Code of Good Practice in Energy Management for Industry

Prepared for:
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EXECUTIVE SUMMARY

The Ministry of Industry, Commerce and Consumer Protection has hired the Building Research Establishment Ltd (BRE), along with its Partners Sinclair Knight Merz (SKM) and Symbant Technologies Ltd in Mauritius, as consultants for the setting up of a Framework for Energy Efficiency and Energy Conservation in Industries (Procurement Reference No: DTC/7/April 2012).

This Code of Good Practice in Energy Management contains guidance aimed at those responsible for energy management in an organisation, from board level to operational staff. A step-by-step approach to energy management - the "BRE five-step plus" - is explained. This was developed by Dr Andy Lewry, building on BRE’s work on energy management systems from the 1990’s in support of the UK government’s Energy Efficiency Best Practice programme (EEBPp).

This approach is in line with the modern management philosophy of continuous improvement, where any system must review and capture the lessons learned and then act on them.

Furthermore, the approach is compatible with the recently introduced international energy management standard (EnMS), which was published in June 2011 - ISO 50001:2011. This like all the modern management standards has the PDCA approach as its underlying philosophy:

- Plan
- Do
- Check
- Act

This approach is used, together with a matrix tool, to show how to underpin the implementation of energy management initiatives within an organisation. This matrix tool can be used to help organisations to identify areas for improvement, prioritise energy management activities and maximise potential benefits.

This is a board level tool and helps position a company in terms of:

- Energy management;
- Financial management;
- Awareness and information.

These matrices help position an organisation and can be used to monitor corporate progress. The impact of the score on a company’s performance is that an increase in level equates to a reduction in energy consumption of 8-10%.

Levels 3 and 4 within the matrices represent best practice, where Level 3 is appropriate for Small and Medium Enterprises whilst Level 4 is aimed at larger organisations.

When progressing up the levels a company should address the low scores first so that the profile levels out and then progress by attempting, for each issue, to move up the ladder at the same pace. Each of these areas contains barriers to the full realisation of the benefits of energy efficiency so each has to be treated with equal weighting.

In addition, the guidance:

- Examines how data from sources such as energy audits and monitoring and targeting can underpin energy management.
• Addresses operational performance and discusses how information is needed to adequately assess the energy performance.
• Gives advice on how to run successful staff awareness campaigns and training initiatives.

The Code of Good Practice in Energy Management for Industry is part of a wider programme to facilitate industry in Mauritius to implement Energy Management and Conservation. In addition, to the code of practice the programme will deliver the following elements:

• Guide book on energy auditing in industrial applications;
• Software calculator tool to estimate and record identified energy saving opportunities;
• Theoretical training in energy management;
• Theoretical training in energy auditing in industrial applications;
• Practical training in conducting energy audits in industrial applications.

This document is complementary to the “Guidebook for energy auditing in industry” and the results of any energy audit should feed into an energy management system to maximise their effect.
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1 Introduction - why manage energy?

There are a number of key reasons to improve energy management in any organisation:

- to save costs;
- to comply with legislation;
- to manage risk.

1.1 Energy prices

The private sector in Mauritius consists mainly of light industries, (textile, agro-food, tourism, etc.) and energy costs were not a major concern in the 1990s when international energy prices were low.

The continuous increase in energy prices (see Figure 1) has led to a very different situation, where energy costs now represent a high proportion of the production costs in most industries. This, along with the general context of increasing international competition, requires organisations to be more efficient in their use of resources in order to reduce their cost base.

![Figure 1: Average import price of energy sources, 2001-2010](image)

1.2 Production of electricity in Mauritius

The production of electricity is increasing dependent on imported resources with coal showing an upward trend and now representing more than 50% of primary energy consumption. With such reliance on imports the issue of security of supply now raises its head as a business issue.

Please note that the GWh in Table 1 represents primary energy input to electricity generation rather than the electricity generated, which is classed as secondary energy. For example, the
value of 2,197 GWh for Heavy Fuel oil represents the energy content of the oil being burnt, which generates 966 GWh of electricity, which is the secondary energy produced.

Table 1: Fuel input and related GHG emissions for electricity production in 2010

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>tonnes</th>
<th>GWh</th>
<th>t CO$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy fuel oil</td>
<td>196,882</td>
<td>2,197</td>
<td>621,840</td>
</tr>
<tr>
<td>Diesel oil and kerosene</td>
<td>8,005</td>
<td>94</td>
<td>25,567</td>
</tr>
<tr>
<td>Coal</td>
<td>643,049</td>
<td>4,646</td>
<td>1,602,799</td>
</tr>
<tr>
<td>Biogas</td>
<td>1,140,383</td>
<td>2,124</td>
<td>N/A</td>
</tr>
<tr>
<td>Total primary energy for power production</td>
<td>9,061</td>
<td>2,250,205</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Electric consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>GWh</td>
</tr>
<tr>
<td>primary/kWh_electricity</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CO$_2$/kWh_electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>938</td>
</tr>
</tbody>
</table>

1.3 Energy costs in manufacturing

If the CEB’s 369 largest industrial customers, who use over 300,000 kWh/year, are taken as a group they are responsible for 87% of industrial electricity use in Mauritius. The sugar sector has been excluded from the breakdown in Table 2, but it can be seen that Textiles represent the biggest sector usage at 46%, followed by the Food industry with 26%.

Table 2: Electricity consumption in industry

<table>
<thead>
<tr>
<th>Electric consumption in industry per sector</th>
<th>number of sites</th>
<th>% of electric consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textile industry</td>
<td>81</td>
<td>46%</td>
</tr>
<tr>
<td>Food industry, cold warehouse</td>
<td>87</td>
<td>26%</td>
</tr>
<tr>
<td>Water systems: irrigation, pumping, treatment</td>
<td>78</td>
<td>11%</td>
</tr>
<tr>
<td>Fossil, Chemicals and Basalt</td>
<td>80</td>
<td>10%</td>
</tr>
<tr>
<td>Metallic and mechanical works</td>
<td>31</td>
<td>7%</td>
</tr>
<tr>
<td>Printing and paper</td>
<td>12</td>
<td>1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>369</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

1.4 Industrial energy bills

On the basis of 2010 energy prices the total energy bill for the large industry consumers is 4,825M MRUs/year. This is split between 41% for electricity and 51% for fossil fuels, with diesel oil being the biggest contributor at 35% – see Table 3.
Table 3: Energy usage and costs for the top 369 Industry consumers

<table>
<thead>
<tr>
<th>Final energy consumption - 2010</th>
<th>annual bill</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GWh/year</td>
</tr>
<tr>
<td>Heavy Fuel oil</td>
<td>437</td>
</tr>
<tr>
<td>Diesel oil</td>
<td>475</td>
</tr>
<tr>
<td>LPG</td>
<td>56</td>
</tr>
<tr>
<td>Coal</td>
<td>156</td>
</tr>
<tr>
<td>Fuelwood</td>
<td>5</td>
</tr>
<tr>
<td>Electricity</td>
<td>605</td>
</tr>
<tr>
<td>total thermal energy</td>
<td>1,129</td>
</tr>
<tr>
<td>total thermal + electricity</td>
<td>1,734</td>
</tr>
</tbody>
</table>

1.5 Benefits to companies

When managing energy one has to overcome the false perception that it is a fixed cost to business and can be reduced only by tariff negotiation. Considering energy as a variable cost to a business provides the opportunity to discover the size of the potential savings. A study carried out by Application Europeenne de Technologies et de Services (AETS) and described in further detail below estimated that the possible saving were of the order of 14% (1).

Companies that embrace energy management normally do so as part of a larger programme of resource management or environmental management. As well as cutting costs, this can lead to gains in the market place as the company is perceived to be well run and to have ‘green credentials’. This approach fits into management best practice initiatives such as total quality management (TQM) and the European Foundation for Quality Management.

In addressing risk to the business first consider the ‘do-nothing’ scenario, but in the light of increasing energy prices and security of supply issues this is not a realistic option. Increasing prices can have a dramatic effect on the cost base of organisations leading to reduced competitiveness and a need for a drive for greater efficiency. Security of supply issues leads to the need to protect essential services, for example, on-site generation to protect servers and prevent potential loss of data. To mitigate these risks organisations now have a need to understand how they use their energy and then manage it.

1.6 Other initiatives in Mauritius

Enterprise Mauritius has carried out a series of energy audits within the manufacturing sectors – sugar cane, textiles etc. Consultants were appointed to carry out a preliminary study on the present situation of energy consumption in these companies and provide recommendations. The reports highlighted modifications in the present set up of the processes with investment in improved equipment wherever applicable. For manufacturing industries, the areas focused on were mainly based in fuel cost, energy savings from boilers, electricity cost and general savings including renewable energy utilization. The uptake of measures (other than no cost) appeared to be low, indicating a low appetite for investment in these sectors.

The Mauritian Chamber of Commerce and industry (MCCI) is one of the core member-organizations of the Joint Economic Council (JEC), the Mauritian private sector’s overall representative structure. The JEC have, with the support of AED published a report in June 2012.
on the “Mapping of energy efficiency in industry and tertiary sector in Mauritius”. The study was
carried out by Application Europeenne de Technologies et de Services (AETS), from February to
May 2012 (1).

The scope of the study was the private sector: industry and large buildings including tourism,
banks, commercial areas and supermarkets, health, etc. It included all kinds of actions leading to
an improvement of the energy efficiency and renewable energy sources as far as they may be
developed in large consumer facilities; for example solar heating systems, photovoltaic systems,
biomass on site, etc. but it did not include the coal-biogas fired power plants.

This report identified the main areas of priority for developing energy efficiency in the private
sector as:

- **Steam systems, mainly in industry:**
  - Steam boilers and distribution systems, including steam traps and condensate
    returns, as well as control systems. The identification of potential projects does not
    require specific knowledge of the sub-sector, but requires experience in steam
    systems.
  - Steam use in process, including heat recovery potential: the analysis may require
    some experience in the respective sub sectors. It is particularly useful to have
    some knowledge of typical energy efficiency projects in similar factories.

- **Cooling systems, including:**
  - Air conditioning in industry and tertiary; this includes split and multi split air-
    conditioning, as well as centralised chilled water systems. This also includes the
    reduction of the cooling needs through adequate control systems, Building
    Management Systems (BMS), and thermal insulation.
  - Refrigeration in the food industry, cold rooms and food stores.

