



# Industrial Energy Management

Achieving energy efficiency in  
South Africa's industry

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## 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

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# Module 1: Introduction to Industrial Energy Management

Context for energy management  
Defining energy management

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## 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

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## Defining Energy Management

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

(Capehart, Turner and Kennedy. Guide to Energy Management, 2<sup>nd</sup> Edition. Fairmont Press Inc., 1997)

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

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## 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

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## 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

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## 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

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## 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?

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# 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?

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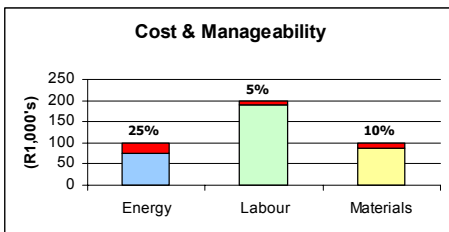
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# Energy is a Manageable Expense




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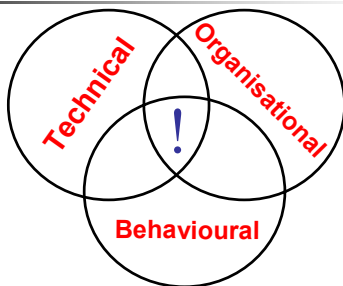
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# The Dimensions of Energy Management




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# Who ~~What~~ Creates Savings?

Category	Actual Savings
People & Technology	23%
People Only	16%
Technology	3%
Technology	-4%

ETSU GPG084: Managing and Motivating Staff to Save Energy

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# 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

ETSU Good Practice Case Study 331: ChiRex Ltd. (fine organic chemicals)

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# 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

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## Module 2: A Strategic Approach to Energy Management

Organisational change  
Strategic phases in energy management

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## 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

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## Planning for Organisational Change



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

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# 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"

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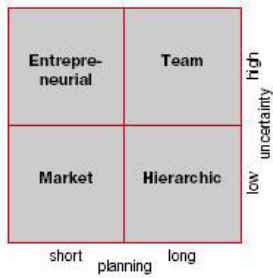
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# Organisational Culture

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




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# Corporate Culture

*The implications for energy management are the importance of gaining the support of the CEO, and of demonstrating that quick returns are possible.*

- 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.

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# Corporate Culture

- Team-oriented
  - wide participation and cooperation in operations, planning and decision-making
  - Energy efficiency teams
  - planning is long-term
  - longer term return on investment.

*In this kind of organization an energy efficiency committee will likely be instrumental in moving forward; such a committee should be broadly representative of the organisation--plant, human resources, finance, etc.*

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# 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.*

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# 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.*

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# Identifying the Culture

	Entrepreneurial	Team	Hierarchical	Market
Characteristic	innovation growth	participation cooperation	structure control	productivity achievement
Focus	outward-looking	staff-oriented	organisation-oriented	towards competitors
Planning	very short-term	long-term	medium-term	short-term
Risk Tolerance	tolerate high risk	tolerate uncertainty	needs certainty	prefer predictability
Leadership	charismatic	supportive	conservative	managerial
Structure	flexible	cooperative	rigid	cost centres
Authority	leader-concentrated	meetings	rules	delegated
TOTAL				

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## 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

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## The Problem



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

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## 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"

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# 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

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# Energy Master Planning



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

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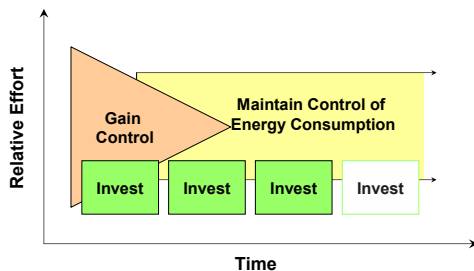
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# A Strategic Approach



