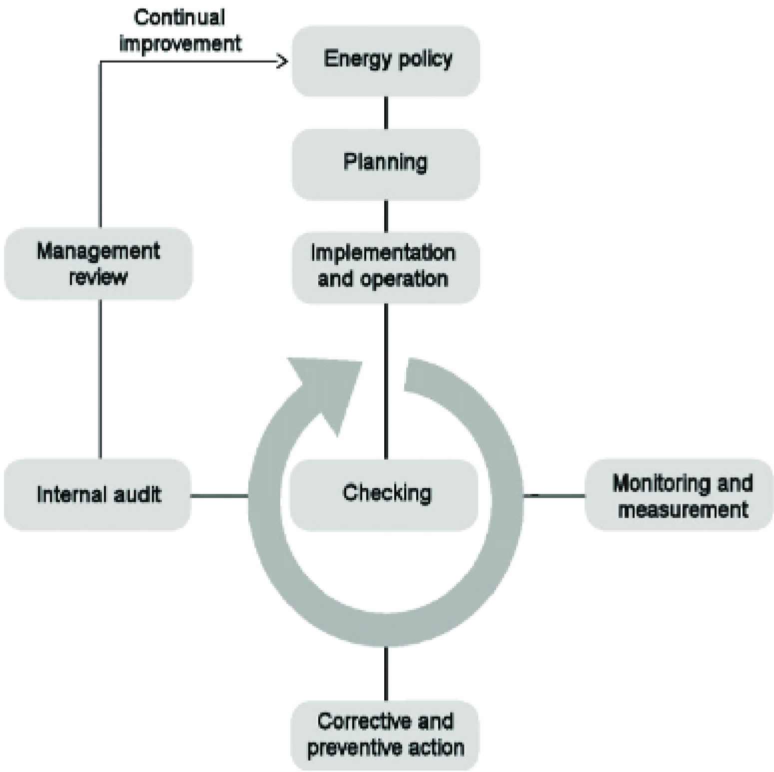



Figure 1 – ISO 50001 Process Overview (Source: Hernandez-Herrera, 2020).

Energy management, however, is not limited to its ISO certified version. It can also be implemented in a simplified and pragmatic way, tailored to the type and size of the SME *(Figure 2)*. Successful energy management at SMEs should find a good balance between *result management* and *method management (Thollander, 2020 – chapter 13.6)*. Result management aims for direct, rapid achievements, bypassing non-essential formalities and paperwork. Method management wants to ensure enduring change and requires a more formal approach by creating methods designed to bring results regardless of the people using them. Without method management, you will not range much further than a one-shot energy audit, returning to business-as-usual all too quickly. Without result management, the whole undertaking risks being abandoned for lack of motivation before any results are harvested.

Energy management is not limited to its ISO certified version. It can be implemented in a simplified and pragmatic way, tailored to the type and size of the SME.

Literature on energy management is abundant, and any SME could assemble its own pragmatic version, tailored to the company's type and size, based on the available information. ISO 50005, first released in 2021, gives guidance for organizations on establishing a phased approach to implement an energy management system. This phased approach is intended to support and simplify the implementation of an energy management system for all types of organizations, in particular for small and medium-sized organizations.

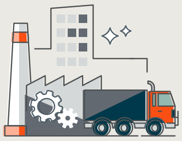
In the following chapters we will explain what a pragmatic approach to energy management could look like.

# Energy management systems for SMEs

## Why Care?

### 1 SUBSTANTIAL SAVINGS

Stop unnoticed energy waste.



### 2 COMPETITIVE ADVANTAGES ACROSS THE GLOBAL MARKET

Energy has become a key factor in gaining a competitive edge.

### 3 MAXIMUM BENEFIT FROM FINANCIAL SUPPORT

Many governments couple financial incentives with sustained energy management.

### 4 IMPROVED PRODUCTIVITY AND PRODUCT QUALITY

Energy management creates a culture of continuous improvement, positively effecting productivity and quality.

## Much More Than Audits

A one-off energy audit is a good start, but **on top of it** energy management assures:

**LARGER SAVINGS**

Adds even more substantial savings.

**LONG LASTING IMPACT**

Promotes structural measures that last.

**CONTINUOUS IMPROVEMENT**

Avoids returning to business-as-usual all too quickly.

## Assemble a Winning Energy Team

**AMBASSADOR: TOP MANAGEMENT**

Involvement of the company's leadership elevates energy efficiency to energy management.

**CHAMPIONS: ALL EMPLOYEES**

Create a behavioral shift.

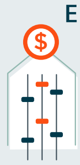
**SUPPORTERS: EXTERNAL CONSULTANTS**

Get help at various stages of the process.

## Measure to Manage

Plug-and-play energy monitoring systems translating metering data right into energy performance indicators have entered the market. They allow SMEs to easily:

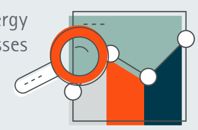
### 1 MAP & TRACK ENERGY USE



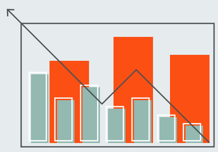
Map all energy using systems and how much they cost.

### 2 REVEAL ANOMALIES

Metering energy use of processes reveals anomalies.



### 3 TRACK ENERGY PERFORMANCE



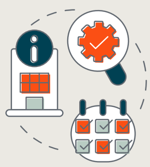
Define KPIs and determine how the data will be gathered and reported.

## Focus on Results, not Paperwork

### 1 START SMALL AND HUMBLE

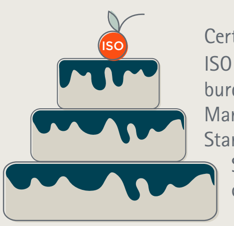
Reflecting the size and resources of your organization.

### 2 DEVELOP STEP BY STEP



Find balance between result management and method management.

### 3 CERTIFICATION NOT ALWAYS NEEDED




Certification, such as ISO 50001, can be a burden. An Energy Management "light" Standard tailored to SMEs should be considered.

## Up Next?

**ENGAGE**

Use #EMS4SME to engage on social media.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# Creating a framework

## MANAGEMENT ENGAGEMENT

Perhaps the most essential condition to be met before any kind of energy-efficiency-oriented system can be elevated to the status of *energy management*, is involving the company's higher management. This is indispensable for many reasons.

As early as the first phase, assessing the current energy use situation, active participation from management is essential. Energy measurement and monitoring actions are best organised from the bottom up, but the results should be translated into a general review of the energy impact on the organisation in terms of costs and risks, and this is typically a management task.

In a later phase, when potential energy efficiency measures have been identified, everything beyond waste-eliminating quick wins will require resources for which management approval is required. In most cases there will be a trade-off between energy efficiency measures and other investment. It is often even the case that energy efficiency measures need to be balanced against investment driven by other environmental concerns. Only an organisation's higher management has the insight, overview and leadership to deal with such trade-offs.

Management's commitment is also important when it comes to measures that seek to create a behavioural shift, aiming to install a culture of energy efficiency among employees. This requires change management, including a strategy to counter resistance, something which is doomed to fail if it does not originate from the top of the organisation.

## ADOPTION INTO THE STRATEGIC PLAN

Management must write the new energy policy into the organisation's strategic plan. In the first phase, the policy can be brief and concise, to be outlined in greater detail in future years.

It must contain the following aims and objectives in some form:

- Committing to continuous energy improvement within the organisation;
- Formulating a regularly updated energy performance action plan, defining KPIs and setting improvement objectives;
- Taking into account energy efficiency and design for energy performance when making investment decisions;
- Allocating resources to create the Energy Team, incorporating external experts as appropriate;
- Communicating the energy policy, to be reviewed regularly.