- **Pumps and fans, which exist in both industry and large buildings. The development of
  Variable Speed Drives (VSD) motors is a main area of potential.**

- **Compressed air systems exist in almost all industrial facilities and are often a field with
  high potential.**

- **Hot water production in hotels, restaurants, hospitals, but also in industry. Solar systems
  should be developed.**

- **Lighting in tertiary but also in industry: fluorescent lamps, electronic ballasts, Light Emitting
  Diodes (LEDs), control systems**

Although these initiatives have dealt with technical and superficially with behavioral issues,
management issues have in the main been ignored.

1.7 **Organisational and managerial**

As mentioned above the one area that often “falls between the cracks” is a review of the
organisation and managerial aspects. The disconnect between the operational aspects of an
organisation and its management; and the inability of the technical staff to talk the same language
as the finance department are common causes of failure to implement recommendations. It is
essential to highlight soft issues such as these, and provide solutions, if energy management is to
be successfully implemented within an organisation. This is an essential pre-requisite before any
energy management programme is carried out to determine the degree and type of measures
that are acceptable and can be taken on-board by the target organisation.
2 Energy management systems

2.1 Underpinning philosophy

To successfully carry out energy management within an organisation a system needs to be introduced that is simple to understand. This should address management issues, both within the organisation and for the processes, buildings and transport, with the resulting energy savings providing a competitive and business advantage. To be successful the system must provide a structured approach and a framework in which to work. It is essential that the outputs provide a clear sense of direction for the organisation and communicate the objectives to all of the stakeholders. Alongside this the system should measure and monitor and, to keep its objectivity and reputation, be easy to audit. Last but not least, the modern management philosophy is one of continuous improvement, where any system must review and capture the lessons learnt and then act on them (2).

2.2 Initial steps

2.2.1 Put a system into place

The system should be robust and with a proven track record. Such a system, which has been tried and tested over many years, is a five-step approach introduced by BRE through the UK’s Energy Efficiency Best Practice programme (EEBPp) in the 1990s. This became a key part of the UK Carbon Trust’s portfolio of publications at both a strategic (3) and implementation (4) level.

The five steps are laid out below, along with the actions required to successfully implement each step of the process. All these actions need to be done and are potential “showstoppers” to the implementation of a successful energy management programme.
Energy management – the five-step approach

Step 1
Get commitment
- Get top-down support – this subject needs to be an item on the boardroom agenda.
- Look for a boardroom champion.
- Build the business case – convince senior managers in their language.
- Embed this into the management approach and systems – especially TQM.
- Develop bottom-up buy-in; carry out an awareness campaign and training programme.
- Start to change the culture – good communication at all levels is essential for this.
- Establish the basic criteria for the energy policy and high level action plan.

Step 2
Understand the issues
- Use energy management matrices to map out the organisation.
- Understand the energy usage.
- Understand the management processes and culture.
- Identify the key decision makers.
- Understand the needs and drivers of all the stakeholders.
- Identify attitudes and motivators at all levels of the organisation.
- Identify barriers and any possible show stoppers.

Step 3
Plan and organise
- Develop an energy strategy and get the managing director or CEO to sign it off.
- Set objectives and targets – these must be Specific, Manageable, Attainable, Realistic and Time dependent (‘SMART’) and have been agreed with the board.
- Produce an action plan with a complete roles and responsibilities matrix.
- Have key staff develop their own action plans.
- Establish monitoring procedures and identify key performance indicators (KPIs).
- Develop a procurement policy.

Step 4
Implement
- Initiate the action plan – go for ‘low-hanging fruit’ initially so you have success stories.
- Marketing campaign – publish performance and success stories to gain momentum.
- Initiate priority actions and investments.
- Overcome barriers and persuade – communicate success through the marketing campaign.
- Carry out staff training and an awareness campaign.
- Establish with line managers and ensure they understand the barriers to implementation.
- Communicate with other business processes and environmental initiatives.

Step 5
Monitor on-going performance
- Assess the programme against the objectives and action plan.
- Review progress – monitoring and targeting (M&T), key performance indicators (KPIs) etc.
- Plan continuous improvement – define standards and targets within the organisation – they must be stretching but not difficult.
- Review and learn lessons – see what works, what doesn’t and why.
- Adopt independent standards – ISO 50001 ([ref.10]).

2.2.2 Energy Policies

It is essential that any energy management programme has top level support and the first step in getting buy-in is the production of an energy policy approved by the Chairperson or CEO.

In developing an energy policy, these key points should be addressed:

- state the way energy is used
- state global targets
- state managerial responsibilities
- state staff responsibilities
- lay out future plans.

It is typically in two parts, where the first part is a high level statement. The second part should have specific objectives and targets and be used to:

- communicate board commitment
- raise staff awareness
• demonstrate commitment to key stakeholders
• underpin the energy strategy
• provide a structure for implementation.

A template is provided in Annex A but care should be taken in setting targets. Global targets should be built up from a sound knowledge base so that informed decision making occurs.

2.3 Refining the system

Although this approach is a great step forward to integrating energy management within an organisation’s managerial processes, it has a fundamental flaw. It does not close the loop and produce an iterative process where the lessons learnt feed back into the process, which is then improved.

Once the simple system is in place it should be refined in a manner that it learns from both its successes and any mistakes.

For the last few years BRE, has been advocating a ‘five-plus step’ approach, shown in Figure 2, where the loop is closed by a review and audit step whose analysis produces the lessons learnt. These are then fed into a plan for improvement which embraces all aspects of the process and includes an action plan for change. This approach should be adopted once the energy management programme has gained momentum.

Figure 2: BRE’s five-plus step approach to energy management
This approach is in line with the approach of a new International Energy Management Standard, EnMS, which was published in June 2011. ISO 50001 (5) took approximately three years to write, drawing on the skills of approximately 60 delegates from 23 countries. At the outset, the International Standards Organisation (ISO) stressed the importance and urgency of this standard to offer a common global approach to a key discipline, against the background of the low carbon future and expected short-term energy price rises. Compatibility with the International Environmental Management Standard (EnMS) ISO 14001 (6) was also seen as key.

2.4 Standardisation

Although the attainment of ISO 50001 should be the ultimate goal, because of the degree of rigour, and as a result, the resource implications, this should be achieved in the longer term. However, that does not mean the underlying philosophy and methodologies should not be taken on-board from the start.

ISO 50001 specifies requirements for an organisation to establish, implement, maintain and improve an energy management system. This allows organisations to take a systematic approach to the continuous improvement of energy performance, including efficiency, end-use and consumption. Even for organisations that have been committed to energy management for a long time, or which may already be certified to ISO 14001, case studies indicate that the more formalised processes required by the new Standard can lead to new opportunities and procedures being identified and implemented.

The framework and the major aims of the Standard are as follows:

- Improve energy performance in a systematic way through objectives, monitoring, use of targets and investment programmes. This is the key purpose of the standard.
- Establish, implement, maintain and improve an energy management system.
- Identify appropriate roles, responsibilities, needs for training, awareness, and so on.
- Include transport within the scope, if appropriate.
- Ensure compliance with the stated energy policy, including senior management reviews.
- Demonstrate conformance to other stakeholders.
- Certify the energy management system by external verification, or carry out self-evaluation and declaration.

2.4.1 PDCA approach

The key to ISO50001 is the approach it has adopted – the Plan, Do, Check, Act (PDCA) approach, set out in Figure 6:

- **Plan**: conduct the energy review and establish the baseline, energy performance indicators (EnPIs), objectives, targets and action plans necessary to deliver results that will improve energy performance in accordance with the organisation's energy policy.
- **Do**: implement the energy management action plans.
- **Check**: monitor and measure processes and the key characteristics of operations that determine energy performance against the energy policy and objectives, and report the results.
- **Act**: take actions to continually improve energy performance and the International Environmental Management Standard.
2.4.2 Applying PDCA

PDCA underpins all modern management standards and the key to applying PDCA is to first map out the clauses in ISO 50001 so that an outline roadmap is produced – see Figure 4.
Figure 4: ISO 50001 mapped out in terms of the PDCA approach
On a more practical level the following steps should be taken:

**Plan**
- Identify the parts of the business that could be improved by better energy use and define the scope/boundaries of the energy management system.
- Produce an energy policy to demonstrate top management commitment, which is vital to success.
- Appoint somebody to be the focal point; ensure they understand their role; are suitability qualified and have authority to act.
- Assign the necessary resources to establish the system.
- Determine any legal requirements plus any other requirements the organisation has signed up to- for example trade body or voluntary schemes.
- Carry out an energy review for the scope/boundary of the system you have set – determine energy sources and baselines and identify energy performance indicators.
- Determine the activities carried out within the boundaries of the system and their likely impact on energy use.
- Identify opportunities and produce an action plan which prioritises them with identifiable resources and timescales for implementation.

**Do**
- Use the learnings from the planning phase to implement the system.
- Train and make aware (of their impact) all the influencers on energy performance.
- Prepare the system documentation and controls.
- Ensure operational and maintenance activities are linked to and co-ordinated with those relating to energy performance.
- Review all processes and systems.
- Procure to energy saving standards both services; and plant & machinery.

**Check**
- Check activities and energy use match up.
- Ensure measuring equipment is fit for purpose.
- When a serious variation in usage is detected, determine the cause first and then take corrective action.
- Legislative compliance – record what was identified and how compliance was achieved.
- Perform internal audits to ensure the system is working; identify any deviations; determine the cause of the deviations and then take corrective action.
- Control and protect records generated by the system. At this point it is advisable to appoint a “Configuration Librarian”. This is a gate keeping role as they act as custodian and guardian of all the master copies.

**Act**
- Review the system regularly with top management – quarterly is the preferred minimum.
- Act on the outcomes of the management review.
3 Establishing the facts

When carrying out an in-depth review of an organisation it is essential to have a systematic approach to data collection and analysis. Alongside this, one must be able to position the company in terms of its organisational and managerial structure. The reasons for this are to determine the company’s attitudes to energy management and to help determine which type of project will be acceptable at board level.