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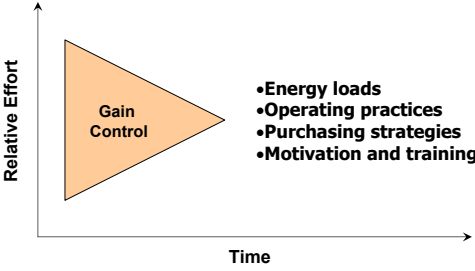
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# Gain Control



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

Relative Effort

Time

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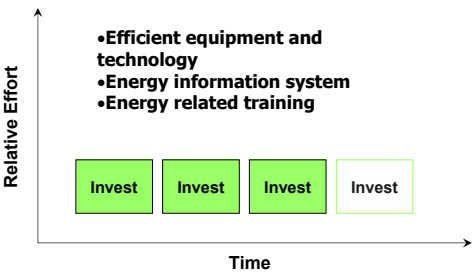
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# Invest



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

Relative Effort

Time

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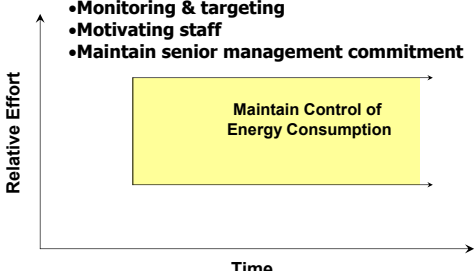
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# Maintain Control



- Monitoring & targeting
- Motivating staff
- Maintain senior management commitment

Relative Effort

Time

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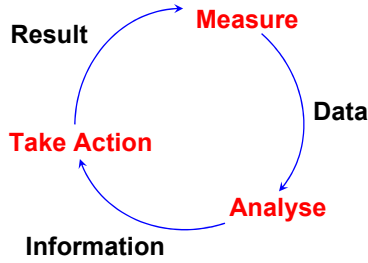
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# Continuous Improvement



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DEPARTMENT OF MINERALS AND ENERGY  
DME-Danida Capacity Building in Energy Efficiency & Renewable Energy

## Module 3: Assessing the Organisation

Priorities for organisational capacity building

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## 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

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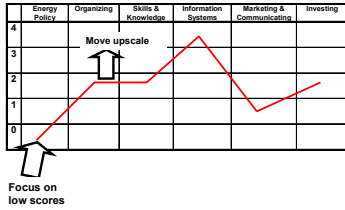
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# Interpreting the Profile

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




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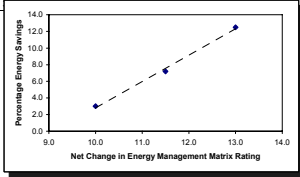
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# Improving Matrix Scores does pay off!

Case		Energy Policy	Organizing	Skills & Knowledge	Information Systems	Marketing	Investment	Rating	Net Change	% Savings
The Sears Group GPCS 327	Before	0.5	1.0	3.0	2.0	2.0	2.0	10.5	11.5	7.2
	After	3.5	3.5	4.0	3.5	4.0	3.5	22.0		
British Telecom GPCS 324	Before	1.0	2.0	1.0	1.0	1.0	3.0	9.0	10.0	3.0
	After	4.0	2.0	3.0	3.0	4.0	3.0	19.0		
Digital Equipment Corporation GPCS 341	Before	1.5	1.0	0.5	1.0	0.0	1.0	5.0	13.0	12.5
	After	3.5	3.0							




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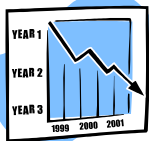
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# Good Practice Case –



- 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




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# An Energy Policy Statement



DEPARTMENT of MINERALS and ENERGY

## HEALTH, SAFETY AND ENVIRONMENTAL POLICY

The Woodbridge Group believes that the health and safety of our employees and protection of the environment is of utmost concern in the operation of our business. This policy applies to all Woodbridge locations and Joint Venture locations where Woodbridge is the managing partner.

