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Agence Marocaine pour l'Efficacité Energétique
Moroccan Agency for Energy Efficiency

Energy Management System according to the ISO 50001 standard

16/05/2025

Amine AHMARRAS
Head of training within AMEE

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Welcome

- Name
- Organisation
- Energy Management Experience
- What do you expect to learn over this program?

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Energy Management Systems (EnMS)

Day 1 – Commitment building

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The approach to Energy Management outlined in this program can be applied to any organization regardless of size or structure

Residential, Small and Medium Sized Enterprises (SMEs), Significant Energy Uses (SEUs), large factory, total corporation, national level, etc..

Energy = Carbon = Money

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Agenda

- Part 1
  - Introduction
  - Context
  - 4 days program
- Part 3
  - Overview of the EnMS
  - Maturity Matrix
  - Energy Manual
- Part 2
  - Building commitment
  - Context
  - Forcefield Analysis
- Part 4
  - Leadership: Scope and Boundaries
  - Leadership: Roles
  - Energy Policy

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Why do you need an energy management system (EnMS)?

Context: Energy costs, pollution, climate change

Better management practices

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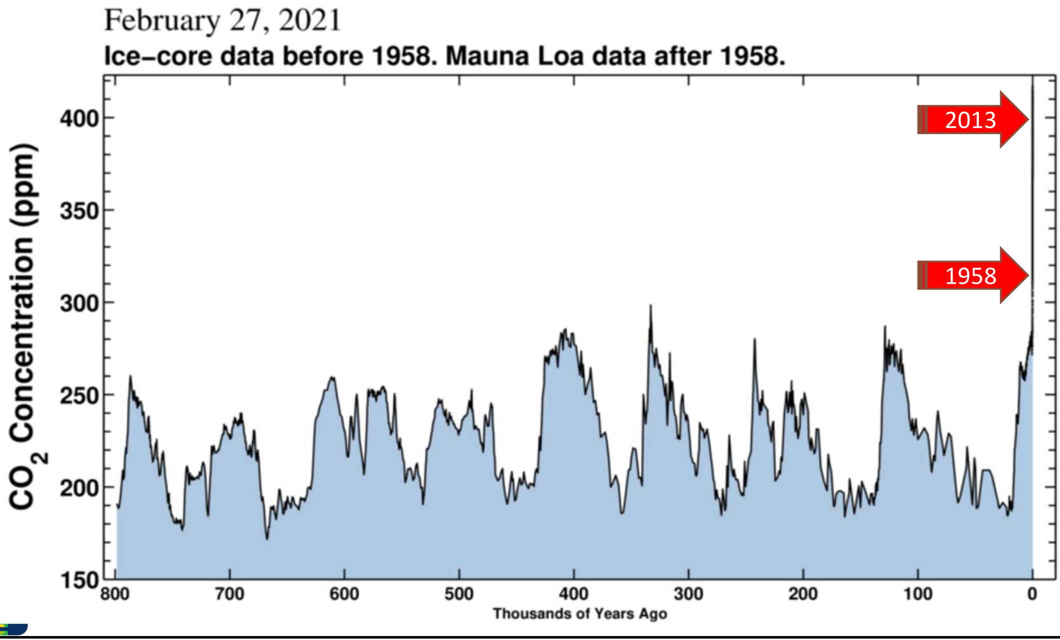
The Keeling Curve



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Context: Climate change

Society is waking up!

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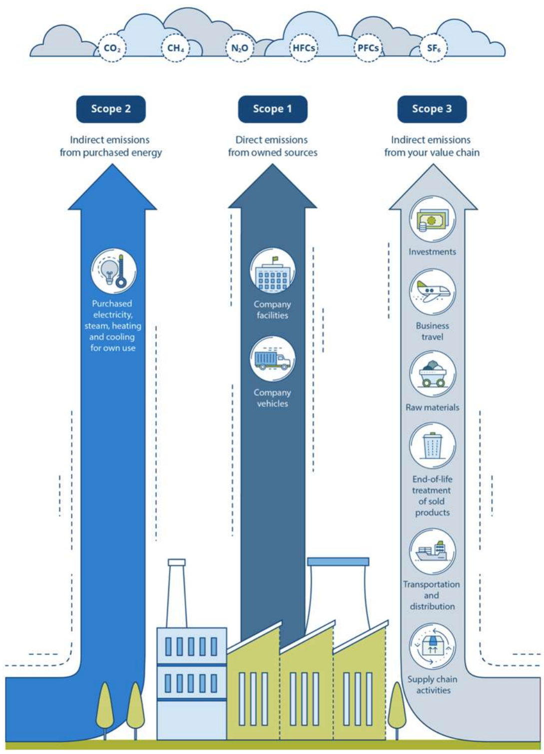
Global environmental trends

Source: Incite S.A.

Carbon footprint (GHGs)

- Scope 1 – Direct emissions
  - Boilers, combustion, vehicles, aircraft, ships, refrigerants
- Scope 2 – From imported energy
  - Electricity, district heating
- Scope 3 – Indirect – throughout the value chain

- Energy is 73% of total global Greenhouse Gas (GHG) emissions



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SUSTAINABLE DEVELOPMENT GOALS

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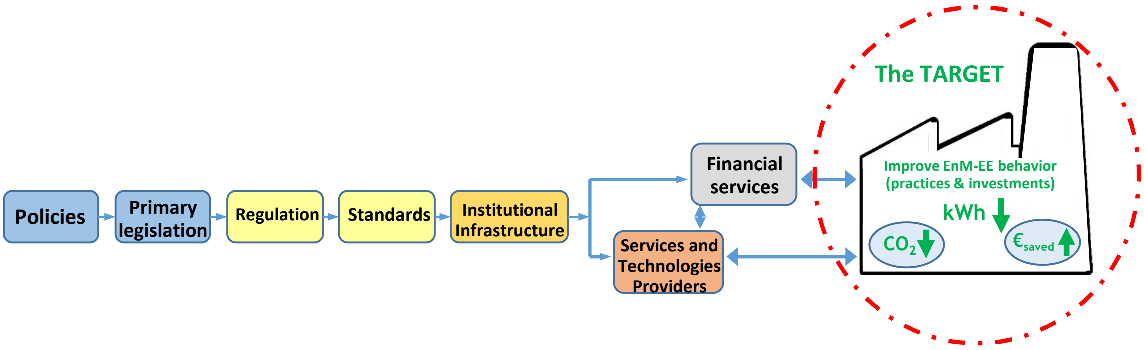
To bear in mind



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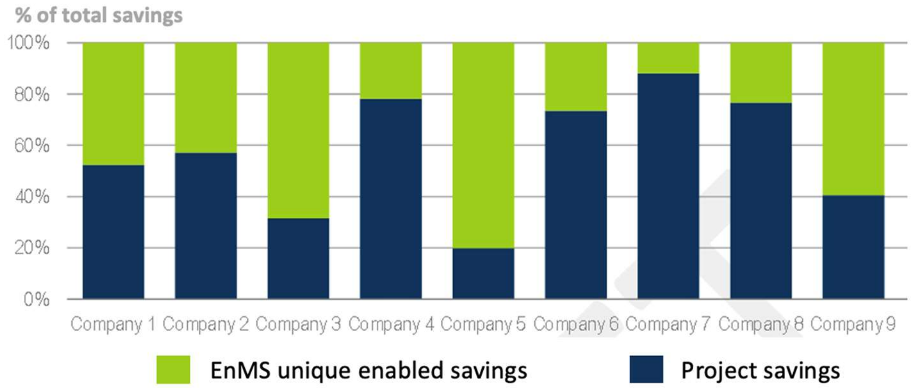
Separation of energy savings types

Comparison of project savings and EnMS unique enabled savings



There is evidence that energy management systems unlock energy savings beyond those from technology replacement or process upgrades

Note: Companies 1-9 are medium-sized and large companies from metal processing, chemicals, automotive, construction material and power generation sectors in Egypt, North Macedonia, South Africa and Turkey

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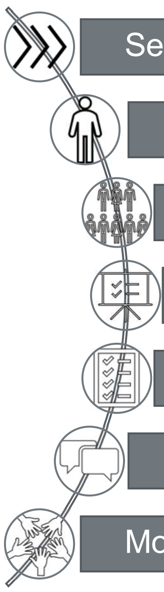
Critical success factors



- Sense of urgency
- Top management commitment and leadership
- Clear roles and responsibilities
- Clear objectives
- Action plans aligned with the objectives
- Communication
- Motivation of the sustainability team

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Critical success factors

- You need to be interested and willing to lead and drive this forward
- You need to win ongoing support from top management
- You need to learn how to improve energy performance through:
  - People
  - Technology
  - Information
- You need to learn how to measure energy performance

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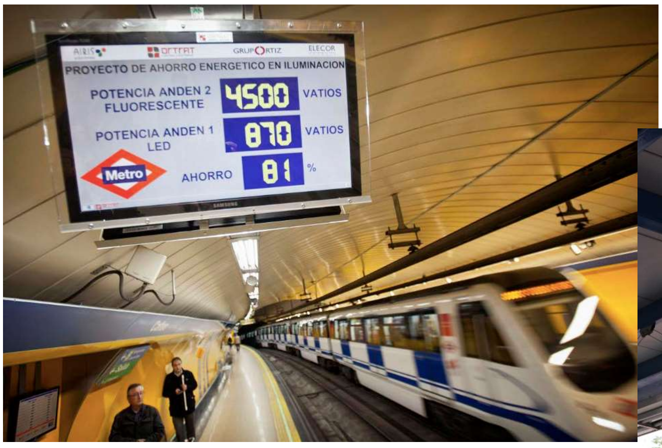
Different priorities



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Industrial Energy Efficiency Benefits

- Energy efficiency has demonstrated, time and again, that
  - It saves money
  - It reduces production and product costs
  - It increase reliability of operations
  - It has a positive effect on productivity and competitiveness
  - It can offer attractive financial and economic returns
  - Reduces risk/exposure to rising energy prices
  - Increases security of supply
  - Reduces green house gas emissions
  - ….

Why it is not happening then?

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BARRIERS to Energy Efficiency in Industry

- M • Management focus is on production & volumes, not on EE
- K • Lack of information and understanding of own energy performance
- K • Lack of adequate skills for identifying, assessing, developing and implementing EE measures and projects
- K • Poor or misused monitoring systems and data
- M • First costs more important than recurring costs → disconnection between capital and operating budgets
- M • Staff behavior and attitude
- F • Financing constraints

✓ *Production, technological, operational and staff changes over time*

- Lack or limited availability of IEE services and product

M Management/organizational barrier K Knowledge/competency barrier F Financial barrier

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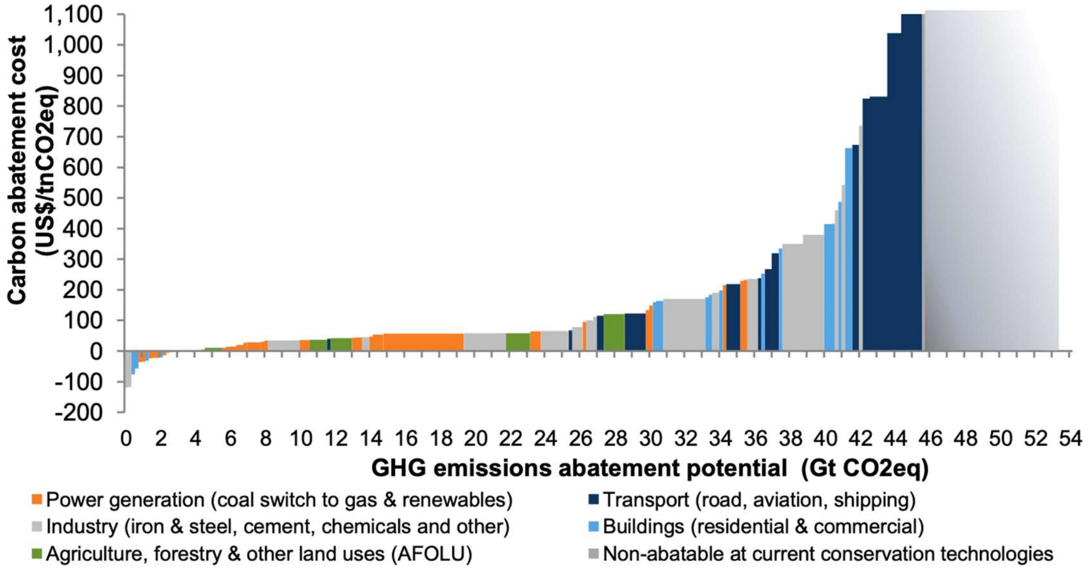

Source: Goldman Sachs ,Carbonimics

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Why are we here? - menti.com

Purpose	Importance
Stop climate change	
Reduce energy cost	
Use less energy	
Improve energy performance	
“My boss sent me”	
Other	

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What is an energy management system?

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Has this situation changed in over 70 years?

The new knowledge that the war uncovered is the sad lack in only too many factories, large and small, of the simple principles governing the economic use of steam. Immense pains are often taken to capture an extra 2 or 3 *per cent.* in the boiler house, yet the factory may be using 2 or 3 *times* as much steam as is necessary.

Lyle, O. 1947, The efficient use of steam, HMSO, London

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What is energy management?

- All activities related to:
  - Understanding your energy use and energy consumption
  - Controlling activities that affect energy consumption
  - Reducing your energy consumption
- Aspects to be managed (three pillars):
  - People
  - Technology
  - Information

An energy management system (EnMS) is a systematic approach to managing all of the above.

ISO 50001 is an internationally recognised standardised approach to developing and maintaining an EnMS.

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What is the purpose of an EnMS?

- Use energy more effectively and efficiently
- Reduce costs
- Reduce exposure to volatile energy prices
- Reduce environmental impact and reduce carbon emissions
- Improve security of supply
- Increase process reliability and stability
- Reduce risk associated with energy supply
- Basis for a decarbonisation strategy
- Co-benefits - Non-energy benefits (NEBs)

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EnMS as a Carbon Management system (CMS)?

It can provide the basis of your decarbonisation plans related to energy:

1. Energy Conservation
2. Energy Efficiency
3. Embedded renewable energy
4. Power Purchase Agreement (PPA)
5. Fuel switching
   - Electrification (where the grid has, or will have, a lower carbon intensity)
6. Carbon sequestration
7. Offsetting

- ISO 14091:2021 Adaptation to climate change — Guidelines on vulnerability, impacts and risk assessment

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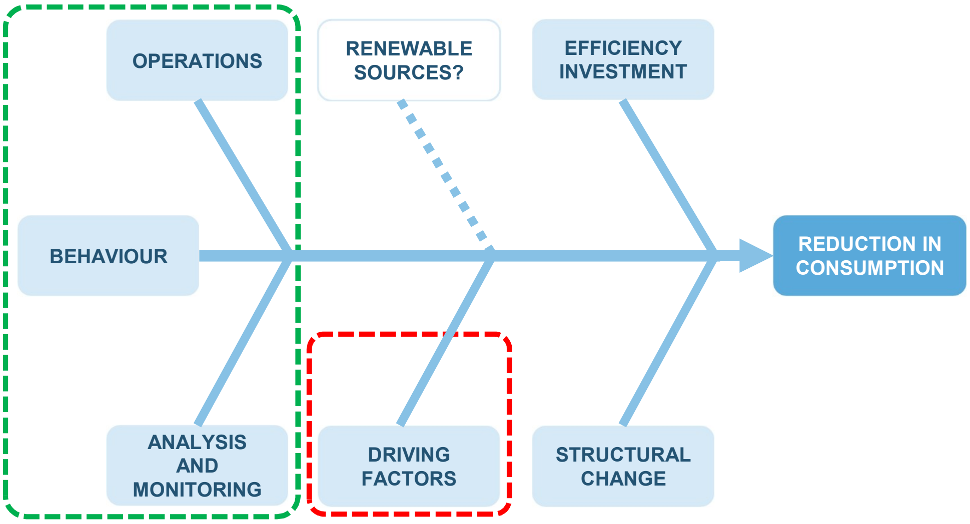
Reduction in energy consumption



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What an EnMS is not!

- Software
- Metering
- Monitoring and targeting
- A large energy efficiency project
- A renewable energy project
- An awareness campaign
- An engineering tool
- A separate "system" from your daily routine work

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Sources of energy

- Fossil Fuels
  - Oil (typically transport)
  - Gas (Natural, LPG, LNG)
  - Coal
  - CO_2 formed in combustion
- Nuclear Energy

- Renewable Energy (RE) examples
  - Solar electric or photo-voltaic (PV)
  - Solar thermal
  - Wind
  - Ocean (wave and tidal)
  - Biomass
  - Biofuel
  - Hydropower
  - Hydrogen….

Energy (ISO 50001:2018): Electricity, fuels, steam, heat, compressed air, and other like media.
The capacity of a system to produce external activity or perform work

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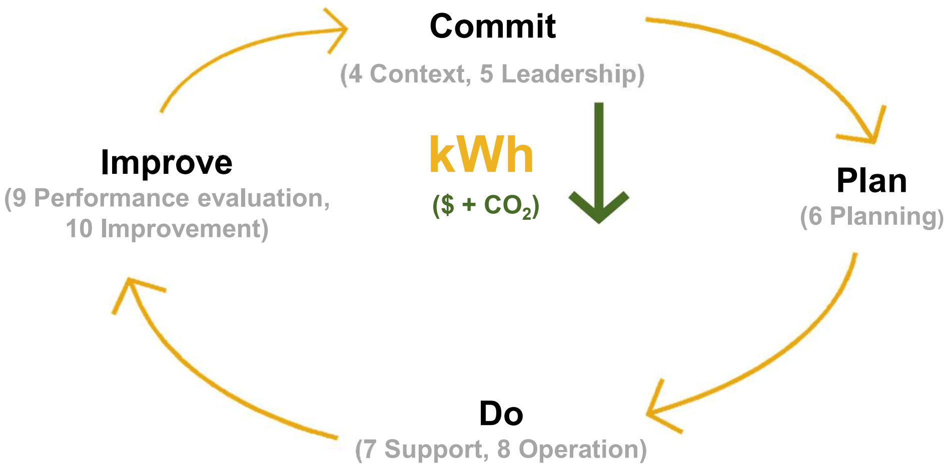
EnMS Cycle



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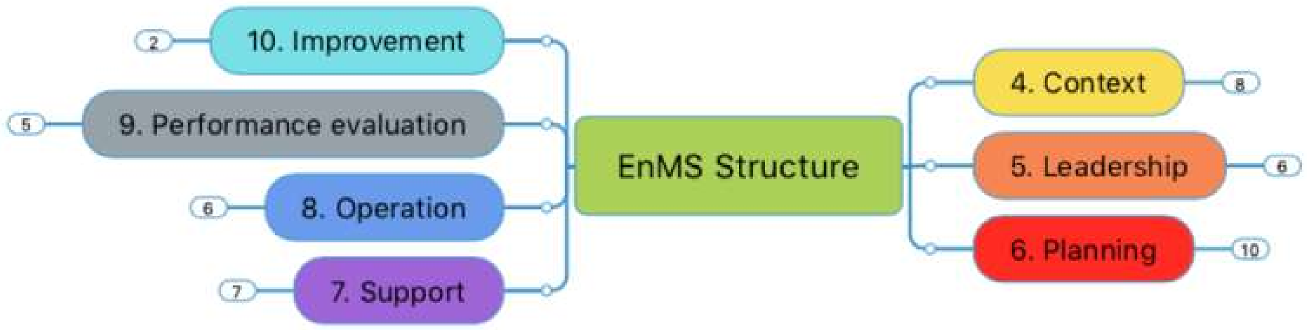
Structure of ISO 50001:2018 (EnMS)



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Structure of ISO 50001:2018

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EnMs Implementation

Day 1 Commitment Building
- PESTLE
- SWOT
- Interested Parties
- Energy Policy
- Scope and Boundaries
- Risk and Opportunities
- Leadership
- Energy Manual
- Change Management
- Document Control
- Communications

Day 2 Planning
- Planning methodology
- Data Collection and Trends
- Energy Balance - SEUs
- Data - Baselines and Performance Indicators
- People and Opera-tional Control
- Technology
- Energy Saving Oppor-tunities (ESOs)
- Targets and Action Plans
- Data Collection plan

Day 3 - Doing
- Operational Control
- Energy Efficient Design
- Procurement

Day 4 Improving
- Performance checking
- Internal Audits
- Management Review
- Continual Improvement

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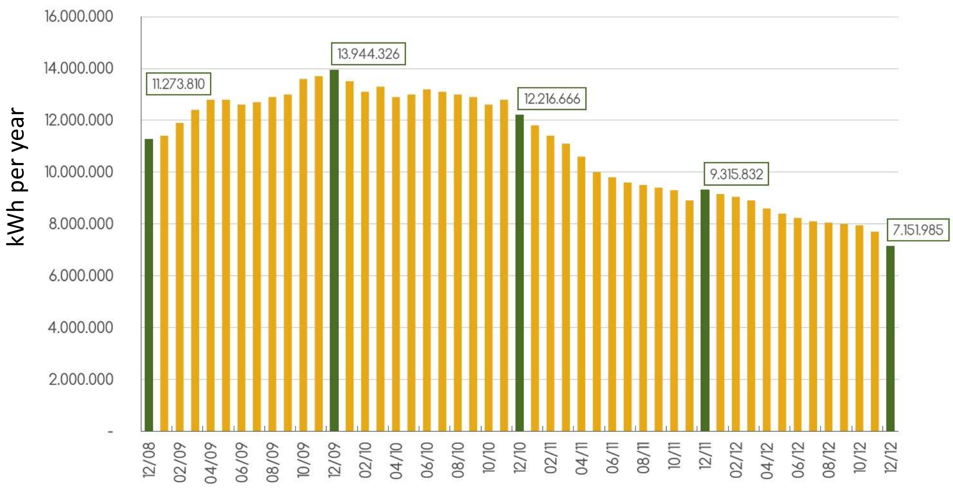
What can be achieved?



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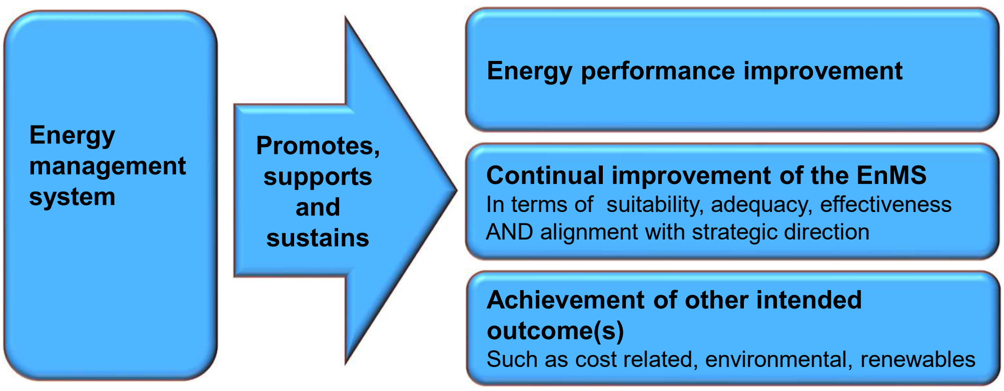
Relationship between energy performance and the EnMS



Adapted from ISO 50001:2018

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See you in 15 minutes!