In the 1990s, the UK’s Energy Efficiency Best Practice programme developed a tool for this – “Energy management priorities – a self-assessment tool” (7).

This tool uses energy management matrices (reproduced in Annex B), which are performance-based, to analyse an organisation in terms of:

- energy management
- financial management
- awareness and organisation
- technical issues.

It has two levels of matrices when applied to industrial situations:

- Top level matrix – this summaries the results for an organisation.
- Second level matrices – organisational matrices which map out the level of activity in each of the areas listed above and then feed into the top level.

It should be noted that not all matrices are relevant to each organisation or project.

The result is a simple tool for prioritising energy management activities by identifying areas for improvement, which will help maximise potential benefits.

A more in-depth discussion of how these matrices are used can be found in Section 8 – Action plan and option appraisal.

A cut-down version, designed for industry audits, is shown in Figure 5

**Figure 5: Simplified Energy Matrix for industrial energy surveys (8)**

<table>
<thead>
<tr>
<th>Policy</th>
<th>Organising</th>
<th>Training</th>
<th>Performance Measurement</th>
<th>Communicating</th>
<th>Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Energy Policy, action plan and regular review have active commitment of top management</td>
<td>Fully integrated into management structure with clear accountability for energy consumption</td>
<td>Appropriate and comprehensive staff training tailored to identified needs, with evaluation</td>
<td>Comprehensive performance measurement against targets with effective management reporting</td>
<td>Extensive communication of energy issues within and outside organisation</td>
</tr>
<tr>
<td>3</td>
<td>Formal policy but no active commitment from top</td>
<td>Clear line management accountability for consumption and responsibility for improvement</td>
<td>Energy training targeted at major users following training needs analysis</td>
<td>Weakly performance measurement for each process, unit, or building</td>
<td>Regular staff briefings, performance reporting and energy promotion</td>
</tr>
<tr>
<td>2</td>
<td>Unadopted policy</td>
<td>Some delegation of responsibility but line management and authority unclear</td>
<td>Ad-hoc internal training for selected people as required</td>
<td>Monthly monitoring by fuel type</td>
<td>Some use of company communication mechanisms to promote energy efficiency</td>
</tr>
<tr>
<td>1</td>
<td>Unwritten set of guidelines</td>
<td>Informal mainly focused on energy supply</td>
<td>Technical staff occasionally attend specialist courses</td>
<td>Invoice checking only</td>
<td>Ad-hoc informal contacts used to promote energy efficiency</td>
</tr>
<tr>
<td>0</td>
<td>No explicit energy policy</td>
<td>No delegation of responsibility for managing energy</td>
<td>No energy related staff training provided</td>
<td>No measurement of energy costs or consumptions</td>
<td>No communication or promotion of energy issues</td>
</tr>
</tbody>
</table>
There is also a need to identify the organisation’s key energy issues and drivers. Some of the key questions to answer are:

- Is energy usage an essential resource for a manufacturing process? If it is, then buildings have usually been considered as simply a shell for the manufacturing process and as a result have been largely ignored. This means that there could be untapped potential savings, but – a word of warning – any proposed measures should not interfere with the process.
- Is the organisation cost-sensitive? Is the organisation high volume/low cost or low volume/high cost?
- Is security of energy supply an issue? Is there a requirement for non-interruptible supplies and on-site generation?
- Are there legislative issues? For example: Environmental or health and safety.

Once you have a good insight into the company you need to dig deeper, and financial issues are the best place to start. You will need to determine who negotiates the supply contracts and where the contracts are located, then who is responsible for checking and paying the utility bills.

You can then go deeper and look at the procurement policy, and see if energy performance is an issue.

Examine the specifications for goods and services – do they have the following features similar to the following procurement standards and specifications:

- Are they on the UK’s government’s Energy Technology List (ETL) list – [http://etl.decc.gov.uk/etl](http://etl.decc.gov.uk/etl).

Remember the adage: “if you cannot measure something you cannot manage it”.

The next important step is to see where the meters are, what type they are, which areas they cover and which services, who reads them and what format the data is in. It is also important to find out whether the readings are used just for billing purposes or whether a monitoring and targeting (M&T) process is in place.

Alongside this, other site data can be useful in setting baselines, such as unit of output for each production line and hours of use.
4 Utility bills and metering

When considering energy usage in your building or site you will need to consider the following:

- Types of supply.
- Understanding your bills.

In general the types of supplies you will consider are:

- Electricity (grid and possibly renewable).
- Liquid Petroleum Gas (LPG).
- Fuel oil.
- Solid fuel.

The first action should be bill verification where the bills are checked against meter readings taken by the user to ensure they are correct and any discrepancies investigated. Remember to check that the identification number of the read meter matches that on the bill!

Then we should consider Consumption versus Cost. Figure 6 shows that if we are considering costs we should address issues with electricity first, because it represents nearly two thirds of the cost base despite being only about forty percent of the consumption.

Figure 6: Consumption and cost data from a simple case study
Secondly, we should remember that the most expensive utilities industry uses are those generated on site; for example compressed air and steam. It is essential that these “secondary” utilities are managed very closely and that their infrastructure is properly maintained.

This leads to questions about where sub-meters should be installed in order to identify where energy is being used most intensively. In general we should target the major usage points. The Carbon Trust guide GIL065, Metering energy in new non-domestic buildings (9), contains a step-by-step approach to sub-metering and makes recommendations for the size of plant where sub-metering would be reasonable (see Table 3). This approach is also valid for industry and is a good place to start as process and building loads need to be separated so they can be measured and managed properly.

Table 3: Size of plant where sub-metering would be reasonable (9)

<table>
<thead>
<tr>
<th>Plant item</th>
<th>Rated power input (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiler installations comprising one or more boilers or CHP plant feeding a common distribution circuit.</td>
<td>&gt;50</td>
</tr>
<tr>
<td>Chiller installations comprising one or more chiller units feeding a common distribution circuit</td>
<td>&gt;20</td>
</tr>
<tr>
<td>Electric humidifiers</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Motor control centres providing power to fans and pumps</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Final electrical distribution boards</td>
<td>&gt;50</td>
</tr>
</tbody>
</table>

4.1 Portable metering

When initially investigating energy usage and where sub-metering should be installed, temporary and portable metering solutions are often the solution (10). These are available in the form of clip on devices and other non-invasive options. They measure the flow of gas, electricity or water without interrupting it. Portable devices are beneficial for sites that require quick access to data (for example for trouble shooting), perhaps for initial analysis, or to inform the design of a more permanent metering and sub-metering solution. Portable solutions are generally regarded as temporary, and are not likely to be able to replace permanent sub-metering or the primary fiscal meter – see Case study 1 in Annex C.
5 Monitoring and targeting (M&T)

Monitoring and targeting (M&T) does not save energy or cut costs in its own right unless the information is acted on: for that to happen effectively, systems such as those described earlier must be in place.

It does, however, introduce systematic procedures for the long-term ‘tracking’ of energy use and identification of areas for improvement. This is achieved by establishing current consumption and comparing it with historical data and benchmarks for similar users. As a result you can set future targets and compare on-going performance against them. It also allows you to identify trends in consumption and areas for improvement by providing information for energy management action. Once a monitoring system is in place it can alert users to irregular patterns of consumption, which may be due to a planned change in activity or to other issues with the building usage or plant - see Case study 2 in Annex C.

As a result, the main benefits of M&T are in helping to control energy use and costs, and to identify anomalies in consumption to allow any problems with plant and machinery to be corrected as soon as possible (11).

M&T also helps to maintain occupant comfort, which has additional benefits such as increased productivity in the workplace. If the system is sophisticated enough, additional benefits are automatic meter reading, automatic reporting and bill validation.

A relatively small site may use a manual spreadsheet system or on-line solution, with invoice checking, monthly consumption and checking with basic targets. Larger sites with energy bills of more than 4.5M Rupees should consider specific M&T software solutions.

The main steps in monitoring and targeting are shown in Figure 7.

Figure 7: M&T process – four steps

<table>
<thead>
<tr>
<th>Step 1 Data collection</th>
<th>Step 2 Data analysis</th>
<th>Step 3 Reporting</th>
<th>Step 4 Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meter readings (half hourly, daily, monthly…)</td>
<td>Verify accuracy</td>
<td>What are the results/key findings of the analysis?</td>
<td>Not much point to M&amp;T if the reports from the data are not acted upon</td>
</tr>
<tr>
<td>Fuel bills</td>
<td>Convert the raw data into useable forms (filter, organise)</td>
<td>Mechanisms so this gets fed back into the ‘actions’ loop</td>
<td>Needs proper management structure to ensure the reports generated are used effectively</td>
</tr>
<tr>
<td>Related data such as units of productions or hours of use</td>
<td>Define targets and benchmarks, compare data</td>
<td>Summary of the key findings to management with more detailed reports of the relevant areas to key end users and responsible persons</td>
<td>Those responsible for energy need to plan actions from reports and obtain feedback on their implementation</td>
</tr>
<tr>
<td>Identify areas of interest or concern</td>
<td>Production of reports also triggered whenever targets are exceeded</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.1 Initial data analysis

Once you have collected the data (from bills, meters, etc.), produce a visual representation, such as histograms or line plots. Plot energy use versus time for day and night where half hourly data
is available (see Figure 8) and compare plots for weekdays and weekends. Ensure readings are taken at consistent times in each time period.

When only monthly data is available, you can take manual readings at the end of Friday and beginning of Monday for comparison. At this point you should look for trends; for example, does the energy use match occupancy and do long term changes match changes in output? This is the minimum you should do and the aim is to increase the frequency of data collection to half-hourly data as soon as possible.

This type of analysis is called **Precedent-based targeting** and is a method in which, usually, monthly consumption is gauged against the same month a year before. This is a simplistic method because it assumes that:

a) conditions were indeed comparable in the precedent month; and  
b) no waste had occurred which would inflate the target for the period being assessed.

Precedent-based targets can also be applied to half-hourly or other high-frequency data, usually by defining a profile ‘template’ on the basis of historical performance. Examples of how this is applied are given below.

**Energy usage**

![Figure 8: An example plot of energy usage over 24 hours](image)

The next step is to see if the base load is unusual. For an 8–12 hour occupancy period night loads should generally be very small (approaching zero), with exceptions for base services, such as IT servers and any associated cooling plant. If there is 24 hour occupancy with significant night occupancy, a rule of thumb is that the night load should be no more than 40% of the typical daytime consumption.