## SELECTING THE ENERGY TEAM

Energy management should be implemented by a carefully selected Energy Team, presided over by an Energy Manager, for whom this could be a part time or full time task, depending on the size of the organisation. The team should ideally comprise internal staff, including a representative of higher management, supported by external expertise as needed *(Capiau, 2015)*. It is important to ensure that all operational divisions of the company are represented, but motivation of potential participants is an equally important selection criterion.

The energy team must ensure that the energy management concept will be an integral and established part of overall corporate strategy.

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Even in smaller companies it is still important to have several people on the energy team, for two main reasons:

- To share the workload of leading, maintaining and developing energy management practice; and
- To ensure that the energy management culture penetrates every functional divisions of the organisation.

Energy team members should be the point of contact for all matters concerning energy management in their own functional divisions of the organisation. The team should also report back and communicate regularly with their colleagues, and take action to reinforce an energy efficiency culture.

## DEVISING AN ACTION PLAN

The first important task of the energy team is putting together an energy action plan to bring energy policy into practice. It may be useful to split the action plan into a part concentrating on result management and one that covers method management. The action plan can be brief and initially outline only major actions and milestones, becoming more detailed over time and as greater insight is gained. As a well-formulated action plan, it should have a clear timeline, define responsibilities, and be regularly updated.

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**Actions seeking direct and immediate results** include:

- Planning and **conducting a walk-through audit** and the execution of quick-win improvements
  - Initial mapping of the energy streams;
  - Identifying major energy using processes based on already available figures and prelimenary estimation;
  - A walk-through audit of the major energy end-use installations;
  - Executing quick-win energy efficiency measures identified during the audit.
- Planning and carrying out **an in depth energy audit**
  - Reviewing all the organisation's activities that çould affect energy performance;
  - Setting Key Performance Indicators (KPIs) for energy use;
  - Defining and carrying out energy monitoring actions to gather additional knowledge about the energy streams;
  - Setting baseline values for the KPIs;
  - Execute an in depth audit to identify potential energy efficiency measures.
- Setting energy **targets (KPIs target values)** and assigning responsibility and ownership to achieve them;
- Developing a plan and timeframe for **carrying out the identified energy efficiency measures** and the achievement of the targets.

**Actions categorized as method management** include:

- **Staff training**. The organisation should provide appropriate training to ensure company-wide awareness of:
  - The importance of the energy policy;
  - Individual roles and responsibilities;
  - The benefits of improved energy performance;
  - Individual impact on energy use.
- **Documentation.** The idea of pragmatic energy management is to focus on results, not paperwork. That said, the core elements should be documented in a concise and structured way for later consultation. This includes energy end-use data, measurement and monitoring results, KPIs and their baselines, energy team meeting reports, audit reports, and brief descriptions of energy efficiency measures carried out.
- **Communication**. A regular structured channel of communication on energy management status should be put in place. Initially, this should be for internal use, directed at staff members. In some cases, external communication can also be useful to inform suppliers about energy performance criteria used to evaluate their services, to inform stakeholders about any achievements, and so that the energy savings and associated carbon emission reductions can be used in marketing communications. It can be good practice to communicate energy performance improvements to investor and financial relations contacts, since they often have a longer-term perspective on the organisation.
- **Reviewing criteria for operations and maintenance**. Action plans for operations and maintenance should include energy efficiency as a major criterion of decision making.
- **Reviewing criteria for investment opportunities**. When designing new, modified or renovated facilities, systems or processes, energy performance improvement should be a major criterion of decision making.

These actions are discussed in greater detail in the chapters that follow.

# Continuous improvement as a guiding principle

The notion of continuous improvement, known as Kaizen, is one of the core principles of the Toyota Production System. From “kai”, meaning change and “zen”, meaning good, it is the quest to always strive to improve.

The concept is often formalized as the PLAN – DO – CHECK – ACT cycle, or PDCA cycle *(Figure 3)*. The ACT step, where you go back to the shop floor after verification (CHECK) to modify the initial DO action, might be more appropriately referred to as the ADJUST step to differentiate it more clearly.

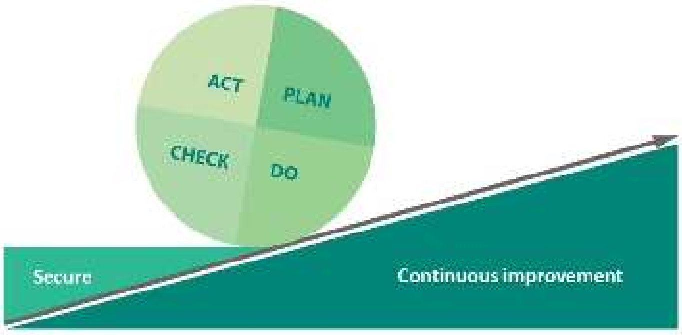


Figure 3 – The PDCA cycle.

In energy management, the PDCA cycle must be applied to both the formal method (for example, writing energy management into the strategic plan, creating the energy team, and staff training) as much as to actual energy efficiency measures.

The PDCA cycle could look like this as it relates to the composition of the energy team:

- **PLAN:** Schedule discussion with staff to assess their motivation to be part of the Energy Team. Schedule a moment to decide on the initial composition of the team and on allocating time for each team member. Plan an inaugural meeting of the team, and a subsequent meeting schedule. Decide when the first CHECK will take place.
- **DO:** Organise the initial team meetings.
- **CHECK:** After an initial period, a preliminary evaluation is made. Are the team’s objectives being met? Is the rhythm of meetings OK? Are crucial people missing from the team? Does any member lack time or motivation? Is the allocation of time for team members realistic?
- **ACT:** Adjust the meeting rhythm. Adjust the time allocation to better reflect reality.
- **PLAN:** Adjust the composition of the Energy Team where appropriate.
- **DO:** The Energy Team, as newly constituted, continues its work.
- **Repeat.**

Such continuous improvement cycles do not always need to be formalised. Once part of the mindset, this type of cycle will often take its course spontaneously for many tasks. The principal focus is on results, not administration.

The advantage for an SME of applying the continuous improvement principle is that you can start small, at a level consistent with the size of the organisation, and develop both the energy management system itself and the energy savings actions following from it, step-by step, without disrupting the existing working schedule too much. ‘Always a better way’ is a slogan still often used by Toyota. The continuous improvement principle also ensures that nothing is ever ‘ready’. The *status quo* is there to be challenged in the quest to constantly drive improvements.

Continuous improvement, as a guiding principle, ensures that energy efficiency continues to receive priority attention in an organisation, with a long-lasting effect on energy performance.

There is, however, an **important rider to the continuous improvement principle**. If energy management is limited to those changes that can be achieved ‘one small step at a time’, organisations risk missing out on significant energy saving opportunities that could make a big difference.

Continuous improvement, as a guiding principle, ensures that energy efficiency continues to receive priority attention in an organisation, with a long-lasting effect on energy performance.

Some opportunities require a substantial one-off investment alone, but bring a continuous harvest of benefits in the years that follow. These opportunities may be in danger of being overlooked if rigid interpretation of the continuous improvement principle is seen as the only way forward. This becomes an even greater danger since major investments are usually perceived as high risk for SMEs. Chapter 'Risk analysis' in this Application Note we will also explain approaches to avoid or mitigate this risk.

It could be that step-by-step improvement, involving a succession of quick-win measures, consumes the entire energy efficiency budget, making it even more likely that other opportunities requiring substantial investment are set aside. To counter this suboptimal deployment of funding, it can be a good idea to develop packages of investments where quick wins are balanced by longer-term investment.