It is the policy of The Woodbridge Group to:

- Actively pursue process innovation and fundamental research to prevent environmental pollution through the reduction and elimination of all forms of waste from our operations, including the reduction of energy consumption and the resultant release of greenhouse gas emissions.

**The reduction of energy consumption and the resultant release of greenhouse gas emissions.**

Using the of energy with our that its operations comply with this policy.

The Woodbridge Group will provide the necessary support and resources as its commitment to the goals and objectives of this policy.

This policy is posted in each facility reception area, in appropriate areas of each plant, and on the company internet and intranet sites. Our employees are an integral element in ensuring continuous improvement in workplace health and safety, and the prevention of environmental pollution. To support their participation, we document and maintain an integrated health, safety and environmental system.

CHAIRMAN *J. L. B. B. B.* 2007 PRESIDENT *R. A. M.* 2007

*H. M. M.*  
DIRECTOR GENERAL WOODBRIDGE 2007

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# Rationale for the Energy Policy



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

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# Energy Policy



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- 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

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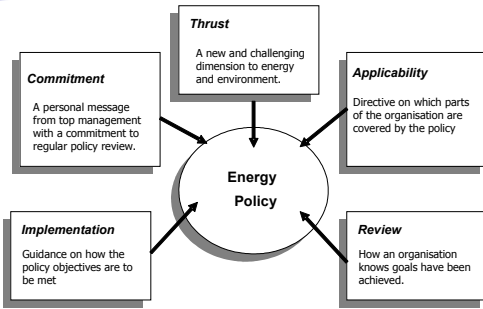
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## 5 Key Elements




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## Goals, Objectives, & Targets

<b>Policy components</b>	<b>Time scale</b>	<b>Primary staff involvement</b>
<b>Goals</b>	<b>Long-term</b>	<b>Top and senior managers</b>
<b>Objectives</b>	<b>Medium-term</b>	<b>Middle managers</b>
<b>Targets</b>	<b>Short-term</b>	<b>Operational staff</b>

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## 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

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## 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

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## 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 CO<sub>2</sub> emissions (tonnes) by z% in the next 12 months.

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## 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

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## Developing a Policy

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

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## Corporate Culture and Policy Development

Corporate Culture	Appropriate Formulation Process
Entrepreneurial	Top down
Team	Bottom up
Hierarchical	Top down
Market	Top down and middle out

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## 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

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## Module 5: Organisational Structure for Energy Management

Placing authority and responsibility in the organisation chart

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## Module 5 Objectives



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

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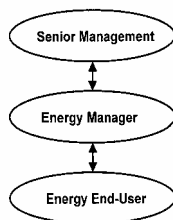
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## Organising



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



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# 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

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# 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

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# Integration of Responsibility

Function	Responsible Person				
	Director	Mgr A	Mgr B	Asst. C	Asst. D
Measure consumption	▲		■		●
Identify energy cost centres			▲	*	■
Track performance					
Set targets for energy usage					
Develop conservation programme	▲	■		●	
Inspect equipment					
Select projects for improvement					
Allocate budget and resources					
Prepare documentation					
Provide training					
Review new projects for energy efficiency					
Carry out energy management audits					

Key: ▲ Approval Authority ■ Responsible for Work ● Perform Work \* Provide Technical Support

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# 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

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# 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

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# 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.***

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## Module 6: Training and Communicating

Communicating for awareness,  
training for competence

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## 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

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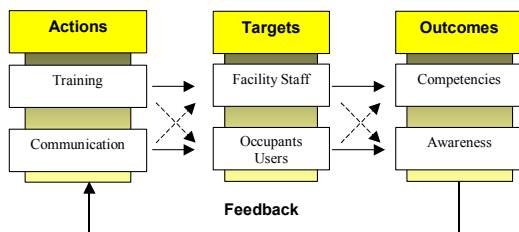
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## Train for Competence, Communicate for Awareness



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## 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

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## 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?