Particular attention should be paid to consumption at the start and end of occupied periods to ensure services are not coming on sooner than required. For example, is consumption still high in the evenings?

Next, look at the profile shape as this can identify items of plant and machinery switching on and off, and any changes. These profiles can also highlight poor control or malfunction and can be used to identify when plant is running (in the absence of sub-metering). The profile in Figure 8 has a double peak which may indicate that the plant shuts off and then re-starts – in general this
is an indication of poor control and should be investigated along with “is it necessary to have the plant running up to 6 pm?”

The next step is to compare the energy profile of different days with each other. Looking at Figure 9 the question that springs to mind is – why is Wednesday’s profile so high? There may well be a simple explanation, such as work continuing during lunch time that day, but it should be investigated.

This leads to Exception reporting when the usage is out of the limits expected and needs to be investigated. If the data collection is automatic, it may be possible to program the software to send an email alert to staff alerting them to the situation and requesting them to investigate. If this facility is available it is advisable to also have an alert where no data is collected, this is normally due to a meter failure or a communication failure between the meter and data collection device.

![Energy usage](image)

**Figure 9: Comparison of daily energy profiles**

Examining daily profiles can also reveal anomalous performance. For example, Figure 9 also shows an unusually high overnight consumption on Wednesday. On investigation the cause was found to be the chiller plant, which had been left running continuously after maintenance.

5.2 More complicated data analysis

Although Precedent-based targeting is a good starting point, once data collection is on-going the analysis should extend once enough data is collected, to Activity-based targeting. This is the process of estimating expected consumption volumes by reference to production throughput and other driving factors. The comparison between expected and actual consumption reveals randomly-occurring accidental avoidable waste and may indicate where plant and machinery are not performing, this leading to preventative maintenance and reduction of down-time.

The next step is statistical analysis: first the driving factor must be identified. In the example in Figure 10 for a factory, this is units of production. Other possible driving factors are given in Table 4.
Table 4: Possible industrial driving factors

<table>
<thead>
<tr>
<th>Energy Use</th>
<th>Driving factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chillers</td>
<td>Outside temperature; possibly humidity; volume of goods stored/processed; weight of goods stored/processed.</td>
</tr>
<tr>
<td>Steam</td>
<td>Quantity of steam produced (m$^3$) and pressure.</td>
</tr>
<tr>
<td>Compressed air</td>
<td>Quantity of air produced (m$^3$) and pressure.</td>
</tr>
<tr>
<td>Drying</td>
<td>Quantity of water removed from product.</td>
</tr>
<tr>
<td>Production process</td>
<td>Production quantity (weight/volume).</td>
</tr>
<tr>
<td>Manufacturing process</td>
<td>Number of units.</td>
</tr>
</tbody>
</table>

Although Figure 10 shows a simple linear relationship, this may not always be the case and more complicated algorithms may need to be investigated. Once this type of relationship is identified the parameters can be determined by linear regression:

For example: $Y \ (\text{kWh}) = [239 \times \text{production}] + 40,000$, then energy usage can be predicted. For example to produce 1000 units, the energy usage would be of the order of 280,000 kWh.

![Figure 10: Linear regression of energy usage versus factory production](image)
5.2.1 Alternatives to linear regression

Due to the complex nature of production processes it may not be possible to use simple variable linear regression and multi-variable analysis may be required. A common example of this is where a plant produces a variety of products, all with different energy intensities.

If it is possible to determine the base load, i.e. what the plant uses when no production takes place, and the energy intensity of each product type in term of KWh per unit; then you can predict the overall energy consumption of product runs.

For example a plant has a base load of 500 KWh per day and produces four products: A, B, C and D which need 1, 2, 5 and 10 KWh per day respectively to be produced.

A daily run might consist of:

- 1000 units of A which implies an expected energy demand of 1000 KWh.
- 750 units of B which implies an expected energy demand of 1500 KWh.
- 500 units of C which implies an expected energy demand of 2500 KWh.
- 300 units of D which implies an expected energy demand of 3000KWh.

The total predicted daily demand would then be 8000 KWh plus the baseline which gives a total of 8,500 KWh for that day.

If you wish to turn this daily energy usage for a product mix into a single variable for straight line analysis, you can consider the use of single product equivalence.

For example the daily run above is equivalent to the 8000 KWh/ 5KWh = 1,600 units of C. This is useful for a quick comparison but remember to take into account the base load when comparing the overall daily usage against a predicted value.

5.2.2 Cumulative SUM (CUSUM) analysis

This technique can be used to predict the energy performance assuming that performance of a process is consistent over a period of time and the actual values will be approximately equal to those predicted. In reality there will be times when consumption exceeds the predicted value and others when it will lower; however in the long run these variances will cancel out as long as the process conditions remain the same.

This sequential analysis technique shows the predicted consumption and the gradient shows the rate of change of use compared to target and indicates the following:

- Big slope = large deviation from target for that period
- Positive gradient = use is above target for period
- Negative gradient = use is below target for period
- Horizontal = use in period according to target.

In the case shown in Figure 11, consumption was reduced due to the installation of new plant (at point A) and then again when a new control system was installed and commissioned (at point B).
5.3 Targets, reporting and actions

As discussed above, targets need to be reviewed, and this should be done at least on an annual basis. They need to be Specific, Measurable, Attainable, Relevant and Time-bound (SMART), but also challenging enough to focus attention and ensure that cost-effective opportunities are not missed. This does not mean that continuously increasing year-on-year savings can be achieved without reference to the technical feasibility of achieving these savings. Also year-on-savings cannot be achieved without investment, so ring-fenced budgets are important to ensure that energy reduction programmes are successful.

If you want the information to be read and actioned, reporting should be targeted at the key stakeholders within the organisation, tailored to their individual needs, and the data kept relevant and concise.
6 Energy surveys, audits and walk-rounds

The terms ‘energy audit’ and ‘energy survey’ are used interchangeably, but the term **Energy Audit** is now the standardised term internationally and is all encompassing. Until the early 1980s energy audits were defined as addressing where energy was used and by what, whereas an energy survey was related to where energy was being wasted and what could be done about it. ISO 50001 refers to “Energy Review” not Audits but in practical terms the audits defined in BS EN 16247 more than meet the requirements.

ISO 50001 - Energy Management Systems (5) defines an **Energy Review** as: “determination of the organization's energy performance based on data and other information, leading to identification of opportunities for improvement”. This is very vague and does not reference any additional guidance except for the following note:

“In other regional or national standards, concepts such as identification and review of energy aspects or energy profile are included in the concept of energy review.”

The standard itself has the following clause covering this review:

**4.4.3 Energy review**

The organization shall develop, record, and maintain an energy review. The methodology and criteria used to develop the energy review shall be documented. To develop the energy review, the organization shall:

a) analyse energy use and consumption based on measurement and other data, i.e.
   – identify current energy sources;
   – evaluate past and present energy use and consumption;

b) based on the analysis of energy use and consumption, identify the areas of significant energy use, i.e.
   – identify the facilities, equipment, systems, processes and personnel working for, or on behalf of, the organization that significantly affect energy use and consumption;
   – identify other relevant variables affecting significant energy uses;
   – determine the current energy performance of facilities, equipment, systems and processes related to identified significant energy uses;
   – estimate future energy use and consumption;

c) identify, prioritize and record opportunities for improving energy performance.

NOTE Opportunities can relate to potential sources of energy, use of renewable energy, or other alternative energy sources, such as waste energy.

The energy review shall be updated at defined intervals, as well as in response to major changes in facilities, equipment, systems, or processes.

Again as stated earlier, there is no underpinning guidance within the standard on how to achieve the requirements of this clause. However, conducting an energy audit is essential in that it provides the data and information required for informed decision making.

A full energy audit is likely to involve a considerable amount of permanent or temporary sub-metering over a year or more. Audits are often carried out as a simple externally sourced exercise which is time and resource limited. If suitability qualified and experienced in-house members of staff are available extended assessments can be carried out. This is particularly important as the important aspects of organisational change and staff awareness are often ignored in favour in techy solutions which are easier to identify and quantify in the short term but may lack persistence in terms of their energy savings.

A desk study of international standards carried out by BRE concludes that although many countries have addressed the process of energy auditing, the audits of existing building energy
use are generally motivated by individual organisational requirements, in order to improve profitability or to demonstrate sustainability to stakeholders, such as shareholders, customers or the general public. Few countries have integrated into their schemes the impacts of the physical building asset and its operation in practice; few have anything other than high level codes of practice and few have underpinned their energy audit schemes with workable accreditation of assessors. This will be covered in BS EN 16247 Part 5: Qualifications of Energy Auditors, however this is in committee stage and yet to be drafted.

Audits should take into account relevant European or International Standards, such as ISO 50001:2011 - Energy Management Systems (5), or BS EN 16247-1:2012 - Energy audits - Part 1: General requirements (12).

Parts 2, 3 and 4, on Buildings, Process and Transport respectively, have been out for public consultation until early 2013, in the form of draft BS ENs 16247-2 (13), 16247-3 (14), and 16247-4 (15),

However, all these standards lack underpinning guidance and as a result Andy Lewry is currently producing a publication - ENERGY SURVEYS AND AUDITS - A guide to best practice. This publication is intended to provide sufficient flesh to the bones of the standard to enable good quality audits to be specified. This is being written in collaboration with ESTA, the Energy Services and Technology Association, the UK’s leading Energy Management industry association (http://www.esta.org.uk/) and will be available from August 2013.

The value of energy auditing is that it:

- Pulls all the relevant data together;
- Identifies data gaps;
- Maps the organisation;
- Identifies the organisation’s needs;
- Is organisation specific;
- Provides a snapshot of where an organisation is in terms of Energy Management;
- Identifies opportunities for savings and barriers to implementation.
- The data collected can also be used to create meaningful improvement targets through the application of data analysis (for example Regression Analysis and CUSUM techniques – see Section 5.2).

