Industrial Energy Management

Achieving energy efficiency in South Africa’s industry

Course Objectives

- Relate industrial energy management to South African context
- Provide strategic leadership for the implementation of energy management in light of the "culture" of your organisation
- Assess current organisational energy management capacity
- Plan actions to increase capacity
- Provide leadership for development and implementation of:
  - policy,
  - organisational structure
  - Training and communications
  - information management;
- Make the business case
- Provide leadership for in-house assessment of energy use and identification of savings opportunities

Module 1: Introduction to Industrial Energy Management

Context for energy management
Defining energy management
Module 1 Objectives

- Define energy management
- Provide a rationale for industrial energy management
- Describe energy supply pressures and government actions
- Explain effective energy management as a multi-dimensional activity

Defining Energy Management

“The judicious and effective use of energy to maximize profits (that is, minimize costs) and enhance competitive positions.”


- Purchase or supply energy at lowest cost
- Use energy at highest possible efficiency
- Employ most efficient technology possible

Industrial Energy Management in South Africa . . . Why Now?

- Industrial competitiveness in a global market
- Restructuring of the energy supply sector
- Energy supply limitations
- Environmental management
  - ISO14001
- Climate change
  - Emission reduction credits
Government Action
- National energy efficiency strategy
- Promoting behavioural change:
  - Capacity building in energy efficiency and renewable energy (CaBEERE) programme supported by Danida
  - Corporate commitment programme
- 3 key components:
  - M&T
  - Motivation – training and awareness
  - Corporate commitment - policy

Industry Sector Objectives
- To delineate the growth of industrial energy consumption from the rate of growth in industrial output
- To bring energy intensities of major industrial sectors into line with international standards and best practice

Energy Supply
- Diverse energy supply mix
- Natural gas supply growing to maximum projected in 2008 – source change opportunities?
- Electricity generation surplus projected to run out 2007 – dealing with a supply deficit?
- Renewable energy opportunities?
3 Questions

- What are the three highest operating expenses?
- What is the potential saving that could be achieved in each?
- What priority should energy management be given?

Energy is a Manageable Expense

![Cost & Manageability Graph]

The Dimensions of Energy Management
Who Creates Savings?

<table>
<thead>
<tr>
<th>People &amp; Technology</th>
<th>People Only</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>-4%</td>
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<td>3%</td>
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<tr>
<td></td>
<td></td>
<td>16%</td>
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<td>23%</td>
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</tbody>
</table>

-10% -5% 0% 5% 10% 15% 20% 25% Actual Savings

An Energy Managing Company – ChiRex Ltd.

- Achievement:
  - 9% reduction in energy and water budget = £ 212 000 per year

- How did they do it?
  - Senior management support through energy policy
  - Energy account centre structure
  - Energy teams
  - Create awareness
  - Monitoring and targeting for information management

What this course is about

- Strategic approach
- Assessing and building capacity
- Organisational commitment and energy policy
- Organisational structure
- Training and communicating
- Energy monitoring, targeting & reporting
- The business case
- Energy assessment and opportunities identification
Module 2: A Strategic Approach to Energy Management

Organisational change
Strategic phases in energy management

Module 2 Objectives

- Describe the organisational culture that prevails in your company
- Contribute to change in the organisation towards effective energy management
- Approach the implementation of energy management practices strategically

Planning for Organisational Change

- Senior Managers may care about
  - the organisation's survival
  - its efficiency or profitability
  - more than energy conservation itself
**Achieving Organisational Change**

- **Who’s Responsible?**
  - energy managers or coordinators
  - line managers responsible for the overall efficiency of their departments

- **What are their responsibilities?**
  - monitoring consumption
  - setting targets
  - identifying and correcting faults
  - motivating staff
  - identifying and implementing energy saving measures

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**Connecting Energy Management to Senior Management**

- **Provide management information on energy consumption to senior managers**
- **Demonstrate effectiveness of energy management**

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**Phases in Organisational Change**

- **Desire to improve energy performance**
  - stimulates action

- **Uncertainty about effectiveness of actions**
  - creative ideas

- **Reconsidering the problem/opportunity**
  - new solutions

- **Improved control becomes “business as usual”**
Organisational Culture

- Can the organisational culture be?
  - Exploited?
  - Circumvented?
  - Changed?

Corporate Culture

- Entrepreneurial:
  - Innovation and rapid growth
  - Leadership from a charismatic CEO
  - Change is a constant process
  - Plan only in the short term
  - Quick returns are usually expected on investments.

- Team-oriented
  - Wide participation and cooperation in operations, planning and decision-making
  - Energy efficiency teams
  - Planning is long-term
  - Longer term return on investment.
Corporate Culture

- Hierarchical
  - more conservative in risk-taking
  - more formal accountability structures
  - need for solid and comprehensive management information
  - may take longer to institute information-gathering system.

There may be a need to clearly establish responsibility for energy management in this kind of organisation, even to create an energy management department.

Corporate Culture

- Market Culture
  - productivity and achievement
  - outward-looking
  - plan mainly in the short term
  - high level of decentralisation

In terms of energy management strategies, the creation of “energy accountability centres”, discussed later in this guide, may be a natural step.

Identifying the Culture

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Entrepreneurial Team</th>
<th>Hierarchical</th>
<th>Market Culture</th>
<th>Identifying the Culture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus</td>
<td>outward-looking</td>
<td></td>
<td>productivit</td>
<td></td>
</tr>
<tr>
<td>Planning</td>
<td>very short-term</td>
<td></td>
<td>achievement</td>
<td></td>
</tr>
<tr>
<td>Risk Tolerance</td>
<td>tolerate high risk</td>
<td></td>
<td>certainty</td>
<td></td>
</tr>
<tr>
<td>Leadership</td>
<td>charismatic</td>
<td></td>
<td>managerial</td>
<td></td>
</tr>
<tr>
<td>Structure</td>
<td>flexible</td>
<td></td>
<td>cost centres</td>
<td></td>
</tr>
<tr>
<td>Authority</td>
<td>leader - concentrated</td>
<td></td>
<td>rules</td>
<td></td>
</tr>
</tbody>
</table>

TOTAL
Corporate Culture and Change – Some Tips

- Entrepreneurial:
  - Get CEO’s support, demonstrate rapid payback
- Team-oriented:
  - Set up broadly representative energy committee
- Hierarchical:
  - Place responsibility on the organisation chart
- Market:
  - Establish decentralised energy account centres

The Problem

Some organisations have saved 20 to 40% of their energy costs through energy management—why doesn’t it happen everywhere?