# Going for quick wins with walk-through audits

In the spirit of continuous improvement and result management it is important to see the first results early in the process. This can be achieved by conducting walk-through audits, and by implementing quick-win energy saving solutions identified during the audit.

The audit is built around **a series of walk-around surveys,** at least two are recommended — one during working hours and one during a break in production or overnight, to identify support processes continuing to operate unnecessarily, such as lighting, ventilation or compressed air. You should not only look around, but listen carefully to identify equipment running during non-production time *(Thollander, 2020 – p.79-83).*

Walk-around surveys kick-off the inventory of energy-consuming equipment and help identify easy-to-implement energy savings.

The surveys can serve two objectives at the same time:

1. to start to compile inventories of energy-consuming equipment; and
2. to identify easy-to-implement energy savings.

In preparing for the survey, it is advisable to spend some time studying plans, schematics, and other available documents. It is also useful to make staff aware in advance of the upcoming survey and its aims, since they may be asked to explain processes and daily routines *(Parker, 2017 – p.9).*

During the walk-around survey it is useful to carry out the following tasks *(Thollander, 2020 – p.79)*:

- **Take an inventory of all energy using equipment**: in addition to its function, note also the installed power and energy use (if the information is readily available);
- **Assess the condition of equipment**: look at how it is operated and whether there are any obvious defects or easily implemented energy savings measures, for example possible pipework insulation, or reducing compressed-air leaks;
- **Assess control systems** and their settings looking for potential savings, for example checking lighting control, motor control, or re-evaluating HVAC settings;
- **Take time to speak with people**: ask how workspaces and equipment are used, and about equipment defects or downtime as well as whether staff have already identified potential energy efficiency measures;
- **Review service and maintenance procedures,** in conjunction with the appropriate staff members, to look for energy saving opportunities.

The walk-around survey is not yet the moment to spend time on detailed measurement since this would divert attention from the search for quick-win opportunities.

The surveys may need to be spread over several days or weeks to achieve a full understanding of the energy processes. It may also be useful to repeat the process at different times of the year since heating, cooling and lighting levels depend on weather conditions *(Parker, 2017 – p.9).*

Subsequent to the walk-around surveys, all the easily implemented energy saving actions could be carried out directly or scheduled in a short-term action plan. Very often, these actions will be immediately visible in the company's energy use figure – an important motivator.

The inventory produced during the walk-around surveys is a valuable tool for the next phase when a monitoring strategy is devised.

# Gaining deep insight

Starting from the inventory created during the walk-around surveys, actions to gain a deeper insight into the energy use of the organisation should be pursued. Without an appropriate level of insight, it is impossible to optimise energy use. For many SMEs, this exercise can be a major challenge, but external help can come from the following:

- **Monitoring systems**. New scalable energy monitoring technologies have entered the market in recent years making it easier to map and track energy end-use and the associated KPIs;
- **Energy audit consultants**. In general, consultants begin with detailed energy-use mapping based on in-depth energy audits, and also carry out monitoring;
- **Energy service companies (ESCOs)** take everything into their own hands: from information gathering and carrying out energy efficiency measures to assessing results.

These three types of assistance are discussed further in the final chapter.

Without an appropriate level of insight, it is impossible to optimise energy use.

## MAPPING ENERGY END-USE AND IDENTIFYING SIGNIFICANT ENERGY USERS (SEUS)

The first major task designed to gain insight is to map energy use and how much it is costing. This makes it possible to determine in sufficient detail:

- Where energy is being used – energy streams can be visualised in Sankey diagrams;
- How much energy is being used (per location, shift, or product, etc.);
- When energy is being used (base load, peak demand, day vs. night, etc.);
- Why energy is being used (which settings, procedures or staff actions trigger energy consumption);
- How much does this energy cost (contracts, invoices, forecasts, etc.).

A bottom-up approach is preferred to a top-down approach when mapping energy streams. Starting from the general energy use and breaking this down into estimates of energy used by individual equipment will bring only limited insight. Measuring actual energy use is a much better approach to reveal anomalies. Energy streams should be mapped independently of production volumes or building occupancy rates *(Thollander, 2020)*.

A good starting point is to gather all readily available information within the company *(Capiau, 2015)*:

- Energy invoices:
  - Total energy cost per year and its share in the operating expenses (OPEX) of the company;
  - Variations in monthly use;
  - Penalties for excessive peak demand and unfavorable power factor;
- Energy contracts:
  - The energy price and how it has varied in recent years;
  - Grid connection capacity and its cost;
  - Peak load cost;
- Consumption data broken down by 15-minute period (can be requested from the electricity supplier);
- Inventory of energy-using systems, taken during the walk-around surveys.

Using the available information, a company should be able to construct a provisional Sankey diagram, mapping the energy streams from intake (e.g. electricity grid connection, natural gas grid connection, or fuel purchases) to end use.

Sankey diagrams can be created in Microsoft Excel using add-ins, making it accessible to every SME. *Figure 4* shows an intermediate version of such a diagram, with a quarter of the energy use for which the destination is still undetermined.

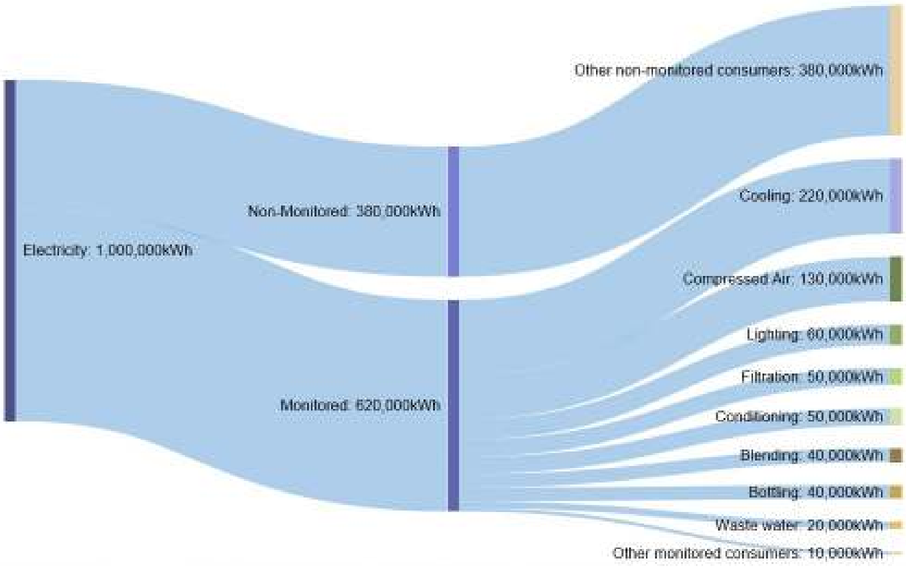


Figure 4 – Sankey diagram showing distribution of energy use.

Based on this, a first prioritisation can be made by identifying areas of Significant Energy Use (SEU). Monitoring actions and optimisation measures can then be focused on these areas.

## DEFINING KEY PERFORMANCE INDICATORS

At this point, the Energy Team should be identifying performance indicators for the SEUs, sometimes referred to as key performance indicators (KPIs), energy performance indicators (EnPIs or EPIs) or energy key performance indicators (e-KPIs). KPIs might, for example, be expressed as kWh per volume or weight produced, kWh per shift, or volume of steam or quantity of compressed air per unit produced.

It is important to choose KPIs in such a way that they provide relevant information. They should be sufficiently differentiated to be able to reflect improvements or crucial changes in operation, but it is not desirable to have a list of KPIs that is too long, since this would complicate any follow-up. Finding the right balance is crucial, as the following example demonstrates *(Capiau, 2015 – p.13-14)*.