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Overview of the EnMS tool

Including the Practical Guide

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EnMS tool

- Make copiy of the file now and work on your master copy
  - **Delete all our examples from your master copie**
  - Use this master copy as the basis of your EnMS.
  - Keep the original for reference
  - Document Control of the master copy

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Exercise: Maturity Matrix (15 minutes)

Score your organization against each criteria

Be as objective and honest as possible

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Maturity Matrix Worksheet – Please complete yours now

SCORE	1. CONTEXT: has external and internal isseus, interested parties and scope and boundaries been developed?	2. LEADERSHIP: Energy policy	3. LEADERSHIP: Roles and responsibilities	4. LEADERSHIP: integration into business processes	5. DATA: date analysis and energy performance monitoring and target setting	6. ACTION PLANS: How are energy performance improvement actions planned
4 (optimised)	A fully documented review of the external and internal context has been completed, risks and opportunities are analysed and the results have been integrated into energy management action plans	The energy policy is written and communicated and its contents are taken into account in routine decision making.	Energy related tasks are fully assigned and understood by all members of the energy team. Others in the organisation also know their roles. All of these people are competent and have received relevant training for their roles. All have sufficient time allocated to complete their roles. Energy management is fully integrated into the management structure	Energy management is fully integrated into peoples day to day roles. Business strategy includes sustainability as a central topic. Societal awareness	Normalised energy consumption at plant level and main process level (SEU) is used as the basis of setting targets and monitoring performance against the targets and action is taken to correct excessive normalised consumption	Coherent process for the identification, evaluation, prioritisation, implementation and verification of energy performance improvement opportunities. Evidence of completed and planned implementations over a number of years. Continual improvement process
3 (managed)	The external and internal context have been reviewed and documented there are some incomplete actions planned but this is not comprehensive	Formal energy policy has been published and communicated but is not part of routine operational decision making.	Energy related roles and responsibilities are well documented but there is no evidence of sufficient time being allocated or there is no evidence of competency being checked and energy training being given.	Sustainability, GHGs, are important but only aware at a organisation level. Business level.	Normalised energy consumption is monitored and compared with actual energy consumption but not integrated into taget monitoring. (Note: specific energy consumption, GJ/unit is not normalisation unless demonstrated to be statistically acceptable)	Recent history of many implemented energy performnace improvement investments and low cost energy improvements
2 (defined)	The external and internal context have been reviewed and documented but there are no plans to take action based on them	Energy is mentioned in another policy such as environmental policy but is not linked to any targets or action plans OR an energy policy is writen but not published or communicated to all staff	There is an energy manager with a documented role, there are others with roles in relation to energy management. No energy training, no competence checking, no evidence of time being allocated.	More than the enegy manager are regularly addressing energy matters	Absolute consumption is trended and reported to top management and some normalisation is being tested but not used for monitoring or decision making	Recent history of a small number of implemented energy performnace improvement investments
1 (ad hoc and irregular)	Some consideration has been given to the external or internal context but there are no plans to take action based on them	An energy policy or strategy is "under construction" but not finished or published	There is an energy manager appointed but they operate on an ad hoc basis without a documented role and responsibilies related to energy management	Only the energy manager has a consistent role	Absolute energy consumption is trended and reported	Ad hoc energy performance improvements (EE and RE) are planned and implemented. Typically based on ideas from vendors. No coherent porcess for identifying, prioritising and implementing energy performance improvement opportunitities
0 (initial)	More or less nothing specific has been completed on this topic	There is no energy policy.	There are no clear roles or responsibilities related to energy management or efficiency	Nothing in place	Energy data is not collected, trended and analysed	There are no plans to take action to improve energy performance
WRITE YOUR SCORE - initial						
WRITE YOUR SCORE - after EnMS implementation						

SCORE	7. COMMUNICATIONS: Energy awareness and communications	8. OPERATIONAL CONTROL: operation and maintenance of enefgy using systems and equipment	9. PROJECTS: energy efficient design and procurement	10. FINANCE: investment, budgets,	11. SUPPORT: top management involvement	12. BEHAVIOUR: Personnel behaviour at all levels
4 (optimised)	Continual planned communications and awareness raising to and from the energy team with top management and all employees. Campaign and feedback. Energy efficient culture. Promotion to external parties.	Operations and maintenance personnel including external contractors are fully trained, skilled in energy operations and operating procedures include energy parameters and corrective actions	Energy efficiency is fully integrated into project management procedures including a policy of using best available technology and energy metering in all projects	Financial and organisational decision making gives priority to sustainability and recognises the roles of energy management in those decisions. LCC.	Energy management and strategy fully integrated into top management. Reporting of energy performance, resources, support, leadership. Top management push for results in terms of energy performance improvement	Personnel feel responsible for energy and continuously improve behavior. Regular proposals from all organisational levels. Good suggestion processes and follow up.
3 (managed)	More frequent communications and awareness raising using professional quality materials and media. Campaign.	Operational and maintenance personnel receive regular energy training and operational and maintenance procedures include energy related parameters and instructions	There is co-operation/coordination between design, procurement and operations and the procedure is documented.	Good financial decision making tools such as NPV or IRR. Good monitoring of energy bills and budgets.	Financial resources and data and technology are supported by top managment	There are active behaviour and consciousness patterns in the organisation.
2 (defined)	Energy related communications and awareness raising are happening but with low frequency and coherence	Some operational and maintenace procedures include enegy related instructions.	Procurement includes documented energy specifications. Design department makes energy decisions independently of process and operational departments.	Investment in short payback opportunities only. No long term invertment strategy. Regular monitoring of energy bills and coordination with operational personnel	Top management delegate responsibility for these matters but are not directly invovled themselves.	The energy consumption is to some extent affected by departments personnel behaviour.
1 (ad hoc and irregular)	Occassional ad hoc communications and/or awareness raising	Operational and maintenance personnel have received some ad hoc energy related training. No documented instructions.	Some purchases include energy specifications, e.g. labelling	Some monitoring of energy bills from financial point of view but no budgets for energy investment	ad hoc interest from top management	Some limited attempts to save energy. Energy behavior is based on individual self awareness.
0 (initial)	No evidence of energy related communicatrions or awareness rainsing	No energy related training or procedures for operational staff	No evidence of energy being taken into account is design and procurement. Design includes small, medium and large scale projects	No investment in energy improvements and no financial monitoring of energy spending.	Top management have no role or priority for energy management and improvement	Energy behaviour is based on individual awareness and willingness to conserve energy.
WRITE YOUR SCORE - initial						
WRITE YOUR SCORE - after EnMS implementation						

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The Energy Manual

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The energy manual

- It’s a map of all the tasks and activities in the EnMS.
- It lists all tasks and:
  - Describes how they should be carried out (the procedure or retained documents)
  - How often
  - Where they are recorded (records or maintained documents)
  - Who needs to know about them
  - Who is responsible for each task
  - Who supports each task and other roles
- It is a summary of all roles, responsibilities and authorities in the EnMS

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The energy manual

Energy Manual (RnR)								
	R: Responsible **A:** Accountable **S:** Support **C:** Consulted **I:** Informed				**Job Title**	**Managing Director**	**Energy management representative**	**Energy r**
ID	**Task**	**What is required**	**Frequency**	**Documents**	**Communication**	Oscar Wilde	Agatha Chrisitie	Charles Dic
	4. Context							
1	External Context	Political, Economic, Social, Technological, Legal and Environmental (PESTLE) analysis	Annually	Context tab	Whole organisation			
2	Internal Context	Strengths, Weaknesses, Opportunities and Threat (SWOT) analysis taking account of the results of the PESTLE analysis.	Annually	Context tab	RnR team			
3	Interested Parties	Who, what, needs, expectations, requirements (= other requirements from 2011 version).	Annually	Context tab	RnR team			
4	Risks and Opportunitites	Based on the expernal, internal contexts and the identification of interested partices, identify an dplan for the risks and opportunities related to the use of energy.	Annually	Risks and Opps tab	RnR team			
5	Identify all legal requirements applicable to the organisation's use of energy and comply with them	Review all laws (=L from PESTLE) relevant to the organisations activities and decide which have an impact and plan compliance with those laws.	Quarterly	Legal tab	RnR team			R
6	Define the boundaries of the EnMS	Define the physical or organization limits included in the EnMS and list the exclusions and the reasons for the exclusions	Annually	Scope tab	RnR team	A	R	I
7	Define the scope of the EnMS	Define the activities and processes that are included in the EnMS and list the exclusions and the reasons for the exclusion. Take account of the external and internal context and legal and other requirements. List all energy sources in the EnMS.	Annually	Scope tab	RnR team	A	R	I
	5. Leadership							
8	Develop, publish and periodically review the energy policy	The energy policy is signed by the director of the organization	Annually	Policy tab	All staff and contractors	A	S	R

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Use of the energy manual

- It is a “live” document and requires continual updating and adjustment
- As we describe each task in this program, you need to assign it to the relevant people and to ensure they know how to complete it
  - Training Needs Analysis: Check competence and provide training.
- It will be the basis of internal auditing and certification auditing
- Each person in your energy team will be documented there

One of the first tasks is to decide who is responsible for document control

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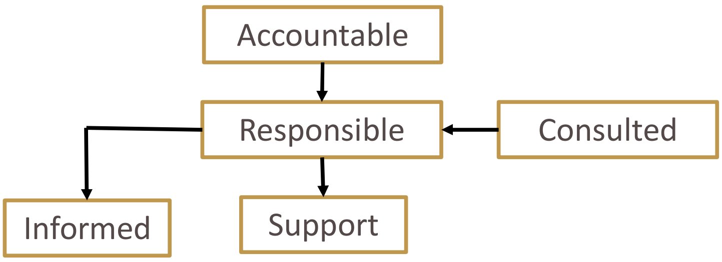
RASCI Matrix

- R: Responsible
- A: Accountable
- S: Support
- C: Consulted
- I: Informed



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Energy team in the energy manual

- The energy team are the people with important roles in the EnMS.
- They are listed in the energy manual columns
- There is typically a core team who do most of the work and others who support with less commitment of time and effort.
  - These are represented in different colours in the tool.

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Building Commitment

"The most difficult part of the EnMS"

Critical Success Factor

Behaviour and culture change

Commitment is needed at all levels, especially at the top

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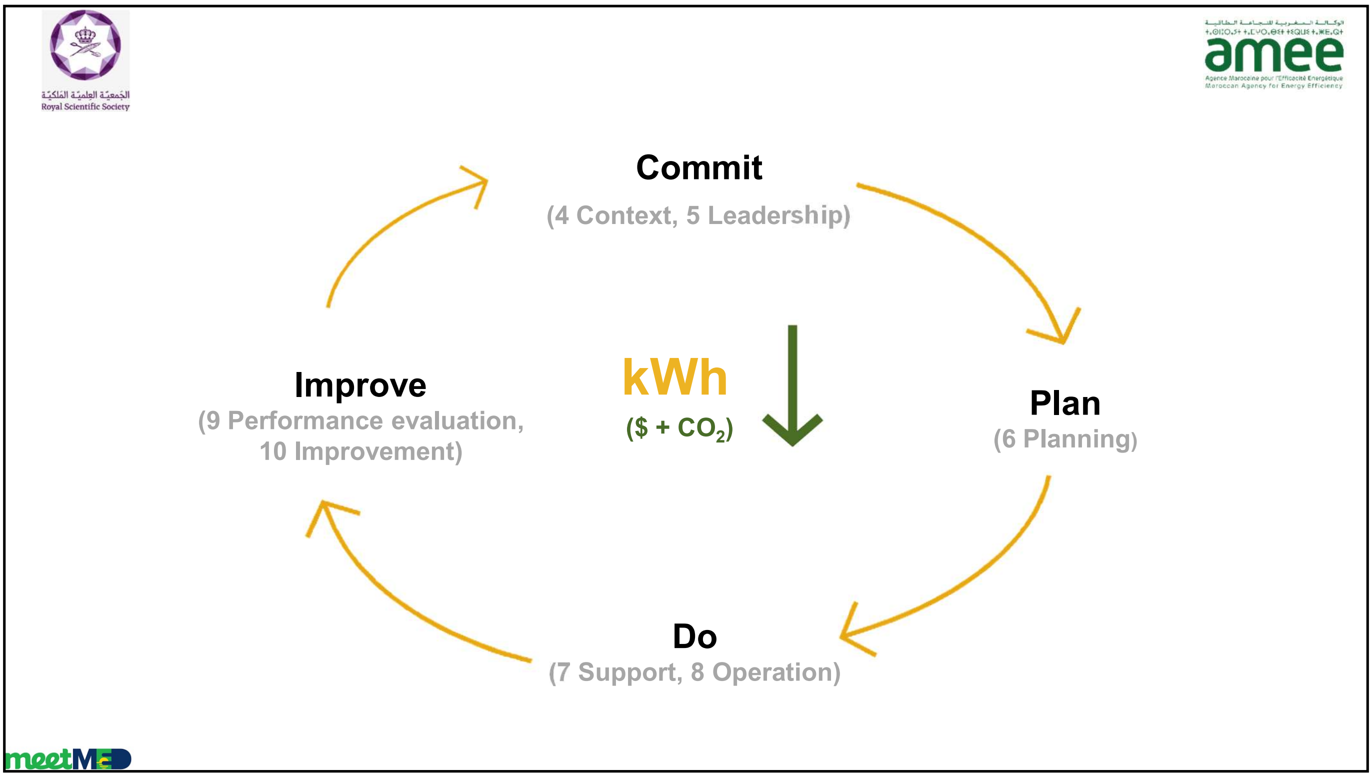
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Moroccan Agency for Energy Efficiency
Commit
(4 Context, 5 Leadership)
Plan
(6 Planning)
Do
(7 Support, 8 Operation)
Improve
(9 Performance evaluation, 10 Improvement)
kWh
($ + CO_2)
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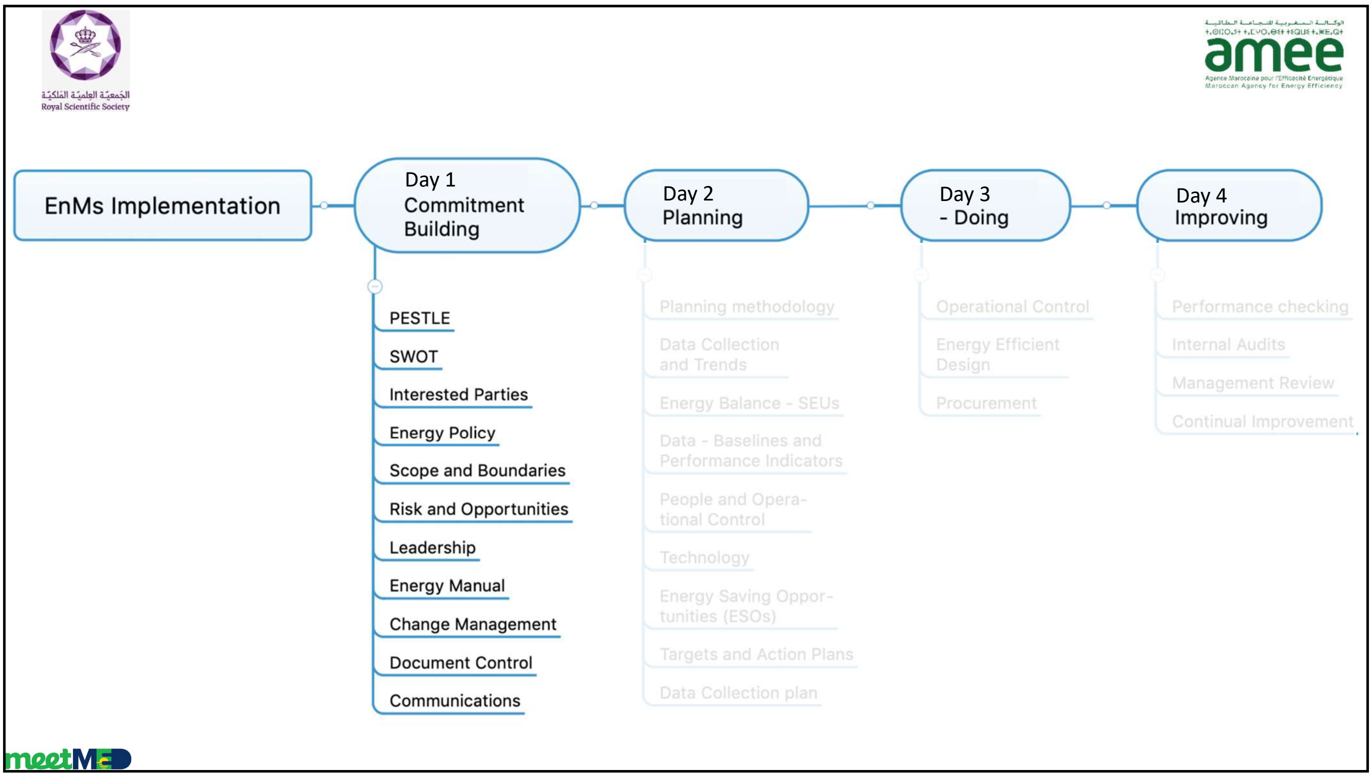
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EnMs Implementation
Day 1 Commitment Building
PESTLE
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Management Review
Continual Improvement
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Context

External and internal context

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The importance of your context

- The energy context of your organisation is going to be a big driver for success
- Use it to create a sense of urgency
- Use it to motivate top management
- Communicate it to relevant people
- Is cost reduction the primary part of your context?
- Is climate change important to your management?
- Is energy part of your decarbonisation plans?
- Identify and plan for risks and opportunities

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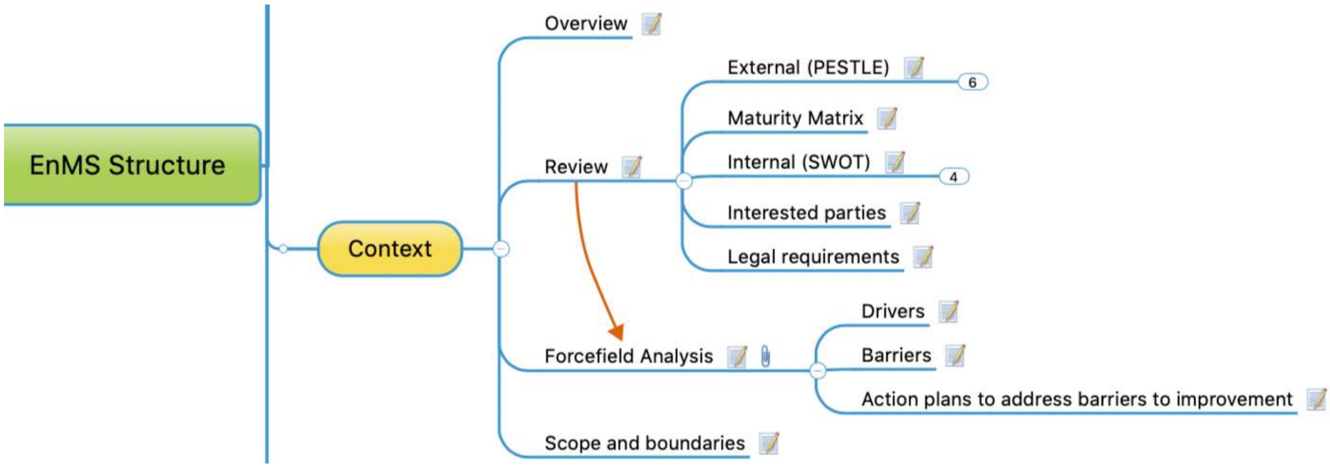

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External context: PESTLE analysis

- Political
  - What are the political decisions that are likely to affect your use of energy? E.G., Carbon tax, SDGs.
- Economical
  - What might happen economically? E.G., rising energy prices
- Societal
  - Is society changing related to energy and green house gases (GHGs)?
- Technological
  - Are there technological changes that might help you?
- Legal
  - What are the laws that apply to your energy use?
- Environmental
  - Are there environmental issues? E.G., noise, pollution, GHGs.

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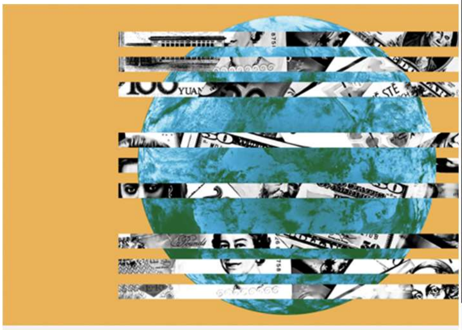
Context:



Climate finance: Time to deliver

UN Chief: Mobilize the world to make the next steps the right ones

Source: UN

Prevention cuts drought costs

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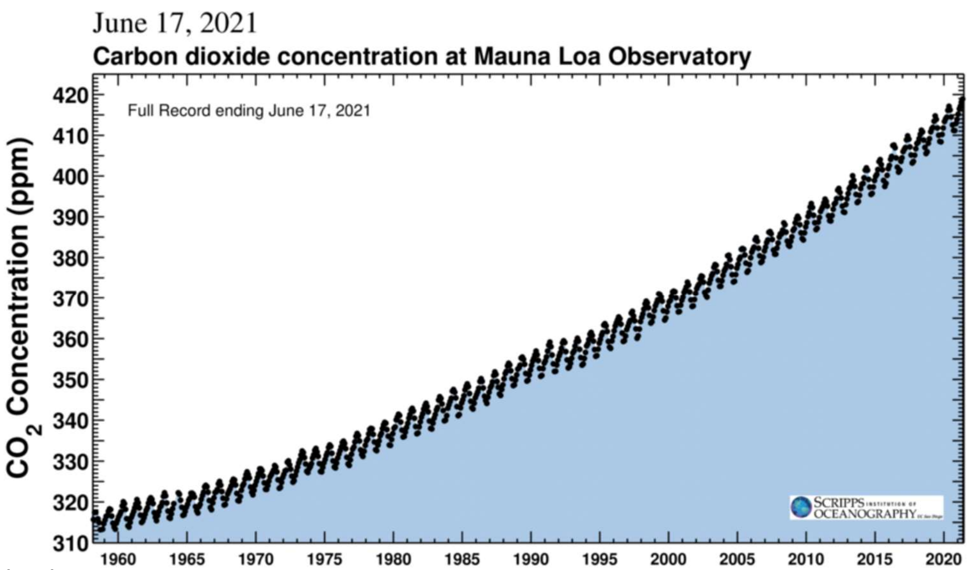
Context: Rising CO_2 concentration since 1960



Source: https://keelingcurve.ucsd.edu

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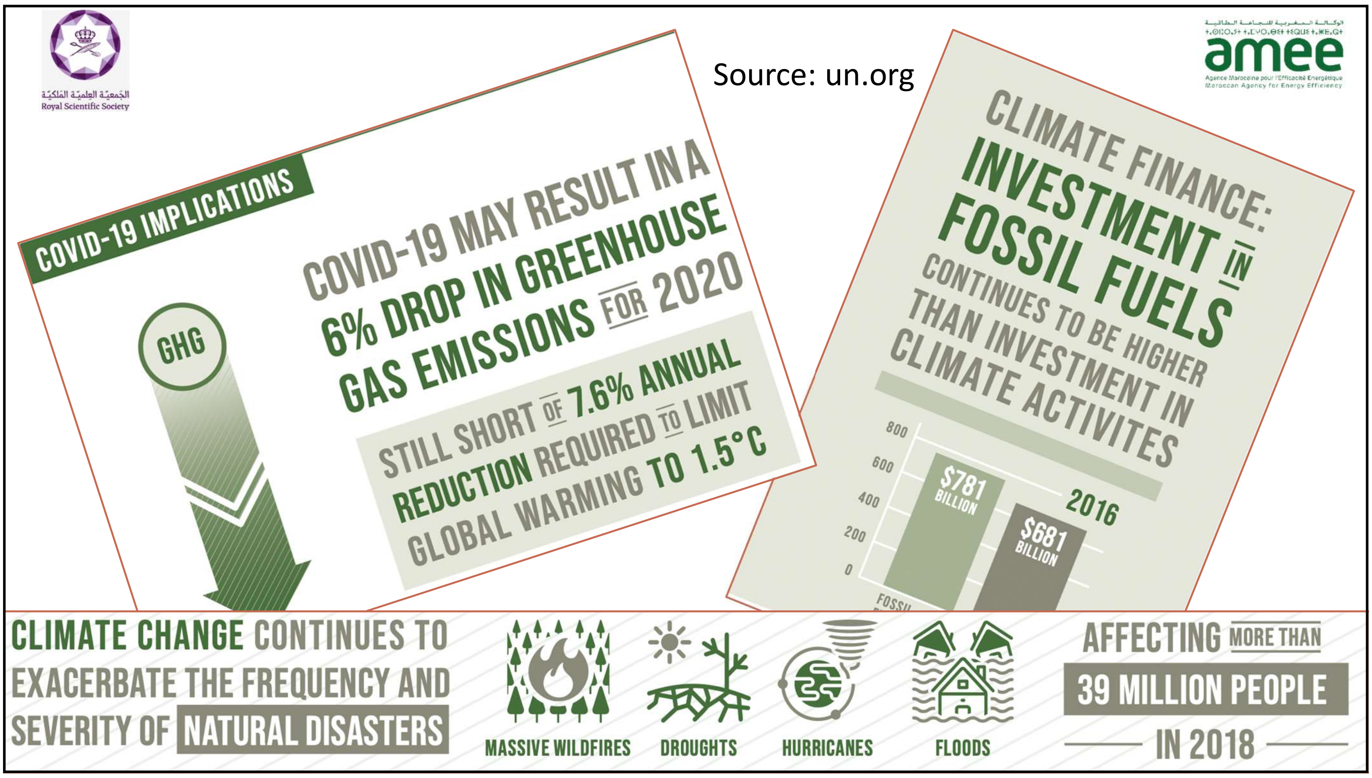
Source: un.org
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Moroccan Agency for Energy Efficiency
COVID-19 IMPLICATIONS
GHG
COVID-19 MAY RESULT IN A 6% DROP IN GREENHOUSE GAS EMISSIONS FOR 2020
STILL SHORT OF 7.6% ANNUAL REDUCTION REQUIRED TO LIMIT GLOBAL WARMING TO 1.5°C
CLIMATE FINANCE: INVESTMENT IN FOSSIL FUELS CONTINUES TO BE HIGHER THAN INVESTMENT IN CLIMATE ACTIVITES
800
600
400
200
0
$781 BILLION
$681 BILLION
2016
CLIMATE CHANGE CONTINUES TO EXACERBATE THE FREQUENCY AND SEVERITY OF NATURAL DISASTERS
MASSIVE WILDFIRES
DROUGHTS
HURRICANES
FLOODS
AFFECTING MORE THAN 39 MILLION PEOPLE IN 2018

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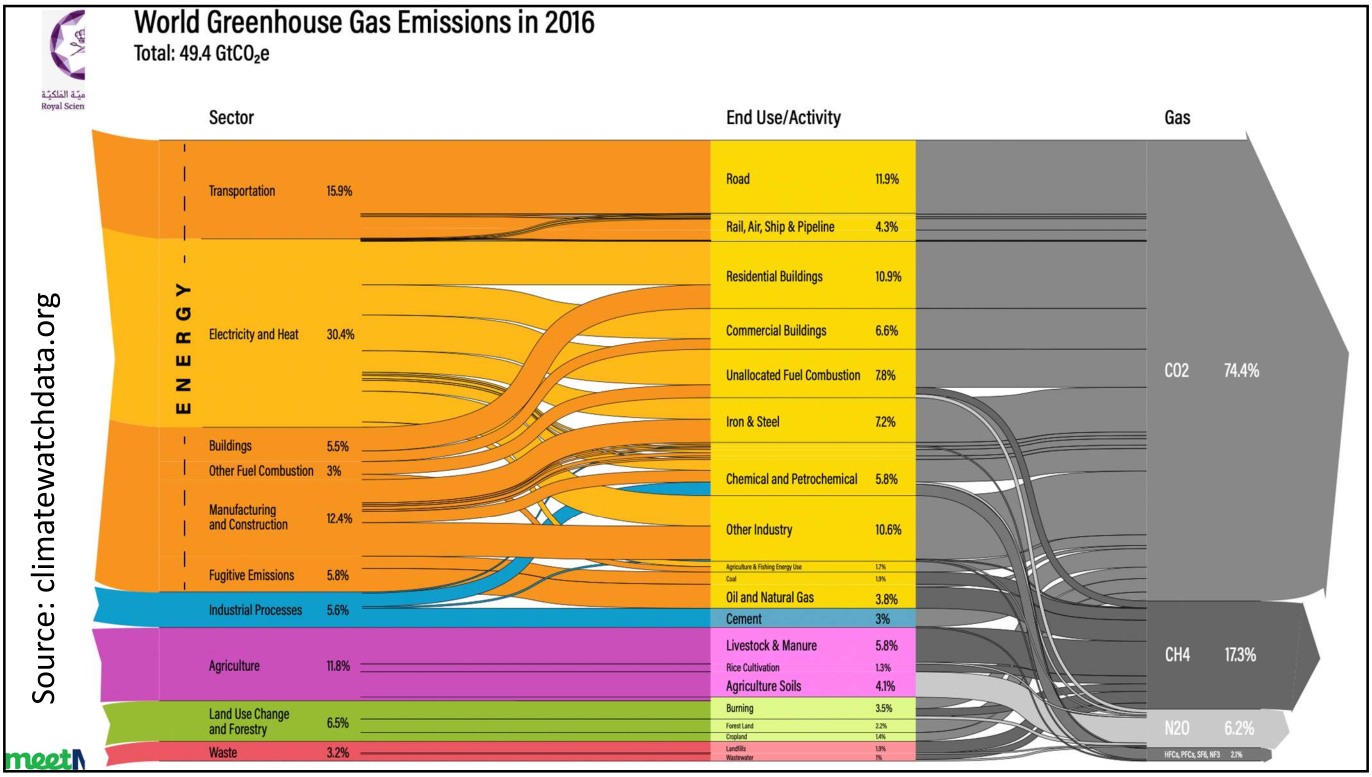
Source: climatewatchdata.org
Royal Scientific Society
World Greenhouse Gas Emissions in 2016
Total: 49.4 GtCO2e
Sector
End Use/Activity
Gas
ENERGY
Transportation 15.9%
Electricity and Heat 30.4%
Buildings 5.5%
Other Fuel Combustion 3%
Manufacturing and Construction 12.4%
Fugitive Emissions 5.8%
Industrial Processes 5.6%
Agriculture 11.8%
Land Use Change and Forestry 6.5%
Waste 3.2%
Road 11.9%
Rail, Air, Ship & Pipeline 4.3%
Residential Buildings 10.9%
Commercial Buildings 6.6%
Unallocated Fuel Combustion 7.8%
Iron & Steel 7.2%
Chemical and Petrochemical 5.8%
Other Industry 10.6%
Oil and Natural Gas 3.8%
Cement 3%
Livestock & Manure 5.8%
Rice Cultivation 1.3%
Agriculture Soils 4.1%
Burning 3.5%
CO2 74.4%
CH4 17.3%
N2O 6.2%
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Internal Context: SWOT analysis

- Strengths
  - What strengths does your organisation have related to energy management? E.G. innovative, technical competence.
- Weaknesses
  - What weaknesses do you have? E.G. lack of technical knowledge, lack of leadership.
  - Your weaknesses will be a barrier to success
  - Overcoming them is a critical success factor
- Opportunities
  - What opportunities exist? These might come from PESTLE analysis.
- Threats
  - What threats are there to your organisation related to energy use? E.G rising energy costs. These might come from PESTLE analysis.

