

Power Quality and Utilisation Guide

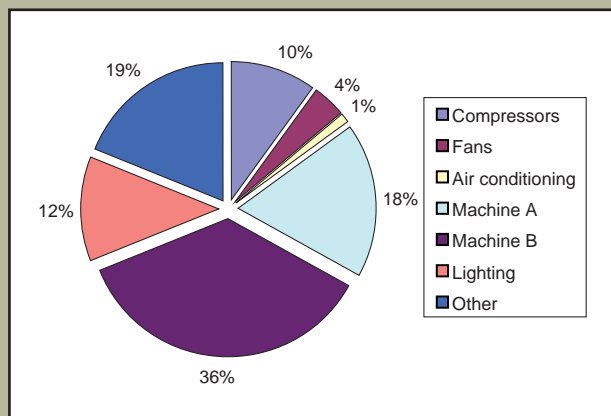
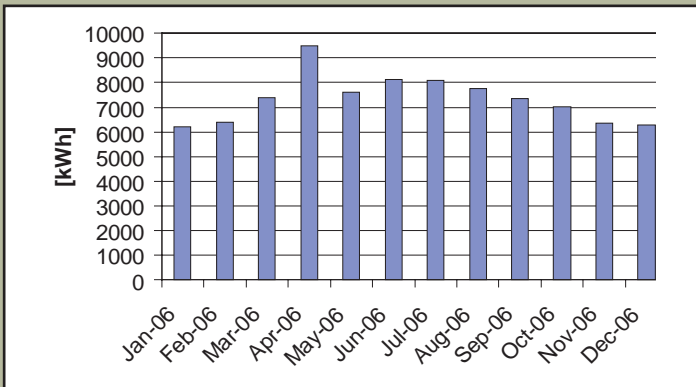


Energy Efficiency

Energy management: self assessment

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1. Introduction

Many industries wish to monitor and improve their energy performance for both economic and ecological reasons. Businesses can benefit significantly by moving towards energy management practices. There are more motives besides reducing costs to implement an effective energy management system; the improved performance can have a positive effect on production, operations, maintenance and environmental issues.

A first step towards an energy management system is a global analysis of the energy flows to better understand the potential for improvement. Getting information about energy consumption is an effective starting point for industries that want to lower their energy bill. Three types of energy use are found in manufacturing facilities: direct production of goods, space conditioning and general facility support such as lighting.

Most energy reduction opportunities in industrial facilities are identified after observation and analysis of the facility. However, much can be done before a site visit to identify possible energy-reduction opportunities.

Basic techniques can:

- Quantify production, space conditioning and non-production related energy use
- Uncover some energy savings opportunities
- Help develop reasonably accurate budgets and costing models
- Tack savings due to better energy usage