> *A food company processes peas and sells them in different forms and packaging (frozen and canned). One single KPI (energy use per volume of peas) could seem appropriate, but may not be accurate given the different production methods. Clearly, frozen vegetables will have a different energy need than canned vegetables stored at ambient temperature.*

It can be a good idea to structure KPIs according to their level of depth in the company processes. For example *(Thollander, 2020 – p.50)*:

- **Level 1:** KPIs for the entire site;
- **Level 2-1:** KPIs for all support processes;
- **Level 2-2:** KPIs for all production processes;
- **Level 3:** KPIs for one type of support process (e.g. lighting, compressed air, ventilation, space heating and cooling);
- **Level 4:** KPIs for individual production processes.

Once the KPIs have been identified, it is important to determine how the data will be gathered, how often, and how they will be reported.

Defining and implementing KPIs is typically where external energy consultants can be of major assistance. It is a crucial but not self-evident task that can often be carried out better by an expert with dispassionate eye. Even SMEs among the world's best in energy management can often require expert assistance to handle KPIs.

Even SMEs among the world's best in energy management can often require expert assistance to handle KPIs.

## SETTING UP ENERGY MONITORING AND REPORTING

Sankey energy stream diagrams will usually be incomplete if they are based only on readily available data. Some of the energy streams will need to be measured or monitored to fill in the gaps and refine the diagram. In the spirit of continuous improvement, these measurement and monitoring actions could be limited initially and be extended in later years to refine the Sankey diagram. The primary goal of monitoring should be to provide real field data for the KPIs.

With time-limited measurements, it is crucial that time slots are chosen to be representative of normal operating conditions. Permanent monitoring systems provide more valuable information since they reflect daily, monthly and seasonal variations. Newly available, easy-to-use monitoring systems accessible to SMEs are discussed in the final chapter.

Additional to the measuring and monitoring schedule it should be decided how the resulting data will be reported and who will be responsible for doing so.

## DEFINING IMPROVEMENT MEASURES – THE IN-DEPTH AUDIT

The in-depth energy audit is a core phase of energy management. It should be repeated at regular intervals (every 4-10 years), but the first audit will, by far, be the most difficult and time consuming. Follow-up audits can learn from the structure and results of former audits and can mainly focus on what has changed in the interim.

The in-depth audit will thoroughly assess every area of Significant Energy Use (SEU) to look for potential actions that will reduce energy use – often called Energy Conservation Measures (ECMs). All kinds of actions will be considered, whether changes in infrastructure, equipment, energy carrier, control systems and their settings, operational procedures or staff behaviour. They will range from small changes, requiring no or limited investment, to large scale projects that require substantial investment and need to be planned years in advance. For every potential energy efficiency measure, an initial estimation will be made of the technical and financial feasibility and of the potential energy and cost savings. For substantial investment projects, a more detailed energy and financial analysis should follow, as will be discussed in the chapter "Assessing potential energy efficiency measures".

The in-depth audit will reveal potential energy efficiency measures that go beyond the obvious measures that can be detected during a walk-around survey. It is precisely this kind of measure that can make a difference to the financial, environmental and competitive position of the company. In the next chapter we will discuss what kind of measure this can be.

An in-depth energy audit is an expert undertaking and will require collaboration between external energy consultants (auditors) and the Energy Team.

Several EU member states offer financial incentives to SMEs to conduct energy audits.

Are regular in-depth energy audits sufficient for an SME to achieve and maintain energy excellence? In contrast to energy audits at regular intervals alone, the continuous approach of energy management allows for more structural measures with a long-lasting impact. These include integrating economic energy efficiency criteria in maintenance, equipment replacement and facility investment plans, as discussed in the next chapter. *Figure 5* shows the difference in energy intensity reduction between both approaches.

An in-depth energy audit is an expert undertaking and will require collaboration between external energy consultants (auditors) and the Energy Team.

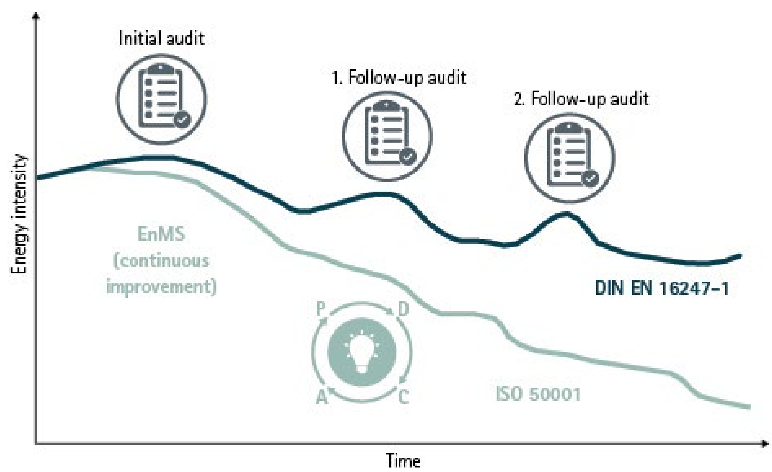


Figure 5 – The energy intensity reduction achieved through regular energy audits alone, compared to the reduction achieved by embedding those audits within an energy management system (Based on Barckhausen, 2019 – p.13).

### SETTING ENERGY TARGETS AND CONFERRING RESPONSIBILITY

Based on detailed energy use data and the conclusions of an in-depth energy audit, ambitious but realistic targets for the energy KPIs can be defined. For each of these targets, a baseline should be determined that follows from a good understanding of the existing situation.

Once the targets are set, an action plan can be devised for the energy efficiency measures proposed in the audit to be carried out to meet these targets.

For each target, a responsible person in the energy team should be assigned, but some targets and measures will go beyond departmental borders. For example, a case where the production department manages to reduce peak demand could provide the purchasing department with the opportunity to negotiate a better energy tariff *(Capiau, 2015 – p.14).*

## Making the difference through energy efficiency measures

Types of energy efficiency measures that could make a substantial difference are discussed below.

### REDUCING WASTE

Waste reduction starts with quick wins identified during the initial walk-through audit. Once energy management is adopted fully by the organisation, the culture of continuous improvement will lead to a further steady reduction in energy waste.

Once energy management is adopted fully by the organisation, the culture of continuous improvement will lead to a further steady reduction in energy waste.

Lights left on all night, compressed air leaks, or suboptimal temperature settings on heating systems, are responsible for a significant part of a company's base load consumption, with energy constantly being consumed independently of production or other activities. By reducing this type of energy waste, the maximum power capacity required by the site will also go down.

But energy waste is not limited to what is lost because of inattentive installation or operation of equipment. On a deeper level, all energy losses can be considered as energy waste. Even if these losses are thought to be inherent to the operation, an in-depth energy audit might still identify opportunities for waste reduction. Taking advantage of this kind of opportunity in general requires substantial financial investment. Examples include the installation of variable speed drives on motor systems, or the addition of heat exchangers to recuperate waste heat.