Why doesn’t it happen?

- Lack of an “energy efficiency culture” and awareness
- Lack of policies that specifically address energy management
- No energy management plan
- Insufficient skills for energy analysis, identification and implementation of energy management measures
- Inadequate energy use information
- Lack of knowledge about when and where energy is used in the plant
- Lack of the business processes to implement energy management as “business as usual”
Characteristics of Energy Managing Organisations
- broad awareness of energy efficiency
- collect and utilise information to manage energy use - energy monitoring & targeting
- energy management plan—short term and long term—and acting on it
- energy management integrated into the overall structure of the organisation
- leadership from a “champion” or energy management team
- energy management policy

Energy Master Planning
- 3 inter-related elements:
  - a strategic approach
  - integration of related management practices
  - information management

A Strategic Approach
- Relative Effort
- Time
- Gain Control
- Maintain Control of Energy Consumption
- Invest
- Invest
- Invest
- Invest

Industrial Energy Management
Gain Control

- Energy loads
- Operating practices
- Purchasing strategies
- Motivation and training

Invest

- Efficient equipment and technology
- Energy information system
- Energy related training

Maintain Control

- Monitoring & targeting
- Motivating staff
- Maintain senior management commitment
Module 3: Assessing the Organisation

Priorities for organisational capacity building

Module 3 Objectives

- Assess the organisation in regard to six critical management functions
- Use the organisational assessment to build consensus around energy the critical issues, and to plan actions that will increase organisational capacity
Assessing the Organisation

A Balanced Profile

An Unbalanced Profile
Interpreting the Profile

- Strive for balance
- Concentrate on raising the lowest scores
- Move all factors upwards

![Graph showing profile interpretation]

Improving Matrix Scores does pay off!

<table>
<thead>
<tr>
<th>Case Description</th>
<th>Organizing Skills &amp; Knowledge</th>
<th>Information Systems</th>
<th>Marketing &amp; Communicating</th>
<th>Investment</th>
<th>Rating</th>
<th>% Savings</th>
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<tbody>
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<td>1.0</td>
<td>0.0</td>
<td>0.5</td>
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<td>1.0</td>
<td>1.5</td>
<td>1.5</td>
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<tr>
<td>British Telecom</td>
<td>1.0</td>
<td>0.5</td>
<td>0.5</td>
<td>0.0</td>
<td>1.0</td>
<td>10.0</td>
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<td>GPC S 324</td>
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<tr>
<td>Digital Equipment</td>
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<td>0.0</td>
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<td>GPC S 341</td>
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<td>1.5</td>
<td>0.0</td>
<td>1.0</td>
<td>12.5</td>
</tr>
</tbody>
</table>

Good Practice Case – The Woodbridge Group

- What did they achieve?
  - $600,000 per year initial savings measures
  - 10% energy reduction target

- How did they do it?
  - Top management commitment in Energy Policy
  - Integration into organisational structure (HSE and ISO14001)
  - Employee training
  - Energy Reduction Management System – M&T
  - Marketing & Communicating through employee awareness campaigns
Planning for Change

Actions needed
To get here
from here

Module 4: Developing an Energy Policy

A rationale for the energy policy
The elements of effective energy policies

Module 4 Objectives

Play a key role in the development of a corporate energy policy
An Energy Policy Statement

Rationale for the Energy Policy

- Expresses corporate commitment
- Sustains the effort in the event that
  - Personnel changes
  - Perceived corporate priorities change

Energy Policy

- Purpose
  - Public expression of your organisation’s commitment to energy management
  - Working document to guide your energy management practices and to provide continuity

- Other Benefits
  - Clear statement of goal
  - Agreed targets
  - Ensure required resources
  - Formal backing of top management
5 Key Elements

Commitment
A personal message from top management with a commitment to regular policy review.

Review
How an organisation knows goals have been achieved.

Implementation
Guidance on how the policy objectives are to be met.

Applicability
Directive on which parts of the organisation are covered by the policy.

Thrust
A new and challenging dimension to energy and environment.

Energy Policy

Goals, Objectives, & Targets

<table>
<thead>
<tr>
<th>Policy components</th>
<th>Time scale</th>
<th>Primary staff involvement</th>
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</thead>
<tbody>
<tr>
<td>Goals</td>
<td>Long-term</td>
<td>Top and senior managers</td>
</tr>
<tr>
<td>Objectives</td>
<td>Medium-term</td>
<td>Middle managers</td>
</tr>
<tr>
<td>Targets</td>
<td>Short-term</td>
<td>Operational staff</td>
</tr>
</tbody>
</table>

Goals – long term

- Broad statement of organisation’s commitment; e.g.
  - Reduce operating costs through EE
  - Minimise GHG emissions
  - Minimise the environmental “footprint”
  - Optimise energy security
Objectives – medium term

- More specific articulation of how goals will be achieved, organisational functions that will be involved; e.g.
  - Implement energy M&T
  - Assign energy budgets to operating units
  - Reduce energy consumption by x% over 5 years

Targets – short term

- Specific, measurable expression of what will be achieved; e.g.
  - Reduce energy costs by x% in the next 12 months
  - Reduce energy consumption (GJ or kWh) by y% in the next 12 months
  - Reduce CO₂ emissions (tonnes) by z% in the next 12 months.