This is especially true when the audit is part of a larger structured energy management programme (7). Figure 12 shows how Energy audits feed in to energy review and planning processes which in turn underpin the Energy Policy.
From the perspective of this code of practice we will limit ourselves to industrial audit but it should be remembered that the process is carried out in a building and this should also be audited. To achieve this, the Mauritius Building Energy Audit Tool (MBEAT) should be used. This tool was produced as part of the Energy Audit Management scheme (EAMs) project for non-domestic buildings. The EAMs and this project are both part of a larger UNDP programme “Removal of Barriers to Energy Efficiency and Energy Conservation in Buildings”.

In addition the one area that often is overlooked is a review of the organisation and managerial aspects – see section 3. A common cause of failure to implement recommendations is the disconnect between the operational aspects of an organisation and its management and these soft issues also need to be highlighted. This is an essential pre-requisite before any audit is carried out to determine the degree and type of measures that are acceptable and can be taken on-board by the target organisation.

### 6.1 Industrial processes

The draft EN 16247-3 (5) concentrates on processes and also has a series of informative annexes:

- Annex B: Example list of data to be collected.
Annex C: Quality of data measurement plan.

Industrial processes are unique to the sector into which they belong, e.g. chemicals. However, they do have commonality in that a range of operations have to be carried out within that process:

- Crushing and grinding.
- Mixing and blending.
- Drying.
- Baking and curing.
- Machining, forming, and fabrication.
- Tanks and vats.
- Treatment booths and cabinets.
- High temperature processes.
- Low temperature processes.

To carry these out a range of technologies are required:

- Compressed air services.
- Central vacuum services.
- Electric motors and drives.
- Fans and pumps.
- Burners.
- Steam systems
- Cooling systems.
- Heat recovery.
- Mechanical handling.

It could be argued that this list is incomplete in that it does not include separation systems, boiler plant and furnaces.

A UK Energy Efficiency Best Practice programme (EEBPp) Good Practice Guide GPG 316 (8) deals with the majority of these subject areas and it should also be remembered that there will be overlap with the building envelope that houses them and its associated services.

In general process is “king” and this is especially true when the process has very specific requirements: for example with clean rooms within the pharmaceutical and semi-conductor sectors; or with ventilation requirements within a sterile environment such as the operating rooms of a hospital; even down to the colour resolution of task lighting when products are inspected during production.

Buildings are important and often ignored within such a working environment, leading to the loss of potential savings.
7 Installation, commissioning and maintenance

Industry has identified the two major sources of inefficiency as poor installation and commissioning, and insufficient maintenance.

Correct installation and commissioning ensure that plant and machinery function correctly, and provide the functionality required by the operators. Once the plant is up and running effective maintenance is needed to ensure that it is kept running efficiently, thus minimising energy costs. An effective maintenance regime will also protect the value of the asset, prolong its service life and minimise expensive repair work. In addition, it reduces risks to the business by minimising the downtime of any processes served, thus increasing productivity, while helping to address some of the organisation’s legal obligations such as health and safety.

However, in order to do this, the maintenance strategy must be preventative. This is where the maintenance is carried out according to schedules or the monitored condition of plant. The strategy aims to address problems by minimising their likelihood of occurring.

To have an effective energy management programme you must integrate and address these issues, and keep the operational staff closely involved.

For some technology areas checklists are available, for example Motors (16) and compressed air (17), or guidance may be part of a larger document (18). In either case these are aide-mémoire and are not to replace the in-depth system requirements as laid down by the manufacturer or supplier.

If you have a maintenance contractor you need to design the contract around the specific requirements of the plant and machinery as laid down in the handbooks supplied by the manufacturer or supplier. The contract selected will determine the level of service that is received. Contracts range from inspection maintenance, which provides a fixed number (usually one) of maintenance visits each year, to comprehensive, which covers scheduled maintenance visits as well as the cost of any further maintenance or repairs.

Suppliers should be able to recommend a good refrigeration service technician. In appointing a contractor, the following points should be considered:

- Are the contractors familiar with your particular type of plant and/or machinery?
- Are the contractors located locally and how quickly can they respond to call-outs?
- How will they provide support when their regular technician is unavailable?
- Do they have standard service and maintenance procedures that are relevant to the plant and machinery?
- Do they hold the correct company certification (for example: meeting the requirements of the F-Gas Regulation when dealing with refrigeration)?
- Are the technicians suitably trained (for example in handling refrigerants effectively and safely when dealing with refrigeration) and qualified?
- Do they operate under quality and environmental management systems?
- Are these accredited to ISO 9000 and ISO 14000 respectively?
- Do they have appropriate health and safety policies and safe systems of work for dealing with equipment and materials?
- Are they adequately insured?

This will help you to compare quotes and tenders for a maintenance contract and will provide a reference against which future performance and delivery can be measured.
8 Action plan and option appraisal

One of the most important tasks in carrying any initiative forward is producing an action plan, but the actions must first be generated. To do this we must go back to our objective of establishing the facts and to populate the energy matrices reproduced in Annex B (see Section 3 – Establishing the facts).

Once we have enough information about the organisation, its site, plant and machinery, building(s) and facilities we can populate these matrices by the following process.

The result will be a series of matrices similar to that in Figure 13.

This will review existing energy management practices within an organisation and create an overview of them. It can also be used to define targets for all activities and help prioritise energy management actions. Figure 13 shows a ‘hills and valleys’ profile, but the optimum profile to aim for is flat and level – therefore the areas with troughs need to be pulled up to the same level.

The next step is to analyse the matrices in more detail and produce high level actions that:

- balance short-, medium- and long-term priorities;
- aim to move up the matrices in a balanced way;
- identify the most important issues;
- concentrate on those issues you can influence;
- identify ‘low hanging fruit’ as ‘bankers’ which will be successful projects and which, in turn, can be used to promote success to senior management and staff;
- identify the actions needed for improvement of an organisation’s energy performance;
- include a costed action plan and timelines;
- consult with management and staff to get them on board.

<table>
<thead>
<tr>
<th>Policy</th>
<th>Organising</th>
<th>Training</th>
<th>Performance measurement</th>
<th>Communicating</th>
<th>Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Energy policy, action plan and regular review have active commitment of top management</td>
<td>Fully integrated into management structure with clear accountability for energy consumption</td>
<td>Appropriate and comprehensive staff training tailored to identified needs, with evaluation</td>
<td>Comprehensive performance measurement against targets, with effective management reporting</td>
<td>Extensive communication of energy issues within and outside organisation</td>
</tr>
<tr>
<td>2</td>
<td>Formal policy but not active commitment from top</td>
<td>Clear line management accountability for consumption and responsibility for improvement</td>
<td>Energy training targeted at major users following training needs analysis</td>
<td>Weekly performance measurement for each process, unit or building</td>
<td>Regular staff briefings, performance reporting and energy promotion</td>
</tr>
<tr>
<td>3</td>
<td>Undeveloped policy</td>
<td>Some delegation of responsibility but line management and authority unclear</td>
<td>Ad-hoc internal training for selected people as required</td>
<td>Monthly monitoring of fuel type</td>
<td>Some use of company communication mechanisms to promote energy efficiency</td>
</tr>
<tr>
<td>4</td>
<td>Lower than set guidelines</td>
<td>Informal mainly focused on energy supply</td>
<td>Technical staff occasionally attend specialist courses</td>
<td>Invoice checking only</td>
<td>Ad-hoc informal contacts used to promote energy efficiency</td>
</tr>
<tr>
<td>5</td>
<td>No explicit energy policy</td>
<td>No delegation of responsibility for managing energy</td>
<td>No energy related staff training provided</td>
<td>No measurement of energy costs or consumption</td>
<td>No communication or promotion of energy issues</td>
</tr>
</tbody>
</table>

Figure 13: A typical energy management matrix
Reproduced from the Carbon Trust publication – Strategic energy management overview (CTV022), 2010, copyright of the Queen’s Printer and Controller of HMSO.

To interpret these matrices the following guidelines can be used:

- **Level 0 score.** Energy management is virtually non-existent within the organisation. There is no energy policy, no formal delegation of energy management responsibilities, and no programme for promoting energy awareness within the organisation. Any equipment is unlikely to be energy efficient or to include any energy-efficient features.

- **Level 1 score.** Informal or rudimentary activities are in place. There is no specific energy policy, and reporting procedures and awareness matters are undertaken on an ad hoc basis. Some plant and equipment include energy-efficient features.
• **Level 2 score.** Senior management recognise the importance of energy management but there is little active support for energy management activities. The active members of staff are likely to be based in a technical department, and the effectiveness of energy management is restricted to the interests of a limited number of employees. Most plant and equipment is energy efficient.

• **Level 3 score.** Energy management is treated seriously at a senior level, and is incorporated within formal management structures. Energy usage is probably assigned to cost centre budgets, and there is an agreed system for reporting energy consumption, and promoting and investing in energy efficiency. Plant and equipment selection will be based on energy efficiency criteria such as the UK government’s Energy Technology List (ETL) list – [http://etl.decc.gov.uk/etl](http://etl.decc.gov.uk/etl).

• **Level 4 score.** This is indicative of a clear delegation of responsibility and authority for energy consumption throughout the organisation. Energy efficiency is regularly promoted both formally and informally. A comprehensive monitoring system is in place and performance is closely monitored against targets. Plant and equipment is selected for energy efficiency and its operation is monitored closely.

Levels 3 and 4 represent best practice for small and medium-sized enterprises (SMEs), and larger companies, respectively. In general stepping up one level represents a reduction in energy usage of 8–10%.

If there are issues of a technical nature, the third level technical matrices can be used to provide underpinning evidence for the four organisational matrices. These third level matrices should be used to support and guide planning for identifying and implementing energy-saving opportunities. In this case it is not as important to maintain a level profile.

The action plan which comes out of this exercise will have the following features:

- It is based on the energy policy objectives and targets.
- It will have been agreed by senior and line managers.
- Actions should fall out of policy objectives and targets.
- Actions should be a mixed portfolio varying in timescale and resource requirements.
- Actions should have clear timelines and reporting deadlines, and be assigned to an individual.
- Authority and responsibility should be delegated clearly.
- Resources – both time and budget – should be realistic.
- Actions should be clearly prioritised.