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## 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

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## 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

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## 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

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## 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

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# Criteria for selection

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

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# A Basis for Planning

Level	Supportive Context	Program Design	Individuals and Relationships	Measurement of Outcomes
4	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.	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.	Energy management fully integrated into management structure, clear designation of responsibility for energy use practices and consumption.	Regular quantitative assess of procedures, values & attitudes, energy use indicators vis a vis program objectives with mechanism to refine program design as needed.
3	Basic policy objectives actively supported by key organizational functions.	Deliberate needs analysis applied to design of customized program for clearly articulated outcomes.	Energy manager accountable to energy committee representing all users, chaired by a senior line manager.	Feedback of MSV informs the program design process
2	A basic adopted policy on energy use practices, with general awareness as part of the organization's policy structure.	Ongoing training and communication adapted to organizational needs and circumstances on the basis of subjective, anecdotal evidence.	Energy manager designated, reporting to ad-hoc committee, but the management and authority are unclear.	Application of some form of on energy performance, not specifically keyed to program outcomes.
1	Guidelines respecting energy use practices informally incorporated into job descriptions and procedures.	Ongoing training and communication using "off the shelf" programs, in parallel with other energy management initiatives.	Energy management the part-time responsibility of someone with only limited authority or influence.	Intuitive sense of program impact on part of EM based anecdotal evidence.
0	No organizational recognition of energy as manageable or an organizational priority.	Sporadic use of "off the shelf" programs without clear determination of their fit to needs.	No energy management or any formal delegation of responsibility for energy consumption.	No effort to assess specific outcomes of training and communication initiatives.

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# 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

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## 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"

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## 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

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## 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

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## 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

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## 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

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## Module 7: Energy Monitoring, Targeting & Reporting

The power of effective energy information management

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# 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

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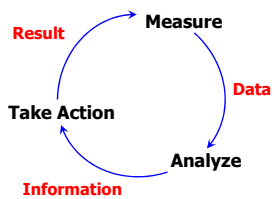
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# Information Systems and MT&R

Information Systems
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.




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# 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

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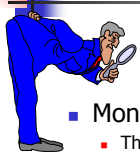
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# Three Distinct Functions



## 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




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# Where can you apply MT&R?

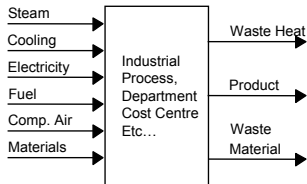
## Utility Inputs

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

## Specific Systems

- Processes
- Boilers
- Compressor etc.

## Cost centre or department




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# 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

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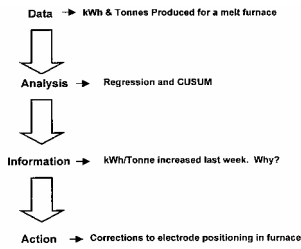
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# Data and Information

- Data is the "raw material"
- Information is the "refined product"
- Action decisions need information




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# 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




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# 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?




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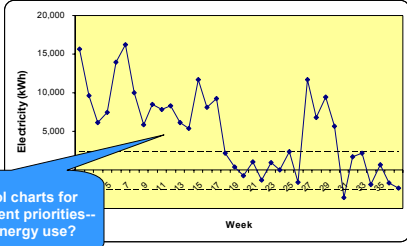
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# Controlling performance



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

Demo

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# What are Targets?

## 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

*From Energy-Wise Practices 6, NZ Energy Efficiency and Conservation Authority*

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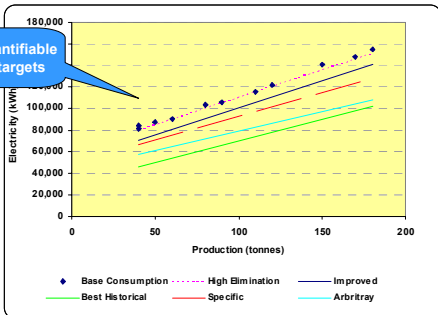
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# Setting targets