Sample Energy Policy Contents

Part 1
- Declaration of commitment to energy management
- Statement of policy
- Statement of objectives, separated into short and longer term goals

Part 2
- Action plan
- Resource requirements
- Responsibility and accountability
- Energy management committee
- Review procedure
Developing a Policy

- Consult
  - plant operations, finance, purchasing, human resources, marketing and sales, corporate communications and information services, etc.
- Draft
- Ratify

Corporate Culture and Policy Development

<table>
<thead>
<tr>
<th>Corporate Culture</th>
<th>Appropriate Formulation Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrepreneurial</td>
<td>Top down</td>
</tr>
<tr>
<td>Team</td>
<td>Bottom up</td>
</tr>
<tr>
<td>Hierarchical</td>
<td>Top down</td>
</tr>
<tr>
<td>Market</td>
<td>Top down and middle out</td>
</tr>
</tbody>
</table>

A Case Study – ICI PLC

- Environmental management goals:
  - to be prudent in the use of the world’s natural resources by minimising waste
  - to provide customers with goods produced in an environmentally sound way.
- Four objectives:
  - reduce environmental impact of new plants by use of best environmental practice
  - reduce waste by 50% by 1995, using 1990 as the baseline year
  - establish a revitalised and more ambitious energy and resource conservation programme
  - encourage recycling in its businesses and with customers
Module 5: Organisational Structure for Energy Management

Placing authority and responsibility in the organisation chart

Module 5 Objectives

- Provide guidance on how best to place responsibility in the organisational structure for energy management

Organising

- Responsibility—concentrated or distributed?
- Energy management is a management function
- All managers are responsible
- Accountability should be distributed to those who control energy
Top Management

- to get agreement for major spending on staff or energy measures
- to provide a summary of progress
- to gain recognition and prestige for your activities

Energy Management is a Managerial Function

- energy policy
- management information
- reporting
- policies and practices for the purchase and combustion of fuels
- energy awareness
- ‘good housekeeping’ and plant operating practices
- training needs
- energy efficiency opportunities identification
- investment programme
- review procedures for return on investment

Integration of Responsibility

<table>
<thead>
<tr>
<th>Function</th>
<th>Director</th>
<th>Mgr A</th>
<th>Mgr B</th>
<th>Asst C</th>
<th>Asst D</th>
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</thead>
<tbody>
<tr>
<td>Measure consumption</td>
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<tr>
<td>Identify energy cost centres</td>
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<tr>
<td>Fuel management</td>
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<tr>
<td>Set targets for energy usage</td>
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<tr>
<td>Monitor consumption programmes</td>
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<tr>
<td>Surplus equipment</td>
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<tr>
<td>Direct projects for improvement</td>
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<tr>
<td>Allocate budget and resources</td>
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<tr>
<td>Analyse operational factors</td>
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<tr>
<td>Financial viability</td>
<td></td>
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<tr>
<td>Monitor products for energy efficiency</td>
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<tr>
<td>Identify projects for energy efficiency</td>
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<td></td>
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<tr>
<td>Audit of energy management policy</td>
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</tbody>
</table>

Key: ▲ Approval Authority  ● Responsible for Work  ◇ Perform Work  ◆ Provide Technical Support
Accountability

- delegation of responsibility to appropriate budget holders, “energy accountability centres (EACs)”
- overall responsibility for co-ordination and reporting
- clear lines of reporting and accountability to that person
- clear lines of reporting and accountability to top management
- a clear inter-departmental committee structure for managing energy

Energy Accountability Centres

- Assign accountability for energy budgets to line managers
- Performance improvement arises from
  - responsibility for energy budget
  - required information on energy performance
- Identified by
  - mapping sub-metering schemes on organisational structure
- Management of energy = management of finances
- Requires use of MT&R techniques

Organising for Implementation

Phase 1 – Gaining Control
- energy efficiency as applied to premises, plant and controls
- education and training

Phase 2 – Investing
- accounting and financial investment appraisal

Phase 3 – Maintaining Control
- motivation, incentives, promotion and publicity
- design and operation of management information systems.

get the right mix of skills and experience in the right place at the right time.
Module 6 Objectives

- Plan and implement internal and external communications strategies for the energy management programme
- Plan and implement personnel training programmes
- Provide advice on the motivation of staff in support of energy management goals

Train for Competence, Communicate for Awareness

- Actions: Training, Communication
- Targets: Facility Staff, Occupants, Users
- Outcomes: Competencies, Awareness, Feedback
Marketing and Communicating

- Communicate to:
  - raise awareness of the importance of energy efficiency to cost control and environmental conservation
  - promote energy efficiency measures
  - publicise energy management achievements inside and outside the organisation

Planning Communications

- Who are the targets?
- What are the objectives for the strategy?
- How are you going to achieve these objectives?
- What resources are available to do this?
- How are you going to justify the strategy to senior management?

Successful Communication Strategies

- Clear goals and objectives
- Address assessed needs
- Use existing communications vehicles
- Clear targets/messages
- Variety of media
- Regular and ongoing
- Evaluation of impact
Sample Communication Tools

- Articles in corporate newsletter
- Fact sheets
- Formal announcements from management
- Work group focus meetings
- “Energy days”
- Posters, stickers, calendars
- Slogan, mascot
- Progress reports
- Link to home
- Rewards and incentives
- Quantitative feedback

Training can create . . .

- Technical skills and knowledge for operations, maintenance, assessment
- Awareness of energy efficiency as a corporate priority
- Understanding of the issue
- Commitment to achievement of goals
- Understanding of personal impact on energy consumption

Types of training

- Short, intensive, face-to-face workshops
- Formal courses for credit, certification, qualification
- Institutional continuing education courses
- Independent study, distance learning
- On-the-job training
Criteria for selection

- Level of support available
- Requirements for flexibility
- Accessibility
- Customisation
- Transfer to the workplace