Possible waste reduction measures include:

- **Heating and cooling settings re-evaluation**: heating and cooling systems are often programmed to heat and cool more than required. For example, you don't need to cool a server room down to 20°C when the ASHRAE Guidelines prescribe temperatures below 26°C. And decreasing the working temperature in an office space from 23°C to 22°C will save a lot over a year and increase productivity.
- **Insulating pipework**: when pipes feel hot, this means they are losing heat. Insulating them could be well worth the effort. Recuperating this heat for other purposes can be another solution.
- **Compressed air**: adding control systems, reducing air leaks, reducing the inlet air temperature and outlet air pressure are all measures that can boost the energy efficiency of a compressed air system. On average, just 4 - 5% of the energy consumed by the compressor is turned into useful compressed air. Proper maintenance of the air systems can lead to much better performance and substantial financial savings *(Timmermans, 2011).*
- **Installing variable speed drives (VSDs) on motorised systems** that need to provide variable output. A pump system for a fluid with a variable flow is a good example of an application where a VSD can be useful. A VSD will have much lower energy losses than a solution with control valves and dampers *(Parker, 2017 – p.13).*
- **Equipment control:** optimising control systems, for example through time switching, auto start/stop or load sensing, can prevent equipment from running unnecessarily.

- **Lighting control**: optimising lighting control, for example by adding movement sensors in spaces with intermittent occupancy or daylight sensors for external lights, can also add to energy savings *(Parker, 2017 – p.20).*
- **Recuperating waste heat**. All energy losses eventually take the form of lower quality heat, no matter whether they originate from mechanical friction, electrical resistance or thermodynamic processes. The best strategy is always to aim to minimise energy losses at source. Any remaining heat losses can still be prevented from turning into waste through heat recuperation. Doing so usually requires the installation of a heat exchanger, which can be a substantial financial investment. If the amount of heat recuperated, or the temperature at which it is recuperated, are of no use to the company, it might still be possible to valorise it elsewhere, for example by selling it to nearby facilities.

## IMPROVING YOUR ENERGY CONTRACT AND VALORISING FLEXIBILITY

**Not every kWh has the same cost**. To reduce the amount paid per unit of energy, you need to understand how your invoice is structured. A next step could be to investigate the company's flexibility in energy use and whether this can be valorised on the energy market – a mechanism expected to gain in importance in the next few years.

### Improving your energy contract

In most countries, the total cost of energy is calculated from the actual cost per kWh, the cost for using the distribution grid, and various forms of taxes and charges.

Penalties for exceeding the contractual capacity limit pass unnoticed because of the disconnect between purchasing, operations and accounting departments.

Contracts often also stipulate contractual peak load limits and penalties for exceeding those limits. A supplier must balance the energy demand of its customers with its own electricity production and purchasing, and this becomes more complicated when customers have widely varying consumption profiles. In some contracts there is even an additional tariff increase for a period of twelve months each time the contractual capacity limit is exceeded. In many companies, such situations pass unnoticed because of the disconnect between purchasing, operations and accounting departments. Adapting the company's work rhythm to spread out energy use and achieve **peak shaving** can in such cases result in a significant saving on the energy invoice without reducing the total kWhs consumed *(Figure 6 and 7).*

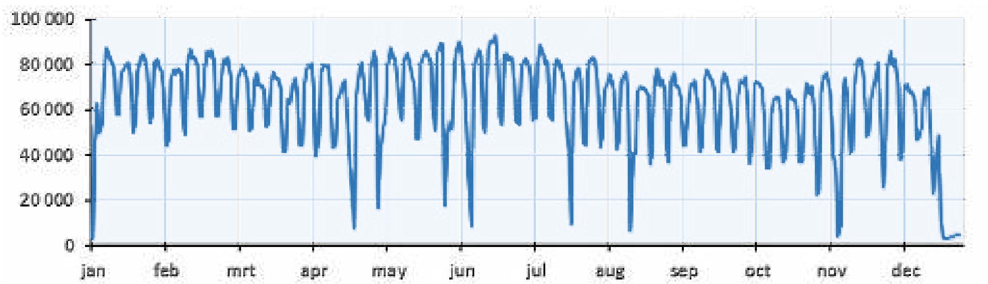


Figure 6—Annual energy consumption profile.

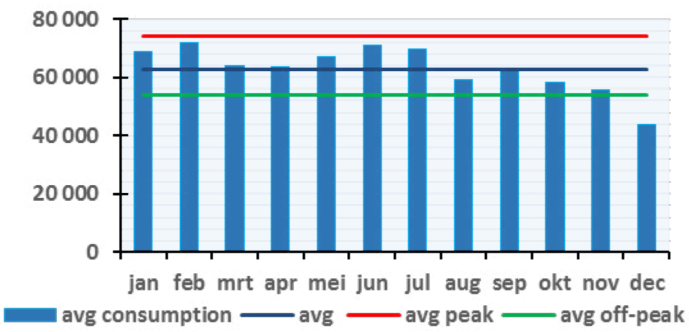


Figure 7—Average monthly energy consumption and peak load distribution.

Transmission and distribution costs are often based both on the amount of electricity consumed and the capacity of the connection to the grid. This capacity may be larger than the peak load registered by the energy supplier. Since it represents a type of reserved capacity which could, technically, be consumed, the grid operators will most likely charge for the available capacity, regardless of the contractual volume stipulated in the energy contract.

This contractual volume will be reduced when significant energy savings are achieved through energy efficiency measures, making the physical grid connection even more over-sized. In such a case, replacing the grid connection by one with a lower capacity might be preferable.

Energy contracts can have a huge impact on a company's cost structure. **Understanding the consumption profile** can help in identifying ways **to reduce energy tariffs, avoid over-dimensioning, avoid peak load penalties, and optimise purchasing strategies.**

### Valorising flexibility

In an increasing number of countries, SMEs can participate in demand side management (DSM) programmes to valorise the company's energy consumption flexibility. The company adapts its electricity consumption to the availability on the grid and is compensated financially for doing so. Space heating and cooling and water treatment installations are examples of energy end use installations that often have a high degree of flexibility and are therefore suitable for DSM.

In its Green Deal, the EU stresses the importance of flexibility markets to integrate various sources of renewable energy. By ensuring that production and consumption of electricity always match, those markets can help Europe become climate neutral by 2050. Considering this political ambition, flexibility is expected to become an important factor in the electricity purchasing process in the near future. SMEs looking to be ready for the future are advised to investigate their options in this respect.

Flexibility will become an important factor in electricity purchasing. SMEs looking to be ready for the future are advised to investigate their options in this respect.

## MAKING OR ADAPTING THE EQUIPMENT REPLACEMENT PLAN

Almost every SME has some kind of equipment replacement plan, perhaps a quite limited one or known by another name. Crucial equipment related directly to the core activity of a company is not usually allowed to run until it fails. It will normally be replaced after a specific number of years to avoid unexpected downtime and to facilitate financial planning. Less crucial equipment is usually left to run until it fails. Often this is the case as well for equipment not directly involved in production activity, but nevertheless crucial for its continuation – a situation that can lead to costly, unplanned outages. A good example is the unexpected failure of a distribution transformer.

Where an SME has an equipment replacement plan, the assessment criteria are usually limited to reliability, production quality and accountancy optimisation (investment planning), while energy efficiency is often ignored. Nevertheless, energy savings and the associated cost savings can be good arguments for early equipment replacement. This is the case when new, more energy efficient models of the same equipment have entered the market in the meantime, or have significantly gone down in price. It can also be the case for equipment that loses energy efficiency over the years, for example due to wear and tear. In both cases, replacing the old equipment with new will result in a direct gain in energy efficiency which can pay back the additional cost of the early replacement.

Energy management is an approach that makes energy awareness penetrate all levels and structures of the organisation. If it functions well, it will also influence the staff responsible for equipment replacement. Two main actions can be determined:

1. **Taking energy efficiency into consideration in all ad hoc replacements** of energy-using equipment.
2. **Making a replacement plan for all SEU equipment** and determining the most economic replacement timeframe. Both the energy efficiency gain and the reliability improvement resulting from early replacement should be part of the equation.