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Interested parties

- Who is affected by your energy use or by your EnMS?
  - E.G. Suppliers, customers, neighbours, regulators, employees, society, management, HQ, etc.
- What are their needs and expectations?
  - How are each of them affected and what do they need from you?
- Which are relevant and require action?
- How will you meet these needs and expectations?
  - What will you do?

- Some of the output will be "other requirements"

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Link from Context to action plans

PESTLE & SWOT

- Risks
- Opportunities

Force Field Analysis

- Drivers
- Barriers
- Action plan

Continual Improvement List

- Action plan
- Who?
- When?
- Verify!

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Legal and other requirements

Legal Requirements

ID	Title of requirement	Reference	Category	Date identified	Relevant (y/n)	What is affected by this requirement?	What action is required	Resp	Reqd date	How often will this be reviewed	Compliance date	Does it require further action?
1	Quarterly energy report		Corporate	01/01/2016	y	All energy data	Generate and deliver	Agatha Chrisitie	Quarterly	Quarterly		N
2	Annual energy agency carbon accounts		Legal	01/01/2016	y	All specified carbon emissions		Umberto Eco				N
3	Boiler emission license limits		Legal	01/01/2016	y	Steam boilers	Monitor and report	Agatha Chrisitie	Continuous	Continuous		N
4	Annual energy budget		Corporate	01/01/2016	y	all purchased energies	Estimate usage and cost	Umberto Eco	01/11/2016			N
5	Emissions trading reporting	EU2012/123	Legal									
6	Energy Efficiency Directive	SI426										
7	Energy Performance of Buildings Directive											
8												
9												
10												

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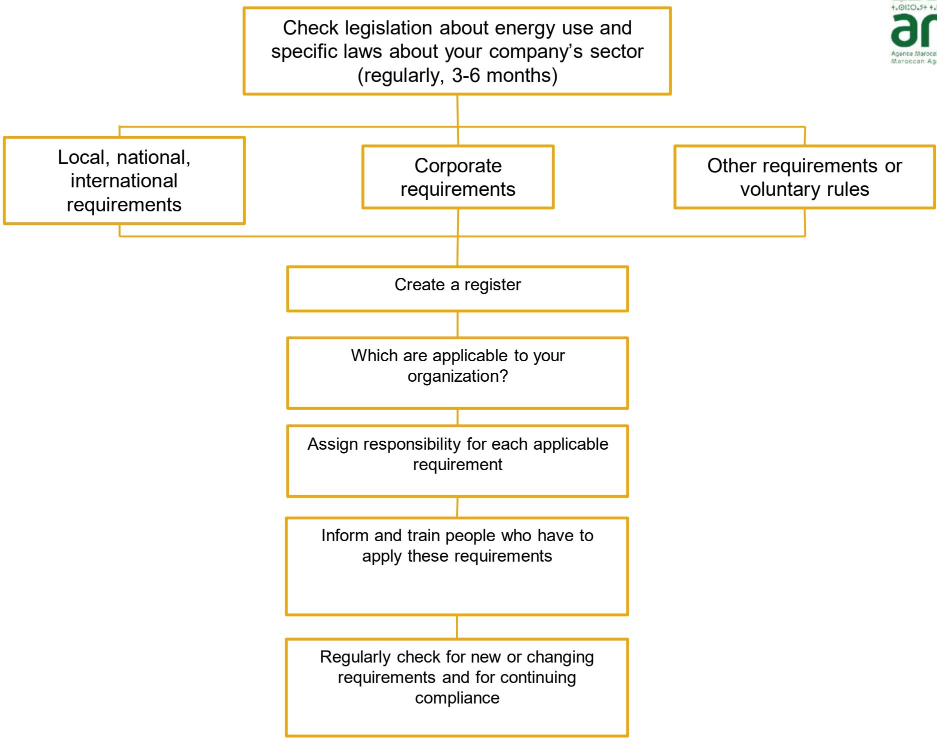

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Discussion – 30 minutes

- Give examples of PESTLE issues and discuss
- Give examples of SWOT issues and discuss
- Examples of interested parties and their needs
- Legal tab

- What risks and opportunities will arise from the above

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Exercise: PESTLE, SWOT, Interested parties
45 minutes

Start to insert items in your worksheets

Ensure the examples are deleted first

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Review the context exercise

Discussion

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Forcefield Analysis

Drivers and Barriers to success

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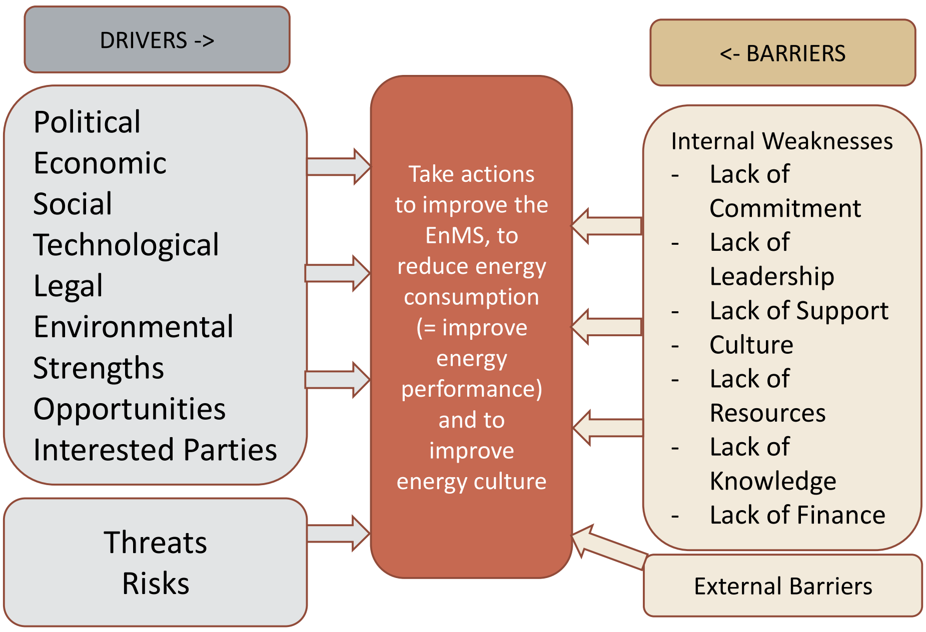

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Exercise: Forcefield Analysis
Part 1 - 30 minutes + 15 minutes discussion

Part 2 = Barriers will be developed on day 3

What are your drivers to improve energy performance?

Drivers and Opportunities	Importance	Plans to address opportunities	Responsable for opportunity plans	Target date	Implemention date
From PESTLE and SWOT analysis results, list the positive factors that will help to develop and effective EnMS. This will be P,E,S,T,L,E and S,O from SWOT.	How important is this factor in helping to develop the EnMS.	How will this opportunity be taken?	Who is responsible?	When will the plan be completed?	When was it actually completed?

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Scope and boundaries

What parts of your organization are managed in the EnMS?

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Boundaries

Take account of the work done on context

Decide your geographical boundary

- Geographical, is it the fence or wall around the property?
- Are there multiple boundaries, i.e., more than one site?
- Are any locations excluded? Why?
- Resist exclusions – all can save energy

Organisational boundaries

- Are all departments included?
- Are any excluded? Why?
- Resist excluding departments which consume energy

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Boundaries tool

	A	B	C	D
1	**Boundaries - geographic and organisation boundaries**			
2				
3	**Included**	**Excluded**	**Rationale for excluding any area**	**Notes**
4				
5	All buildings	Old warehouse	It is not occupied normally and consumes less than 0.5% of our energy	
6	All departments	Testing laboratory personnel	It reports to another entity outside the plant management	
7				
8				

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Scope

Activities

- List the activities that are included.
  - Production, Warehousing, Transport, Utilities, Waste management, etc.
- Are any excluded? Why? Resist!

Energy types (sources)

- These are normally purchased from outside
- Electricity, Natural Gas, Fuel oil, LPG, Water, Biomass, Coal, Acetylene, etc.
- Renewable energy (on-site)
- Don't exclude any
- Minimal effort for minor types

Note: Cogeneration: the energy type is natural gas.

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Consider potential changes to scope and boundaries

- Are there known organizational or business changes coming?
- Is there potential for new energy sources:
  - District heating or cooling
  - New natural gas pipeline near the facility
- Are there product changes with an energy impact:
  - A product that requires fuel oil or other energy type might be starting up or shutting down

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Scope - activities

Scope - activities in scope			
Included	**Excluded**	**Rationale for excluding any area**	**Notes**
All operations within the boundaries	N.A.	N.A.	N.A.
All transport activities	N.A.	N.A.	N.A.

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Scope - energy types (sources)			
List of all energy sources	**Significance of this source**	**Comment on significance of this source**	**Notes**
Electricity	Significant	N.A.	N.A.
Natural Gas	Significant	N.A.	N.A.
Water	Significant	N.A.	Even though water is not energy, it will be managed in this system
Bulk Liquid Nitrogen	Significant	N.A.	Even though nitrogen is not energy, it will be managed in this system
Maintenance workshop welding gases	This is a very minor energy use in terms of cost and impact	Other than making maintenance personnel aware of the need to conserve these gases, there will not be other activities within the EnMS	N.A.

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Exercise: Scope and boundaries (45 minutes)

What parts of your organization are managed in the EnMS?

Update the Commit tool

Discuss each organization to ensure everyone is clear

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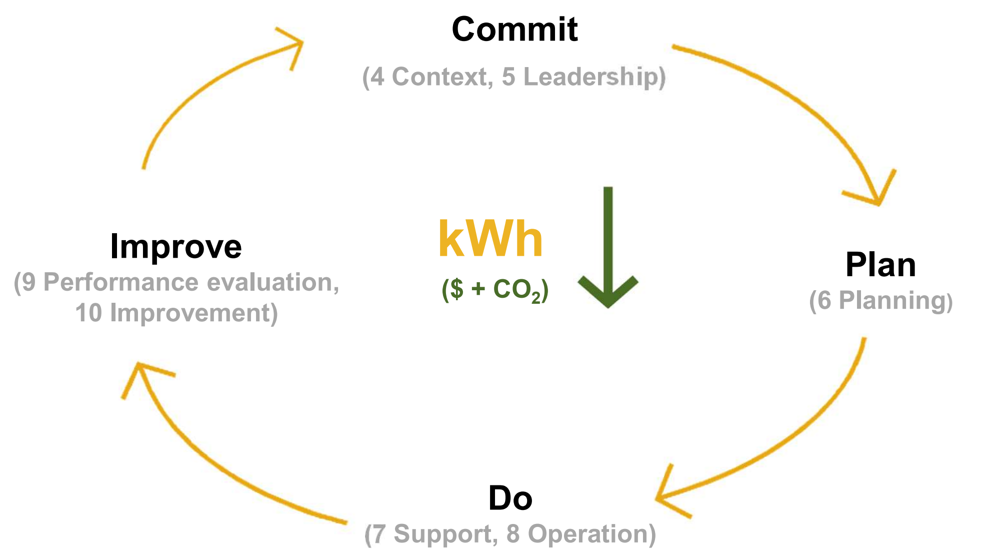

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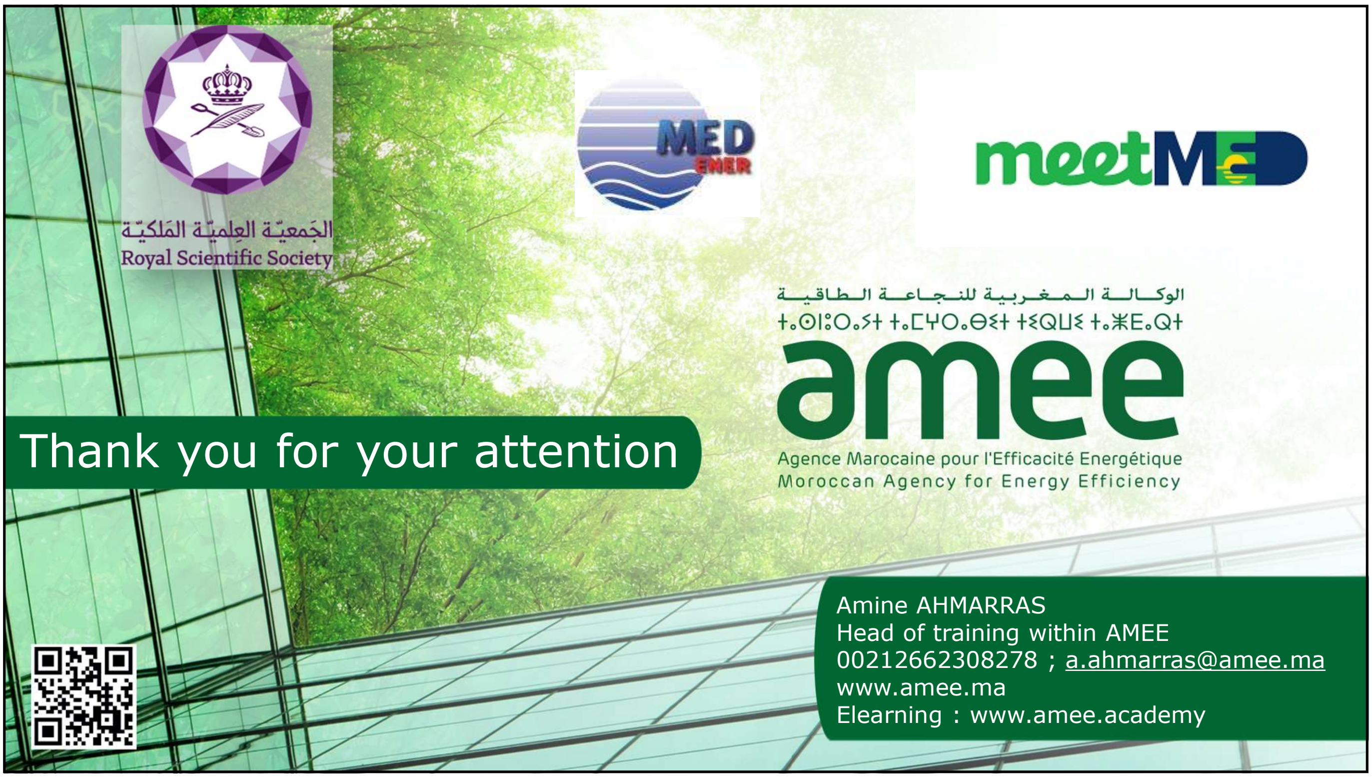

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Energy Management Systems (EnMS)

DAY 2 – Commitment Building (part 2)

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Leadership

Roles and resources

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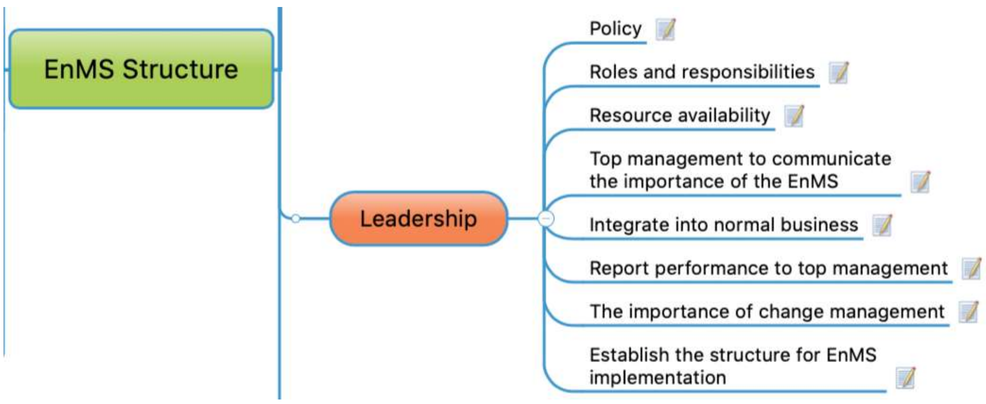

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Leadership

- Commitment
  - Communication
  - Decision making
  - Support
- Roles and Responsibilities (Energy Manual)
  - Who does what and when?
  - Competence (support)
- Resources (Support)
  - Personnel time
  - Financial
  - Knowledge
  - Information
- Energy Policy

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Roles and Responsibilities (Energy Manual)

- Importance of the topic
- Barriers, strengths
- What, how, who, how often!
- Energy Manual tool
- Communication of roles
- Competence checking
- “Live” document

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Important Roles

- Top management support and leadership
- Management Representative: Someone at the top level of the organisation to lead the energy management activities
  - Direct the activities
  - Represent energy management at senior level
  - Gain support for energy management
- Energy Manager: Someone to run the EnMS on a routine basis
  - Know it in detail
  - Coordinate its development
  - Represent it at external audits
- Energy team: makes it happen

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Management representative

- Ensuring that the energy management system is effective
- Reporting to top management on the performance of the energy management system
- Reporting to top management on the energy performance of the organisation
- Formation of an energy management team
- Plan and direct energy management activities
- In a larger organisation, most of the day to day energy work may be completed by others, e.g. energy manager
- Integration into day to day business
- Supports resource allocation

100

Energy Manager (team leader)

- Often not a full time job
  - For example, maintenance or engineering
  - Probably a technical person with energy engineering knowledge
- Role
  - Implements and owns the EnMS
  - Manages energy use
  - Acts as auditee for the EnMS
- Responsibility
  - Varies with organisation
  - Implementation
  - Energy budget
  - Reporting

101

Energy management team

Decide structure and membership based on size and complexity of your organisation

Representatives from relevant departments

Production, finance, engineering, operations, senior management representative, energy manager or engineer, etc.

Cross functional cooperation

Common and shared goal

Deliver energy performance improvement

102

Critical role of top management

- Instill a sense of urgency
- Communicate clear scope and vision
- Ensure resources are available – especially time
- Agree, support and push towards targets
- Make decisions to support improvements
- Remove barriers
- Motivate the energy team
- Expect energy savings and push for them
- Understand that energy = cost = carbon

- Link energy performance to the overall business strategy

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Exercise: Do you have support and leadership? (15 mins)

Question	Evidence
Do top management regularly ask you, how much energy is being saved?	
Have top management informed all employees that energy management and energy savings are important to the organisation?	
Do top management encourage all departments to integrate energy management in business processes?	
Do top management encourage all departments to support energy saving actions?	
Do top management push for bigger savings targets?	
Do top management make decisions to support increasing energy savings?	
Have top management agreed the time availability of all employees with an important role in the EnMS?	

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Exercise: Energy Manual (20 minutes)

Review and update all of the roles and responsibilities for all tasks discussed to this point.

Discuss each organization to ensure everyone is clear

105

Discussion: Integration of roles into normal job role (10 minutes)

This is not a project

The roles are not temporary during this program

The roles are not separate from your "normal job"

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Forcefield Analysis – Part 2

Drivers and Barriers to success

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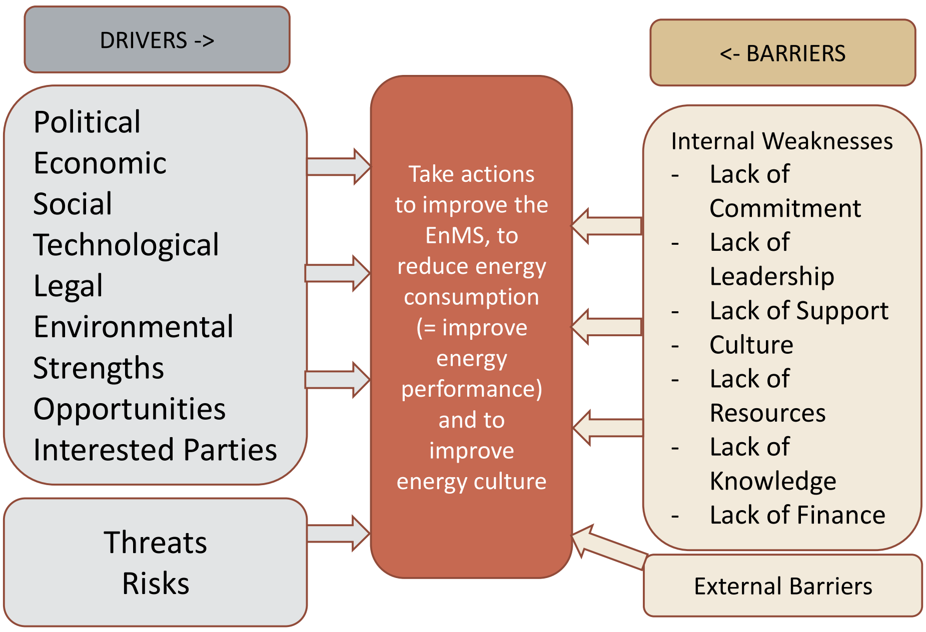

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Exercise: Forcefield Analysis
Part 2 - 20 minutes + 10 minutes discussion

Part 3 will be about action plans related to these barriers

What are your barriers to improving energy performance?

Risks and barriers	Severity (L/M/H)	Chance of occurring (L/M/H)	Plans to address barriers	Responsable for barrier plans	Target date	Completion date
From PESTLE and SWOT analysis results, list the risks and barriers that will hinder the development of an effective EnMS. These will be mostly related with Weaknesses and Threats from SWOT.	How important is the factor as a barrier to develop and EnMS.	How likely is this issue to occur?	What action will be taken to address this risk or barrier?	Who is responsable?	When will the plan be completed?	When was it actually completed?

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Energy Policy

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Energy Policy

- Management commitment
- Not just a signature!
- Appropriate to scale
- Must be communicated
- Must be documented
- Reviewed and updated periodically

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Energy policy requirements

- Is appropriate to the purpose of the organisation
- Provides the framework for setting and reviewing energy objectives and targets
- Includes a commitment to ensure the availability of information and of necessary resources to achieve objectives and targets
- Includes a commitment to comply with applicable legal and other requirements related to energy use, consumption and efficiency
- Includes a commitment to continual improvement in energy performance **and** the EnMS
- Supports the purchase of energy efficient products and services
- Supports design for energy performance improvement

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Example Energy Policy

Our company, in conformance with our commitment to sustainable development and growth, respect for the environment and corporate social responsibility is implementing an energy management system. In doing so, we commit to:

Reduce energy consumption in all our manufacturing operations

Ensure continual improvement in our energy performance

Deploy information and resources to achieve our objectives and targets

Uphold legal and other requirements regarding energy

Consider energy performance improvements in design and modification of our facilities, equipment, systems and processes

Effectively procure and utilize energy-efficient products and services

The scope of the EnMS is all activities and all departments of the company except transport activities. It includes all purchased energy sources and water.

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Process to develop energy policy

- Involve the energy team
- Brainstorm potential policies
- Ask top management to present their views
- Select best components
- Produce draft energy policy
- Review and finalise
- Approve
- Communicate

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Exercise: Energy Policy

Start to develop your energy policy

Discuss with your group

Use Microsoft Word with bullet points

Discuss further with relevant people in your organization over the coming month

115

Behaviour change

Change management

The successful organizations in this program have been able to manage change well

116

Idle electricity

- Total electricity use reduced by 25 %
- Idle electricity use reduced by 57 %
- Total energy savings of 20.1 GWh
- Saved more than 1 260 ton of CO_2 emissions
- Energy bill in 2015 was 2.1M Euro lower compared to 2014
- Many "Non-Energy Benefits" (NEB's)

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Where do we need behaviour change?

- Top management need to change, support and make decisions
- Middle management are often a barrier to change
- Operational control requires changing work practices
- Energy reduction is one of the few costs in an organisation which does not have personal impact
- Why do we resist?
  - Personal status
  - Blame culture
  - Fear!

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Change Management Process

Eight step change model (*John P. Kotter :* Leading Change)

1. Create a sense of urgency
2. Build support from key influencers
3. Create a vision of what can be achieved
4. Communicate the vision
5. Remove obstacles
6. Create short term wins
7. Build on the improvements
8. Anchor the change in your culture

This process can be aligned with your EnMS development

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1. Create a sense of urgency

- External or internal context (PESTLE analysis)
- Cost Reduction
- Climate Change
- Carbon Emissions/Decarbonisation
- Competition
- Changes to the market
- Non-energy benefits
- Price rises
- **Needs top management support**

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2. Build support from key influencers

Support

- Management
- Employees
- About bringing people with you on change journey
- Momentum
- Communication
- Emphasise urgency

Key Personnel

- Influencers of change (Informal leaders)
- Senior Management
- Production
- Quality
- Engineering
- Employee Representatives

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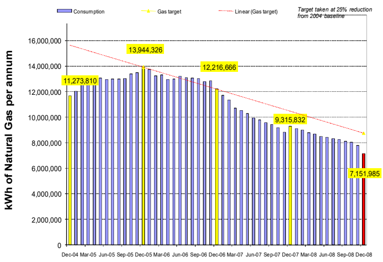
3. Create a vision of what can be achieved

What is possible

- Long Term
- Use Examples e.g. 50% reduction achieved elsewhere
- Previous success
- What are competitors doing?
- Goal Alignment

Do not accept

- They are different
- It's easy for them
- etc.



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4. Communicate the vision

The 5 W's

- Who should be told
- When to communicate
- What is the message
- Where will it be delivered
- Who is responsible

Non Verbal

The message

- Urgency
- Benefits
- What others have achieved
- Your plans
- What success looks like

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5. Remove obstacles (link to Risks and Opportunities)

What barriers?

- Weakness and threats from SWOT analysis
- Resistance to change
- Lack of commitment
- Lack of Knowledge
- Existing procedures and practices

What solutions?

- Communication
- Negotiation
- Urgency
- Benefits (including non-energy benefits)

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6. Create short term wins

Opportunities

- Easily implemented
- Highly visible
- Large impact
- Low cost (operational control)
- Use data where possible

What kind

- Compressed air leaks
- PIR on lighting
- Boiler house noise reduction
- Reduced heat in process area
- Convince the non-believers

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7. Build on the improvements

Action Plans

- Communication the successes
- Continual improvement
- Stakeholder involvement
- More technical projects
- Larger teams
- Relentless focus

Focus on the Vision

- Regular engagement
- Take on bigger improvements
- Engage with more personnel
- Continue communicating
- Not a project

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8. Anchor the change in your culture

Relentless Focus

- Re-evaluate the vision
- Communication
- Not a Project
- Need to make it the new culture
- Make the switch to sustainability permanent
- Integrate into business

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Change Management

"It is not the strongest of the species that survives, nor the most intelligent; it is the one that is the most adaptable to change"

Charles Darwin

Source: John P. Kotter Leading Change

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Discussion: Change Management – 45 minutes

How can you create the sense of urgency?
How can you increase support for energy performance improvement?
Consider all the barriers you will encounter
What is your vision for the EnMS in 3 years time?