A Basis for Planning

<table>
<thead>
<tr>
<th>Level</th>
<th>Supportive Context</th>
<th>Program Design</th>
<th>Individuals and Relationships</th>
<th>Measurement of Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Comprehensive policy on energy use practices, actively supported by senior management and key organizational functions—HR, financial, technical—encompassing all practices that impact directly and indirectly on energy use.</td>
<td>Systematic design process utilized, based on deliberate assessment of needs and circumstances of targets, providing regular, ongoing intervention to achieve clearly understood and articulated outcomes as integral element of overall energy management strategy.</td>
<td>Energy management fully integrated into management structure; clear designation of responsibility for energy use practices and consumption.</td>
<td>Regular quantitative assessment of procedures, values &amp; attitudes, energy use indicators vis-à-vis program objectives, with mechanism to refine program design as needed.</td>
</tr>
<tr>
<td>3</td>
<td>Basic policy objectives actively supported by key organizational functions.</td>
<td>Deliberate needs analysis applied to design of customized program for clearly articulated outcomes.</td>
<td>Energy manager accountable to energy committee representing all users, chaired by a senior line manager.</td>
<td>Feedback of M&amp;V information to the program design process.</td>
</tr>
<tr>
<td>2</td>
<td>A basic adopted policy on energy use practices, with general awareness as part of the organization's policy structure.</td>
<td>Ongoing training and communication adapted to organizational needs and circumstances on the basis of subjective, anecdotal evidence.</td>
<td>Energy manager designated, reporting to ad-hoc committee, but line management and authority are unclear.</td>
<td>Application of some form of assessment of energy performance, not specifically keyed to program outcomes.</td>
</tr>
<tr>
<td>1</td>
<td>Guidelines respecting energy use practices informally incorporated into job descriptions and procedures.</td>
<td>Ongoing training and communication using &quot;off the shelf&quot; programs, in parallel with other energy management initiatives.</td>
<td>Energy management the part-time responsibility of someone with only limited authority or influence.</td>
<td>Intuitive sense of program impact on part of EM based on anecdotal evidence.</td>
</tr>
<tr>
<td>0</td>
<td>No organizational recognition of energy as manageable or an organizational priority.</td>
<td>Sporadic use of &quot;off the shelf&quot; programs without clear determination of their fit to needs.</td>
<td>No energy management or any formal delegation of responsibility for energy consumption.</td>
<td>No effort to assess specific outcomes of training and communication initiatives.</td>
</tr>
</tbody>
</table>

4 Key Success Factors

- **supportive context**: the organisation regards energy efficiency as a corporate priority, and acts accordingly
- **program design**: the training and communication initiatives are well-designed
- **individuals and relationships**: proponents of efficiency improvement are able to make and influence decisions
- **measurement of outcomes**: the organisation measures the impact of these initiatives and uses that information to refine future actions
Motivating Employees

- answer the question “what’s in it for me?”
- build commitment to achieving the corporate goal
- demonstrate the importance of energy efficiency
- involve people in the process
- provide a means for feedback
- communicate effectively
- accomplish “attitude adjustment”

How to Motivate

Factors
- financial rewards
- job security
- job enrichment
- peer pressure
- public recognition
- increased responsibility and greater autonomy.

Strategies
- ensure that people get something out of what you propose
- give rewards and/or recognition
- link energy savings to the individual’s own best interests

Whom to Motivate

- Senior managers
  - improve the performance of your organisation through cost reduction and increased profitability
- Middle managers
  - make them budget holders on energy costs
- Key personnel (plant managers, maintenance staff, system operators)
  - measure their personal performance and job satisfaction in terms of increasing the energy efficiency of the plant they control
Whom to Motivate

- General staff
  - Make it personal - environmental considerations may be as significant as saving money
  - Emphasise benefit of having a stronger, more competitive company—for example, in terms of job security and wages

Whom to Motivate

- Energy Management “Champions”
  - Having clear goals, discrete assignments, measurable outcomes
  - Opportunities to meet new challenges
  - Work with others as a team
  - Learn new skills and knowledge to enrich their jobs
  - Receiving recognition

Module 7: Energy Monitoring, Targeting & Reporting

The power of effective energy information management
Module 7 Objectives

- Understand how MT&R can manage your energy consumption downward
- Use existing energy data
- Describe the difference in purpose and activity of M&V and M&T

Information Systems and MT&R

- Comprehensive system sets targets, monitors consumption, identifies faults, quantifies savings and provides budget tracking.
- Monitoring and targeting reports for individual areas based on sub-metering, but savings not effectively reported to user.
- Monitoring and targeting reports based on supply meter data. Energy unit has ad-hoc involvement in budget setting.
- Cost reporting based on invoice data. Engineer compiles reports for internal use within technical department.
- No information systems. No accounting for energy consumption.

The Benefits of MT&R

- Cost savings due to energy reduction - 5 to 15% typical
- Coordination of energy management policy
- Selection of most effective initiatives
- Acquisition of financing for energy efficiency projects
- Baseline energy use & verification of savings
- Improved product and service costing
- Improved budgeting
- Better preventative maintenance
- Improved product quality
- Better control of production processes
- Waste avoidance
- Water consumption & materials management
Three Distinct Functions

- Monitoring
  - The regular collection of data on energy use
  - Analysis of data
  - The investigation of deviations from expected performance

- Targeting
  - the identification of the level of energy consumption which is desirable

- Reporting
  - putting information in a form that enables control of energy use and achievement of targets

Where can you apply MT&R?

- Utility Inputs
  - Gas, fuel, electricity
  - Water, air, steam
  - Etc.

- Specific Systems
  - Processes
  - Boilers
  - Compressor etc.

- Cost centre or department

MT&R Tasks

- Measuring energy consumption over time
- Relating energy consumption to drivers
- Setting targets for reduced consumption
- Frequent comparison of consumption to targets
- Reporting variances
- Taking action to correct variances
**Data and Information**
- Data is the “raw material”
- Information is the “refined product”
- Action decisions need information

**Data May Already Exist!**
- Consumption data
- Consumption drivers
  - production in manufacturing plants
  - Units
  - Quantity (mass or volume)
  - On-line time
  - Weather - CDDs
  - possibly sales
- Sources:
  - Monthly utility invoices
  - Production records
  - Manual data forms periodically
  - Portable data loggers
  - Fully automated measurement

**Two Critical Questions**
- How does energy use vary with production (or weather, or some other driver)?
- How does the relation between energy use and production (or other driver) change with time?
A Worked Example

- How many energy saving measures have been introduced?
- When did each take effect?
- How much energy has each measure saved?
- Are all the energy saving measures still working?
- Have any breakdowns been restored?
- How much energy will be required for a budgeted production of 120 tonnes a week in the next quarter?
- What further savings can be achieved?