Options for quantifiable performance targets




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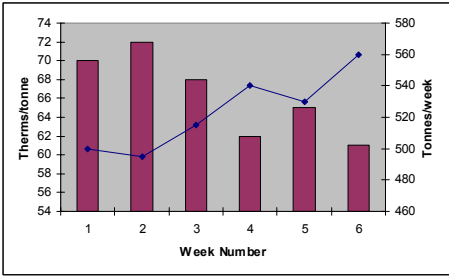
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# Benchmarks as Targets




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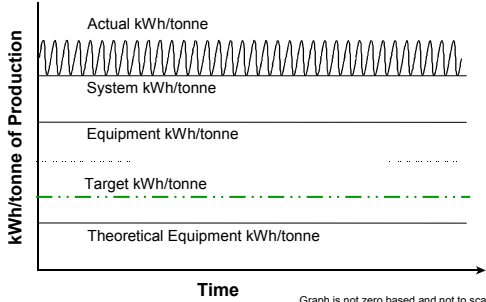
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# Process Energy Use



Graph is not zero based and not to scale

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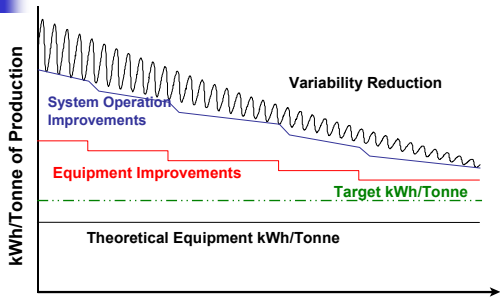
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# What Types of Actions Must be Taken?



Graph is not zero based and not to scale

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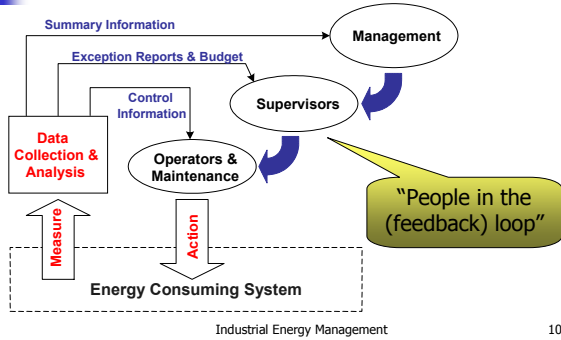
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# How Will It Sustain Savings?




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# 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

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# Who Needs What & When?



An example – each organization & site is unique

	Annual Report	Monthly Report	Weekly Report	Key Indicators (1)	Exception Report
Managers	X	X		X	X
Supervisors		X	X	X	X
Operators & Maintenance				X	

(1) Key Indicators appropriate to tasks/responsibility

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# Information Needs and Decision Making



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Information Needs	Level of Decision Making			
	Information	Operational Control	Managerial Control	Strategic Planning
Source	internal	internal	internal	external
Precision	high	medium	medium	Low
Timing	exceptional	periodic	periodic	Irregular
Notice	sudden	Anticipated	Anticipated	none
Nature	warning	warning	results	Predictive

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# A Starting Point



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- 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

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# Case: M&T in a Brewery



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- 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

Reference: ETSU Good Practice Case Study #273: Charles Wells Ltd., Eagle Brewery

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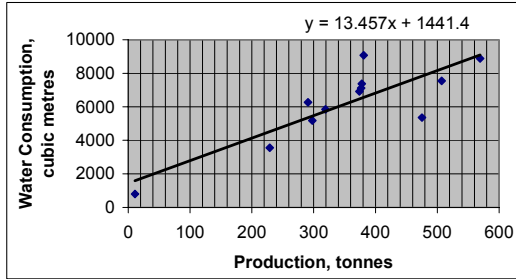
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# MT&R and Water Efficiency



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# 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



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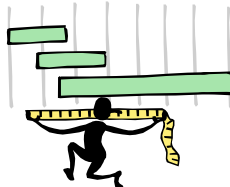
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# Why Verify Savings?