129

Plan and control documented information

130

Document Control

- Identify changes and current revision status
- Approved
- Reviewed and updated
- Available where needed
- Remain legible and readily identifiable
- Documents of external origin are identified and distribution controlled
- Obsolete documents are suitably identified if retained to prevent unintended use
- Maintained documentation

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Typical Barriers

- Overly complex formats
- Excessive controls
- Too many levels of approval
- Document managers/coordinators
- Lack of ownership

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Retained documentation (Records)

- Records support the CHECKING processes by providing evidence that you are doing what you said you would do.
- Controlling records means controlling the data and other evidence that your system is implemented and effective.
- Their location is specified in your energy manual (column E)
- Records can be routinely used to review issues and incidents for diagnostic purposes.

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Maintained documentation (Procedures)

- Describe how activities will be completed.
- Described in the energy manual (Column C).
    - Review and update the text for your specific situation and processes
    - Link to existing or other new procedures
- Who is responsible for each?
- Are they competent?

134

Exercise: Document control – 30 minutes

Who will have roles in your document control?

Look at the documentation columns in your energy manual (column C and column E)

Are there additional documents needed in your case?

Examine the document control instructions in the manual:

Do they need to be changed in your case or can you use them as they are?

If you have an existing document management system, use it. Modify the manual to reflect this.

135

Develop communications plans

The importance of good communications

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10 reasons why change management initiatives fail

1. Lack of communication of why the change is happening.	3. Lack of a shared vision of the new direction	5. Lack of bottom up support	7. Not enough time allocated to embed the change	9. Lack of planning for organisational politics
2. Failure to plan for resistance to change	4. Failure to engage with and involve employees	6. Lack of understanding of the benefits and why the change makes sense	8. Lack of a consistent message	10. Lack of consideration for the existing culture

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10 reasons why change management initiatives fail?

1. Lack of communication of why the change is happening.	**3. Lack of a shared vision of the new direction**	5. Lack of bottom up support	7. Not enough time allocated to embed the change	9. Lack of planning for organisational politics
2. Failure to plan for resistance to change	**4. Failure to engage with and involve employees**	**6. Lack of understanding of the benefits and why the change makes sense**	**8. Lack of a consistent message**	10. Lack of consideration for the existing culture

Half relate to communications

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Communication plan

Who do you need to communicate with?

↓

What do you want to communicate?

↓

When do you want to deliver the messages?

↓

How will you do it? What resources are required?

↓

What do you want to be different as a result of communicating?

↓

How will you know if the messages have been understood?

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Types of Communication

Internal

- Inside the boundaries of the EnMS
- Between different levels, functions, shifts
- Written procedures, newsletters, bulletin boards, intranet, emails, communication screens, screen savers
- Social Media, apps, etc.

External

- Outside of the boundaries of the EnMS
- Regulators, media, community members, etc.
- Community meetings, newspaper, television, website

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Communication

Internal Communication

- Top management to everyone
- EnMS
- Energy performance
- Commitment, awareness, and understanding
- Process for comments or suggestions

External Communication

- Decide what to communicate
- Some to/from interested parties
- Plan for communication

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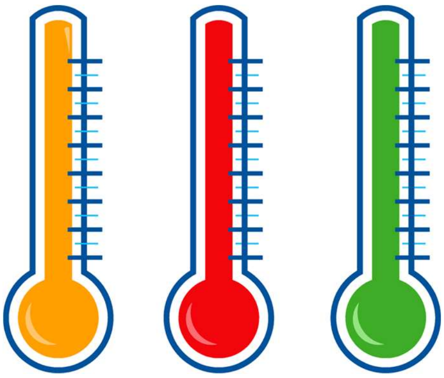
Internal Communication



- Policy
- Objectives, targets, action plans
- Energy performance
- Responsibilities
- Suggestion process

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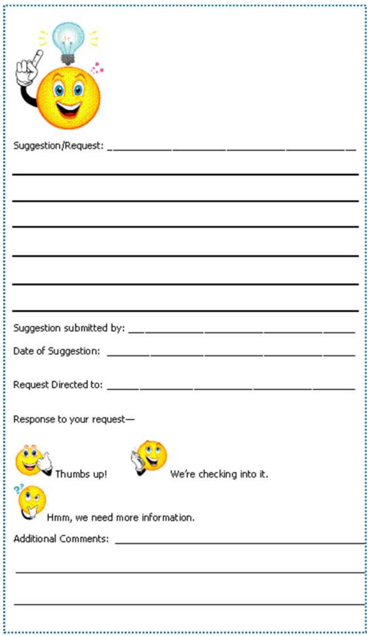
Suggestion process

- Anyone can make suggestions
  - Employees
  - Contractors
- Need a means to collect suggestions
- Need a means to direct them to the correct person(s) for evaluation
- Need a means to respond and implement where appropriate
- Need evidence it is working



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Exercise – 30 minutes

- Use the communication tab
- What energy related information is important and to whom should it be communicated?
- What energy awareness topics should be communicated?
- What are some techniques for providing appropriate EnMS and awareness information? (In addition to "standard" communication methods, think outside the box of unique ways for providing relevant EnMS information.)
- What are some techniques for providing/receiving suggestions and comments?
- Plan for initial communication about the EnMS in the coming weeks.

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Non-energy or co-benefits

There is more to be gained than only energy savings

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There is more to EnMS than ENERGY

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What are NEBs ?

Non-energy benefits from efficiency improvements

Waste	Emissions	Operation and maintenance
Use of waste fuels, heat, gas	Reduced dust emissions	Reduced need for engineering controls
Reduced product waste	Reduced CO, CO2, NOx, SOx emissions	Lowered cooling requirements
Reduced waste water		Increased facility reliability
Reduced hazardous waste		Reduced wear and tear on equipment/machinery
Materials reduction		Reductions in labor requirements
Production	**Working environment**	**Other**
Increased product output/yields	Reduced need for personal protective equipment	Decreased liability
Improved equipment performance	Improved lighting	Improved public image
Shorter process cycle times	Reduced noise levels	Delaying or Reducing capital expenditures
Improved product quality/purity	Improved temperature control	Additional space
Increased reliability in production	Improved air quality	Improved worker morale

E. Worrell

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How can they be assessed?

- Use the values from research = energy saving X 2.5

NON-ENERGY BENEFITS FROM COMMERCIAL AND INDUSTRIAL ENERGY EFFICIENCY PROGRAMS:
ENERGY EFFICIENCY MAY NOT BE THE BEST STORY

Nick P. Hall, TecMarket Works
Johna A. Roth, TecMarket Works

The results indicate that businesses place significant importance on the non-energy benefits associated with the installed technologies, and that the value of these benefits are equal to about 2.5 times the projected energy savings for the installed measures. In summary, businesses report that the

- Questionnaire

- Calculation

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Production of liquid gases

- If the temperature of the cooling water goes up, it increases the energy consumption in the production of liquid gasses.
- Systematic metering introduced in connection with the implementation of EnMS, indicated rising temp over time, due to fouling of the heat exchanger.
- In spite of chemical treatment of the cooling water.
- Special investigation pointed towards an ozone unit together with a sand filter
- Result: temp decreased with 1-2 degrees

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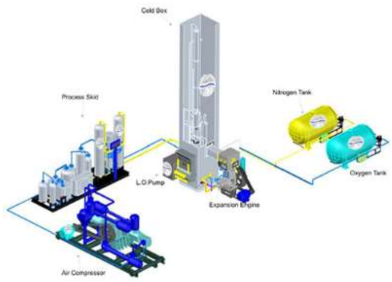
Production liquid gases



- Savings -energy:
  - 153.000 kWh/year or 12.000 US dollar
- Payback 3.6 years

- NEBs

• Chemicals	50.000 US dollar/year
• Corrosion inhibiter	12.000 US dollar/year
• Reduced corrosion	20.000 US dollar/year
• Reduced labour cost	not calculated
• Reduced down time	not calculated
• Reduced environmental influence	not calculated
• Better working environment	not calculated

Payback less than half a year

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So what do we achieve besides saving electricity, if we go from halogen to LED in a shop?

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NEBs of LED lights

- Reduced maintenance LED life 25000 hours, halogen 1000 hours
  - Reduced procurement and installation cost
- Reduced cooling
  - Less heat from LED, less cooling, that leads to less energy consumed by aircon, less time for aircon means less maintenance and extended life of aircon
- LEDs does not change colour of clothing, that means less clothing has to be sold at sale prices
- LEDs reduce fire risk
- LEDs do not give off heat: maybe people stay longer, shop more ☺
- LEDs gives shop green image
- Less hazardous waste disposal on replacement

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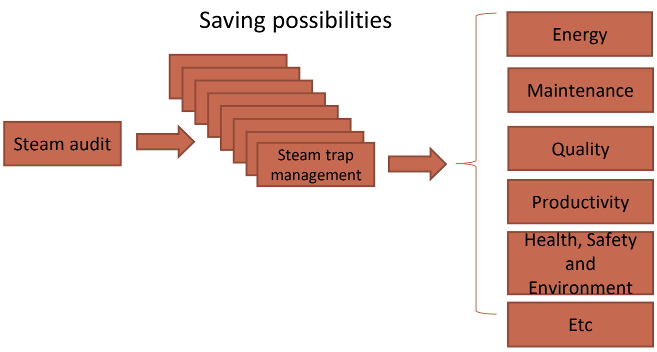
NEB assessment process



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NEB in the ESO List

H	I	J	K	L	M	N
Technical and financial appraisal of each ESO						
Non-energy benefits (NEB)	NEB Value ($ per year)	Estimated electricity saving (kWh p.a.)	Estimated Gas Savings (kWh p.a.)	Estimated Water saving (m3 p.a.)	Estimated cost savings ($ per year)	Estimated CO2 Saving (Ton p.a.)

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Discussion

- What NEBs are there for the following:
  1. Steam trap management program
  2. Improved steam insulation in a boiler house
  3. Implement a leak repair program for compressed air
  4. Improve building insulation (envelope)
  5. Use of automatic lighting control systems
  6. Use of solar shading on buildings

155

Agenda – Overview of the remainder of the EnMS

- Part 1
  - Planning
  - Planning Exercise
  - COFFEE
- Part 2
  - Support
  - Doing
  - Improving
  - LUNCH
- Part 3
  - Energy Performance Measurement and Indicators
  - Review of Commitment
  - COFFEE
- Part 4
  - Force Field Analysis
  - Summary for Senior Management
  - Next Steps

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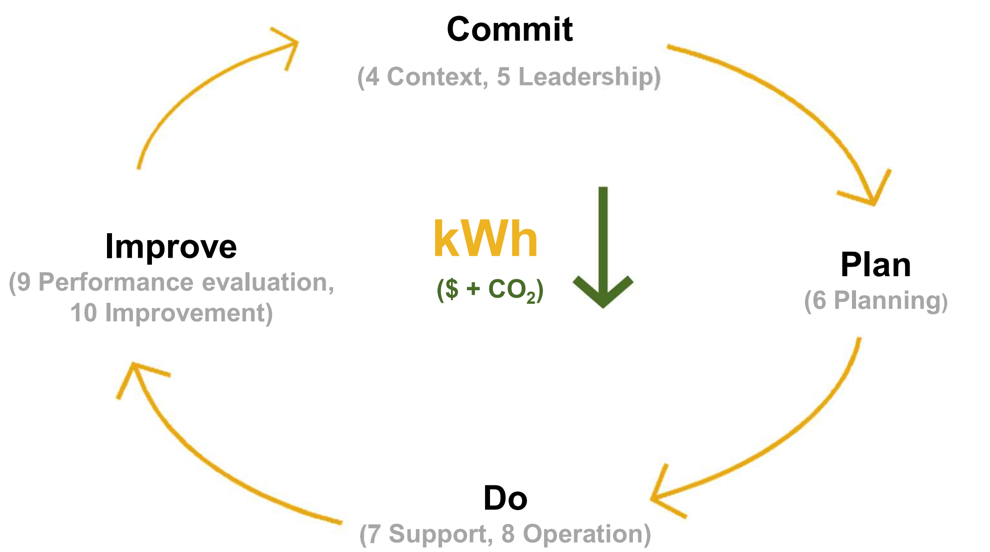
Planning

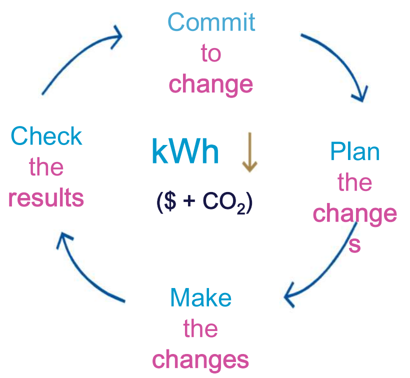
Decide what actions will be taken to save energy and to measure those savings!

157



158

Planning



What are you going to do?

Translating the commitment and energy policy into targets and action plans

159

Planning

- How much energy are you consuming?
- Where are you using it?
- Which are the largest uses (SEUs)?
- What variables are affecting it?
- Who is influencing its use?
- Do you need to have an energy audit?
- Energy System Optimization
- Renewable energy options
- Develop baseline & indicators
- Set energy targets
- Action Plan

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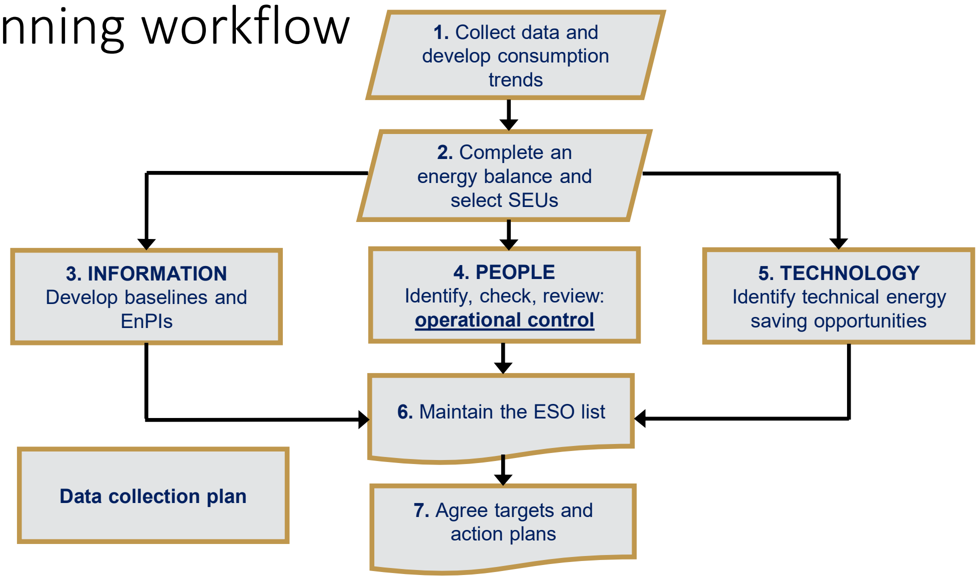
Planning workflow



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How much energy are you consuming?

- How many people here know how much energy their organisation consumed in the 12 months ending last month?
- How much did it cost?
- How much did you consume the previous year?
- How much are you going to consume next year?
- How are you performing against your financial budget?
  - Why are there deviations?
- Are you consuming too much energy?
  - If so, how much should you be consuming?

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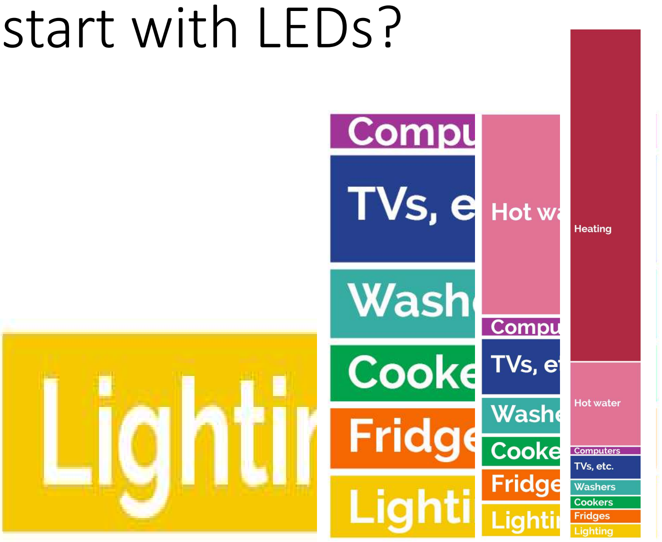
Should we start with LEDs?



Source:
The British Energy Challenge

163

Develop an Energy Balance for each energy type in the scope

1. List all the uses
   a. Brainstorm, drawings, process flow diagram, energy flows, etc.
2. For each use, estimate the annual energy consumption
   a. Not a scientific research project
   b. Purpose is to focus resources and effort
   c. Estimation is acceptable if no measurements are available.
   d. Try to establish where all the energy is consumed.
   e. "Others" is acceptable for minor uses.
3. Use of Motor list
4. Use of Heat list
5. Use of Lighting list
6. Use of Information Technology (IT) list

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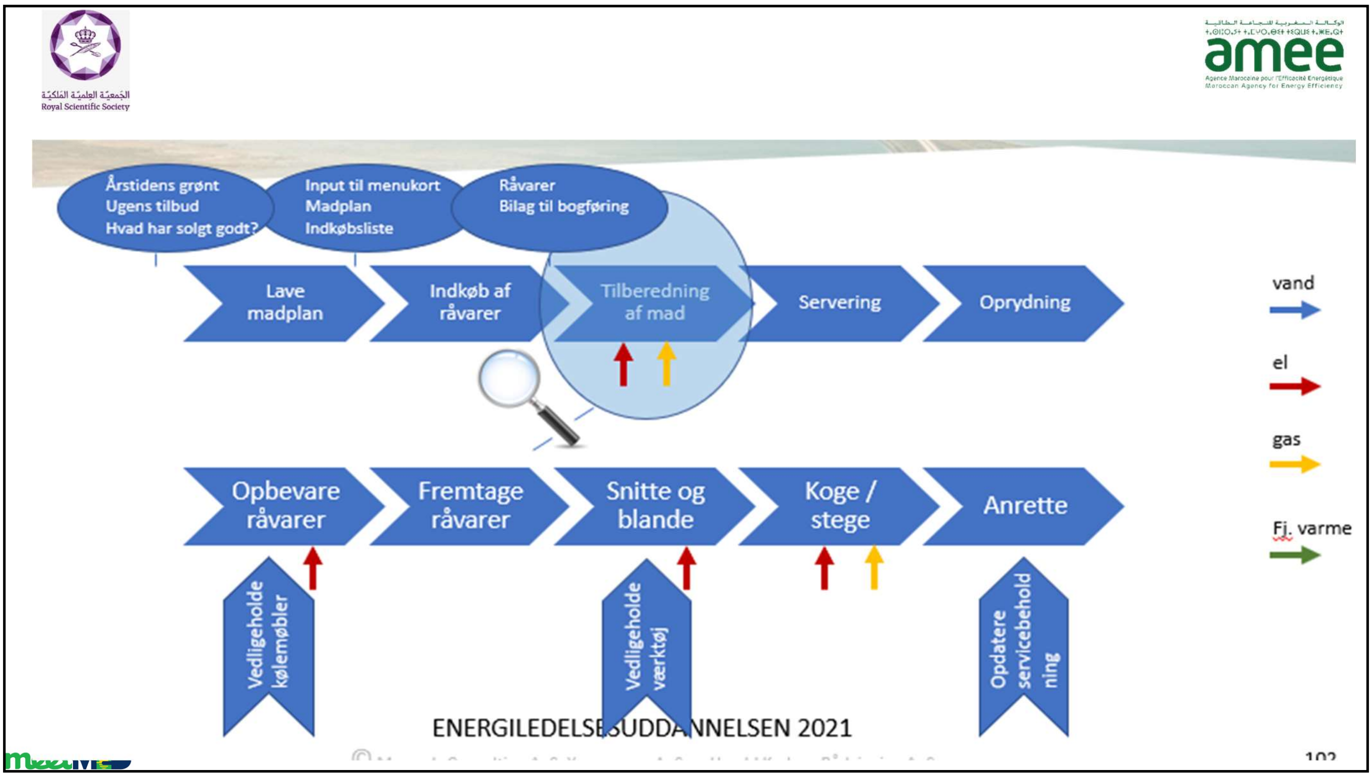
Royal Scientific Society
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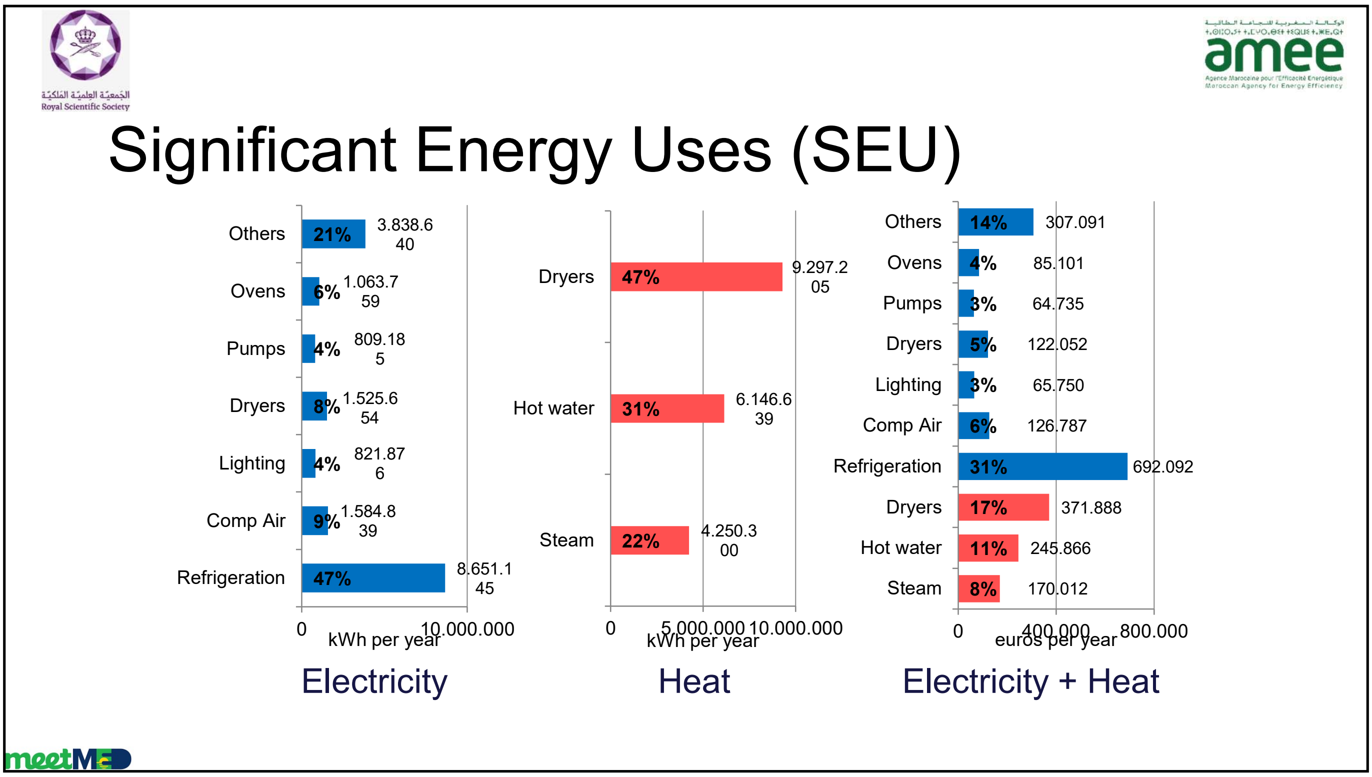
Agence Marocaine pour l'Efficacité Energétique
Moroccan Agency for Energy Efficiency
Årstidens grønt
Ugens tilbud
Hvad har solgt godt?
Input til menukort
Madplan
Indkøbsliste
Råvarer
Bilag til bogføring
Lave madplan
Indkøb af råvarer
Tilberedning af mad
Servering
Oprydning
vand
el
gas
Fj. varme
Opbevare råvarer
Fremtage råvarer
Snitte og blande
Koge / stege
Anrette
Vedligeholde kølemøbler
Vedligeholde værktøj
Opdatere servicebehold ning
ENERGILEDELSESUDDANNELSEN 2021

165


Royal Scientific Society
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Agence Marocaine pour l'Efficacité Energétique
Moroccan Agency for Energy Efficiency
Significant Energy Uses (SEU)
Others 21% 3.838.640
Ovens 6% 1.063.759
Pumps 4% 809.185
Dryers 8% 1.525.654
Lighting 4% 821.876
Comp Air 9% 1.584.839
Refrigeration 47% 8.651.145
0 10.000.000
kWh per year
Electricity
Dryers 47% 9.297.205
Hot water 31% 6.146.639
Steam 22% 4.250.300
0 5.000.000 10.000.000
kWh per year
Heat
Others 14% 307.091
Ovens 4% 85.101
Pumps 3% 64.735
Dryers 5% 122.052
Lighting 3% 65.750
Comp Air 6% 126.787
Refrigeration 31% 692.092
Dryers 17% 371.888
Hot water 11% 245.866
Steam 8% 170.012
0 400.000 800.000
euros per year
Electricity + Heat
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166

Establish energy performance indicators (EnPIs)

- Metric for monitoring energy performance
- Varying levels of complexity
- Absolute energy consumption
- Simple Ratios
- Regression analysis
- Try to have an EnPI for each energy source
- Try to have an EnPI for each SEU if data is available.

- More details tomorrow

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Review Operation control

- This is aligned with the review of training needs
  - It additionally checks operating and maintenance procedures
- Check operating procedures
- Are operators familiar with the energy impact of operations?
- Check maintenance procedures
- Check maintenance frequencies
- Are maintenance staff familiar with the energy impact of their work?
- This review will help to assess training needs

168

Critical operating parameters

- Each SEU has operating parameters which affect its energy use
- These need to be identified, quantified, recorded and communicated, monitored and controlled
- Boiler examples:
  - Pressure, Total dissolved solids (TDS), stack temperature (variable), stack O2, condensate return rate, feedwater tank temperature
- Refrigeration examples:
  - Delivery temperature, condensing temperature (temperature lift), evaporator and condenser approach temperatures
- Compressed air
  - Pressure, dryness, pressure drops

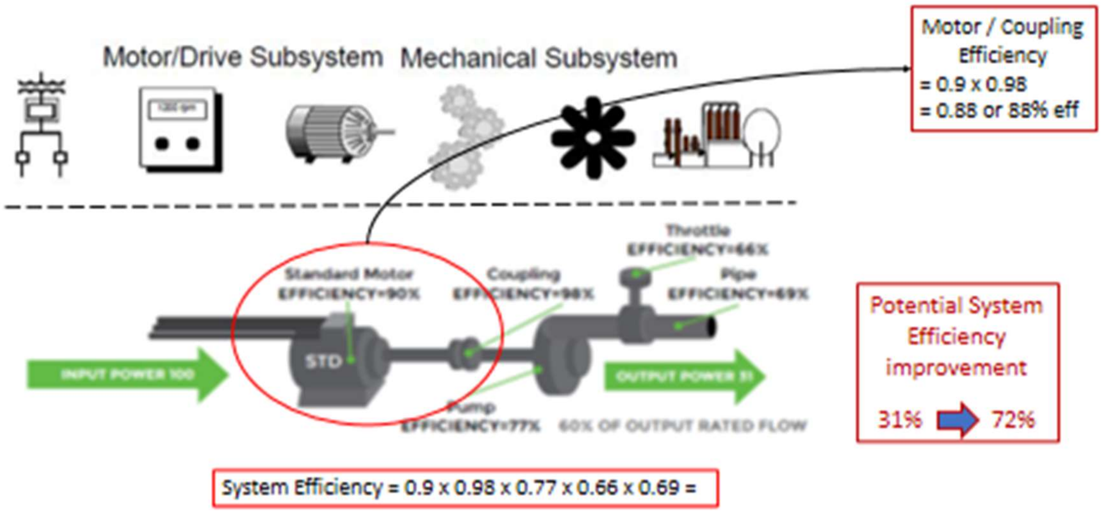
169

Energy System Optimisation

- Examine the whole system and not individual components
- Establish user requirements and specification
- Examine energy use
- Examine distribution
- Examine generation last.