Options should be prioritised using a grid like that shown in Figure 14.
Once you have your portfolio of prioritised projects detailed financial cases can be put together.
9 Financial appraisal

In order to present an effective case to management to gain any form of commitment and investment, a transparent financial appraisal must be put forward. Effective financial appraisal will identify the best investments, optimise benefits, address risk management issues and carry out a performance analysis (19).

In putting a case together the steps below should be followed:

- Identify potential savings.
- Identify measures.
- Establish the costs and savings.
- Calculate the key financial indicators:
  - simple payback;
  - gross/net returns and their rates;
  - discounting and net present value (NPV);
  - index of profitability (IOP).
- Optimise the return.
- Establish the size of the pot.
- Optimise capital expenditure.
- Prioritise the projects.

The main issues that result in a failed case are poor base data, poor justification and the lack of a ‘do nothing’ scenario. Ensure the figures add up and can withstand scrutiny.

Other factors that will make the case more favourable are including maintenance savings and estimating increased productivity. The latter will probably need a staff survey to identify issues and wastage, and this may invoke sensitivities, so results and analysis should be made anonymous.

In addition you may have to persuade the funders that payback, although simple, can lead to misleading results. These results are not in the best interests of the organisation, because they will not lead to the best investment choice. This is because simple payback does not take into account savings over the lifetime of the project or the time value of money. Therefore, better simple metrics are net return (which is a measure of the benefit) and average net rate of return, which annualise this benefit over the lifetime of the project.

Some organisations use discounting and net present value (NPV) for project evaluation. However, even sophisticated metrics have their limitations. For example the disadvantage of NPV is that it does not take into account the initial capital (CapEx) outlay.

The most transparent metric is probably the index of profitability (IOP) which does take into account the CapEx outlay and should be at least 1 for a project to be considered.

These projects can be financed in a number of ways such as energy services contracts and shared savings.
10 Implementation and monitoring

Once all the management barriers have been overcome and resources made available all the actions have to be implemented. The most effective way of doing this is through an implementation plan. This will initiate priority actions and investments, with a view to carrying out training and awareness-raising to overcome resistance and publicise performance. This plan should have the following key features:

- It should be born out of the action plan.
- It should be launched internally to communicate and consult.
- Individual project plans should be derived from and be consistent with it.
- It should contain a process to monitor progress.
- It will aim to report progress and successes.
- It will aim to review the strategy and itself annually.

An essential part of keeping the momentum going and being able to show continuous improvement is the ability to monitor on-going performance. Monitoring and targeting must provide a live assessment of the programme which reviews progress through targets, which are linked to key performance indicators. From this on-going monitoring, continuous improvement can be planned and the whole process must be auditable, preferably by achieving independent standards.

11 Review, lessons learnt and continuous improvement

Earlier we discussed the five-step plus approach to energy management. This emphasizes the importance of having a continuing system of learning from both mistakes and successes, which can be carried forward iteratively. Therefore, as part of the audit processes you must identify these lessons. Once you have identified the successes and failures you can go through the learning exercise to produce an action plan for change. The plan should build on the successes and attempt to learn from failures by tackling any barriers.

When energy-saving projects are carried out, it is important to check how effective they have been. This is essential where there are contractual consequences, but it can be equally true where there are not. Rigorous evaluation increases transparency and trust, and enables you to discriminate between ineffective projects and those which deserve to be replicated. It can also identify projects which have failed because of some minor issue which can be readily resolved. It discourages cowboys and fraudsters, and makes a proposal for a project far more credible. As a result a project is more likely to attract funding if it is known that its results will be exposed to thorough scrutiny. The International Performance Measurement and Verification Protocol (IPMVP) Volume I (20) sets a framework for, and defines the terms used in, the evaluation of energy saving (or what it terms 'avoided energy use'). IPMVP seeks to secure transparency, completeness, conservativeness, consistency and relevance in evaluations without being excessively prescriptive; it is rapidly being adopted worldwide as a de facto standard.
12  Staff awareness campaigns

An essential part of any energy management programme is to raise awareness and encourage culture changes. A major part of this is awareness campaigns and there are four steps to embedding this within an organisation (21):

- Good planning – so you can realistically achieve your goals;
- Effective implementation – choosing the correct time and assigning roles and responsibilities;
- Checking the effectiveness of the programme and reviewing awareness throughout your company – allowing room for feedback;
- Maintaining the right level of commitment.

12.1  Planning

This is fundamental to the success of an energy awareness programme. The main points to consider are:

- Support and resources;
- Your current situation;
- Your target audience and goal setting;
- Messages and communication channels.

Support from senior management is critical and should be visible to all staff in the organisation. Without their support, your programme will probably fail; persuading a member of the senior management team to champion the campaign will significantly improve its chances of success.

You will need dedicated resources especially with the following aspects:

- Marketing – you will dedicate support in this area especially with messaging, production of materials and routes to market.
- Services – especially IT.

The need step is then to address the following issues:

- **Secure a budget** – this should be realistic and of the order of 1-2% of the total utility bill. An investment of this magnitude has been shown to realise savings of between 5 and 10%.
- **Time allocation** – within the budget the organiser should have sufficient time allocated and this should be in a dedicated slot within their work schedule.
- **Current situation** – you must assess where you are and map the organisation - see Section 3. At this point a **staff survey** is necessary to determine attitudes and awareness around energy waste. **Identify high usage and possible waste** – using M&T (section 5) and auditing (see section 6).
- **The target audience and goal setting** – Define the audience, target high-energy users, identify what they need to do and set goals.
- **Messages and communication channels** - Create content, select relevant motivational themes (see table 4), use appropriate language and select the right communication channels.
### Table 4: What will motivate staff to save energy?

<table>
<thead>
<tr>
<th>Motivation</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased productivity</td>
<td>More efficient equipment allows people to do their jobs better.</td>
</tr>
<tr>
<td>Marketing</td>
<td>Energy efficiency is a positive step towards greater environmental responsibility. Corporate responsibility is important in many boardrooms, and being seen as ‘green’ enhances an organisation’s reputation amongst customers and shareholders.</td>
</tr>
<tr>
<td>Improved reliability</td>
<td>Equipment used efficiently and correctly works better and longer, resulting in cost savings, less equipment downtime and fewer demands on maintenance staff.</td>
</tr>
<tr>
<td>Financial</td>
<td>Energy awareness leads to cost savings which lead to higher profit margins. Be aware that employees are usually only motivated to save money for their employer when they feel that better financial performance leads to increased job security and/or profit-related bonuses.</td>
</tr>
<tr>
<td>Environmental</td>
<td>Make people aware of the positive effect their actions can have on their global and local environments. Saving energy is one of the simplest green actions. For some, environmental issues are significant. By making the link between energy use, carbon dioxide emissions and the environment, people can appreciate that they can make a difference.</td>
</tr>
<tr>
<td>Improved comfort</td>
<td>Better control of heating and lighting leads to a more comfortable working environment. This may have potential health benefits and may result in greater productivity.</td>
</tr>
<tr>
<td>Morale</td>
<td>Having better working conditions as a direct result of being energy efficient has a positive effect on the attitude of most people.</td>
</tr>
<tr>
<td>Saving in the home</td>
<td>Although staff may not always respond to energy awareness at work, most will be interested in saving energy at home and on the road. People are motivated by self-interest; persuade them that methods used to save energy at work can apply to the home and save them money.</td>
</tr>
<tr>
<td>Charitable giving</td>
<td>Some people are motivated by helping others. Appeal to them by agreeing to donate a percentage of the energy cost savings to charities nominated by staff.</td>
</tr>
<tr>
<td>Competition</td>
<td>Some people respond to the challenge of competition. Set up on-going competitions to see which sites, buildings or departments can make the greatest energy savings. Publicise the results regularly and if possible award a prize to the best every year.</td>
</tr>
<tr>
<td>Recognition</td>
<td>Recognise the actions and successes which staff make with energy savings. This will encourage them to make further suggestions</td>
</tr>
</tbody>
</table>

#### 12.2 Implementation

The programme has been planned and now it has to be actioned – part of the above should be an action plan which covers the following:

- **Timings** – programmes should start avoid times when the organisation is really busy, holiday periods or when staff morale may be low.
- **Length** – the campaign should continuous as the message becomes embedded with re-enforcement. However, there is a danger it could become stale and this is where re-enforcement with statistics and a creative touch are essential to longevity.
- **Assign roles and responsibilities** – but with authority to act and any Energy Team must represent all interested parties within an organisation.
- **Champions** – local delivery is essential and on-the-ground champions are essential to success – this could be done at a departmental, building or floor level.
- **Gather and prepare promotional materials** – enlist the help of the marketing department to ensure these look professional with short, catchy and punchy themes and slogans.
• **Launch** – need to kick start your campaign and an opening event which the majority of staff attend is usually most successful. Ensure it has senior management buy-in and that they endorse it and fully participate in all activities.

• **Feedback** – collect people’s comments and suggestions with resources in place to address them where appropriate.

### 12.3 Reviewing and communicating

In order to give the campaign credibility you must measure the success of the programme transparently. This is where using M&T (section 5) and auditing (see section 6) are essential in tracking the progress of the organisation along with revisiting the energy matrices (see annex A) to see which areas have progressed.

Success stories can then be used to show success and give the campaign momentum. At this point staff feedback should be formally captured and actioned so that buy-in is achieved. Consideration should be given to a staff forum such as an electronic noticeboard to capture the feedback and show the consequent actions.

It is also important to get on the board room agenda to report the successes and progress so that senior management continues to support the initiative.

### 12.4 Maintaining awareness

The ultimate aim is for energy awareness to become embedded in the organisational culture in the same way as health and safety, quality and customer care. As a result awareness is a great tool but should not stand-alone. The wider management issues need to addressed and as mentioned earlier in section 2.2.2 the energy policy must be the focal point for all this activity.