Motors and transformers are examples of electrical equipment for which a well-thought-out replacement plan will usually bring economic and operational advantages.

### Example 1: electric motors

The Leonardo Energy Application Note 'Electric Motor Asset Management' *(De Wachter, 2015)* describes how to develop a repair and replacement plan for electric motors. This is motivated by the following introduction:

> *Electric motors are the primary mover for a vast majority of industrial and tertiary sector activities. Some motors are visible as a separate entity; others are built into more complex packaged products such as air compressors, heat pumps, water pumps, and fans. [...] When motors are not managed optimally, the result is higher energy losses and [...] a reduced reliability and availability at the production site. Early replacement of electric motors is unusual, with most companies running motors to failure. Once failure occurs, they are repaired or replaced as quickly as possible. Replacement typically takes place without considering more than the basic technical requirements. A more detailed look at all cost factors reveals however, that an early replacement of an electric motor is often paid back in a very short time. This payback is fed by improved energy efficiency, by reduced maintenance costs, and by avoiding unplanned outages and their associated losses.*

A decision process when to replace or repair a motor should be developed based on a calculation of the total cost of ownership (TCO) which should consider the following factors *(De Wachter, 2015)*:

- Purchase/repair cost
- Initial energy efficiency of a new motor and the annual decrease in efficiency during operation
- Electricity tariff and its annual increase
- Daily running hours of the motor
- Average loading of the motor
- Estimated remaining technical lifetime
- Cost of motor downtime
- Motor resale value

Note that the energy efficiency of the motor is often assumed to be constant, but this does not reflect reality, since accidental damage, additional heating through build-up of dirt, and mechanical wear lead to a steady decline in efficiency. Repairing a motor also degrades its energy efficiency, except when it is carried out with extreme care by highly skilled technicians.

Note that the energy efficiency of the motor is often assumed to be constant, but this does not reflect reality, since accidental damage, additional heating through build-up of dirt, and mechanical wear lead to a steady decline in efficiency.

The application note includes the following example from Bryant University in Rhode Island, USA:

> *To keep computers cool and students comfortable, the university requires a large HVAC system, containing a large number of electric motors. The university has had an energy efficiency programme in effect for several years. As a result, most of its motors meet the NEMA Premium efficiency requirements. The only exceptions are a few special purpose models. Conscious that small savings can add up to big returns over time, the following actions have been carried out:*
>
> - *Four hot and cold water circulation pumps of 18.75 kW were replaced. The old motors were installed in 1988 and had a high efficiency for that time. However, the motor market has evolved rapidly since then. Replacing the motors with new and up-to-date high efficiency models led to an annual saving of $679 each, resulting in a payback period of only 1.5 years.*
> - *A 30 kW motor with standard efficiency driving the water pump of a condenser was replaced with a new more efficient model. This resulted in an annual saving of 10.3 MWh and $1,059. The payback time was 1.5 years.*

**Example 2: transformers**

The Leonardo Energy Application Note 'MV Transformer Replacement Decisions' *(De Wachter, 2017)* describes how to develop a replacement plan for transformers, including a calculation example.

> *Transformer replacement before failure can be motivated by several legitimate reasons. These include changes in the load or the voltage level, an increased risk of failure due to transformer ageing, environmental and fire safety regulations or the aim to improve the energy performance. This last motivation is less common. This is unfortunate, because replacing a transformer before its end of life with a new one with higher energy performance will in many cases lead to a lower Life Cycle Cost of the unit. [...] The methodology proposed is to calculate the Equivalent Annual Cost (EAC) for the upcoming year of both the existing and the new transformer. In the majority of cases, the EAC is dominated by the energy losses.*

The minimum equivalent annual cost (EAC) for the coming year can be determined as follows *(De Wachter, 2017)*. First, the annuity factor (AF) must be determined to re-calculate cost components to the present monetary value.

$$AF(i,n)= \frac{1-\frac{1}{(1+i)^n}}{i}$$

i = annual discount rate

n = number of years in the life cycle of the transformer

The EAC for the upcoming year, in the event that the transformer is replaced, can be calculated as follows:

$$\frac{(\text{Investment cost new})}{AF(i,n) * n} - \frac{(\text{Residual value old today})}{AF(i,n) * n} + \text{Running cost next year new}$$

The EAC for the coming year, in the event that the old transformer remains in place, will be the following:

$$\frac{\text{(Investment cost new)}}{\text{AF(i,n+1)} * \text{(n+1)}} - \frac{\text{(Residual value old today)}}{\text{AF(i,n+1)} * \text{(n+1)}} + \text{Running cost next year old}$$

With the running cost for next year calculated as follows:

**Running cost next year = no load losses + load losses + maintenance cost + cost of failure risk**

The better of the two options will be the one with the lowest EAC. Since it is only the difference in EAC that counts and not the absolute values, terms in the annual running cost for which this difference is estimated to be small can be left out. Imagine, for instance, that the new transformer mainly improves the energy performance, while the reliability and maintenance cost are expected to stay at the same level. In that case, the running costs can be limited to the energy losses.

The EAC method follows the same principles as the net present value (NPV) method, which will be discussed in the next chapter: "Assessing project profitability". Compared to the NPV, the EAC is well suited for supporting a decision whether to keep an old device in use or to replace it with a new one.

## INCLUDING ENERGY EFFICIENCY IMPROVEMENTS IN THE FACILITY INVESTMENT PLAN

An in-depth energy audit will result in a list of potential energy efficiency improvement measures, including large-scale projects that require substantial investment. For every measure, the audit will include an initial estimation of technical feasibility, potential energy savings, the investment required, and the financial profitability, providing a first insight into the scale and complexity of the project. These investment projects cannot usually be launched all at once, and will require careful planning years in advance. Without the continuous monitoring of energy management, the risk would be that the measures would be set aside 'for later' and will never be carried out in the end. With higher management being engaged in the Energy Team, such eternal postponements can be avoided. Large scale but highly profitable energy efficiency improvement investment will be given priority in the company's general investment plan for the years to follow.

Without the continuous monitoring of energy management, the risk would be that the measures would be set aside 'for later' and will never be carried out in the end.

Such investment could include:

- Installing a waste heat recovery system;
- Re-sizing electricity cables, busbars and connectors;
- Installing a building automation and control system (BACS);
- Improving the building fabric for better thermal insulation;
- A re-lighting project in an office building.

For investment projects of this kind, the first estimations made by the energy audit should be followed by a detailed energy and financial analysis, as discussed in the next chapter: 'Assessment of potential energy efficiency measures'.

## CHOOSING THE RIGHT ENERGY CARRIER

All projects involving either the replacement of energy-using equipment or investment in new energy-using facilities, should include time **to scrutinise the choice of energy carrier** (e.g. natural gas, diesel oil, electricity, steam, wood pellets, compressed air…). Sometimes, a change of energy carrier can justify an investment project in its own right, bringing substantial cost and energy savings in the long run. With evolving technology, the increasing decarbonisation of grid electricity, and government incentives for decarbonisation initiatives, electricity has often become the most advantageous energy carrier in cases once dominated by fossil fuels. Striving for the lowest life cycle cost should be the aim here too.

Electrification projects include:

- Changing a natural gas process heating system to a dielectric, induction or infrared system;
- Installing a heat pump for space heating instead of a fossil fuel burner;
- Switching from a hydraulic or pneumatic system to electrical actuators;
- Converting a fossil fuel vehicle fleet to electric vehicles.

### INVESTIGATE OPTIONS FOR ON-SITE RENEWABLE ENERGY GENERATION

Installing an on-site renewable energy generation system is not strictly an energy efficiency measure. It is, however, an energy-related investment that cannot be viewed separately from the energy use and energy contract. The investment decision, installation and operation of local renewable energy generation therefore needs to be incorporated into the energy management system.