170

Energy System Optimisation



171

Examine potential for renewables and alternative energy sources

- Which renewable sources are available?
  - Solar (thermal or photovoltaic)
  - Wind power
  - Biomass
  - **Note:** these do not typically reduce consumption
- Which renewable technologies are economical with these resources?
- Which alternative energy sources are available?
  - Waste heat recovery
  - Fuel switching
- Which might be economical?
  - Cogeneration (Combined Heat and Power (CHP)

172

Energy Savings Opportunity (ESO) List

- **<u>The most important activity in the EnMS!</u>**
- This is the activity that directly leads to savings
- Develop a list of all potential ideas
- Select items for implementation
  - Prioritisation
- Plan and manage their implementation
- Note: the name of this list doesn't matter alternatives include:
  - Savings Register
  - Opportunities list
  - We will use "ESO List" = Energy Savings Opportunities list.
- Consider PDCA cycle to manage ESOs

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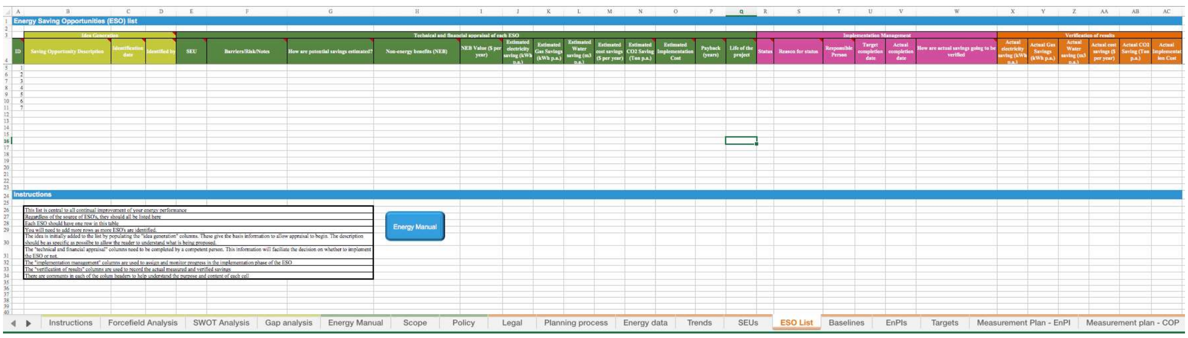
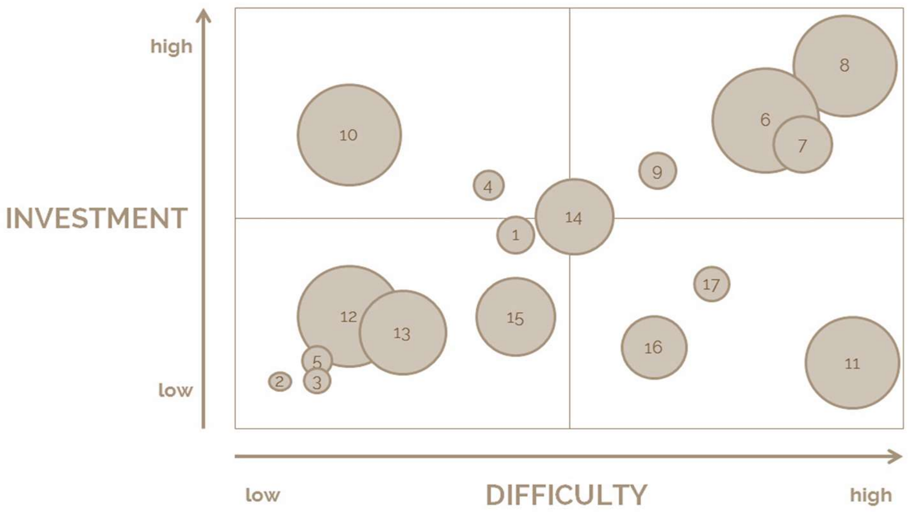
Energy Savings Opportunity (ESO) List



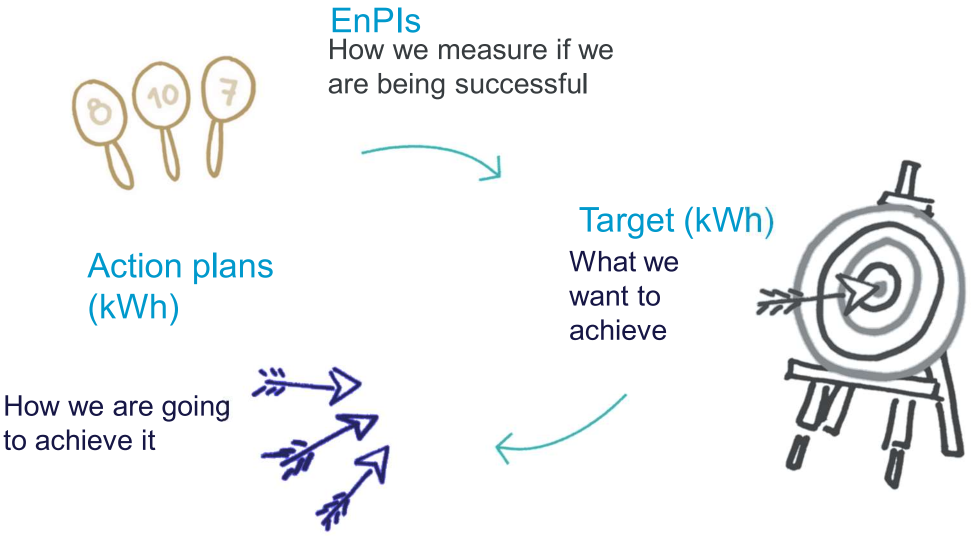
174

Which opportunities to implement?



175

Targets and action plans



176

Exercise: energy plan for the building you are in

- What are the energy trends of this building?
- What are the SEUs for electricity?
- For one SEU, what are the relevant variables?
- For that SEU, what opportunities exist?
- What would be a good target and plan?

- 45 minutes

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Support

Resources, competence, awareness, communication and documentation

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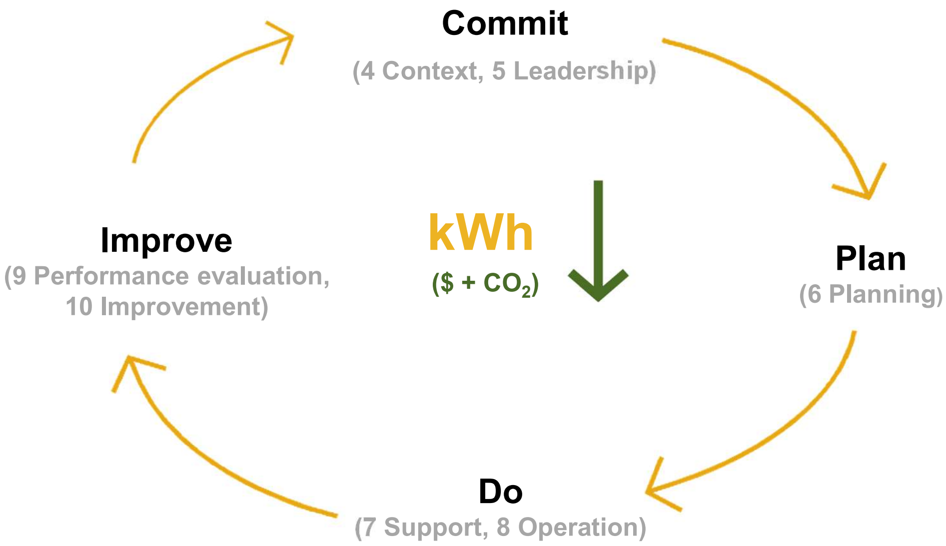
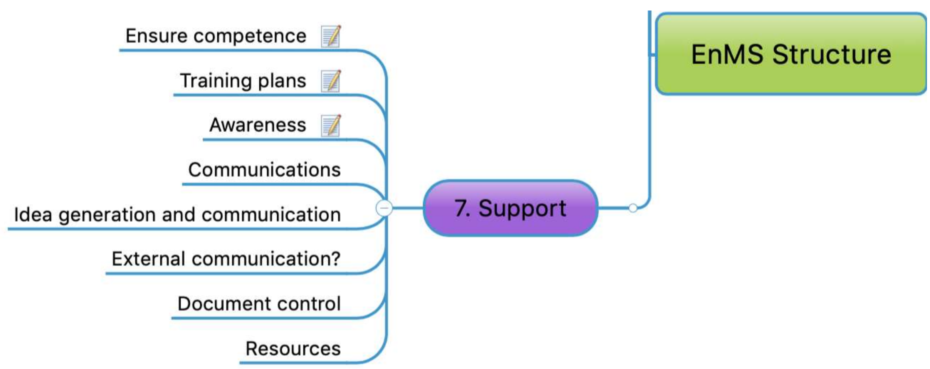


179

Support



180

Support tasks

7. Support					
24	Ensure that relevant personnel understand their roles, responsibilities and are competent for their own role in the EnMS implementation	All personnel who can significantly affect the energy consumption of the organisation need to be competent and to understand their roles. This includes management, technical and operational personnel. The competencies needed are listed in this worksheet	Continuously. This will mainly be reviewed during planning activities but is updated when roles and responsibilities change	Energy Manual - this tab	RnR team
25	Implement training plans and maintain training records	Ensure that all personnel, who may significantly impact the energy performance are competent to carry out their roles through a mixture of education, training, experience and skills	Continuously	Training tab	RnR team
26	Ensure people are aware of EnMS, benefits, roles, impacts, link of behaviour to objectives and targets, consequences of departure from procedures	This includes all staff and contractors. It also includes communicating the energy policy	Continuously	Awareness campaign materials	All staff
27	Ensure energy performance and the EnMS are communicated internally	Routinely communicate energy performance to interested parties	As planned	Communication tab	All staff
28	All personnel need to be given an opportunity to comment and make suggestions to improve the EnMS.	Ensure all staff have an opportunity to suggest energy saving ideas and add to the ESO list as appropriate and also to improve the EnMS itself.	Continuously	Communication tab and ESO list tab	All staff
29	Decide if there will be external communication.	In some instances you may decide to communicate about energy performance externally and this needs to be planned carefully. It is	Annually	Communication tab	RnR team
30	Develop a process to manage and control documented information	1. This spreadsheet together with the planning and baseline spreadsheets and all their tabs are the core of the EnMS. They will be maintained as follows: 2. The energy manager maintains the spreadsheets and is the only one with write access. He/she will update them as required. 3. Every time one of them is updated, its file name is updated to reflect the revision number in the form of YYMMDD, e.g. 160922. 4. Older versions are kept in an archive folder and held for a period of 3 years. 5. This electronic copy is the master copy, any printed versions are superseded by this document on a daily basis, i.e. Any printed version is out of date at the end of the day it is printed. 6. Any tab that is updated as part of a regular review has its date of updating at the top of the sheet. 7. All documents need to be approved prior to use.	Annually	Specified here in this row	Energy team

181

Resources

- Management support
- Time to complete roles and responsibilities
  - Integration into normal role
- Data and information
- Knowledge
  - Technical
  - Management
  - Data analysis
- Finance
  - Training
  - Low-cost opportunities
  - Investments

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Training & Competence

- The following staff need to be competent:
  - Staff with a significant impact on energy use need to be competent
  - Those with a role in the EnMS
- Competence improvement:
  - Education
  - Training
  - Experience
  - Skills
- Potential consequences of departure from procedures
- Training plans are to be implemented
- Training records must be kept
- Include external service providers where relevant

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Training plans

1. Review the roles and responsibilities of each energy team member (Energy Manual).
2. Decide on the level of competence (basic or advanced) required for each person in relation to each task (Training Plan).
3. Interview each person to assess their competence for each assigned task (record results in the training plan)
   - Training Needs Analysis
4. The gap in competence should be filled by training
5. Begin this training for module 1 as soon as possible

184

Awareness

- All people on site need to be aware of the EnMS
- All people on site need to be aware of the energy policy
- All people on site should be aware of the benefits to the organisation of improved energy performance
- It is usually desirable that all people on site are aware of the issues surrounding energy efficiency
  - Context
  - Climate change
  - Energy cost
  - Success stories
  - The organisations interest in these areas
  - Security of supply
- Feel good factor for employees

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Awareness – Behaviour Change – Social Norms

✓Safety Belts in Cars
✓Smoking in public places
✓Smoking while Pregnant
✓Safety glasses
✓Etc
✓Etc
✓Energy Waste?

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Documentation

- Documentation requirements
  - Paper or electronic
  - Describe the core elements of the EnMS
  - Relevant records need to be available and controlled
- Control of documents
  - Approval prior to use
  - Periodic review and update
  - Revision control
  - Must be legible and identifiable
  - Readily located
  - Latest versions only in circulation
- Integrate into existing document control if available
- The energy manual worksheet is the core document and map of the EnMS
- Retained (records) and maintained (procedures) documents.

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Document control

1. This spreadsheet together with the planning and baseline spreadsheets and all their tabs are the core of the EnMS. They will be maintained as follows:

2. The energy manager maintains the spreadsheets and is the only one with write access. He/she will update them as required.

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6. Any tab that is updated as part of a regular review has its date of updating at the top of the sheet.

7. All documents need to be approved prior to use.

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Exercise: (20 minutes)

Consider who will have a role for each of the support tasks

Input your initial thoughts in the Energy Manual including names and role

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Operations

Operational control, design and procurement

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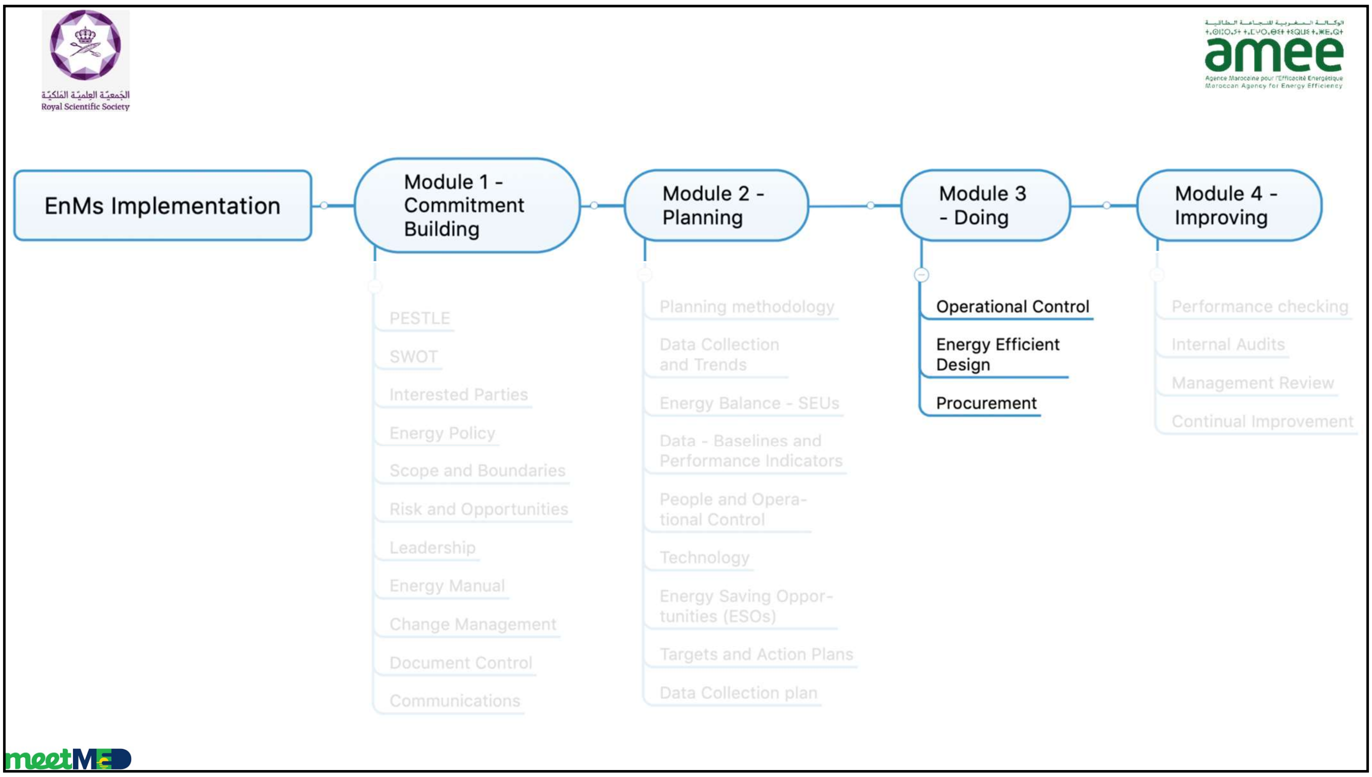
Royal Scientific Society
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EnMs Implementation
Module 1 - Commitment Building
PESTLE
SWOT
Interested Parties
Energy Policy
Scope and Boundaries
Risk and Opportunities
Leadership
Energy Manual
Change Management
Document Control
Communications
Module 2 - Planning
Planning methodology
Data Collection and Trends
Energy Balance - SEUs
Data - Baselines and Performance Indicators
People and Operational Control
Technology
Energy Saving Opportunities (ESOs)
Targets and Action Plans
Data Collection plan
Module 3 - Doing
Operational Control
Energy Efficient Design
Procurement
Module 4 - Improving
Performance checking
Internal Audits
Management Review
Continual Improvement
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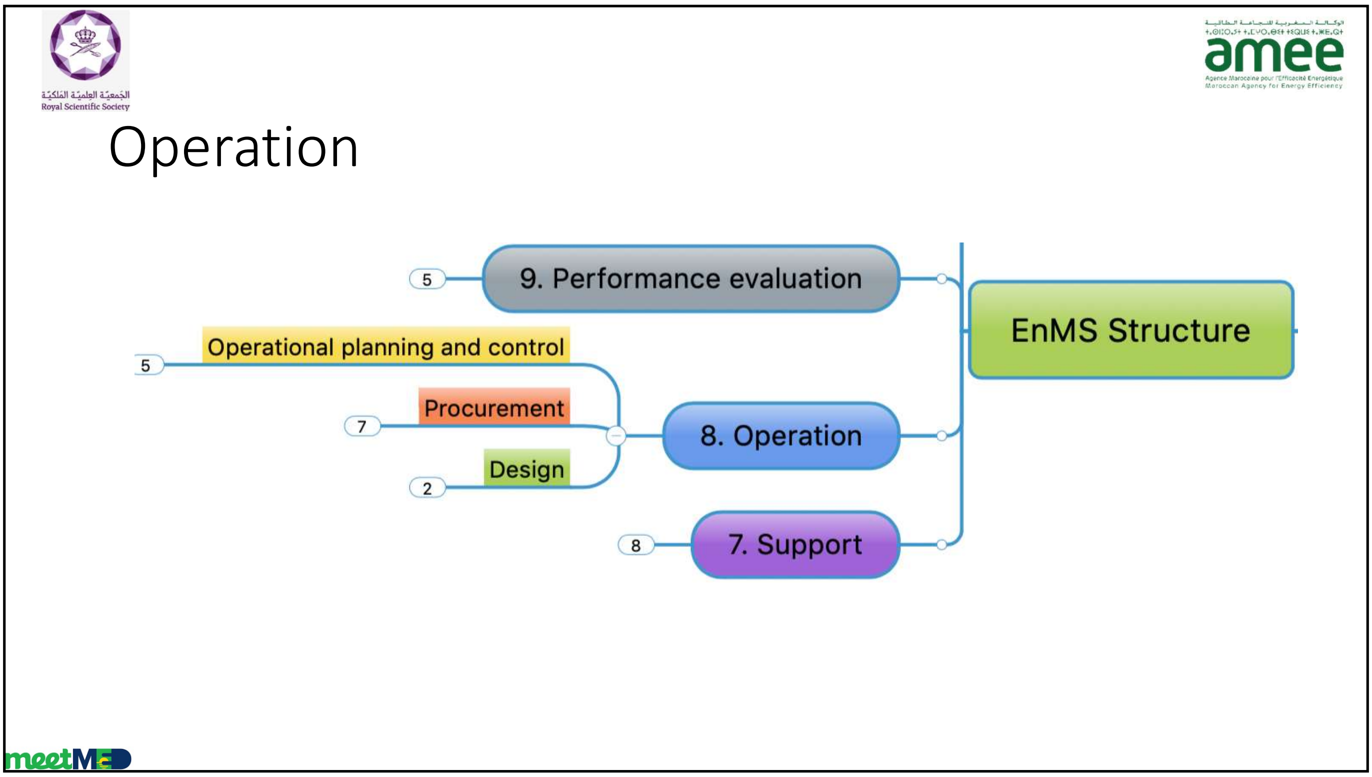
Royal Scientific Society
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Operation
5
9. Performance evaluation
EnMS Structure
5
Operational planning and control
7
Procurement
8. Operation
2
Design
8
7. Support
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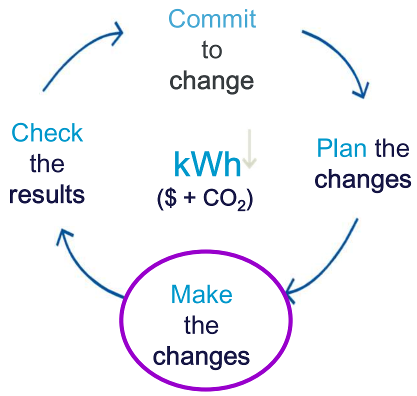
Operation



- Operational control
  - Operation and maintenance
- Design
  - Energy Efficient Design (EED)
- Purchasing energy, services, goods
- Implement action plans
  - ESOs
  - Risks and Opportunities
  - Training plans

193

What is this step

- Doing - *Daily activities to improve energy performance*
- You have an energy policy with management support, resources, strategic direction and committed team members
- You will also have objectives, targets and action plans
- Now, you must implement the action plans, day to day control and continual improvement of your energy consumption

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Operation

- This is a continuous daily process – not a project
- It needs to be part of day to day habits
- This is the part where energy savings and energy performance improvements are actually made
  - All other parts of the system support this
- This may be a major change for your organisation
- It may be a major change for you!!!
- Change is always difficult to manage
- Needs involvement, support and communication
- If you don't change you can't improve

"If you want to make enemies, try to change something" **~Woodrow Wilson**

195

Operational Control

- This is a very critical part of the EnMS
  - Only a small part of ISO 50001
- Operation of SEUs
  - Critical operating parameters
  - Operating procedures
  - Record keeping (Logs - electronic and manual)
- Maintenance of SEUs
  - Maintenance procedures and schedules
  - Training of external contractors
- Monitoring of operations, records, action plan & EnPIs

196

It is critical that all significant energy uses are operated and maintained in the most energy efficient way feasible.