Understanding what drives energy consumption

A functional relationship between production & energy consumption

Understanding the trends with CUSUM

Critical points - what happened?
Controlling performance

We use control charts for other management priorities—why not for energy use?

What are Targets?

- Are a statement of what management wishes to achieve
- Are determined from a position of knowledge
- Must challenge the organization but be achievable
- Convey management priorities
- Have two essential components:
  - an amount
  - a time

Setting targets

Options for quantifiable performance targets
### Benchmarks as Targets

![Bar chart showing therm/tonne vs week number with 7 bars and a line graph.](image)

### Process Energy Use

![Graph showing kWh/tonne of production with different energy uses and time.](image)

### What Types of Actions Must be Taken?

![Graph showing kWh/Tonne of production with different types of improvements and time.](image)
How Will It Sustain Savings?

- Summary Information
- Exception Reports & Budget
- Control Information
- Operators & Maintenance
- Supervisors
- Management
- "People in the (feedback) loop"
- Data Collection & Analysis
- Measure
- Energy Consuming System

Reporting Principles

- Information directed according to who has control / direct influence
- Recipient must understand what it means to them
- Minimum extraneous information
- There must be a means of ensuring action

Who Needs What & When?

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Managers</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Supervisors</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Operators &amp; Maintenance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

(1) Key Indicators appropriate to tasks/responsibility
Information Needs and Decision Making

<table>
<thead>
<tr>
<th>Information Needs</th>
<th>Level of Decision Making</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>Operational Control</td>
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<tr>
<td></td>
<td>Managerial Control</td>
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<tr>
<td></td>
<td>Strategic Planning</td>
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<td>Precision</td>
<td>Internal</td>
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<tr>
<td></td>
<td>medium</td>
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<tr>
<td></td>
<td>Low</td>
</tr>
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<td>Timing</td>
<td>exceptional</td>
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<td></td>
<td>periodic</td>
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<tr>
<td></td>
<td>Irregular</td>
</tr>
<tr>
<td>Nature</td>
<td>warning</td>
</tr>
<tr>
<td></td>
<td>results</td>
</tr>
<tr>
<td></td>
<td>Predictive</td>
</tr>
</tbody>
</table>

A Starting Point

- Read meters daily/weekly:
  - Identify best performance modes/periods
  - Track your "turn down"
- Measure & feedback process equipment performance by batch/period:
  - Best practice suggests an opportunity of 6% or more

Case: M&T in a Brewery

- Actions:
  - Used existing computer systems and utilities metering supplemented with additional sub-metering
  - Expanded the system for data collection and analysis as savings warranted
- Results:
  - Costs: £15,000 initial, £9,000/yr. for 4 years, plus £1,200/yr. O & M
  - Savings:
    - £24,660 (energy), £15,190 (water), £39,850 total in first 12 months
    - £524,320 over next 4 years, average 11,700 GJ/yr.
  - Payback in 5 weeks
MT&R and Water Efficiency

\[ y = 13.457x + 1441.4 \]

Measurement & Verification

- A process of quantifying energy consumption before and after an Energy Conservation Measure is implemented to verify and report on the savings actually achieved.

Why Verify Savings?

- to increase energy savings
- to reduce the cost of financing projects
- to encourage better project engineering
- to demonstrate and capture the value of reduced GHG emissions
Spend more to reduce costs?

Verification
- Increases the confidence of funders
- Reduces investment risk
- Reduces your costs of borrowing

M&V Options under the IPMVP

A. Partially Measured Retrofit Isolation
   - With assumption/stipulations
B. Retrofit Isolation
   - Fully measured
C. Whole Facility
   - Or sub-metered part
D. Calibrated Simulation
   - With software

Expectations and Uncertainty

- What is uncertainty?
- How much uncertainty can we tolerate?
- What is our purpose for implementing a Verification Method?
- What are the sources and degrees of uncertainty?
Sources of Uncertainty in M&V

- Instrumentation Error
- Modeling Error
- Sampling Error
  - Random error in sampling
- Assumption Error
  - Anticipated
  - Not anticipated

Un-quantifiable Uncertainty

- Human errors
- Technique errors
  - manual measurements
- Unaccounted for changes in conditions
- Placement of transducers
  - automated measurements
- M&V plan should present the range of possible impacts

The Cost of M&V Depends Upon..

- Option selected
- ECM number complexity & interactions
- Number of energy flows isolated (A,B,D)
- Complexity of measurements
- Sample sizes & metering duration
- Engineering required for stipulations (A & D)
- Effort required to document the base year
- Required accuracy
- Reporting requirements
Savings Determination

Savings = Baseline Energy Use adjusted - post ECM use

Quantitative Basis for M&V

- Energy performance model:
  - Prior year’s data – if there are no “factors of influence”
  - Regression analysis – as in M&T
  - Simulation

Baseline Adjustments

- Changes in production and/or weather
- Changes in operating schedule or processes
- Changes in function of the facility
Monitoring of Energy... Always a Good Practice

- Gain & maintain control of energy consumption
- Avoid slippage
- Verify the savings from a retrofit
- M&V may be part of an Energy Performance Contract (EPC)
- Report savings from an Awareness Campaign
- Reinforce peoples actions
- Report to management
- All of the above!