On-site photovoltaic (PV) solar power generation is common in businesses of all sizes. It can be a good way to valorise extensive rooftop areas. More on this topic in the Leonardo Energy Application Note: 'PV Powered Building Applications in Commercial Buildings' *(Eclareon, 2015)*.

On-site wind turbines are less common but, for some SMEs with a sufficiently large and well-located property, it can be a profitable investment. More on this topic in the Leonardo Energy Application Note: 'Assessing Flexibility for Wind Powered Industrial Processes' *(Kernan, 2019)*.

The self-consumption of locally generated renewable energy can be maximised by adding energy storage systems. More on this topic in the Leonardo Energy Application Note 'Behind-the-meter energy storage systems for renewables integration' *(Jaffe, 2016)*.

## Assessing potential energy efficiency measures

### PROJECT PROFITABILITY

Purchasing energy efficient equipment can require a substantial additional investment, and so it is a natural reflex to ask how quickly this investment will be won back by reductions in energy use. The calculation is easy but misleading: the additional investment is divided by the yearly reduction in energy cost to give **the payback time** in number of years. Often, three years is seen as a psychological barrier – it is hard to look further ahead in small or medium scale businesses. Three years is already an eternity. As sound as this kind of thinking might seem, the result is that highly profitable investment opportunities are passed over.

Calculating the payback time of an investment is easy but misleading; highly profitable investment opportunities are often passed over.

A first issue is that an amount of money next year does not have the same value as today. Future costs and revenues should be calculated back to the present time by applying a discount rate. This is reflected in the **discounted payback time**. In this formula, the discounted reductions in energy cost are subtracted from the initial investment until it reaches zero. The discounted payback time can be a good instrument for risk assessment *(see below)*, but is not suitable for assessing the overall profitability of the investment or for comparing different investment options, since it ignores what happens after the investment has been paid back.

**Life cycle costing** (LCC) reflects the real financial impact of an asset for the company over its entire lifetime. There can be a reluctance to use LCC calculations because of the uncertainty of how long an asset will actually remain in use – so much can happen over the years – but this can be offset through risk assessment and mitigation, both of which can be outsourced. This is discussed in more detail below. A full LCC calculation includes all the costs relating to an asset over its entire life cycle. This can include the purchase cost, as well as the cost of installation, staff training, energy use, maintenance, repair, unplanned outages and decommissioning. It should also include subsidies, tax reductions and other forms of financial incentives, which can be included as a negative cost. Often it will be obvious which cost factors are dominant, and which of them can be ignored because they will not have a major influence on the final decision. In the case of a power cable, for example, the cost of purchase, installation and energy use will be dominant and the other factors will be too minor to have any influence. In the case of a transformer, it might be necessary to add the costs of maintenance and unplanned outages to the calculation to acquire the full picture.

The life cycle costing principle is reflected in two different calculation methods: the Net Present Value (NPV) and the Internal Rate of Return (IRR).

**The net present value** (NPV) is defined as the sum of the investment cost and all the cost components calculated over the life cycle of the asset, with each cost discounted according to the year in which it occurs. It can be expressed as *(Forte, 2015 – p.13)*:

$$NPV = C_0 + \sum_{k=1}^{T} \frac{C_k}{(1+i)^k}$$

With $C_0$ the investment cost, $T$ the total time horizon, $C_k$ the sum of all costs occurring in year $k$, and $i$ the discount rate.

NPV is the ideal instrument to compare different investment options, taking the total cost impact over the complete time horizon of the asset into account. To highlight the savings potential of an energy efficiency measure, you will have to compare the NPV of the project with that of a base case scenario (business-as-usual). Note that precise calculation of NPV should take the company's tax rate into account. The formulas to achieve this can be found in *Thollander (2020), p. 149-150*. Investments assessed as unprofitable before tax can become profitable if taxes are taken into account, but the opposite is never true.

Life cycle costing (LCC) reflects the real financial impact of an asset for the company over its entire lifetime.

The **internal rate of return (IRR)** gives the discount rate for which the NPV of all costs compared to the base case becomes positive. By calculating the IRR you determine what the maximal discount rate is that still allows you to have a profitable investment. The **IRR of a particular project should be greater than the cost of capital** for the company concerned in order for the project to be advantageous.

More on LCC, NPV and IRR in Forte (2015), p.11-16 and *Thollander (2020), p.147-152*.

All the above methods presume that the yearly energy cost of the various investment options and of a business-as-usual scenario are known. Estimating them, however, requires an assessment in its own right.

## ASSESSING THE ENERGY SAVINGS (EX-ANTE AND EX-POST)

Quantifying the anticipated energy savings is arguably the most complex part of an investment decision involving energy efficiency measures (EEMs). Energy use is typically the result of many factors, including local conditions, the quality of implementation and commissioning, and operational and maintenance practices. These factors can vary from year to year, making it difficult to assess the expected savings. Because of this uncertainty and complexity, decisions whether to implement energy efficiency measures are often either postponed or avoided.

Having an energy management system in place has the advantage that the organisation has already gained some insight into the energy streams of its facilities and how they can be measured. However, if the organisation lacks the resources or focus to forecast the energy savings, outsourcing this part can be a good solution.

A first step is to choose **a suitable simulation model** which encompasses the relevant energy and economic input data, the boundary conditions, and an appropriate calculation method. With this model, two assessments should be made: one before implementation based on forecasted data (ex-ante assessment) and one after implementation based on actual monitoring data (ex-post assessment).

In **the ex-ante assessment**, the simulation model is first validated using existing data from preceding years to determine the *Current Baseline*. This serves as the basis for a *Forecasted Baseline* (future situation with business-as-usual scenario) and a *Forecast with EEM* (future situation with EEM implementation). The difference between the *Forecasted Baseline* and the *Forecast with energy efficiency measure* leads us to the *Forecasted EEM Savings*, which allows the organisation to decide whether and which energy efficiency measures are implemented.

Since the assessment produces a forecast and not an exact measurement, it is important to verify what would happen to the result of the calculation if some of the conditions deviated from the supposed values. This is what **a sensitivity analysis** does. It shows the effects of major uncertainties and determines whether the result will stay within the previously defined target.

If it were decided to go forward with the implementation of the energy efficiency measure, an **ex-post assessment** can be carried out to compare the simulated outcome with real monitoring data. This allows the investor to determine any deviation from what was predicted, adjust the boundary conditions, and make a new, more accurate forecast.

More on ex-ante and ex-post energy savings assessments in the Leonardo Energy Application Note 'Assessment of energy savings' *(Offerman, 2019)*.

## RISK ANALYSIS

By definition, an investment means that a certain amount of money is expended today to purchase a system that will lead to a financial return in the future. As the future is never entirely predictable, **investments always involve risk**. A system, for example, could become obsolete because of changes in the organisation, the return can be less than predicted because of changing external factors, or the system can require more maintenance than predicted.

**Whether this risk needs to be formally assessed depends on the size and the time horizon of the investment.** For a small investment – no matter its payback time – the potential loss is small, and a formal risk assessment will be too costly. Any investment – no matter what size it is – that is won back quickly carries a smaller risk too, since the near future is relatively predictable. For larger investments with a longer time horizon, a formal risk assessment is highly recommended and will often be critical in gaining access to external financing. Is the risk an investor is willing to take worth the return they can potentially achieve?

A risk analysis, in proportion to the circumstances and the size of the investment, is usually a good idea.