This area is very commonly neglected

It is not difficult

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Behaviour Change – operation control

- "We have always been operating (maintaining) things this way"
- "Why do we need to change?"
- "Production is critical – if we change something we may affect production"
- Change is uncomfortable
- It is difficult to sustain
- Communication is very important
- Discuss difficulties and solutions re: operation control

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Causes of failure to complete action items

- Lack of real commitment
  - Lack of focus, failure will not be poorly viewed
- Unclear roles and responsibilities
  - "It's not my job"
- Lack of technical ability
  - Need good ability to overcome other barriers
- "I'm too busy"
  - = lack of commitment
- Lack of finance
  - Should have been agreed at planning stage
- Lack of communication
  - Need to understand expectations
  - Need to understand roles

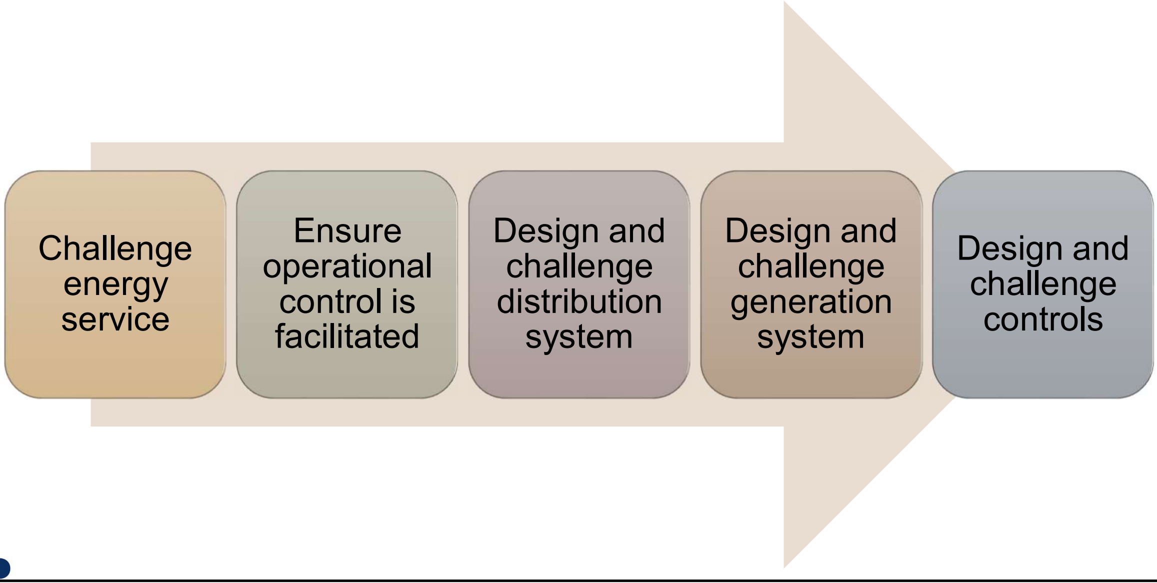
199

Monitoring operational control

- It is a day to day activity to ensure that equipment and systems are operating efficiently
- Give most attention to SEUs
- Someone should be completing operational checks on a regular (daily?) basis
- These form the basis of the operator logs or other monitoring process
- These logs need to be checked routinely
- Also check maintenance activities
- Importance of checking critical operating parameters

200

Energy Efficient Design (EED)



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Procurement

- Can have a significant impact on your energy performance
- Inform vendors that you have an EnMS that requires energy performance to be assessed as appropriate when purchasing
- Ask vendors how they can help with your energy performance
- You need to be able to assess the energy performance and impact of items that you purchase
- Need to move towards Life Cycle Costing (LCC)
- Not all vendors can supply the most efficiency solutions

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Procurement

- Services
  - Maintenance
  - Designers and architects
  - Constructors
  - Energy advisors
- Equipment
  - Boilers, chillers, compressors, etc.
  - Production equipment
  - Spare parts; lamps, fan belts, lubricants, etc.
- Energy
  - Check tariffs for electricity and natural gas
  - Check specifications for fuels

203

Performance evaluation and Improvement

Checking and continual improvement

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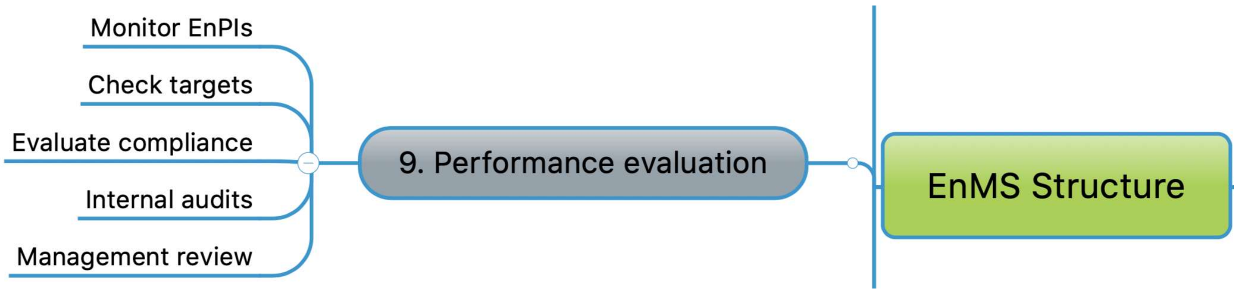
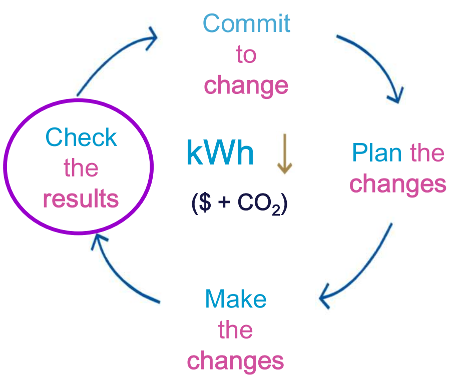
Performance evaluation



205

Performance evaluation and improvement



- Monitor energy performance
  - EnPIs
- Are targets being achieved?
  - EnPIs
- Check legal compliance
- Carry out internal audits
- Hold the management review
- Non-conformity management
- Continual improvement

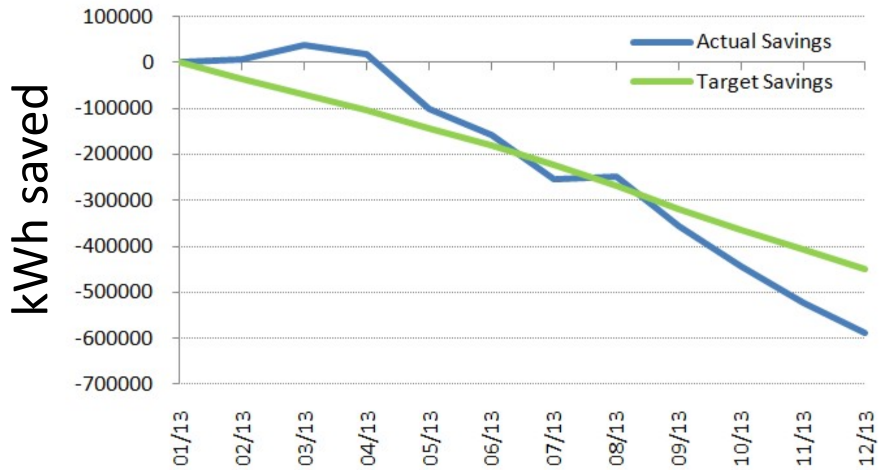
206

Performance checking

- We have a baseline energy performance
- We have targets for performance improvement
- We need to know if we are meeting our performance improvement targets
- We have Energy Performance Indicators (EnPIs)
- This can be a complex topic depending on your industry and your energy drivers
- You need to regularly compare actual EnPIs with expected values
- One EnPI for each energy source
- If possible, at least one EnPI per SEU

207

Cumulative savings



208

What is an internal audit?

- Independent review of part or all of the EnMS
- The purpose is to determine if the EnMS is being used effectively
- Is everyone fulfilling their roles
- Is the EnMS effective in improving energy performance?
- Is it achieving its objectives?
- Does the EnMS meet the requirements of a standard if certification is being sought, e.g. ISO50001
- It is an essential part of continual improvement

209

System checking and improvement

- Non-conformity (NC)
  - Not fulfilling a requirement
  - Beware of excessive numbers of NCs
  - Critical part of continual improvement
- Corrective action
  - Action including prevention of recurrence of a non-conformity
  - Removing the cause of the non-conformity
- Internal Audit
  - Check that the system is being run in accordance with its requirements

210

What is reviewed

- Context
- Risks and opportunities
- Energy review
- Compliance with legal and other requirements
- Awareness, training and competence
- Communication
- Document control
- Internal audits (yes!) and non-conformances
- Management reviews
- **Performance improvement (EnPIs)**

211

Management review

- It is part of building commitment and leadership.
- Usually happens once a year (can be more often).
- Top management and people involved in RnR should attend it.
- Review the organisation's EnMS to ensure it is continually improving.
- Review energy savings to ensure they are continually improving.
- Alignment with strategic direction
- They look at the past and future of the EnMS.

212

Management review: Inputs

- Follow up actions from previous management reviews
- Changes in external and internal issues and risks and opportunities
- Review of the energy policy
- Review of energy performance and related EnPIs
- Compliance with legal requirements and changes
- Objectives and targets have been met?
- EnMS audit results
- Status of non-conformities and corrective actions
- Projected energy performance for the following period
- Recommendations for continual improvement

213

Management review: Outputs

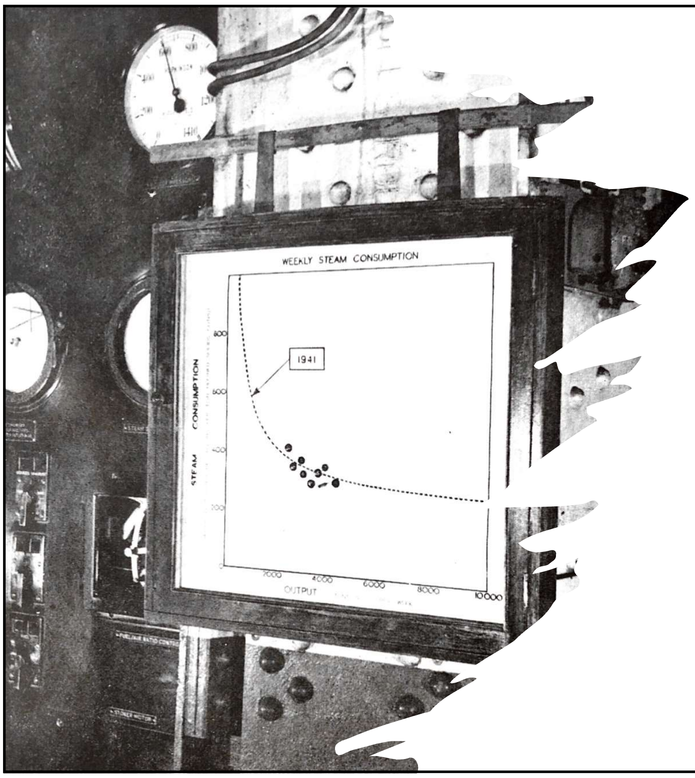
- Opportunities to improve energy performance
- Changes to the energy policy
- Changes to the EnBs and EnPIs
- Changes to objectives, targets or other elements of the EnMS
- Improvements in integration with business processes
- Changes to allocation of resources
- Improvements in competence, awareness and communications

214

Energy performance measurement and Indicators (EnPMI)

Delusions and barriers

215



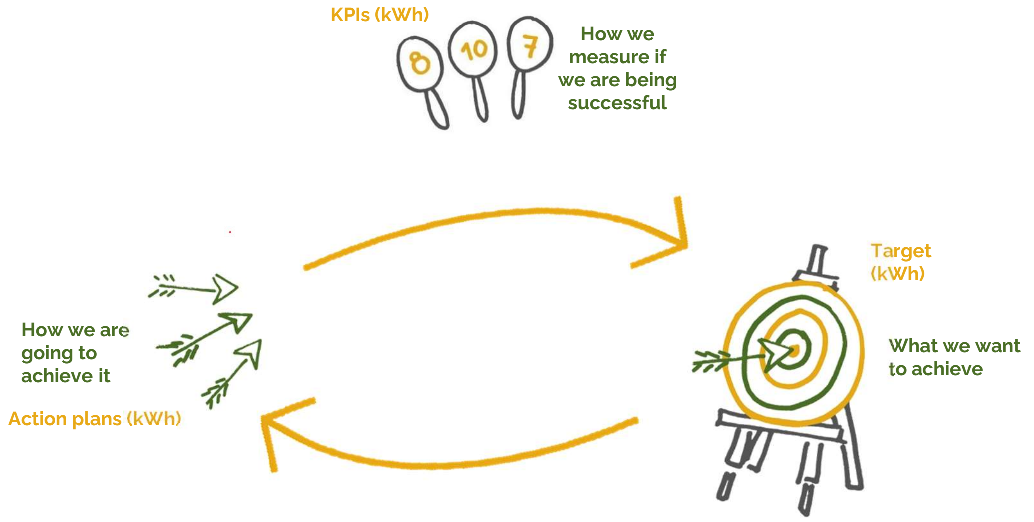
Nothing new here!

- Steam consumption control chart in a sugar refinery in 1941
- How many of us are doing this in 2021?

Lyle, P. 1946, *Regression analysis of production costs and factory operations*, 2nd ed., Oliver and Boyd, Edinburgh

216

Alignment with targets



217

UNIDO Case Study – Brewing Industry

- ✓ Large brewing company with 8 production and packaging plants
- ✓ In 2012 top management hired a new Energy Manager in the 2nd largest plant to increase work on energy efficiency
- ✓ In 2012 top management approved allocation of about 500,000 Euro for 2013 for EE projects and investments in the plant.
- ✓ The plant was/is a modern facility in term of technologies and advanced, by EU standards, with regard to metering and monitoring systems.

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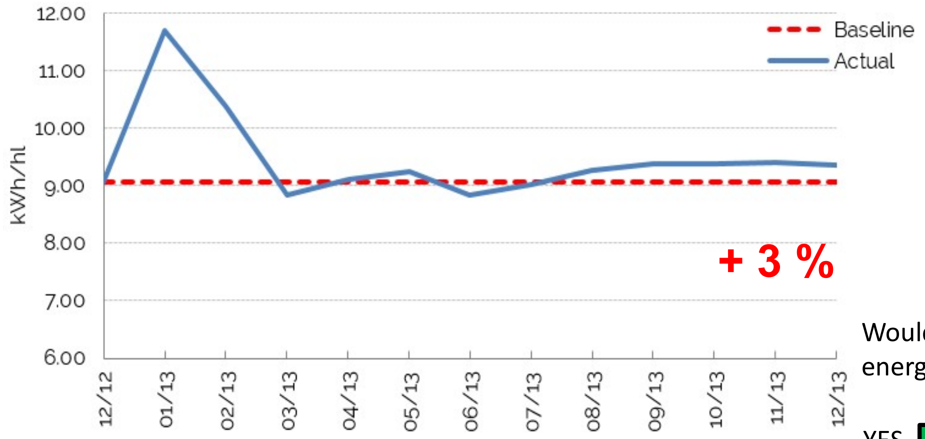
Case Study – Brewing Industry: View 1

2013 - Ratio kWh/hl



Would you have retained the new energy manager?

YES NO Don't know

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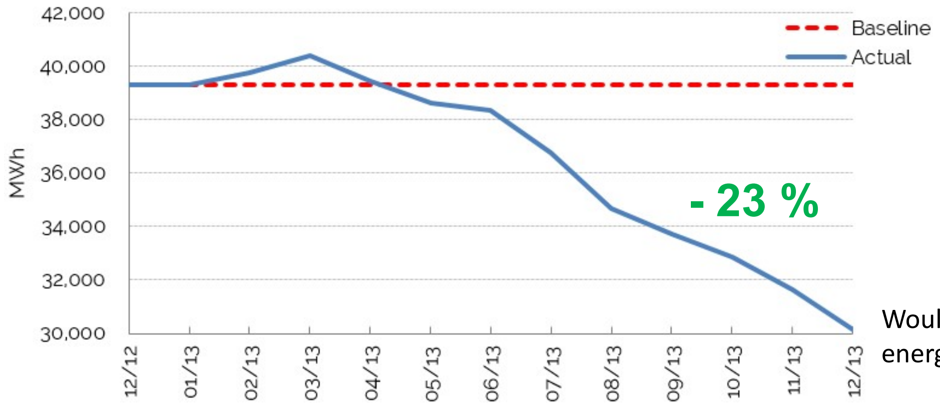
Case Study – Brewing Industry: View 2

Absolute consumption

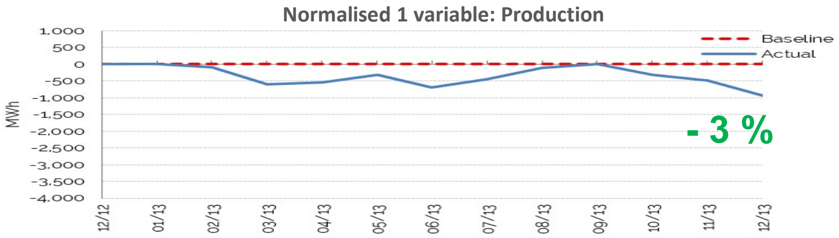


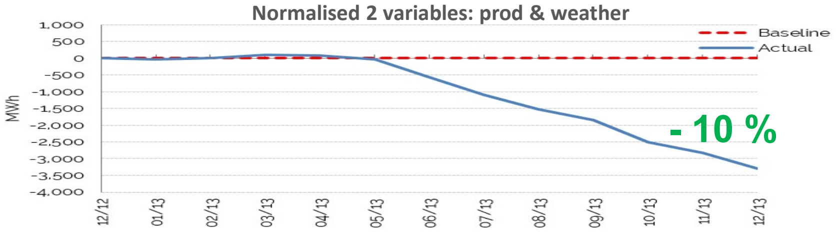
Would you have retained the new energy manager?

YES NO Don't know

220

Case Study – Brewing Industry: View 3



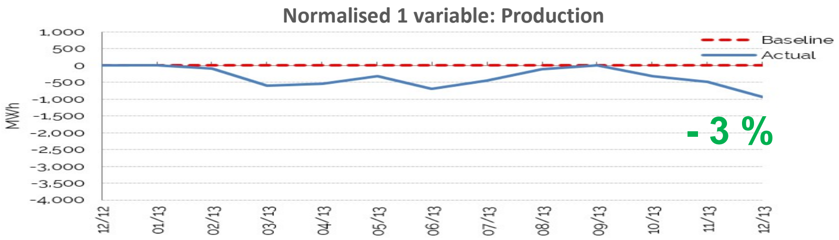


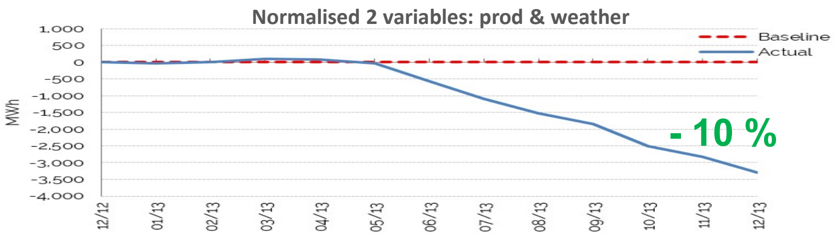
Would you have retained the new energy manager?

YES NO Don't know

221

Case Study – Brewing Industry: View 3





Would you have retained the new energy manager?

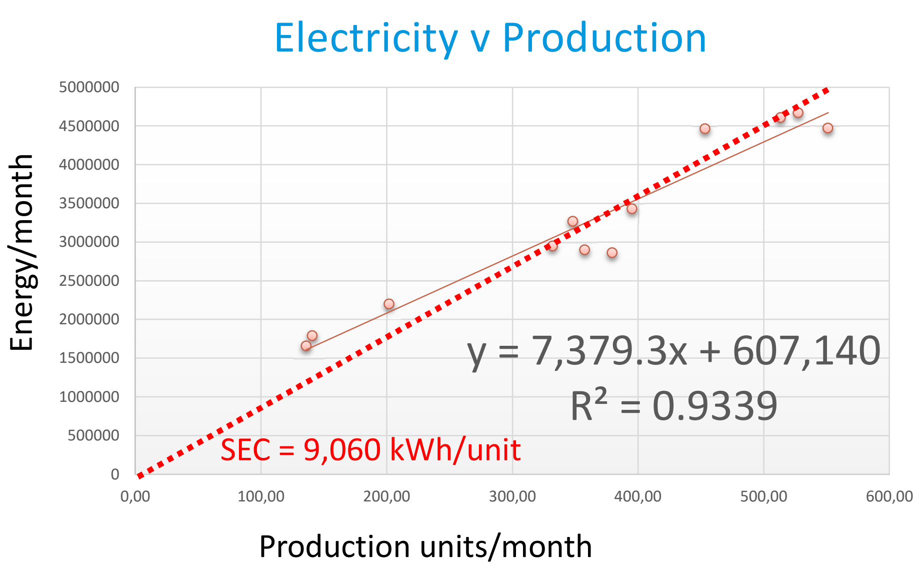
YES NO Don't know

222

680. VARIATION OF HEAT CONSUMPTION WITH OUTPUT. How many managers have been told by their staff that heavy steam or coal consumption was due to low output ? How is it possible for management to judge whether this is an excuse or a reason ? Simple statistical analysis will generally go a long way towards providing the answer.

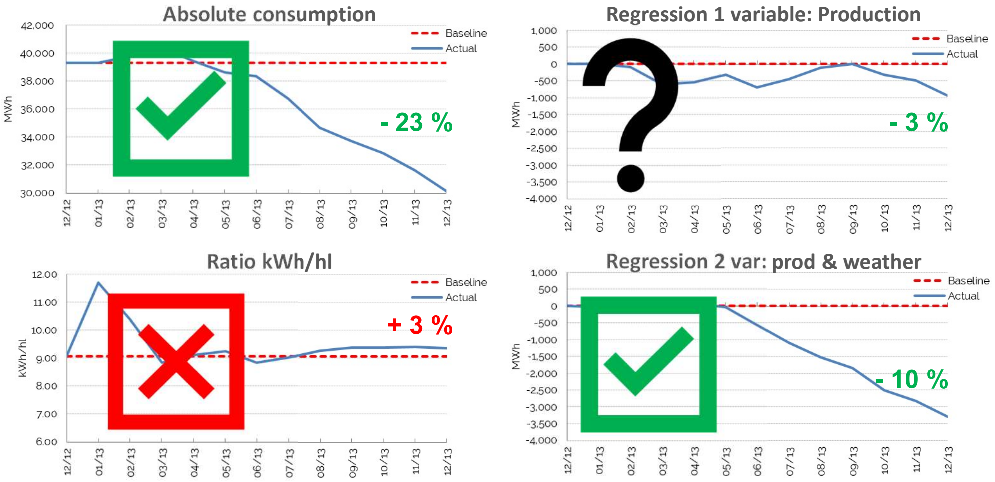
Lyle, O. 1947, The efficient use of steam, HMSO, London

223



224

Energy performance in Industry – Which is right?



Brewing industry

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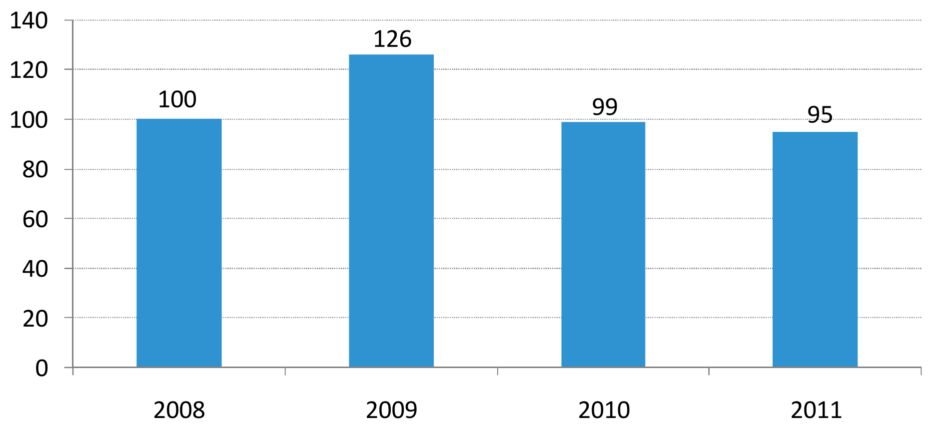
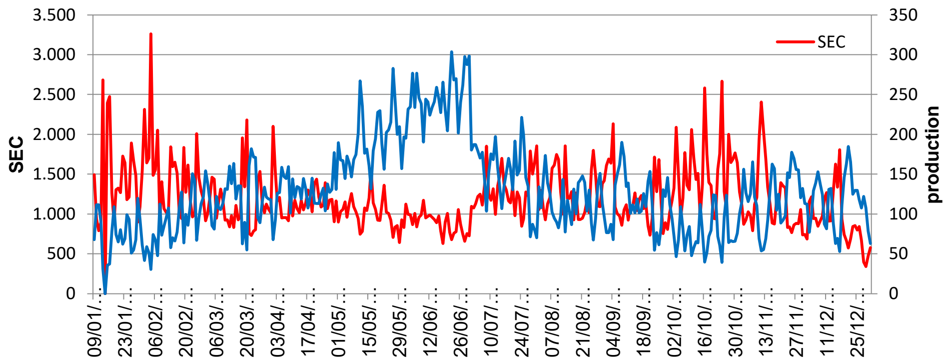
Energy per unit of production



Car assembly industry

226

Specific Energy Consumption (SEC): Up and down



- When production goes UP, SEC goes DOWN
- When production goes DOWN, SEC goes UP

Drink industry

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Energy performance indicators: Criteria

- Only responds to changes in energy performance
- Unaffected by weather, production outputs or other relevant variables
- Direction and magnitude of change consistent with change of performance

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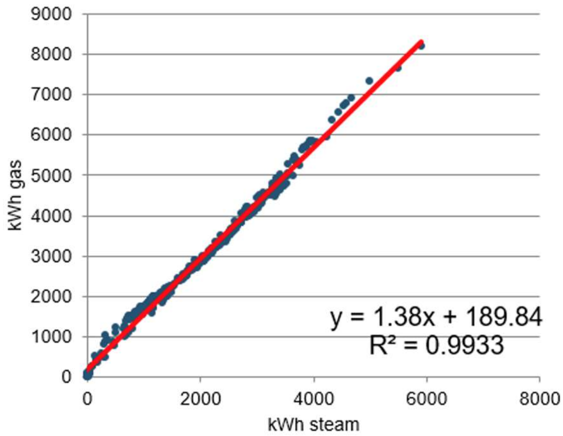
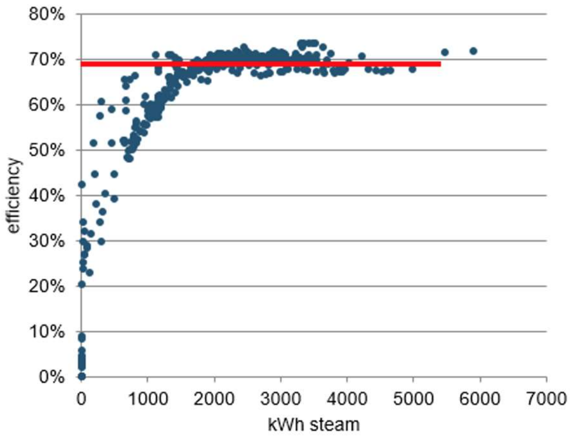
Technical example – steam boilers





- 1.38 kWh of gas to get each kWh of steam.
- Standing losses of 189.84 kWh of gas
- The efficiency is lower when the output (and input) is lower.

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Discussion

Is Specific Energy Consumption (SEC) useful?

In fields of specialized knowledge, we aim to render an account that is plain and simple, yet does no violence to the difficulty of the subject, so that the uninformed reader can understand us while the expert cannot fault us.

We try to keep in mind a saying attributed to Einstein—that ***everything must be made as simple as possible, but not one bit simpler****.*

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How do you measure energy performance?

- **Absolute Values?**
  - Actual cost compared with budget?
  - kWh last month compared with the same month last year?
  - Moving total of 12 months kWh
- **Ratios?**
  - kWh/m2 compared with another facility
  - kWh/unit of production
  - Coefficient of performance
  - Energy efficiency (out/in)
  - Energy intensity (GJ/$)
- **More complex and precise methods?**
  - Normalized consumption taking into account relevant variables

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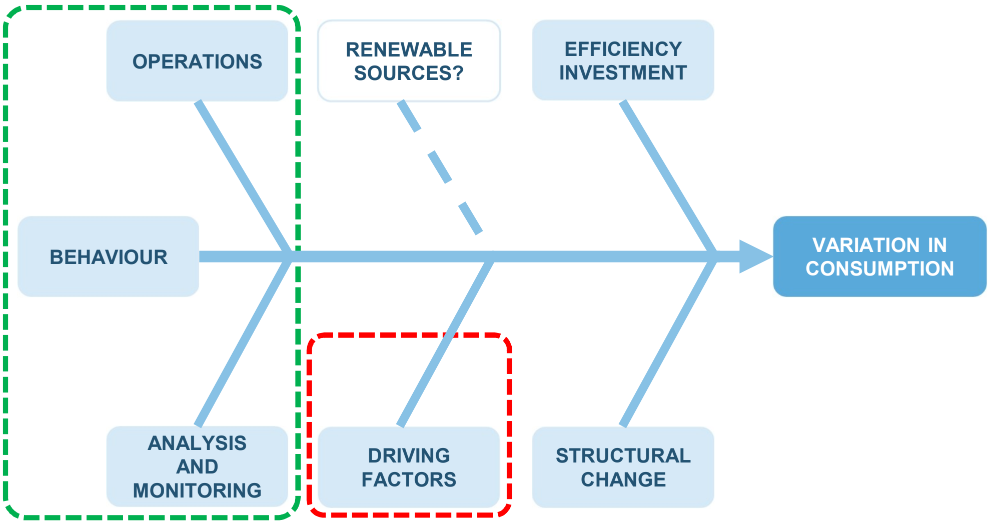
Causes of variation in consumption



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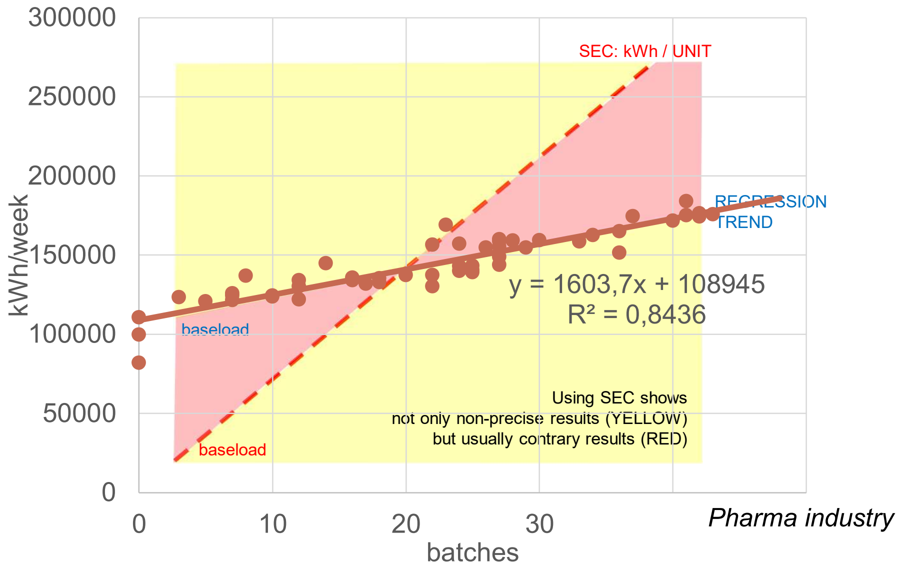
Regression vs SEC



Pharma industry

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Discussion

Is Specific Energy Consumption (SEC) useful in the EnMS context?