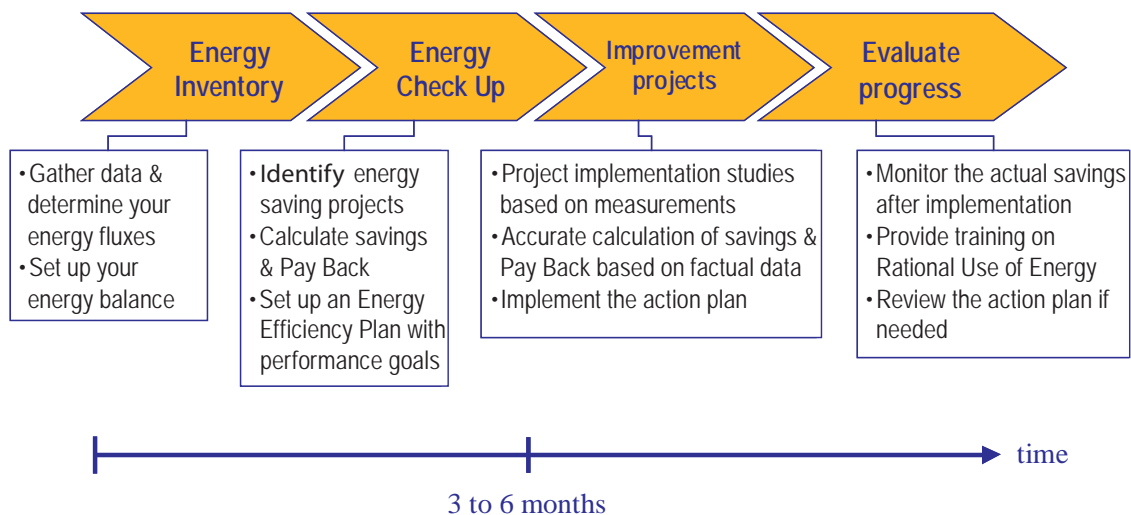


Figure 1: A roadmap towards energy savings

2. Organisational issues

The following table provides a way to gain insight into a company's current approach to energy matters. Each column deals with one of the six important energy management issues. For evaluation, consider each column individually. (The table is based on BRESCU 1993 Energy Management Matrix)

Energy management policy	Organising	Staff motivation	Monitoring and reporting systems	Staff awareness and training	Investment
Energy management policy, action plan and regular review have commitment of top management as part of a corporate strategy. Energy management fully integrated into management structure.	Clear delegation of responsibility for energy consumption.	Formal and informal channels of communication regularly exploited by energy manager and energy staff at all levels.	Comprehensive system sets targets, monitors consumption, identifies faults, quantifies savings and provides budget tracking.	Marketing the value of energy efficiency and the performance of energy management both within the organisation and outside it.	Positive discrimination in favour of energy saving schemes with detailed investment appraisal of all new buildings, equipment and refurbishing opportunities.
Formal energy management policy, but no active commitment from top management.	Energy manager accountable to energy committee representing all users, chaired by a member of the managing board.	Energy committee used as main channel together with direct contact with major users.	Monitoring and targeting reports for individual premises based on submetering, but savings not reported effectively to users.	Program of staff training, awareness and regular publicity campaigns. Some payback criteria employed as for all other investment.	Cursory appraisal of new building, equipment and refurbishment opportunities.
Unadopted energy management policy set by energy manager or senior departmental manager.	Energy manager in post, reporting committee, but line management and authority unclear.	Contact with major users through ad-hoc committee chaired by senior departmental manager.	Monitoring and targeting reports based on supply meter data.	Energy unit has ad-hoc involvement in budget setting. Some ad-hoc staff awareness and training.	Investment using short-term payback criteria only.
An unwritten set of guidelines. Energy management is the part-time responsibility of someone with only limited authority and influence	Informal contacts between energy manager and a few users.	Cost reporting based on invoice data.	Energy manager compiles report for internal use within technical department.	Informal contact used to promote energy efficiency	Only low-cost measures taken.
No explicit policy. No energy manager or any formal delegation of responsibility for energy consumption.	No contact with users.	No information system	No accounting for energy consumption.	No promotion of energy efficiency.	No investment in increasing energy efficiency in premises/sites

Table 1: Energy Management Matrix

The table presented above allows for quickly assessing an organisation's current energy management and where it should aim for. It provides therefore an overall roadmap on how to improve an organisation's energy management and the different aspects of energy management. There are 5 important domains in energy management:

1. Organisational issues: including commitment to energy management, appointed energy manager and responsibilities
2. Staff motivation: e.g. channels of communication, accessibility of data
3. Monitoring and reporting systems: gathering and analysing the data
4. Staff awareness and training: influence of energy efficiency in decision making
5. Investment: Commitment towards energy efficiency concerning new investments

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3. Energy inventory

3.1 Standard Billing Analysis

A first step towards a more efficient energy use is a closer look at the energy bills. The purpose is to identify the major cost drivers of energy consumption and obvious anomalous energy usage.

A standard billing analysis includes the following tasks:

- Graph trends

In general, our eyes are much better at identifying patterns and trends from graphical information than from tables of numbers. It facilitates thus the tracking of anomalies in the demand data. For example, in Figure 2, it is immediately clear that the electricity consumption in April is anomalously high.

- Summarize rate schedules

Most electrical rate schedules can be simplified into charges for service, total energy use, peak electrical demand and low power factor. This is to learn more about the real energy cost driver(s).