How fast an investment will be won back – its time horizon – can be calculated by the **discounted pay-back time**. A short-term investment (< 1 year payback) does not require a formal risk analysis. For a medium-term investment (1-5 years payback), executing a risk analysis before taking the final decision is usually a good idea, depending on the circumstances and the size of the investment. For a long-term investment (> 5 years payback), a formal risk assessment should always precede the final investment decision. If the organisation lacks the resources or focus, this risk assessment can also be outsourced to external consultants.

A risk assessment can be divided into the following three phases:

- Risk identification;
- Risk (and return) valuation;
- Risk hedging decisions, depending on the amount and type of risk the investor is willing to take.

The best—and often mandatory—tool for risk assessment is **due diligence (DD)**. This process identifies and evaluates every potential risk a project can reasonably be expected to face. The risks identified during the due diligence process should be further assessed through a sensitivity analysis. To mitigate the risk, a number of **hedging instruments** can then be employed, such as contracts, insurances, credit enhancement instruments, revenue support policies and direct concessional agreements.

A due diligence risk assessment requires a rigorous process following the path illustrated in *Figure 8*:

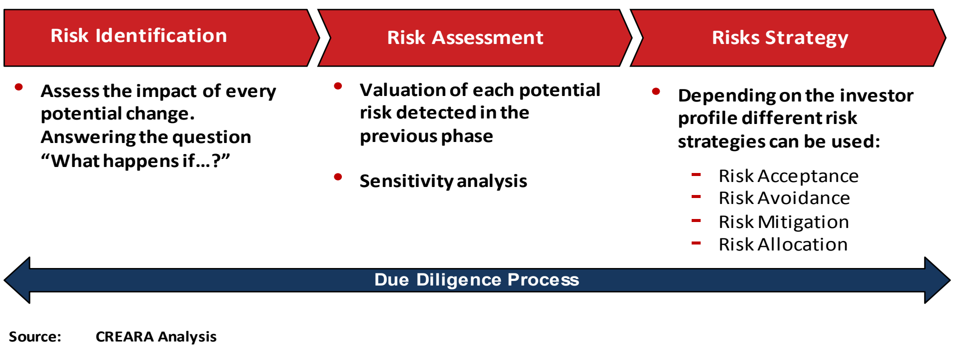


Figure 8 – Risk assessment process (source: Creara Analysis).

More on risk assessment in the Leonardo Energy Application Note: 'Investing in Long-Life Renewable Energy and Energy Efficiency Assets' *(Creara Energy Experts, 2018).*

# Energy management technology and service providers

Time and resources are limited at SMEs, which could lead to a certain reluctance to implement an energy management system or to launch substantial energy savings investment projects. The assistance of plug-and-play technology and of external service providers can counter this barrier and make sure the dedicated time remains within the confines of the organisation.

## MEASURING AND MONITORING SYSTEMS

A major evolution in energy monitoring technology has brought genuine energy management within the reach of SMEs. In the past, the installation of metering systems could be complex, and processing the quarter-hour consumption figures into useful data was highly time consuming. In recent years, markets have welcomed easy-to-install, plug-and-play energy monitoring systems that provide both real-time and historical energy consumption, PV production, and electrical storage data. They collect electricity and gas consumption data down to the appliance level through clamps and submeters and then send the quarter-hourly data to a processing unit which can be integrated into the device, or an external unit connected over the internet. The data come back in an aggregated format, which can be a user-friendly app for direct use or a more detailed dashboard for in-depth analysis. The systems can also aggregate the data directly into the energy performance indicators, making it easy to keep track of the objectives. These are affordable, modular solutions that can be used by staff with no technical background and SME energy auditors alike.

Energy monitoring systems include:

- SMAPPEE (Belgium): highly scalable, for use in residential buildings, tertiary sector and industry;
- Enconnect, (Belgium): for all buildings and industry, from SME to multinational;
- French Fluida Smart Energy Components (France): for all types of buildings;
- Nuuka Energy (Sweden): for all types of building;
- Dexma Energy Intelligence (Spain): for all buildings and industry, from SME to multinational.

## AUDITORS, CONSULTANTS AND INVESTORS

External consultants can be called in during various phases of energy management and the implementation of energy efficiency measures.

In larger SMEs with sufficient resources, it can be a good idea to invite **an external energy consultant to be part of the Energy Team**. An external consultant will have a fresh and unbiased outlook on the organisation and can bring in a lot of energy efficiency optimisation knowhow. If this is too ambitious, an external consultant might simply be invited only at critical phases, for example during start up, for the in-depth energy audit, or the evaluation phase of potential energy efficiency investment.

An external consultant will have a fresh and unbiased outlook on the organisation and can bring in a lot of energy efficiency optimisation knowhow.

**Defining and implementing Key Performance Indicators** (KPIs) is typically where external energy consultants can be of great help. It is a crucial, but not self-evident task that can often be carried out better by an outside expert with an objective eye on the company.

The **in-depth energy audit** is also an action that can be outsourced easily. There are many energy consultancies specialising in such audits, in part because of the EU's energy auditing scheme for large companies.

External energy consultants can also be called in **to evaluate potential energy efficiency investment projects**. They can assist – or take the lead – in assessing energy savings and financial return, analysing risk and researching external financing.

Some **external investors** will also be able to offer assistance in financial assessment and risk analysis of energy efficiency investment projects.

### ENERGY SERVICE COMPANIES (ESCOS)

An Energy Service Company (ESCO) combine all of the above and **takes over the entire process of energy efficiency investment**. It carries out an audit of the company's premises and identifies potential energy efficiency measures, analyses the profitability and risk of those measures, provides financing for those investments judged profitable, manages implementation, and carries the risk on the return. Effectively, the process from A to Z is outsourced. The resulting energy cost savings are used to pay back the ESCO over a period of five to twenty years, after which the cost savings become pure profit for the organisation.

As a result of EU regulations, ESCOs are known primarily in the European building market and are less present in industrial environments. That said, they can be an ideal solution for SMEs looking to reach a higher level of energy efficiency but who do not have the required time, focus, financial capital and risk resilience. Hiring an ESCO can avoid major energy efficiency investments being constantly postponed and can ensure that the energy management itself stays lean. The Energy Team can concentrate on daily monitoring only, without having to carry major, time-disruptive projects. All this, of course, comes at a cost. The resulting cost savings will flow to the ESCO for the length of the contract.

Hiring an ESCO can avoid major energy efficiency investments being constantly postponed and can ensure that the energy management itself stays lean.

### ENERGY EFFICIENCY NETWORKS

An energy efficiency network is a group of SMEs that roll out an energy management process together. It is a way to combine forces among organisations of a similar type and size in order to reduce the effort and improve the quality of energy management. The SMEs share the cost of a full time 'in-sourced' energy efficiency coordinator who drives the Energy Team and coordinates the energy audits. A model originating in Switzerland and later prominent in Germany and Sweden, energy efficiency networks run for a pre-defined time, typically three or four years.

More on energy efficiency networks in *Thollander (2020), p. 251*.

# Conclusion

Energy management can be of great value for a SME, even if it is not particularly energy intensive. It should not necessarily be the aim of SMEs to go for ISO accreditation, but rather to implement the main principles of energy management pragmatically. Easy-to-install, plug-and-play energy monitoring systems that have come on to the market in recent years have brought energy management even more within the reach of SMEs, especially when combined with the assistance of external energy consultants.

Compared to one-shot energy audits, energy management avoids the topic being treated in a tick-box manner. Instead, it takes a systems approach to energy use and looks at the entire life cycle of energy-using equipment. If energy management is well executed, it deeply embeds energy efficiency in the organisational culture, daily practice, and purchasing and investment procedures.

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