Module 8: Developing the Business Case

Analysing the investment opportunity
Financing implementation

Module 8 Objectives

- Establish the business case for energy management investments
- Calculate simple payback and ROI
- Do cash flow analysis
- Determine NPV and IRR
- Propose alternative strategies for financing projects
- Consider the use of energy performance contracting
- Assess the potential for employing the clean development mechanism (CDM)
**Investment Needs**

- new equipment
- building renovations
- process improvements
- staff training
- energy information system
- other priorities

**Making the Case**

- the size of the energy problem
- the technical and good housekeeping measures to reduce waste
- the predicted return on any investment
- the real returns achieved on particular measures over time

**Steps in Building the Business Case**

- Assess the baseline
- Identify and prioritise possible measures
- Analyse costs and benefits
  - investment appraisal
- Select financing and implementation mechanism
Assessing the Baseline

- Ensure that:
  - best performance from existing plant and equipment being achieved
  - energy tariffs and purchase agreements optimised
  - the most cost-effective energy forms—fuels or electricity—being used as efficiently as possible
  - operations and maintenance optimised

Identify and Prioritise Measures

- Focus on largest energy consumers first
- Internal identification of opportunities
  - “7 Steps”
- External identification
  - energy audit

Consider all the Costs

- direct project costs
- new maintenance costs
- cost of operational adjustments (additional staffing, different production rates, etc.)
- training of personnel on new technology or operations
Consider all the Benefits

Financial:
- energy savings
- water savings
- maintenance savings
- increased productivity
- improved product quality

Non-financial:
- improved workplace environment
- mitigation of external environmental impact

Setting Priorities

Consider:
- energy consumption per unit of production
- current state of repair and energy efficiency of plant and services, including controls
- residual life of existing plant and equipment
- effect on staff attitudes and behaviour

Objectives of Investment Appraisal

- to determine which investments make the best use of available money
- to ensure optimum benefits from any investment made
- to minimise the risk from making investments
- to provide a basis for subsequent analysis of the performance of the investment
A “Level Playing Field”

- Energy management investments should be assessed by the same criteria as investments in other priorities.

Financial Analysis Methods

- Simple Payback Period
  \[ SPP(\text{years}) = \frac{\text{Capital Cost}}{\text{Annual Savings}} \]

- Return on Investment
  \[ ROI = \frac{\text{Annual Net Cash Flow}}{\text{Capital Cost}} \times 100\% \]

- Life Cycle Analysis
  - Net Present Value
  - Internal Rate of Return

Cash Flow Analysis

- Graph showing cash flow for projects A and B over their respective life spans.
Cash Flow Table

Table 8.1: Cash Flow Table for Purchase of new Boiler

<table>
<thead>
<tr>
<th></th>
<th>Year 0</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
<td>(90.0)</td>
<td>(10.0)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Costs</td>
<td>0</td>
<td>24.0</td>
<td>48.0</td>
<td>48.0</td>
<td>48.0</td>
<td>48.0</td>
</tr>
<tr>
<td>Savings</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Net cash flow</td>
<td>90.0</td>
<td>14.0</td>
<td>48.0</td>
<td>48.0</td>
<td>48.0</td>
<td>48.0</td>
</tr>
<tr>
<td>Net Project value</td>
<td>(90.0)</td>
<td>(76.0)</td>
<td>(28.0)</td>
<td>20.0</td>
<td>68.0</td>
<td>116.0</td>
</tr>
</tbody>
</table>

Cash Flows

- Capital costs:
  - design, planning, installation and commissioning
  - usually one-time costs
- Annual cash flows:
  - annual savings or costs
  - taxes, insurance, equipment leases, energy costs, servicing, maintenance, operating labour
- Intermittent cash flows
  - occur sporadically during life of project

Other Factors in Annual Cash Flow Calculations

- marginal tax rate applied to positive or negative cash flows
- impact of asset depreciation on taxes
Time Value of Money

\[ FV = PV \times (1 + i)^n \]

where
- \( FV \) = future value of the cash flow
- \( PV \) = present value of the cash flow
- \( i \) = interest or discount rate
- \( n \) = number of years into the future

or

\[ PV = \frac{FV}{(1 + i)^n} \]

Discount Factors

Table 8.2: Discount Factors \( \frac{1}{(1 + i)^n} \)

<table>
<thead>
<tr>
<th>Year (n)</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount Factor</td>
<td>6%</td>
<td>10%</td>
<td>20%</td>
<td>30%</td>
<td>40%</td>
<td>45%</td>
</tr>
<tr>
<td>Discount Factor</td>
<td>0.942</td>
<td>0.909</td>
<td>0.833</td>
<td>0.769</td>
<td>0.714</td>
<td>0.690</td>
</tr>
<tr>
<td>0.888</td>
<td>0.826</td>
<td>0.751</td>
<td>0.691</td>
<td>0.651</td>
<td>0.616</td>
<td>0.588</td>
</tr>
<tr>
<td>0.840</td>
<td>0.731</td>
<td>0.675</td>
<td>0.612</td>
<td>0.565</td>
<td>0.524</td>
<td>0.492</td>
</tr>
<tr>
<td>0.792</td>
<td>0.683</td>
<td>0.579</td>
<td>0.482</td>
<td>0.404</td>
<td>0.350</td>
<td>0.270</td>
</tr>
<tr>
<td>0.747</td>
<td>0.620</td>
<td>0.482</td>
<td>0.347</td>
<td>0.260</td>
<td>0.186</td>
<td>0.132</td>
</tr>
</tbody>
</table>

Net Present Value Calculation

Table 8.3: NPV Calculation

<table>
<thead>
<tr>
<th>Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net cash flow (R$000s)</td>
<td>90.0</td>
<td>14.0</td>
<td>48.0</td>
<td>48.0</td>
<td>48.0</td>
<td>48.0</td>
</tr>
</tbody>
</table>

The discounted cash flow at 10% can be found as follows:

\[
\begin{align*}
\text{Year 0} & : 90.0 \\
\text{Year 1} & : 0.909 \times 14.0 = 12.73 \\
\text{Year 2} & : 0.826 \times 48.0 = 39.65 \\
\text{Year 3} & : 0.751 \times 48.0 = 36.05 \\
\text{Year 4} & : 0.683 \times 48.0 = 32.78 \\
\text{Year 5} & : 0.620 \times 48.0 = 29.76 \\
\end{align*}
\]

The NPV = the sum of all these values = 60.97 (compare to net project value = 116.0)
Internal Rate of Return