- Verify billing amounts
- Identify major savings opportunities

Disaggregated energy costs enable a good view of energy consumption and its related costs; thus for determining significant saving opportunities

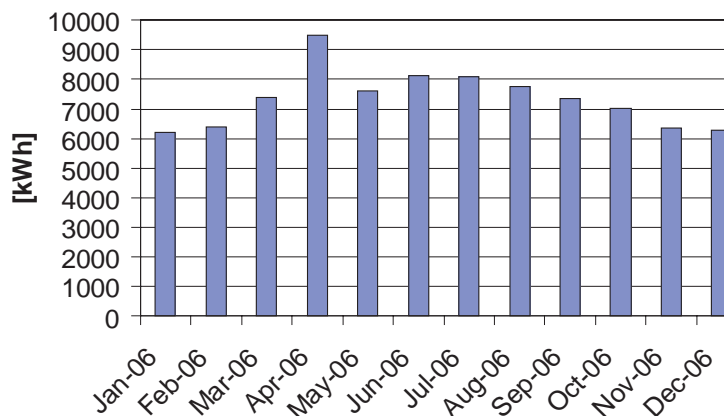


Figure 2: Monthly electrical demand

3.2 Energy breakdowns

Energy breakdowns help target and screen energy saving opportunities. In doing so, a business automatically gets a better understanding where and how energy is used. An energy flow scheme will be the outcome.

Electrical demand can, as a first estimate, be segregated into production and air conditioning by drawing a line through winter demand. Electrical demand below the line is for production and electrical demand above the line is for air conditioning. Thermal energy use can also be divided into production and space heating components by drawing a line through summer gas use. Roughly speaking, gas use below the line is for production and gas use above the line is for space heating. Finally, energy use by equipment can be estimated based on rated power, fraction loaded and hours of operation. Initial estimates of electricity and gas use by equipment should be calibrated to match the breakdowns of electricity and gas use into production and space conditioning components. This process insures that estimated energy use by equipment does not exceed the actual quantities purchased and conforms to the patterns of use is evident in the billing data. Estimates can be improved by the use of historical data.

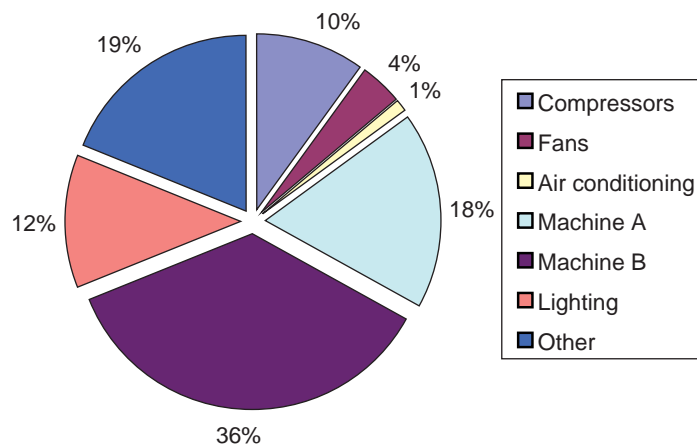


Figure 3: Example of electricity use breakdown by equipment

Rules of thumb for effective monitoring:

- Record only the most relevant variables
- Record historical data form the past 24 months at least
- Ensure measurements are accurate enough to be useful
- Ensure measurements are regular and frequent enough to pick up any relevant highs and lows, and are compatible with the rate at which control actions occur.
- Plot the ratio of peak and off-peak electricity
- Plot actual versus charged demand (electricity & gas)
- Record relevant associated data simultaneously (e.g. production rate)
- Monitor large plant items individually

4. Energy check-up

4.1 Energy analysis

Based on the acquired data on electricity and gas use, correlations can be calculated with influential variables. These influential variables usually consist of production parameters (such as quantity of units produced) and the outdoor air temperature.

These correlations result in one or two parameter models for the different consumption components (being facility, space conditioning and production). The models enable users to:

1. quickly and accurately determine baseline energy use,
2. predict future energy use,
3. understand factors that influence energy use,
4. calculate retrofit changes,
5. identify operational and maintenance problems.

Low data scatter usually indicates tight process control. E.g.: a model of natural gas use as a function of outdoor air temperature in a well controlled heat-treating plant can be expected to have low data scatter when plotting gas consumption versus outdoor air temperature.