- 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



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## Spend more to reduce costs?



### Verification

- Increases the confidence of funders
- reduces the investment risk
- reduces your costs of borrowing

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## 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

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## 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?



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## Sources of Uncertainty in M&V



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



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## 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

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## 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

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# Savings Determination

$$\text{Savings} = \text{Baseline Energy Use}_{\text{adjusted}} - \text{post ECM use}$$

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# 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

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# Baseline Adjustments

- Changes in production and/or weather
- Changes in operating schedule or processes
- Changes in function of the facility

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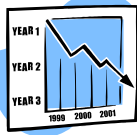
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# Monitoring of Energy... Always a Good Practice



- 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!



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DEPARTMENT OF MINERALS AND ENERGY  
DME-Danida Capacity Building in Energy Efficiency & Renewable Energy

## Module 8: Developing the Business Case

Analysing the investment  
opportunity  
Financing implementation

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## 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)

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## Investment Needs



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

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## 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

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## 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

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## 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

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## Identify and Prioritise Measures

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

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## 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

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## 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

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## 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

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## 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

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# A "Level Playing Field"



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

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# 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

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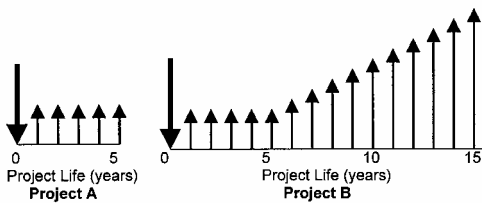
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# Cash Flow Analysis




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# Cash Flow Table

**Table 8.1: Cash Flow Table for Purchase of new Boiler**

Capital Expenditure	R100,000	90% on delivery/commissioning, and 10% performance guarantee due at one year				
Expected Savings	R48,000/year	Half in first year, full amount in all remaining years				
(Values in R'000)						
Year	0	1	2	3	4	5
Costs	(90.0)	(10.0)	0	0	0	0
Savings	0	24.0	48.0	48.0	48.0	48.0
Net cash flow	(90.0)	14.0	48.0	48.0	48.0	48.0
Net Project Value	(90.0)	(76.0)	(28.0)	20.0	68.0	116.0

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# 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

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# Other Factors in Annual Cash Flow Calculations

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

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# Time Value of Money

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

or

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

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

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# Discount Factors

Table 8.2: Discount Factors  $1/(1+i)^n$

Year (n)	0	1	2	3	4	5
Discount Factor						
6%	1	0.942	0.888	0.840	0.792	0.747
10%	1	0.909	0.826	0.751	0.683	0.620
20%	1	0.833	0.694	0.579	0.482	0.402
30%	1	0.769	0.591	0.466	0.350	0.270
40%	1	0.714	0.510	0.364	0.260	0.186
45%	1	0.690	0.476	0.328	0.226	0.156
50%	1	0.666	0.444	0.297	0.198	0.132

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# Net Present Value Calculation

Table 8.3: NPV Calculation

Year	0	1	2	3	4	5
Net cash flow (R\$000s)	(90.0)	14.0	48.0	48.0	48.0	48.0
The discounted cash flow at 10% can be found as follows:						
Year 0	1 x (90.0) = (90.0)					
Year 1	0.909 x 14.0 = 12.73					
Year 2	0.826 x 48.0 = 39.65					
Year 3	0.751 x 48.0 = 36.05					
Year 4	0.683 x 48.0 = 32.78					
Year 5	0.620 x 48.0 = 29.76					
NPV = the sum of all these values = 60.97 (compare to net project value = 116.0)						

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# 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

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# 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

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# 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)

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# 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

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# 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