- The Discount Factor for which NPV = 0
- Often the basic criterion for corporate investment decisions

<table>
<thead>
<tr>
<th>Year</th>
<th>Net Cash Flow</th>
<th>Discount Rate</th>
<th>NPV</th>
<th>IRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-90,000</td>
<td>10</td>
<td>R61,048.67</td>
<td>30%</td>
</tr>
<tr>
<td>1</td>
<td>14,000</td>
<td>20</td>
<td>R25,216.05</td>
<td>25%</td>
</tr>
<tr>
<td>2</td>
<td>48,000</td>
<td>25</td>
<td>R11,885.44</td>
<td>30%</td>
</tr>
<tr>
<td>3</td>
<td>48,000</td>
<td>30</td>
<td>R753.50</td>
<td>35%</td>
</tr>
<tr>
<td>4</td>
<td>48,000</td>
<td>35</td>
<td>-R8,627.04</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>48,000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Payback and IRR

Risk and Sensitivity Analysis

- Consider three scenarios:
  - Optimistic
  - Realistic
  - Pessimistic
- in energy costs
- interest rates
- tax rates
Financing Alternatives

- **In-House**
  - from a central budget
  - from a specific departmental or section budget
  - payment for energy services by individual budget holders
  - retaining the savings achieved.

- **External**
  - capital loans
  - energy performance contracts
  - leasing

Energy Performance Contracts and ESCOs

A comprehensive package of services:

- An energy efficiency opportunity analysis
- Project development
- Engineering
- Financing
- Construction/implementation
- Training
- Monitoring and verification

Benefits of EPC

- Reduced or eliminated need for corporate capital
- Decreased operating costs
- Turnkey installation
- Participation of local energy utilities
- Enhanced staff training
- Savings fund repayments, based on performance against quantifiable results
- Accelerated equipment upgrading, retrofits, and/or modernization
- Transferred risk to a third party (ESCO)
EPC Options

- First Out
  - ESCO retains savings until an agreed-upon financial goal is achieved; client company then receives future savings
- Shared Savings
  - ESCO and client company share savings as they are achieved

EPC Options

- Guaranteed Savings
  - ESCO guarantees project costs (exclusive of client add-ons); debt service is covered by the income stream
- Discounted Energy Savings (Chauffage)
  - Client company pays ESCO a fee equal to the base year energy bill minus an agreed upon discount; ESCO pays actual energy bill

Clean Development Mechanism

1. Project Identification
2. PDC Development
3. CDM/EB Approval of the Methodology
4. Validation
5. Letter of Approval
6. Registry
7. Monitoring
8. Verification
9. Certification
10. Sale of CER

Designated Operational Entity
CDM EB – UNFCCC
Small-scale CDM Projects

- More economical for execution than large projects
- renewable energy projects up to 15 MW
- energy efficiency improvement with savings up to 15 GWh/year
- other GHG emission reduction projects that themselves have direct emissions less than 15 kt CO$_2$e/year

Module 9: 7 Steps for Energy Management

Assessing energy use
Identifying opportunities for savings

Module 9 Objectives

- Advise on the implementation of a systematic assessment of energy systems and identification of savings opportunities
The Seven Steps

Seven Steps to Energy Savings

1. Understand the Cost of Energy
2. Compare Yourself
3. Understand When Energy is Used
4. Understand Where Energy is Used
5. Match the Requirement (Eliminate Waste)
6. Maximize Efficiency
7. Optimize Energy Supply

Step 1: Understand the Cost of Energy

- Electricity
  - Demand (R/kVA)
  - Energy (R/kWh)

- Fuel
  - Cost per m$^2$ or litre or tonne
  - Cost per equivalent kWh or GJ
Why Understand Costs?

- Verify your bills - spot errors.
- Be aware of the impact of tariff changes.
- Be aware of how usage patterns impact unit costs
  - i.e. the **incremental** cost of energy

Unexpected Cost Increase

- May 2003
  - 600 000 kWh cost R 168 000
- June 2003
  - 601 000 kWh cost R 170 688
  - Energy up by 0,16%
  - Costs up by 1,1%  ???

Impact of the Rate

<table>
<thead>
<tr>
<th></th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Demand</td>
<td>R12/kVA</td>
</tr>
<tr>
<td>Energy On-peak</td>
<td>R0.28/kWh</td>
</tr>
<tr>
<td>Energy Off-peak</td>
<td>R0.09/kWh</td>
</tr>
</tbody>
</table>

A 100 kVA load for 10 hours = approx. 1000 kWh
Billing Analysis

Comparative Energy Costs

Don’t Pay Too Much!

- A utility metering error at one industrial plant resulted in a 66% increase in electricity costs
- In some areas demand charges make up 40-50% of an electricity bill
Step 2. Compare Yourself

- Externally
  - versus industry figures
  - other benchmarking studies
- Internally
  - Historical comparison
  - Temporary metering & analysis
  - Permanent metering – need manageability

Benchmark Comparisons

- Internal benchmarks (for example):
  - Average for Period: 92 kWh/kg
  - Minimum Month: 77 kWh/kg
  - Maximum Month: 165 kWh/kg
- External benchmarks:
  - Best industry practice: 65 kWh/kg
  - Industry average: 85 kWh/kg

Finding Internal Benchmarks by Regression Analysis

![Graph showing the relationship between monthly energy usage and production.](image)
Step 3: Understand When Your Plant Uses Energy

An Electrical Fingerprint

Patterns Revealed
- Peak Demand
- Night Load
- Start-Up
- Shut-Down
- Weather Effects
- Cyclical Loads
- Interactions among systems
- Production Effects
- Problem Areas
Savings Opportunities

- Scheduling – reduce startup peaks
- Investigate off-production usage
- Infrequent demand peaks – avoidable
- Shift on-peak to off-peak usage pattern
- Equipment loading – consider sequencing

Expensive Co-incidences

- Purchased too quickly, electricity can be as much as 200 times more expensive
- One 15-30 minute period sets the demand portion of the bill for the whole month