4.2 Installation inspection

Based on the gathered information, important (i.e. large) consumers and possible irregularities in consumption are identified. Focusing on these installations, a general installation inspection will lead to energy saving projects.

The feasibility of the different proposed energy saving projects can be determined based on cost-effectiveness. Rough estimates of installation cost and energy savings returns allow for the calculation of pay back and internal rate of return of the investment.

Checklists exist for basic analysis of the performance of installations. The following fields ought to be covered during this energy check-up:

- Compressed air
- Cooling systems
- Boiler and steam systems
- Load management
- Lighting
- HVAC
- Engines and drives

One should be aware of the two fundamental processes of energy consumption:

- Energy efficient transformation of energy into utilities
- Rational use of utilities in industrial processes

4.3 Set performance goals

Performance goals drive energy management activities and promote continuous improvement. Setting clear and measurable goals is critical for understanding intended results, developing effective strategies and improving the energy efficiency. Communicating and posting goals can motivate staff to support energy management efforts throughout the organization. It helps to identify progress and setbacks at a facility level.

Production metrics, benchmarks or indices serve as standards for controlling energy use and assessing performance. When benchmark levels for current performance have been defined and accepted in practice, targets can be set for improvements in the efficient use of energy. However, targets should be set in consultation with those managing and working in particular areas rather than being imposed from above. Improvements may involve changes in operating practices, modifications to existing plant or buildings, or capital investment in more energy efficient plant or buildings.

5. Energy system improvement projects

5.1 Project implementation studies

Once the review of potential energy savings activities has been undertaken, the company is in a position to make decisions regarding priorities. A plan for future action is then developed. This need not be a stand-alone process. For many companies it is far more effective to integrate energy planning into the general strategic planning of the business and its operations.

The action plan needs to be manageable in size and clearly structured so that it provides clear information, and can be easily used as a key document in the development of the energy management system. In preparing the action plan, an energy manager needs to identify energy concerns and problem areas and, if possible, prioritize these and other potential impacts and describe the weaknesses of existing energy management practices.

Possible favorable energy saving projects can be investigated more detailed based on measurements (if possible). This enables the accurate calculation of savings & payback time, based on factual data. Make sure priorities are assigned to the various energy management activities and a structured timeline is built and used.

A final comprehensive report should cover the following topics:

- Summary of historical data (e.g. using an initial energy review of the whole facility which can be used to establish the baseline for the development of the energy management system)
- The purpose and scope of the plan
- An executive summary outlining the key information on projects (e.g. potential energy savings and paybacks, greenhouse gas emissions, quality improvement, monitoring of process, savings in maintenance)
- Priorities for action (e.g. issues requiring urgent action, issues where no immediate action is required but there is a need for longer-term improvement, and strategically important areas for future development)
- The process or means of achieving the objects and target(s)
- The timeframe and resources required
- Allocation of responsibilities
- Evaluation processes to assess the effectiveness of the program, including an annual review.

5.2 Implement an action plan

Gaining the support and cooperation of key people at different levels within the organization is an important factor for successful action plan implementation. Reaching the set goals frequently depends on the awareness, commitment, and capability of the people who will implement the projects. Implementation of the action plan will take time.

To implement an action plan, consider taking the following steps:

- Develop targeted information for key audiences about the energy management program
- Build support at all levels of the organization for energy management initiatives and goals
- Through training, access to information, and transfer of successful practices, procedures and technologies, you can expand the capacity of the people involved.

6. Evaluate progress

Evaluate progress includes formal review of both energy use data and the activities carried out as part of the action plan as compared to the performance goals.