In addition to maintain momentum the following should be carried out:

• New employee induction should include a section on energy.
• Continue with messages.
• Where possible build energy into job descriptions.
• Include energy efficient processes in workplace and managerial processes.
• Include energy usage in the procurement of plant and machinery, and when training staff on how to operate it.
• Refresh all promotional materials at regular intervals.
• Use staff completions as a vehicle but be careful to make the playing field fair otherwise this can lead to demotivation amongst some of the participates.
### References


3. Carbon Trust, Strategic energy management overview (CTV022), 2010.


10. Carbon Trust, Metering – Introducing the techniques and technology for energy data management (CTV061), 2012.


Carbon Trust publications are downloadable from [www.carbontrust.co.uk/publications/pages/home.aspx](http://www.carbontrust.co.uk/publications/pages/home.aspx)

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Corporate policy statement

Our long and medium-term corporate goals are:
Commit organisational resources to energy management
Reduce our energy costs
Give high priority to energy efficiency investments
Consider life-cycle energy costs for all new projects
Minimise CO$_2$ emissions
Minimise environmental impact
Where possible, to use energy from sustainable sources.

Our short-term objectives are:
Publish a corporate energy policy
Reduce environmental impact of fuels used by reducing our emissions of a tonnes of CO$_2$ by $x$% over $y$ years
Reduce consumption of energy by $x$% of $z$ units of energy delivered over (say) $y$ years
Reduce energy consumption to typical/good practice benchmark levels within $y$ years
Achieve accreditation under the Energy Efficiency Accreditation Scheme
Achieve the emissions reduction target set in our climate change agreement
Implement a regular programme of energy audits
Set and publish performance improvement targets
Report performance changes and improvements annually
Increase staff awareness
Nominate employees to act as departmental energy champions
Seek competitive tenders for gas and electricity supplies
Identify all cost-effective energy efficiency measures
Establish a monitoring and targeting system
Provide regular management reports on costs and consumption
Establish a budget for investing in energy efficiency
Specify energy efficient design of new buildings, and procure energy efficient plant and equipment.

Endorsed by the Board: ..........................................................................................................................

Date: ...........................................................................

NB. Long term – 3-5 yrs.; Medium term – 1yr; Short term – a few months
Statement of commitment

We are committed to:

- Purchasing energy at the most cost-effective price
- Increasing energy efficiency in terms of, for example, energy consumed per unit of production (for industry)
- Reducing CO$_2$ emissions
- Investing in new technology where this meets investment criteria (including renewable energy sources)
- Considering life cycle energy costs when procuring new projects
- Purchasing energy-efficient plant and equipment (including office equipment)
- Reducing environmental emissions associated with travel (including employee travel to work, business travel and distribution of goods)
- Entering into a climate change agreement via our trade association
- Investing in energy-saving technologies that are eligible for enhanced capital allowances.

We will address energy efficiency in all areas of our business including:

Management issues
- Define roles and responsibilities for energy
- Educate and raise awareness among staff
- Encourage continual professional development (CPD) for technical staff involved in energy
- Establish clear reporting procedures
- Publicise our performance and report areas for improvement

Procurement issues
- Procure equipment with low energy ratings
- Consider life-cycle energy costs for new projects and modifications to existing plant
- Establish technical guidelines for new projects and refurbishment

Financial issues
- Establish ownership of energy costs at departmental level
- Establish ownership for invoice verification

Technical issues
- Establish procedures for operation of plant and equipment.

We will improve on past performance.

Over the past $y$ years:
- Our energy costs have increased/decreased by $x\%$
- Our energy efficiency has increased/decreased by $x\%$
- Our emissions of CO$_2$ have increased/decreased by $x\%$
- Our consumption of fossil fuels has increased/decreased by $x\%$
- Our consumption of renewable energy has increased/decreased by $x\%$
- Our investment in clean, energy-efficient technologies has increased/decreased by $x\%$

We are committed to reversing/reinforcing/accelerating this trend/these trends through a strategic action plan which will be reviewed for progress and updated each year.

Chair’s signature: .......................................................... ..........................................................

Date: ..........................................................
## Annex B - Energy management matrices

**TOP-LEVEL MATRIX – ENERGY PERFORMANCE**  
(using results from the four ‘organisational matrices’)

<table>
<thead>
<tr>
<th>Level</th>
<th>Column 1 score</th>
<th>Column 2 score</th>
<th>Column 3 score</th>
<th>Column 4 score</th>
<th>Column 5 score</th>
<th>Column 6 score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Awareness and information</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## SECOND-LEVEL MATRIX – ENERGY MANAGEMENT

<table>
<thead>
<tr>
<th>Level</th>
<th>Energy policy</th>
<th>Organising</th>
<th>Motivation</th>
<th>Information systems *</th>
<th>Marketing</th>
<th>Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Energy policy, action plan and regular review have commitment of top management as part of an environmental strategy.</td>
<td>Energy management fully integrated into management structure. Clear delegation of responsibility for energy consumption. Energy committee chaired by board member.</td>
<td>Formal and informal channels of communication regularly exploited by energy manager and energy staff at all levels.</td>
<td>Comprehensive systems set targets, monitor consumption, identity faults, quantify savings and provide budget tracking.</td>
<td>Marketing the value of energy efficiency and the performance of energy management both within the organisation and outside it.</td>
<td>Positive discrimination in favour of ‘green’ schemes with detailed investment appraisal of all new-build and refurbishment opportunities.</td>
</tr>
<tr>
<td>3</td>
<td>Formal energy policy, but no active commitment from top management.</td>
<td>Energy manager accountable to energy committee representing all users.</td>
<td>Energy committee used as main channel together with direct contact with major users.</td>
<td>M&amp;T reports for individual premises are based on sub-metering. Achieved performance against targets reported effectively to users.</td>
<td>Programme of staff awareness and regular publicity campaigns.</td>
<td>Same payback criteria employed as for all other investment.</td>
</tr>
<tr>
<td>2</td>
<td>Un-adopted energy policy set by energy manager or senior departmental manager.</td>
<td>Energy manager in post, reporting to ad hoc committee, but line management and authority are unclear.</td>
<td>Contact with major users through ad hoc committee chaired by senior departmental manager.</td>
<td>Monitoring and targeting reports based on supply meter data. Energy unit has ad hoc involvement in budget setting.</td>
<td>Some ad hoc staff awareness training.</td>
<td>Investment using short-term payback criteria only.</td>
</tr>
<tr>
<td>1</td>
<td>An unwritten or uncoordinated set of guidelines.</td>
<td>Energy management is the part-time responsibility of someone with limited authority or influence.</td>
<td>Informal contacts between engineer/technical staff and a few users.</td>
<td>Cost reporting based on invoice detail. Engineer compiles reports for internal use within technical department.</td>
<td>Informal contacts used to promote energy efficiency.</td>
<td>Only low-cost measures taken.</td>
</tr>
<tr>
<td>0</td>
<td>No explicit policy.</td>
<td>No energy management or any formal delegation of responsibility for energy consumption</td>
<td>No contact with users.</td>
<td>No information system. No accounting for energy consumption.</td>
<td>No promotion of energy efficiency.</td>
<td>No investment in increasing energy efficiency in premises.</td>
</tr>
</tbody>
</table>

* refer to third-level matrix: ‘monitoring and targeting’ for information to support this column.
## SECOND-LEVEL MATRIX – FINANCIAL MANAGEMENT