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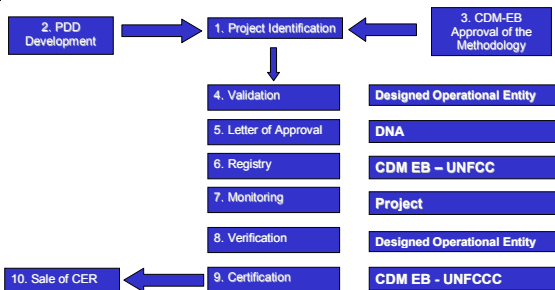
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# Clean Development Mechanism




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# 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<sub>2</sub>e/year

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DEPARTMENT OF MINERALS AND ENERGY  
DME-Danida Capacity Building in Energy Efficiency & Renewable Energy

# Module 9: 7 Steps for Energy Management

Assessing energy use  
Identifying opportunities for savings

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# Module 9 Objectives



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

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# The Seven Steps




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# 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




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# Step 1: Understand the Cost of Energy

- Electricity
  - Demand (R/kVA)
  - Energy (R/kWh)
- Fuel
  - Cost per m<sup>3</sup> or litre or tonne
  - Cost per equivalent kWh or GJ




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## 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

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## 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% ???

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## Impact of the Rate

Maximum Demand	R12/kVA
Energy On-peak	R0.28/kWh
Energy Off-peak	R0.09/kWh

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

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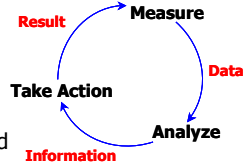
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## Step 2. Compare Yourself



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




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## 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

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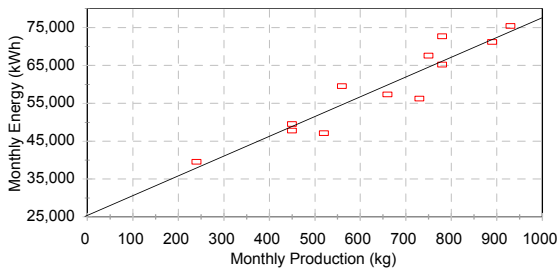
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## Finding Internal Benchmarks by Regression Analysis




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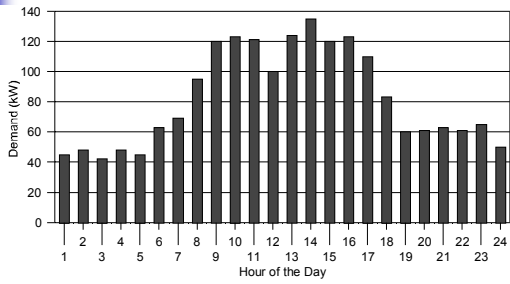
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## Step 3: Understand When Your Plant Uses Energy



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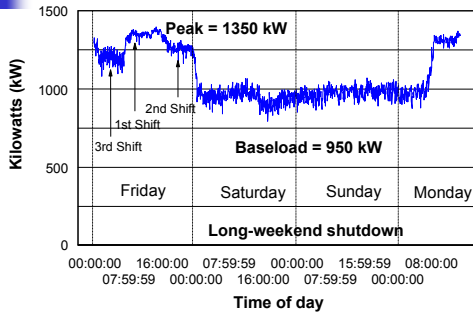
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## An Electrical Fingerprint



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## Patterns Revealed



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

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## 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

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## 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

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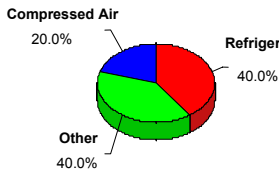
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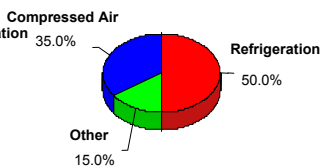


## Step 4: Understand Where Your Plant Uses Energy

### Demand



### Energy




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# The Load Inventory

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

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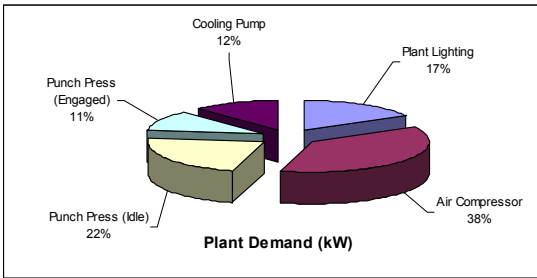
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# Demand Breakdown