Measure results:

- Review energy use and cost data (capital and operating expenses)
- Analyze energy efficiency achievements based on your established performance metrics
- Compare energy performance to baselines and/or expected energy use based on developed simulation models

Review action plan:

- Get feedback
- Gauge employee and organizational awareness
- Quantify side benefits such as reduced operation and maintenance expenses or productivity improvement
- Reward achievings

7. Auditing

Consultants also often execute the whole process of evaluating the energy use and improving the current situation. An energy audit can be defined as a systematic study or survey to identify how energy is being used in a building or plant, and identifies energy savings opportunities. An energy audit provides the energy manager with essential information on how much, where and how energy is used within the organization. The approach is comparable as mentioned in previous paragraphs:

- Step 1: Send energy checklist
- Step 2: Visit installations and collect more data
- Step 3: Make a list of potential saving projects
- Step 4: Perform calculations
- Step 5: Make report and discuss draft
- Step 6: Present the final report

Audits can be categorized into two types, being the preliminary and detailed audit. A walk-through or preliminary audit comprises one day or half-day visit to a plant and the output is a simple report based on observation and historical data provided during the visit. The findings will be a general comment based on rule-of-thumbs, energy best practices or the manufacturer's data. A detailed audit will provide technical solution options and economic analysis for the factory management to decide project implementation or priority. A feasibility study will be required to determine the viability of each option.

8. Energy Savings Checklist

The following checklist can be used to identify some first energy saving opportunities. It is important to consult those that work with the below listed equipment to evaluate advantages and disadvantages of the proposed measures on a case-by-case basis.

8.1 Plant drives

- Determine the overall efficiency of the current motor and evaluate the effects by replacing it with a high efficiency motor
- Examine the possibilities of a motor-controlling unit of some kind (e.g. on/off, soft-start unit), certainly for those motors running in partial load
- Examine the possibilities of variable speed (or at least multi-speed) drives for those motors running in partial load
- Compare the nominal characteristics of the engine with the load characteristics. Consider replacing oversized motors
- Ensure the appropriate drive is used (i.e. direct drive, v-belt, notched belt, flat belt, etc.)

8.2 Boilers and steam systems

- Minimize hot water requirements and allow for local boosting
- Install or upgrade insulation on hot water/steam lines
- Consider decentralization of heat production for remote users
- Reconsider installed gas burner versus the merits of a new and more efficient gas burner with controlling unit for power adjusting and burner management (via CO and/or oxygen measurements in flue gas)
- Check and optimize boiler excess air level to practical minimum
- Check for steam leaks from boiler over pressure valves and in the distribution system

- Check insulation of the boiler
- Examine the feasibility of reducing the steam pressure in the distribution net to reduce the steam temperature (and thus its correlated heat losses)
- Check the condensate return lines insulation, pressure (higher pressure > higher temperature) and return levels
- Check potential of a blowdown waste heat recovery system
- Check potential of waste heat recovery from incineration
- Check potential for utilization of flash steam
- Check cogeneration potential

8.3 Lighting Systems

- Evaluate possibility of replacing existing ballasts with modern low-loss ballasts
- Ensure lighting levels comply with requirements
- Consider the different lighting options and its characteristics (average life span, efficiency, light colour and colour rendering)
- Consider delamping, voltage reduction, motion detectors, light sensors, time switches, better reflectors and better skylighting
- Discourage use of extra low voltage lights due to total cost, frequent replacement and effect on air conditioning costs

8.4 Compressed air systems

- Check compressed air distribution net for leaks
- Check system's air pressures are the lowest practical for the different applications; consider decentralization and/or pressure regulators where appropriate.
- Examine possibilities to lower the air inlet temperature (e.g. relocation of air inlet)
- Use only compressed air tools where necessary, consider alternatives
- Examine the compressor capacity and regulation versus the actual demand profile: consider the use of a VSD compressor
- Use vacuum pumps in stead of a venturi system

8.5 HVAC in buildings

- Check adequacy of ceiling insulation and install or upgrade as necessary
- Select the most appropriate heating system (radiation versus convection)
- Check if filters are maintained and replaced in time to avoid excessive pressure drops
- Check the potential of heat recuperation and air recycling
- Set heating thermostats to appropriate temperatures
- Check zoning of HVAC systems
- Discourage the use of personal radiators and fans
- Use time clocks to control system operation
- Examine the use of VSD on fans

8.6 Refrigeration equipment

- Examine insulation on the distribution system and end use storerooms
- Examine the compressor capacity adjustment technique (e.g. VSD versus compressor bypassing)
- Evaluate the possibilities of a floating condenser temperature
- Evaluate the set cooling temperature
- Evaluate the advantages and disadvantages of centralized and decentralized cooling equipment
- Increase utilization of cold room space by closing off unused sections

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