<table>
<thead>
<tr>
<th>Level</th>
<th>Identifying opportunities</th>
<th>Exploiting Opportunities</th>
<th>Management Information</th>
<th>Appraisal Methods</th>
<th>Human Resources</th>
<th>Project funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Detailed energy surveys are regularly updated. Lists of high-and low-cost opportunities already costed and ready to proceed immediately.</td>
<td>Formal requirement to identify the most energy-efficient option in all new-build, refurbishment and plant replacement projects. Decisions made on the basis of life cycle costs.</td>
<td>Full management information system enabling identification of past savings and further opportunities for investment meeting organisation’s financial parameters</td>
<td>Full discounting methods using internal rate of return and ranking priority projects as part of an on-going investment strategy.</td>
<td>Board take a proactive approach to a long-term investment programme as part of a detailed environmental strategy in full support of the energy management team.</td>
<td>Projects compete equally for funding with other core business investment opportunities. Full account taken of benefits which do not have direct cost benefit, e.g. marketing opportunities, environmental factors.</td>
</tr>
<tr>
<td>3</td>
<td>Energy surveys conducted by experienced staff or consultants for buildings likely to yield largest savings.</td>
<td>Energy staff are required to comment on all new-build, refurbishment and plant replacement projects. Energy efficiency options often approved but no account is taken of life cycle costs.</td>
<td>Promising proposals are presented to decision-makers but insufficient information (e.g. sensitivity or risk analysis) results in delays or rejections.</td>
<td>Discounting methods using the organisation’s specified discount rates.</td>
<td>Energy manager working well with accounts/finance department to present well-argued cases to decision makers.</td>
<td>Projects compete for capital funding along with other business opportunities, but have to meet more stringent requirements for return on investment.</td>
</tr>
<tr>
<td>2</td>
<td>Regular energy monitoring/analysis identifies possible areas for saving.</td>
<td>Energy staff are notified of all project proposals with obvious energy implications. Proposals for energy savings are vulnerable when capital costs are reduced.</td>
<td>Adequate management information available, but not in the correct format or easily accessed in support of energy-saving proposals.</td>
<td>Undiscounted appraisal methods – e.g. gross return on capital.</td>
<td>Occasional proposals to decision makers by energy managers with limited success and only marginal interest from decision makers.</td>
<td>Energy projects not formally considered for funding from capital budget, except when very short-term returns are evident.</td>
</tr>
<tr>
<td>1</td>
<td>Informal ad hoc energy walkabouts conducted by staff with checklists to identify energy-saving measures.</td>
<td>Energy staff use informal contacts to identify projects where energy efficiency can be improved at marginal cost.</td>
<td>Insufficient information to demonstrate whether previous investment in energy efficiency has been worthwhile.</td>
<td>Simple payback criteria are applied. No account taken of lifetime of the investment.</td>
<td>Responsibility unclear and those involved lack time, expertise and resources to identify projects and prepare proposals.</td>
<td>Funding only available from revenue on low-risk projects with paybacks of less than one year.</td>
</tr>
<tr>
<td>0</td>
<td>No mechanism or resources to identify energy-saving opportunities.</td>
<td>Energy efficiency not considered in new-build, refurbishment or plant replacement decisions.</td>
<td>Little or no information available to develop a case for funding.</td>
<td>No method used irrespective of the attractiveness of a project.</td>
<td>No-one in organisation promoting investment in energy efficiency.</td>
<td>No funding available for energy projects. No funding in the past.</td>
</tr>
<tr>
<td>Level</td>
<td>Energy management responsibilities</td>
<td>Energy efficiency awareness</td>
<td>Reporting procedures</td>
<td>Review of energy performance</td>
<td>On-going training</td>
<td>Market awareness</td>
</tr>
<tr>
<td>-------</td>
<td>----------------------------------</td>
<td>----------------------------</td>
<td>----------------------</td>
<td>-----------------------------</td>
<td>------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>4</td>
<td>Lists of responsibilities and their assignment exist and are comprehensive and regularly reviewed. All staff have responsibilities.</td>
<td>Energy efficiency performance regularly presented to all staff. Full use made of publicity. Advantage taken of all available dissemination routes for promoting new measures for saving energy.</td>
<td>Comprehensive reporting of current status compared with best practice, on regular basis and geared at a variety of audiences. Full support to public statements.</td>
<td>Energy and water efficiency regularly reviewed. Performance compared against internal and external references or benchmarks. Ideas actively sought.</td>
<td>Continuous professional development properly resourced for technical and premises staff. Active technical library. All staff have ready access to domestic and non-domestic energy efficiency information.</td>
<td>Keep abreast of technological developments by on-going monitoring of trade journals, literature and other sources on issues affecting energy efficiency.</td>
</tr>
<tr>
<td>3</td>
<td>Lists of responsibilities and their assignment exist for key energy staff and all departments.</td>
<td>Energy efficiency status presented to all staff at least annually. Occasional but widespread use of publicity to promote energy-saving measures.</td>
<td>Current status reports issued annually to shareholders and staff. Impartial reporting of performance to staff and departments on a regular basis.</td>
<td>Frequent energy efficiency reviews using monitored consumption and cost data. Analysis is regular, wide-ranging but ritualistic.</td>
<td>Continuous professional development for technical and premises staff. All staff are aware of and have access to an energy efficiency library.</td>
<td>Regular studies carried out on trade journals, literature and other sources to assess current developments impacting on energy efficiency.</td>
</tr>
<tr>
<td>2</td>
<td>Some staff and departments have written responsibilities.</td>
<td>Energy performance presented to staff on a regular basis. Occasional use of publicity for promoting energy-saving measures.</td>
<td>Occasional issue of energy efficiency status reports. Concentrates on good news.</td>
<td>Occasional technical energy efficiency reviews. Regular cost checks with exception reporting. Analysis of limited scope.</td>
<td>Technical and premises staff development mainly via professional and technical journals. Occasional initiatives to train staff in energy efficiency.</td>
<td>Trade journals, literature and other sources scanned on an ad hoc basis for information on the latest developments relating to energy efficiency.</td>
</tr>
<tr>
<td>1</td>
<td>Unwritten set of responsibility assignments.</td>
<td>Energy performance occasionally reported and known to very few staff. Energy-saving measures are rarely promoted.</td>
<td>Reports only issued if prompted by a business need. Most reports will contain only good news.</td>
<td>Energy review activity based on revenue costs. Limited exception reporting only.</td>
<td>Energy efficiency awareness generally low. A few staff have knowledge of energy efficiency techniques and facts. Little, if any, training in energy efficiency for staff.</td>
<td>Trade journals, literature and other sources studied for energy implications when a purchase is imminent.</td>
</tr>
<tr>
<td>0</td>
<td>No evidence of assignment of energy efficiency tasks and duties.</td>
<td>No staff have explicit responsibilities or duties.</td>
<td>No reporting.</td>
<td>No monitoring activity to underpin review processes.</td>
<td>Little, if any, knowledge of energy efficiency amongst staff. No attempt made to inform staff of techniques and benefits of energy efficiency.</td>
<td>Energy efficiency not a consideration when keeping up to date on products or technology.</td>
</tr>
</tbody>
</table>
## Second-Level Matrix – Technical

<table>
<thead>
<tr>
<th>Level</th>
<th>Existing Plant and Equipment*</th>
<th>Plant and Equipment Replacement</th>
<th>Maintenance Procedures</th>
<th>Operational Knowledge</th>
<th>Documentation and Record Keeping</th>
<th>Operational Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>The majority of existing equipment (fixed plant and portable appliances) incorporates best practice energy-efficient features, is correctly commissioned for energy efficiency features, and is correctly commissioned for energy efficiency and well maintained.</td>
<td>Equipment is selected to be the most appropriate to the application. Life cycle costs and energy efficiency are taken into account. Energy saving is a major consideration in product selection.</td>
<td>Maintenance is based on needs, with formal condition appraisal methods being performed for all equipment and fabric elements affecting energy efficiency. Results acted upon where necessary.</td>
<td>All staff understand how their roles impact on energy efficiency and take positive steps to minimise energy use. Staff receive targeted training in energy efficiency.</td>
<td>Fully detailed descriptions of system concepts, plant control and operation. Detailed schedules of all plant, instrumentation and controls.</td>
<td>Operation methods and settings for energy efficiency defined and implemented. Full utilisation of feedback from monitoring.</td>
</tr>
<tr>
<td>3</td>
<td>Equipment and plant is appropriately selected, energy efficient, commissioned low energy consumption and well maintained.</td>
<td>Equipment is selected to be appropriate to the application with energy-saving features taken into consideration. Life cycle costs and energy efficiency are evaluated.</td>
<td>Condition surveys carried out regularly on equipment and fabric elements affecting energy efficiency. Action undertaken for most defects identified.</td>
<td>Staff are aware of how they affect energy use and take all good housekeeping measures to save energy. Further training received on a regular basis.</td>
<td>Detailed descriptions of plant control and operation, and outline system concepts. Reasonably detailed schedules of all plant instrumentation and controls.</td>
<td>Delivered conditions and operating methods for energy efficiency defined and implemented. Informal use of information from monitoring.</td>
</tr>
<tr>
<td>2</td>
<td>Most equipment is not specifically energy efficient, but either was commissioned or is being regularly maintained for low energy consumption.</td>
<td>Equipment selected to be fit for purpose, bearing in mind likely life cycle costs and energy efficiency factors.</td>
<td>Condition surveys carried out regularly on all equipment and fabric elements affecting energy efficiency. Remedial work constrained by budgets.</td>
<td>Most good housekeeping practices are adhered to in an attempt to reduce energy usage. Occasional energy efficiency training received.</td>
<td>Basic descriptions of plant control and operation. Basic plant instrumentation and control schedules for most control systems.</td>
<td>Targets set against realistic budgets, and maintained through financial procedures.</td>
</tr>
<tr>
<td>1</td>
<td>Equipment is not energy efficient, but has been commissioned for economy and undergoes periodic maintenance.</td>
<td>Power efficiency data on products obtained as part of selection process.</td>
<td>Condition surveys and occasional activity, often prompted by plant failure or safety considerations. Remedial work only carried out on major defects.</td>
<td>Energy-saving techniques are only adopted where they can be easily accommodated within traditional working practices.</td>
<td>Minimal or poor plant control and operation. Plant instrumentation and control schedules for only some of the plant and control systems.</td>
<td>Targets set by default through budget through budget setting procedures.</td>
</tr>
<tr>
<td>0</td>
<td>Energy performance has not been considered during the procurement, commissioning or maintenance of existing plant and equipment.</td>
<td>No consideration of energy efficiency in product selection.</td>
<td>No regular surveys or maintenance carried out.</td>
<td>No consideration is given to energy efficiency during working operations.</td>
<td>None available.</td>
<td>No targets set.</td>
</tr>
</tbody>
</table>

* Where necessary, refer to further detail in the technical (third level) matrices for information to support this column.
Annex C – Industrial case studies

Case study 1: CHEP

CHEP, the global leader in pallet and container pooling services, has implemented an environmental sustainability programme to reduce the impact of its plant operations. CHEP is now using Elcomponent’s SPC Pro portable three-phase energy data loggers to monitor the energy use of individual plant and processes across Europe. CHEP selected SPCPro for this application because it is easy and safe to use, it requires no special knowledge of electrical systems to operate and because of its compact and lightweight, yet robust, construction.

The SPCPro energy data loggers are playing a key role in CHEP’s ‘Measure to Manage’ programme, which the company has implemented to provide accurate and detailed information about the energy consumed by machines and equipment in its service centres in the UK, Ireland, Benelux and Spain.

The information produced by the data loggers is carefully analysed, using the ‘PowerPackPro’ software package supplied as part of the SPCPro kit, to reveal areas of high consumption and to identify opportunities for improving energy management so as to reduce both the company’s expenditure on energy and its carbon footprint.

Since CHEP has so many sites and so much equipment, portable instruments were the logical (and very cost-effective) choice for this application. Many portable three-phase energy data loggers, however, require specialist knowledge to use safely since they require voltage connections to be made to all three phases, usually with some form of temporary connector such as a crocodile clip. While this is no problem for a properly trained technician, it is certainly not a task that should be attempted by anyone who does not have the appropriate skills.

By contrast, the SPCPro requires only one voltage input and this is easily and safely obtained by plugging the instrument in to the nearest wall socket - a job which anyone can do safely. The instrument’s current transformers are fully insulated flexible loop types and are, therefore, equally safe and easy to use.

Case study 2: Chemical works

A chemical works applied M&T to the steam consumption in some distillation columns, carrying out a weekly assessment of consumption against theoretical demand calculated from 20-minute-interval data on material flows and temperatures. It found a number of instances of avoidable waste, such as a case where the operators had bypassed a heat recovery unit and another where steam was leaking through a faulty trap.

In the latter case the fault was already known about, but its cost implications were not.

The company also discovered (by chance) that it was possible to operate slightly outside the stipulated ‘reflux ratio’ and achieve higher thermal efficiency. Manual control was replaced with an automatic loop by reprogramming the plant control system, and the more efficient settings were adopted as the norm.
The factory’s process managers found the M&T scheme useful for comparing the relative thermal efficiencies of their distillation columns, enabling them to schedule production on a least-energy basis. It also gave them the ability to optimise maintenance shutdowns, as internal fouling and disintegration can now be detected through a deteriorating energy efficiency. They also welcomed the fact that operators no longer have to try to assimilate dozens of flow and temperature readouts, nor guess whether any deviations are significant or not; the overspend league table gives them a simple weekly summary of where, if anywhere, waste is occurring.