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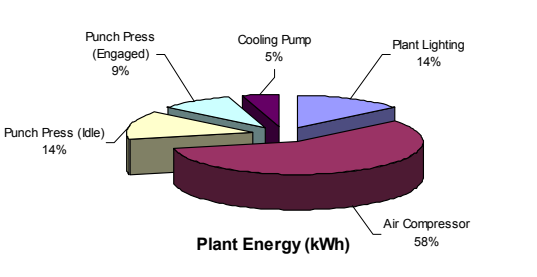
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# Energy Breakdown




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# 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 you electricity bill?

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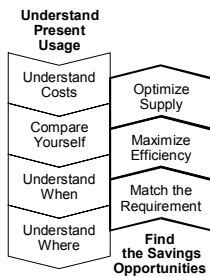
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# Identify Opportunities: Starting at the End Use




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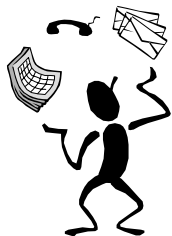
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# Logical Order

- 1st - Match the requirement = Eliminate the waste
- 2nd - Maximise the efficiency
- 3rd - Optimise the source




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## 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




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## 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




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## Overall Approach: Match & Maximize



Action	Lower Cost (operational)	Higher Cost (technological)
<b>Eliminate Waste</b>	1. Manual control	2. Automatic control
<b>Maximise Efficiency</b>	3. Operating conditions	4. Efficient equipment

Match the Need

Reducing waste is as simple as turning it off!

Reduce Losses

Efficiency is a result of good maintenance

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## 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

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## 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

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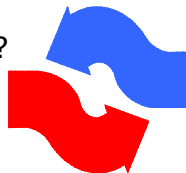
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## Consider Heat Recovery

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




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## Apply Heat Recovery

- "Low Technology"
  - Heat from air compressor
- "Higher Technology"
  - Boiler blow-down
  - De-superheat refrigerant
  - Boiler economiser




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## Cost vs. Benefits

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|---|---|
| <ul style="list-style-type: none"> <li>■ Benefits:           <ul style="list-style-type: none"> <li>■ direct energy savings</li> <li>■ in-direct energy savings</li> <li>■ comfort/productivity increases</li> <li>■ operation &amp; maintenance cost reductions</li> <li>■ environmental impact reduction</li> </ul> </li> </ul> | <ul style="list-style-type: none"> <li>■ Costs:           <ul style="list-style-type: none"> <li>■ direct implementation costs</li> <li>■ direct energy costs</li> <li>■ in-direct energy costs</li> <li>■ operation &amp; maintenance cost increase</li> </ul> </li> </ul> |
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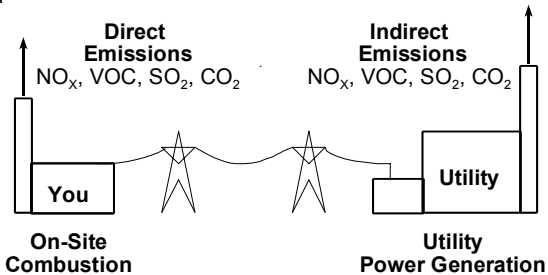
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## Environmental Impact




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# GHG Emission Factors . . . Environmental impact



Energy Source	Emission Factor (kg CO <sub>2</sub> /ekWh)
Electricity from grid	0.90
Coal	0.33 (2.44 tonnes CO <sub>2</sub> /tonne coal) typical <sup>1</sup>
Heavy Fuel Oil	0.26
LPG	0.21
Natural Gas	0.19

<sup>1</sup> 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)



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