In fields of specialized knowledge, we aim to render an account that is plain and simple, yet does no violence to the difficulty of the subject, so that the uninformed reader can understand us while the expert cannot fault us. We try to keep in mind a saying attributed to Einstein—that ***everything must be made as simple as possible, but not one bit simpler****.*

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Review of commitment building

Context, Leadership and some elements of Support

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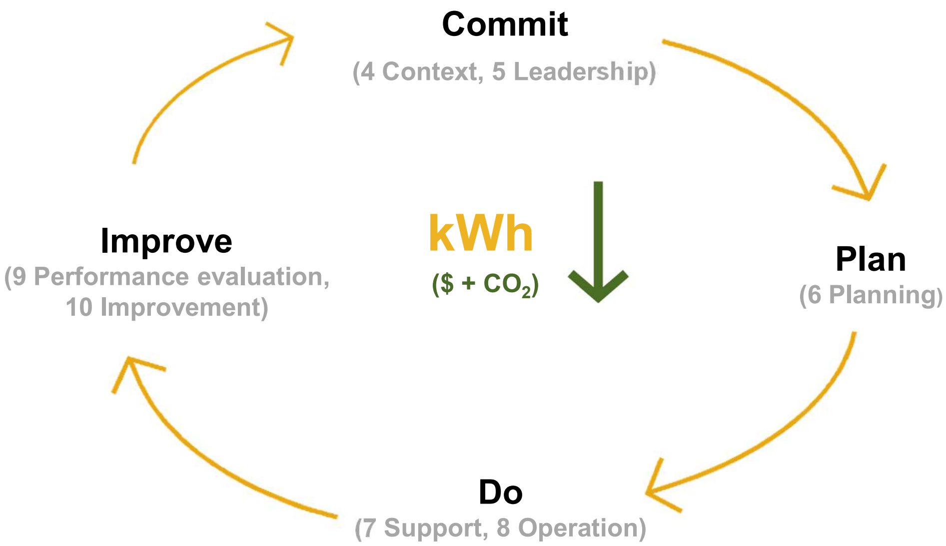

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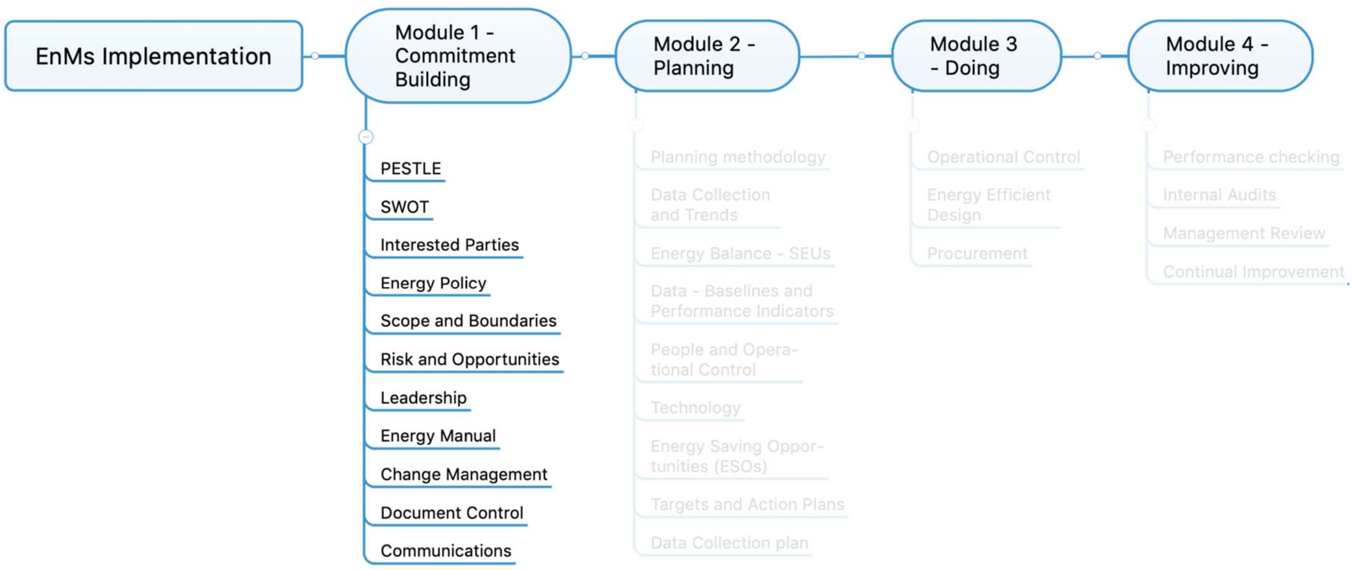

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Forcefield Analysis – Part 3

Drivers and Barriers to success

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Risks and Opportunities tab

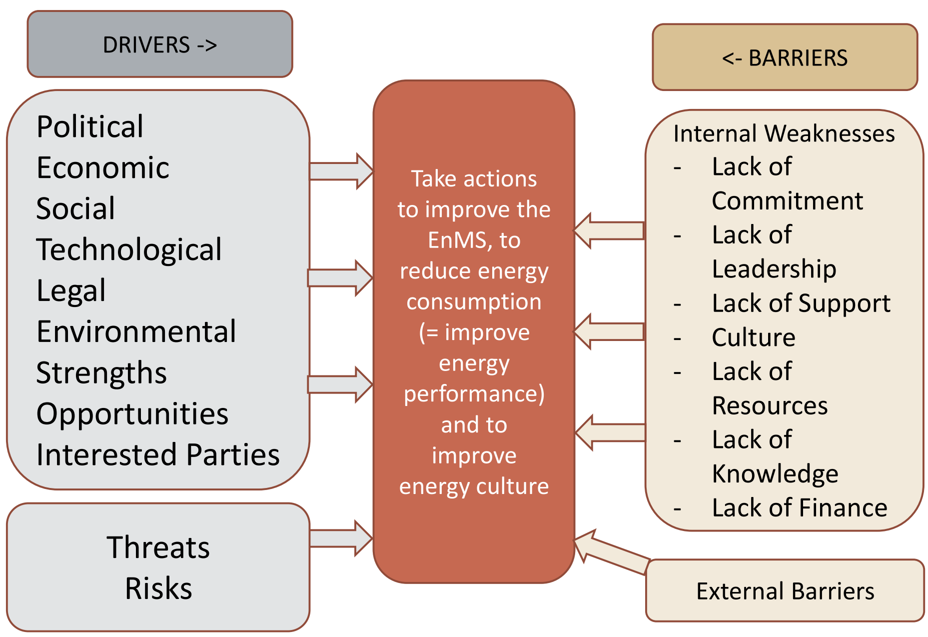
Drivers and opportunities

Drivers and Opportunities	Importance	Plans to address opportunities	Responsable for opportunity plans	Target date	Implemention date
From PESTLE and SWOT analysis results, list the positive factors that will help to develop and effective EnMS. This will be P,E,S,T,L,E and S,O from SWOT.	How important is this factor in helping to develop the EnMS.	How will this opportunity be taken?	Who is responsible?	When will the plan be completed?	When was it actually completed?

Risks and barriers

Risks and barriers	Severity (L/M/H)	Chance of occurring (L/M/H)	Plans to address barriers	Responsable for barrier plans	Target date	Completion date
From PESTLE and SWOT analysis results, list the risks and barriers that will hinder the development of an effective EnMS. These will be mostly related with Weaknesses and Threats from SWOT.	How important is the factor as a barrier to develop and EnMS.	How likely is this issue to occur?	What action will be taken to address this risk or barrier?	Who is responsable?	When will the plan be completed?	When was it actually completed?

239



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Add more risks and barriers?

- Describe the risks or barriers clearly
- Consider external risks from PESTLE analysis
- Consider weaknesses and threats from SWOT analysis
- Grade each from (Low/medium/high) in terms of importance or severity
  - Prioritise the most serious ones

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Exercise: Forcefield Analysis
Part 3 - 45 minutes + 15 minutes discussion

This is the critical part - How will you overcome the barriers?

Review/update your barriers and develop action plans to address them

Risks and barriers	Severity (L/M/H)	Chance of occurring (L/M/H)	Plans to address barriers	Responsable for barrier plans	Target date	Completion date
From PESTLE and SWOT analysis results, list the risks and barriers that will hinder the development of an effective EnMS. These will be mostly related with Weaknesses and Threats from SWOT.	How important is the factor as a barrier to develop and EnMS.	How likely is this issue to occur?	What action will be taken to address this risk or barrier?	Who is responsable?	When will the plan be completed?	When was it actually completed?

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Summary for senior management

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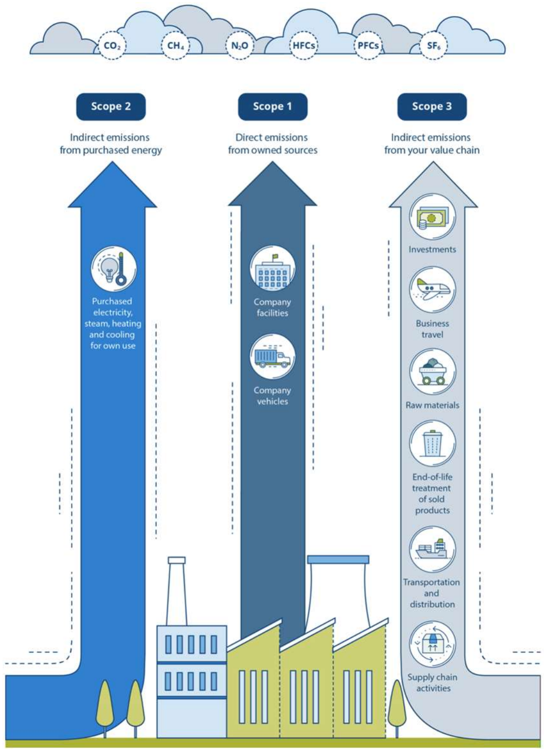
Global environmental trends

Source: Incite S.A.

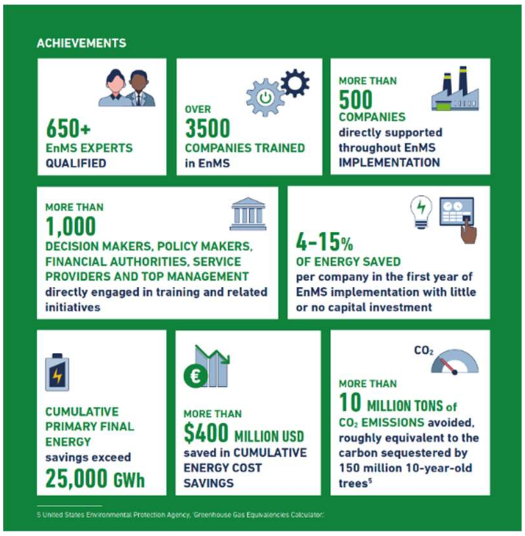
Carbon footprint (GHGs)

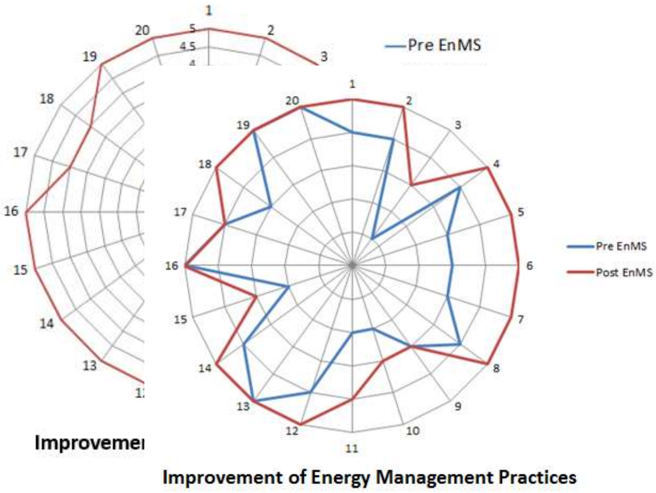
- Scope 1 – Direct emissions
  - Boilers, combustion, vehicles, aircraft, ships, refrigerants
- Scope 2 – From imported energy
  - Electricity, district heating
- Scope 3 – Indirect – throughout the value chain

- Energy is 73% of total global Greenhouse Gas (GHG) emissions



Impact of UNIDO EnMS-ISO 50001 Programme (2010-2020)





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Critical Success Factors

- A sense of urgency
- Leadership and commitment from the top
- Clear roles and responsibilities
- Clear targets
- Action plans aligned with the targets
- Aligned processes
- Communications
- Enthusiastic energy manager and energy team

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BARRIERS to Energy Efficiency in Industry

- **M** Management focus is on production & volumes, not on EE
- **K** Lack of information and understanding of own energy performance
- **K** Lack of adequate skills for identifying, assessing, developing and implementing EE measures and projects
- **K** Poor or misused monitoring systems and data
- **M** First costs more important than recurring costs → disconnection between capital and operating budgets
- **M** Staff behavior and attitude
- **F** Financing constraints

✓ *Production, technological, operational and staff changes over time*

- Lack or limited availability of IEE services and product

M Management/organizational barrier **K** Knowledge/competency barrier **F** Financial barrier

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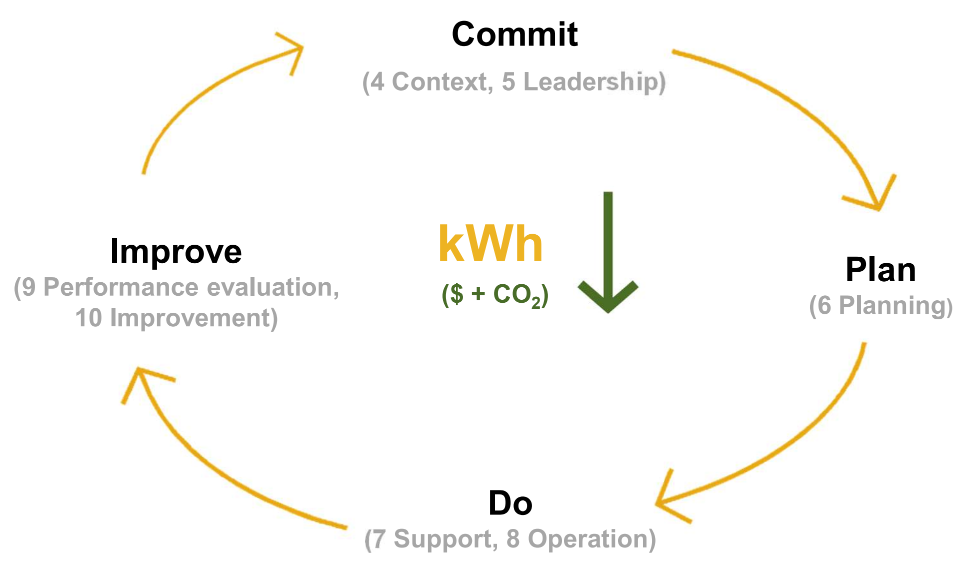

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The energy manual

- It's a map of all the tasks and activities in the EnMS.
- It lists all tasks and:
  - Describes how they should be carried out
  - How often?
  - Where are they recorded?
  - Who needs to know about them?
  - Who is responsible for each task?
  - Who supports each task and other roles?
- It is a summary of all roles, responsibilities and authorities in the EnMS

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Important Roles

- Top management support and leadership
- Management Representative: Someone at the top level of the organisation to lead the energy management activities
  - Direct the activities
  - Represent energy management at senior level
  - Gain support for energy management
- Energy Manager: Someone to run the EnMS on a routine basis
  - Know it in detail
  - Coordinate its development
  - Represent it at external audits
- Energy team: makes it happen

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Critical role of top management

- Instill a sense of urgency
- Communicate clear scope and vision
- Make resources available, especially time
- Agree, support and push towards targets
- Make decisions to support improvements
- Remove barriers
- Motivate the energy team
- Expect energy savings and push for them
- Understand that energy = cost = carbon

- Link energy performance to the overall business strategy

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Do you have support and leadership?

Question	Evidence
Do top management regularly ask you, how much energy is being saved?	
Have top management informed all employees that energy management and energy savings are important to the organisation?	
Do top management encourage all departments to integrate energy management in business processes?	
Do top management encourage all departments to support energy saving actions?	
Do top management push for bigger savings targets?	
Do top management make decisions to support increasing energy savings?	
Have top management agreed the time availability of all employees with an important role in the EnMS?	

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Change Management Process

Eight step change model (*John P. Kotter :* Leading Change)

1. Create a sense of urgency
2. Build support from key influencers
3. Create a vision of what can be achieved
4. Communicate the vision
5. Remove obstacles
6. Create short term wins
7. Build on the improvements
8. Anchor the change in your culture

This process can be aligned with your EnMS development

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Change Management

"It is not the strongest of the species that survives, nor the most intelligent; it is the one that is the most adaptable to change"

Charles Darwin

Source: *John P. Kotter* Leading Change

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10 reasons why change management initiatives fail

1. Lack of communication of why the change is happening.	3. Lack of a shared vision of the new direction	5. Lack of bottom up support	7. Not enough time allocated to embed the change	9. Lack of planning for organisational politics
2. Failure to plan for resistance to change	4. Failure to engage with and involve employees	6. Lack of understanding of the benefits and why the change makes sense	8. Lack of a consistent message	10. Lack of consideration for the existing culture

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10 reasons why change management initiatives fail?

1. Lack of communication of why the change is happening.	**3. Lack of a shared vision of the new direction**	5. Lack of bottom up support	7. Not enough time allocated to embed the change	9. Lack of planning for organisational politics
2. Failure to plan for resistance to change	**4. Failure to engage with and involve employees**	**6. Lack of understanding of the benefits and why the change makes sense**	**8. Lack of a consistent message**	10. Lack of consideration for the existing culture

Half relate to communications

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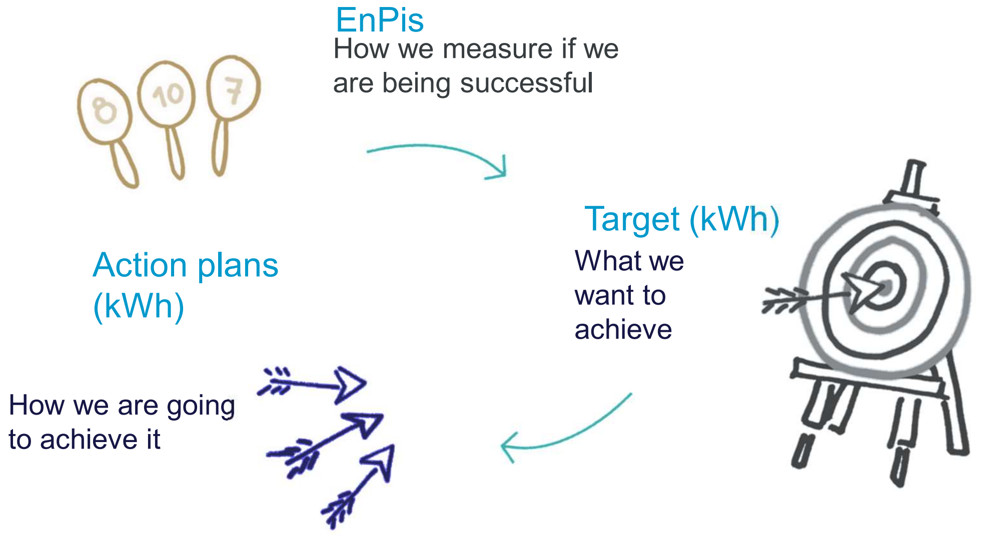
Targets and action plans



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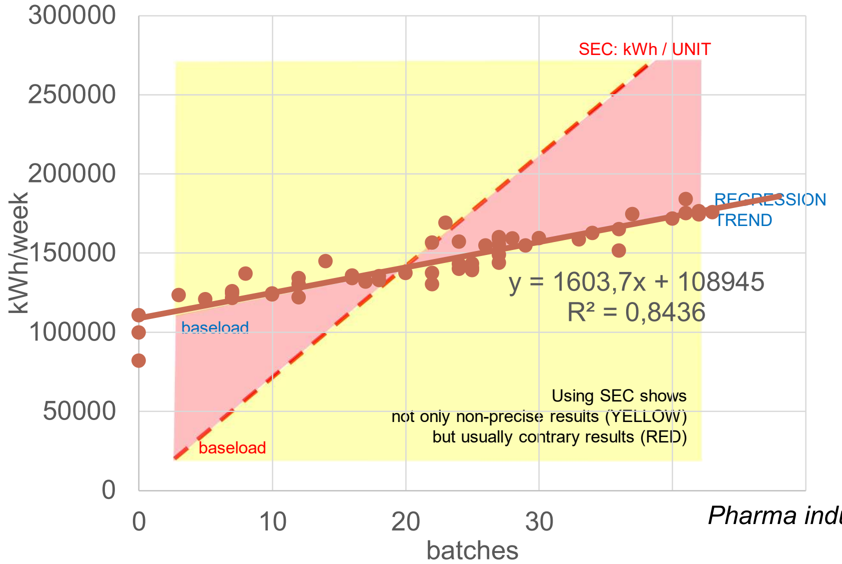
Regression vs SEC



Pharma industry

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Training plans

Role → Competence check → Training plan

1. Review the roles and responsibilities of each energy team member (Energy Manual).
2. Decide on the level of competence (basic or advanced) required for each person in relation to each task (Training Plan).
3. Interview each person to assess their competence for each assigned task (record results in the training plan)
4. The gap in competence should be filled by training
5. Begin this training for module 1 as soon as possible

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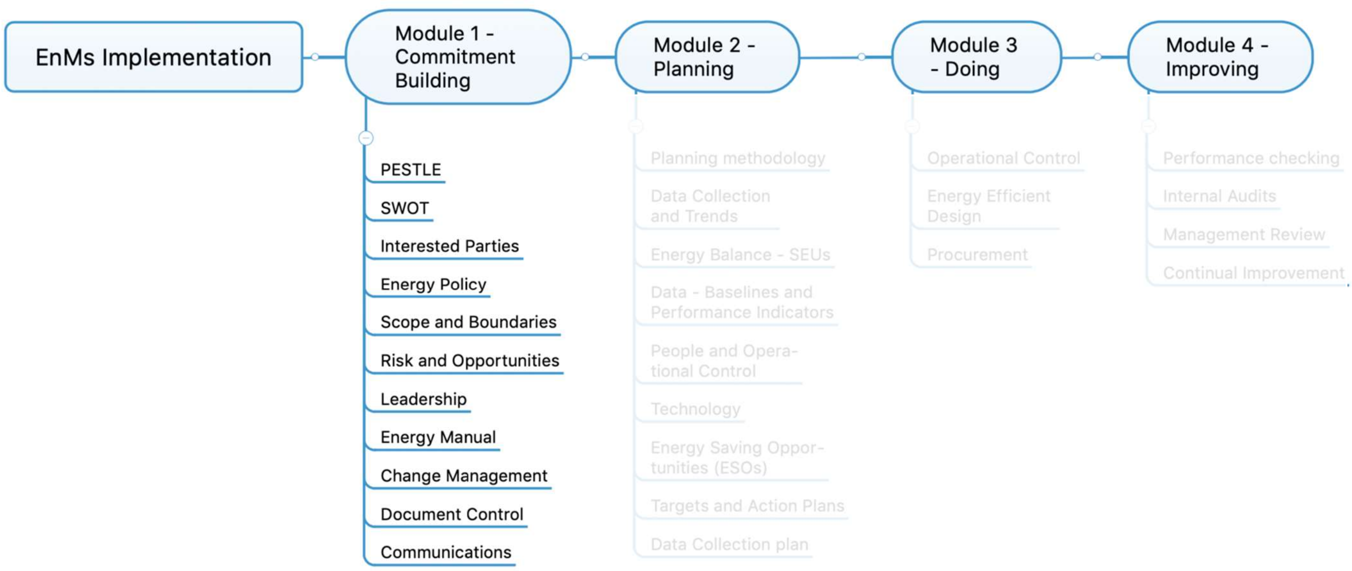

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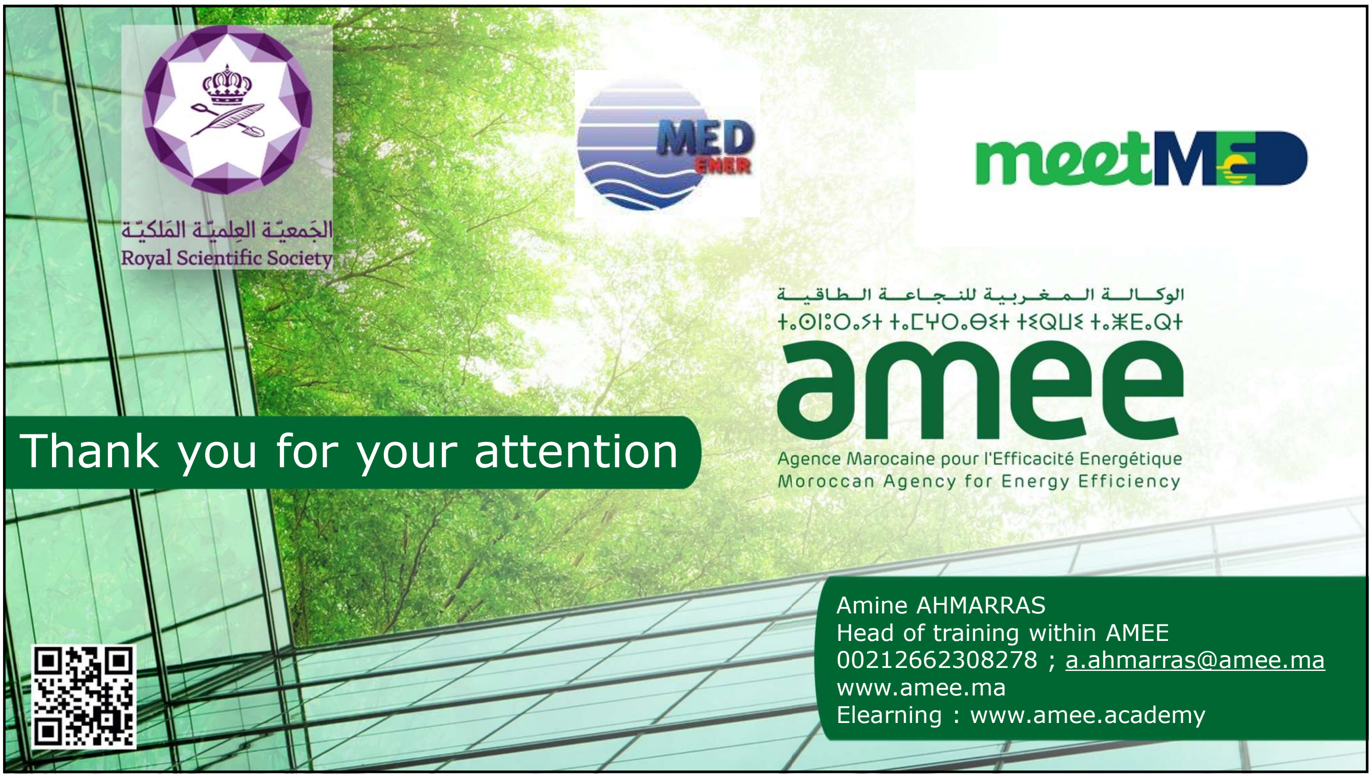
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Moroccan Agency for Energy Efficiency
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Moroccan Agency for Energy Efficiency

Energy Management System according to the ISO 50001 standard

16/05/2025

Amine AHMARRAS
Head of training within AMEE

1

Energy Management Systems (EnMS)

Day 3 – Planning

2

	Morning Agenda
Part 1	Review Context
Part 2	Overview of planning
	Break
Part 3	The energy savings opportunities (ESO) list

3

Overview of planning

4

What is planning?