Step 4: Understand Where Your Plant Uses Energy

**Demand**

- Compressed Air: 20.0%
- Refrigeration: 40.0%
- Other: 40.0%

**Energy**

- Compressed Air: 35.0%
- Refrigeration: 50.0%
- Other: 15.0%
The Load Inventory

<table>
<thead>
<tr>
<th>Load Description</th>
<th>Quantity</th>
<th>kW</th>
<th>Unit kW</th>
<th>Total kW</th>
<th>Diversity Factor</th>
<th>Peak kW</th>
<th>Hours</th>
<th>Energy kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Lighting</td>
<td>50</td>
<td>0.5</td>
<td></td>
<td>25.0</td>
<td>100%</td>
<td>25.0</td>
<td>400</td>
<td>10,000</td>
</tr>
<tr>
<td>Air Compressor</td>
<td>1</td>
<td>50.0</td>
<td></td>
<td>50.0</td>
<td>100%</td>
<td>50.0</td>
<td>732</td>
<td>36,600</td>
</tr>
<tr>
<td>Punch Press (Idle)</td>
<td>2</td>
<td>15.0</td>
<td></td>
<td>30.0</td>
<td>100%</td>
<td>30.0</td>
<td>300</td>
<td>9,000</td>
</tr>
<tr>
<td>Punch Press (Engaged)</td>
<td>2</td>
<td>75.0</td>
<td></td>
<td>150.0</td>
<td>10%</td>
<td>15.0</td>
<td>40</td>
<td>6,000</td>
</tr>
<tr>
<td>Cooling Pump</td>
<td>1</td>
<td>20.0</td>
<td></td>
<td>20.0</td>
<td>80%</td>
<td>16.0</td>
<td>150</td>
<td>3,000</td>
</tr>
<tr>
<td><strong>Total Load</strong></td>
<td></td>
<td>136.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>64,600</strong></td>
</tr>
</tbody>
</table>

Demand Breakdown

- Plant Lighting: 17%
- Air Compressor: 38%
- Punch Press (Engaged): 11%
- Punch Press (Idle): 22%
- Cooling Pump: 12%

Energy Breakdown

- Plant Lighting: 14%
- Cooling Pump: 9%
- Air Compressor: 58%
- Punch Press (Idle): 14%
- Punch Press (Engaged): 9%
Unnoticed Consumption

- Unknown, and in many cases, unnecessary uses of energy can amount to 5% or more of the entire electricity bill!
- What is 5% of your electricity bill?

Identify Opportunities: Starting at the End Use

- Understand Present Usage
- Understand Costs
- Compare Yourself
- Understand When
- Understand Where
- Optimize Supply
- Maximize Efficiency
- Match the Requirement
- Find the Savings Opportunities

Logical Order

1st - Match the requirement = Eliminate the waste
2nd - Maximize the efficiency
3rd - Optimize the source
Step 5: Eliminate Energy Waste

“Turn it off”
- Lights, fans, pumps, conveyors
- Compressed air & vacuum leaks
- Freezer/cooler air leakage
- Leaking steam traps

“Turn it down”
- Temperature, water & air flow
- Compressed air pressure & flow

“Control it”
- Exhaust / make-up air balance

Step 6: Maximise Efficiency

- Filters and lubrication
- Clean heat exchangers and pipes
- Minimise refrigeration “lift”
  - Condenser size and pressure
- Motor conditions
  - voltage & cooling
- Combustion efficiencies
- Sequence compressors and pumps

Overall Approach: Match & Maximize

<table>
<thead>
<tr>
<th>Action</th>
<th>Lower Cost (operational)</th>
<th>Higher Cost (technological)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxime Efficiency</td>
<td>3. Operating conditions</td>
<td>4. Efficient equipment</td>
</tr>
</tbody>
</table>

Reducing waste is as simple as turning it off!
Efficiency is a result of good maintenance

Match the Need
Reduce Losses
Why this Order?
- End-use actions influence all other parts of the system – do this first
- Lower cost actions are operational – at end-use
- Higher cost actions are technological – higher efficiency components
- End-use determines supply requirement

Step 7: Optimise the Supply
- Heat Recovery – utilizing waste heat sources
- Heat Pumps – using a low grade heat source
- Co-generation – generate heat and electricity
- Renewable energy – solar, wind...
- Competitive Supplier – negotiate supply contracts

Consider Heat Recovery
- Waste heat Source?
  - quantity
  - temperature
- Use?
  - energy & temperature
  - time coincidence
  - location
- Practical recovery %?
Apply Heat Recovery

”Low Technology”
- Heat from air compressor

”Higher Technology”
- Boiler blow-down
- De-superheat refrigerant
- Boiler economiser

Cost vs. Benefits

Benefits:
- direct energy savings
- indirect energy savings
- comfort/productivity increases
- operation & maintenance cost reductions
- environmental impact reduction

Costs:
- direct implementation costs
- direct energy costs
- indirect energy costs
- operation & maintenance cost increase

Environmental Impact

Direct Emissions
\[ \text{NO}_x, \text{VOC, SO}_2, \text{CO}_2 \]

Indirect Emissions
\[ \text{NO}_x, \text{VOC, SO}_2, \text{CO}_2 \]

On-Site Combustion

Utility Power Generation

Utility
### GHG Emission Factors...

**Environmental impact**

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Emission Factor (kg CO₂/ekWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity from grid</td>
<td>0.90</td>
</tr>
<tr>
<td>Coal</td>
<td>0.33</td>
</tr>
<tr>
<td>Heavy Fuel Oil</td>
<td>0.20</td>
</tr>
<tr>
<td>LPG</td>
<td>0.21</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>0.19</td>
</tr>
</tbody>
</table>

*Emission factors for coal depend on the type and quality of coal and its calorific content (assumed to be 26.5 GJ/t here)*.

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### How do we begin?

- Plan strategically (module 1)
- Assess the organisation & act to move upscale (module 2)
- Implement MT&R (module 3)
- Assess current use - identify savings opportunities (module 4)