We have leadership, support, resources, strategic direction and committed team members

We now want to translate this commitment into an

action plan

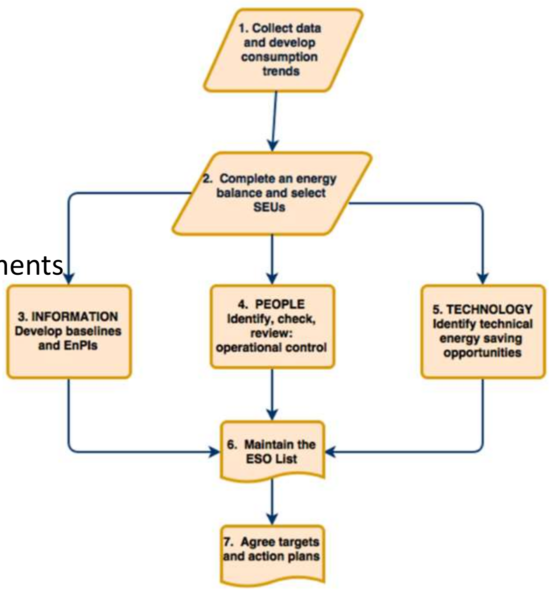
for improved energy performance

within the scope and boundaries

5

Planning overview

1. How much energy am I using?
2. Where am I using it (SEUs)?
3. What is driving it?
4. Who is influencing its use?
5. What legal and other requirements are related to my energy use?
6. System Optimization
7. Renewable energy options
8. Develop baseline & indicators
9. Set objectives and targets
10. Action Plans



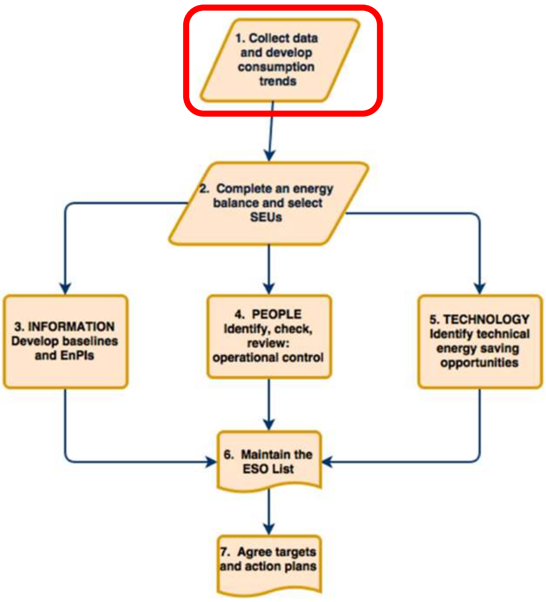
6

1. Past and present energy consumption

- Collect data
  - Bills
  - Other meters
- Develop and **analyse** trends
- Rolling sum of consumption

Tool:

- Data tab
- Trends tab



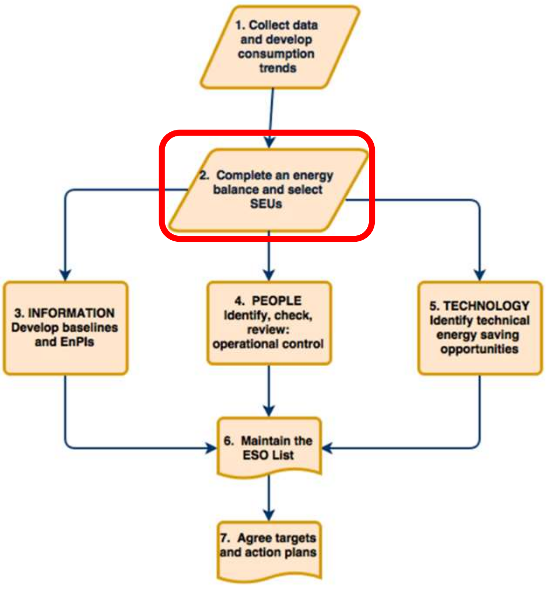
7

2. Energy Balance & SEUs

- For each source (type):
  - Identify all energy uses
  - Estimate consumptions
    - Measure where possible
  - Sort in order of consumption
  - Select SEUs (approx 80%)

Tool:

- SEU Tab



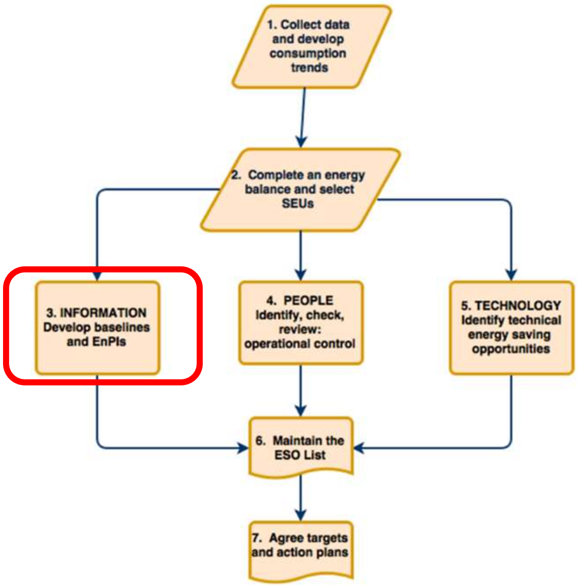
8

3. Information

- Whole plant & each SEU
  - Consumption
  - Variables
  - Relationship
  - Energy Baseline(s)
  - Energy Performance Indicators (EnPIs)

Tool:

- Baseline tab
- EnPI tab



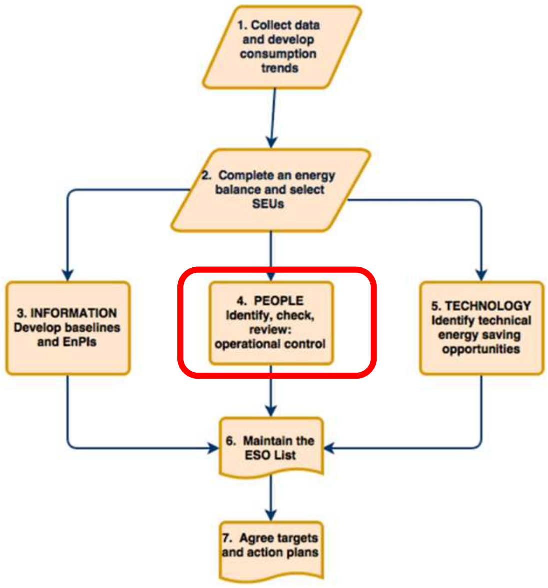
9

4. People

- For each SEU – Who?
  - Competence
  - Training
  - Operational control
  - Critical operating parameters

Tool:

- Energy Manual
- Training
- Operational control
- Critical operating parameters
- ESO list



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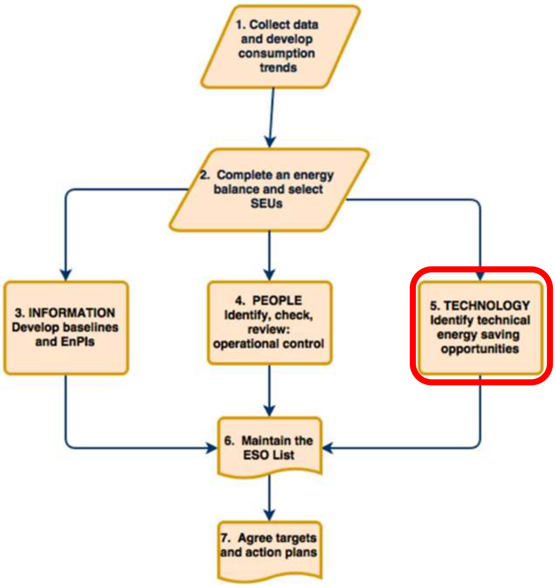
5. Technology

- Energy Saving Opportunities (ESOs)
  - ✓ New methods
  - ✓ Upgrading
  - ✓ New equipment
- Investment
  - ✓ No cost/ low cost
  - ✓ Medium
  - ✓ High

Tool:

ESO List



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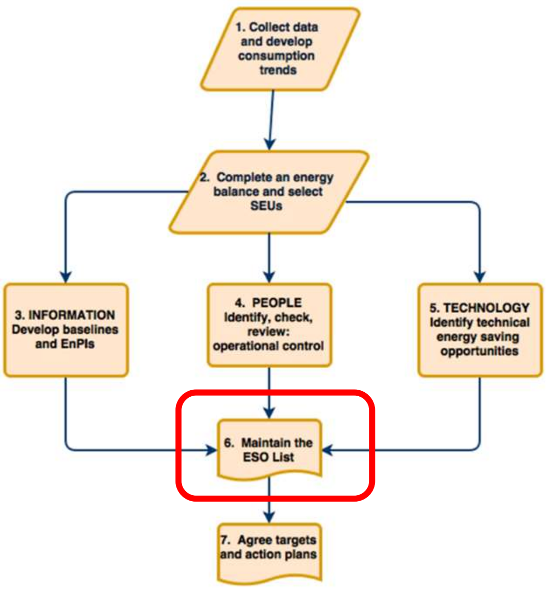
6. ESO List

List all opportunities and ideas of Energy saving

- Evaluation
  - ✓ Financial
  - ✓ Technical
- Verification
- Prioritization

Tool:

- ESO List



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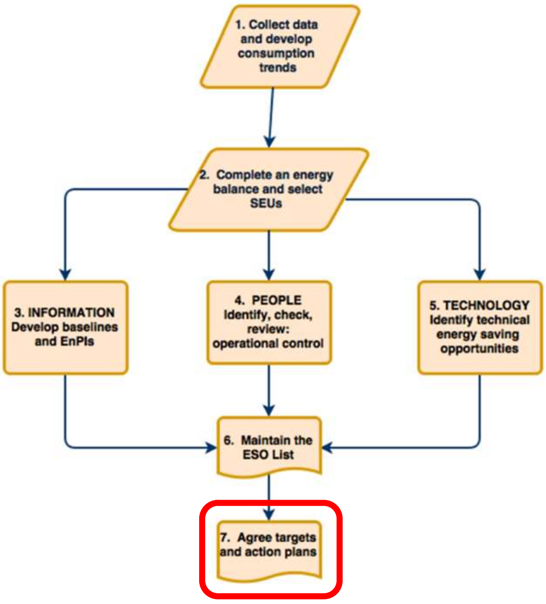
7. Targets and action plans

- Select opportunities
- Set savings targets
- Action plans

Tool:

- Objectives and targets
- ESO List (approved)



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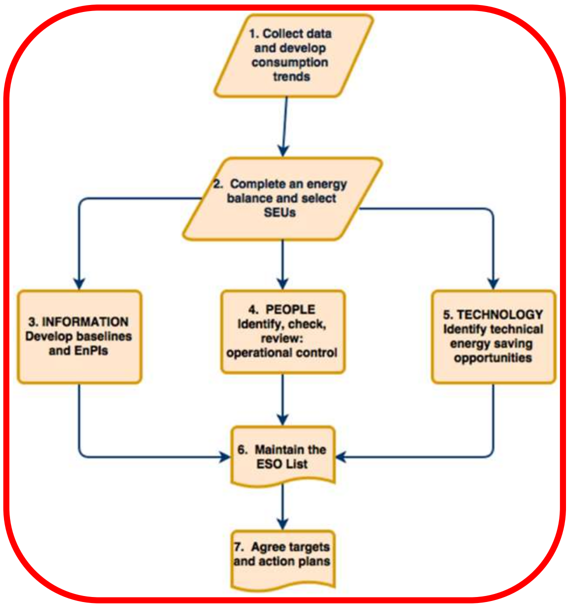
Data collection plan

- EnBs & EnPIs
  - Consumption
  - Relevant variables
  - Static factors (?)

- Operational Control
  - Critical operating parameters

Tool:

- 2 tabs (EnB and EnPI)



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Continual improvement – The energy savings opportunity list

ESO List

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Continual improvement – ESO list

”small steps, everyday, involving everyone”

- Continually identify new energy saving opportunities
- Continually evaluate them to decide which to implement
- Continually implement the selected ones
- Can the idea be replicated elsewhere?

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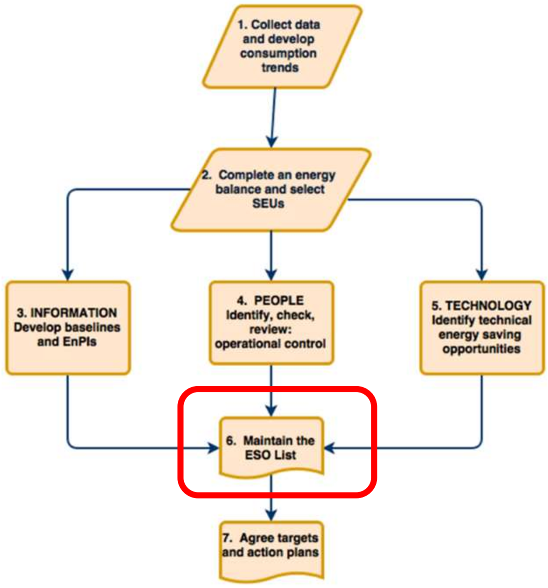
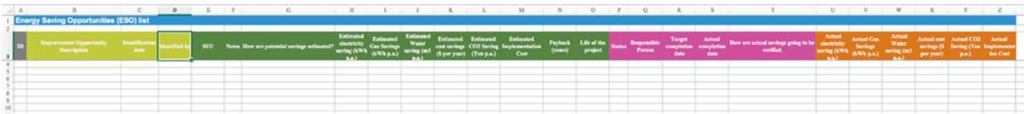
Planning workflow

- The ESO List



ESO List - Workflow



Generate ideas → Evaluate → Implement → Verify

	A	B	C	D
1	Energy Saving Opportunities (ESO) list			
2				
3		Idea Generation		
4	ID	Saving Opportunity Description	Identification date	Identified by
5	1	Ideas from Data Analysis		
6	2	Ideas from SEU lists		
7	3	Ideas from Energy Audits		
8	4	Ideas from personnel		
9	5	Ideas from reviewing people		
10	6			
11	7			
12				
13				
14				
15				

- Unique ID for each item
- Description (what to do)
- Identification date
- Whose idea is it?
- Include contractors, service people, and suppliers

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Generate ideas → Evaluate → Implement → Verify

				Technical and financial apprais
SEU	Barriers/Risk/Notes	How are potential savings estimated?	Non-energy benefits (NEB)	NEB Value (€ per year)
Insert SEU name from a dropdown list	Consider what barriers and risks are involved and how to minimise them. Insert additional notes and information. If you wish add another column for notes	Describe the information and calculations that will be used to estimat the savings in energy, money and CO2	Consider what other benefits will accrue from this ESO besdies energy savings	Try to put a financial value on the NEBs where possible

l of each ESO							
Estimated electricity saving (kWh p.a.)	Estimated Gas Savings (kWh p.a.)	Estimated Water saving (m3 p.a.)	Estimated cost savings (€ per year)	Estimated CO2 Saving (Ton p.a.)	Estimated Implementation Cost	Payback (years)	Life of the project

- EM to complete these 5 fields
- Estimate energy, cost and CO_2 savings
- Use formulae in fields where applicable and not result of a calculation
- E.g. = 24h*7d*52w*100 kW
- Constants: prices, CO_2

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Generate ideas → Evaluate → **Implement** → Verify

Implementation Management					
Status	Reason for status	Responsible Person	Target completion date	Actual completion date	How are actual savings going to be verified
	Why was the item rejected or put on hold. Circumstances might chasnge in the future				Decide how it will be M&V'd in advance

- Status:
  - Idea
  - In Progress
  - Rejected
  - On Hold
  - Complete
- Specific
- Measurable
- Achievable
- Relevant
- Timed

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Generate ideas → Evaluate → Implement → **Verify**

Verification of results					
Actual electricity saving (kWh p.a.)	Actual Gas Savings (kWh p.a.)	Actual Water saving (m3 p.a.)	Actual cost savings (€ per year)	Actual CO2 Saving (Ton p.a.)	Actual Implementation Cost

- Actual savings will never equal estimated savings
- This step is important and is not typically completed
- Change the status to “complete” after this step

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Generate ideas → Evaluate → Implement → Verify

Energy Saving Opportunities (ESO) list

ID	Improvement Opportunity Description	Identification date	Identified by
1	Reduce office lighting energy by 5%		
2	Investigate heat energy		
3	Reduce office tempartures to 19C in the winter		
4	Install PIRs in all low occupancy areas		
5	Train workshop personnel in the operation of their HVAC systems		
6	Raise awareness		
7	cooling water distribution pumps Install variable speed drives of the		

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Reporting

- Open ideas
  - Status = "Idea"
- Action plan for this year
  - Target Date = "2017"
- Total savings last year
  - Status = "complete"
  - Completion date = "2016"
  - Sub-total actual savings
- Items which are late
  - Status = "In progress"
  - Completion date is blank
- Items which are my responsibility
  - Responsible person = "me"

Useful tools

- Sorting
- Filtering
- Sub-totals
- Pivot tables

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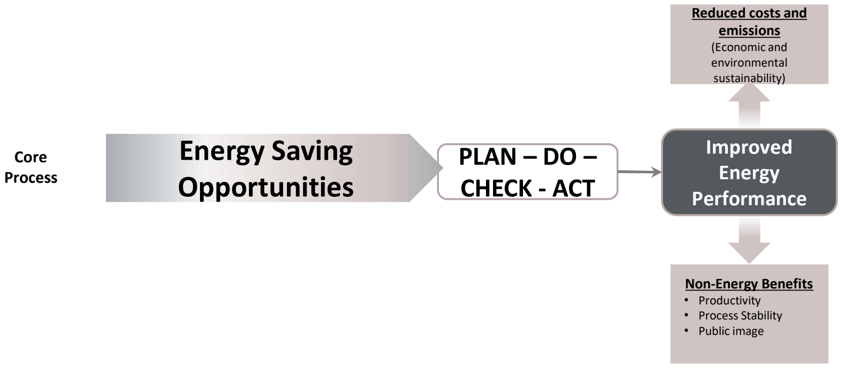
EnMS processes – the importance of the ESO list



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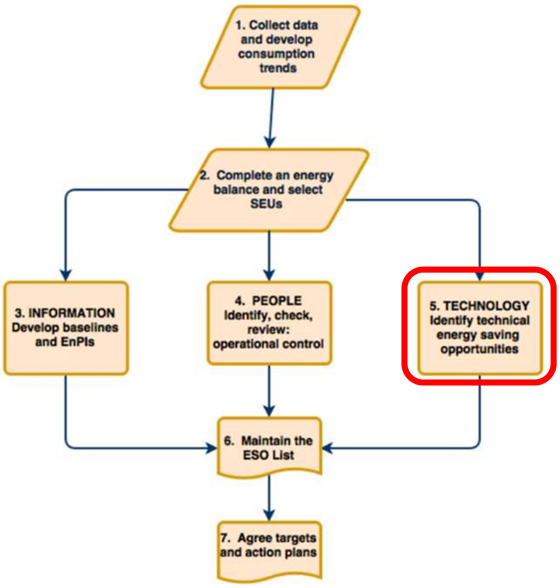
Planning workflow

- Technology
  - Identify energy saving opportunities



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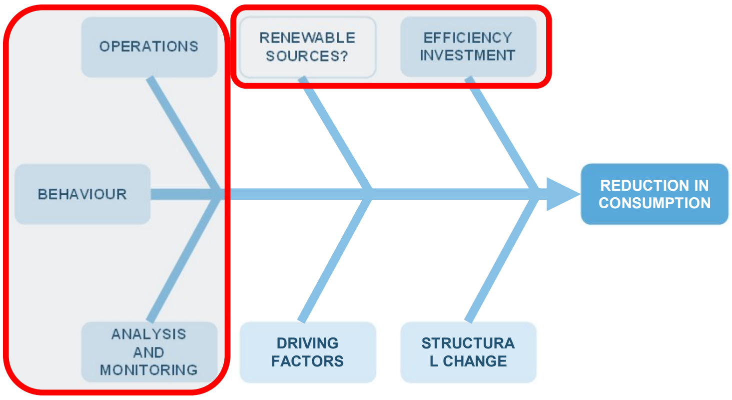
Planning reduction in energy consumption



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Planning Notes

- Continual improvement v planning “phase”
- Continually develop energy saving ideas
- Typically complete data analysis (EnB’s) annually
- Ideally monitor performance weekly (monthly if only billing data is available)
- Future Energy Consumption
    - Financial budgets

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	Afternoon AGENDA
Part 1	Data collection
Part 2	Introduction to energy baselines and performance indicators
	Break
Part 3	Developing energy baselines – Part 1

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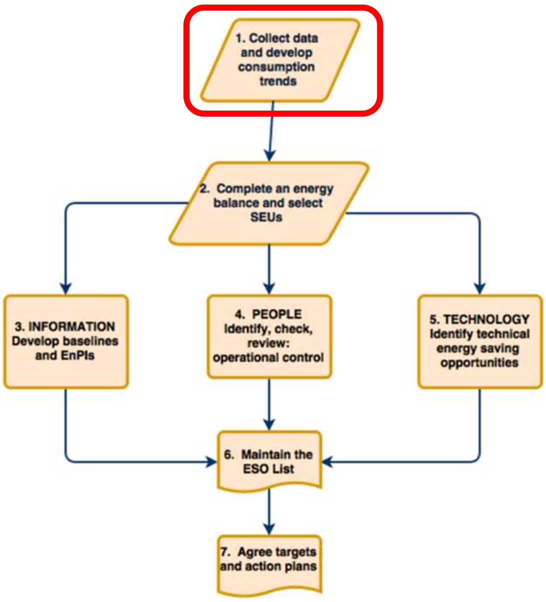
1. Past and present energy consumption

- Collect data
  - Bills
  - Other meters
- Develop and analyse trends
- Rolling sum of consumption

Tool:

- Data tab
- Trends tab



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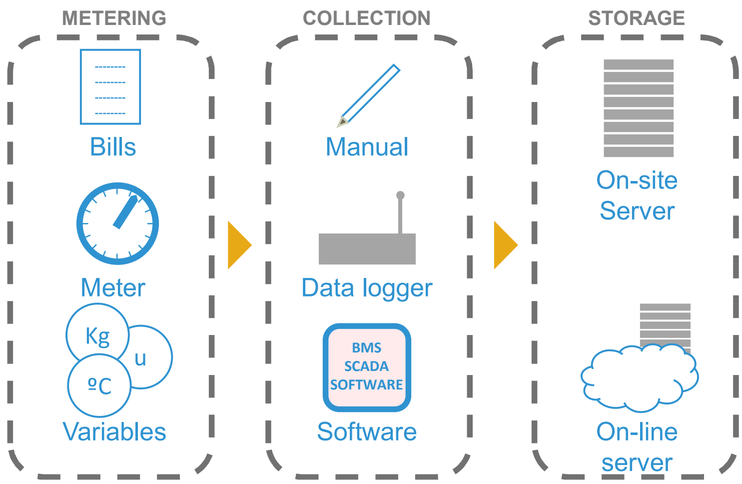
Data collection and storage



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What to measure and collect

PARAMETER	PREFERABLE	NOT A GOOD IDEA
Electricity	kWh	kW, Amps
Natural Gas	kWh, GJ, Nm3	kW, GJ/s, Nm3/hr
Production	Tonnes, units	T/hr, units/hr
Outside Temperature	HDD or CDD	Average temperature
Temperature, pressure, speed, analysis results, etc	Average	Instantaneous

Note: Totalisers versus interval data

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Data requirements: good example

- Data in columns
- Continuous history. No gaps.
- Free of estimates
- Equal intervals
- Synchronized with reporting interval (or more frequent)

	Date	Bread plant A gas (kWh)	Bread Plant B gas (kWh)	Bread plant A outpu (tonne)	Bread pl (tonne)
5	28/09/02	148778	137405	622.5	317.7
6	05/10/02	143472	136760	598.8	325.0
7	12/10/02	149774	138167	653.7	321.5
8	19/10/02	144645	139340	600.6	326.0
9	26/10/02	140981	140043	561.2	305.8
0	02/11/02	153321	138754	665.9	308.3
1	09/11/02	155753	139809	688.0	316.7
2	16/11/02	158890	139164	696.6	316.8
3	23/11/02	151503	139633	641.5	321.3
4	30/11/02	155255	131719	670.2	280.1
5	07/12/02	152998	139985	661.3	315.8
6	14/12/02	155577	139369	691.2	326.6
7	21/12/02	156662	140014	703.3	337.0
8	28/12/02	107275	107128	472.5	228.7
9	04/01/03	140659	123747	528.3	255.2
0	11/01/03	159798	137991	702.5	317.5
1	18/01/03	156515	144557	664.1	362.6
2	25/01/03	146814	154522	640.3	363.4
3	01/02/03	145847	145700	609.5	313.3
4	08/02/03	162436	136966	760.7	315.1
5	15/02/03	163667	135617	681.8	334.3

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Data requirements: bad example

- Discontinuous.
- Unequal intervals
- Extraneous values
- Estimates

Week/Yr	Date	Total KWh	kWh used
46	17/11/2013	410517	12484
47	24/11/2013	422377	11860
48	01/12/2013	432119	9742
49	08/12/2013	443846	11727
50	15/12/2013	455635	11789
51	22/12/2013	467424	11789
52	29/12/2013		
			540433
1	05/01/2014	475490	8066
2	12/01/2014	487088	11598
3	19/01/2014	498602	11514
4	26/01/2014	510154	11552
		517633	7479
5	02/02/2014	520624	2991
6	09/02/2014	533721	13097
7	16/02/2014	541942	8221
8	23/02/2014	554224	12282
	28/02/2014	564103	9879
9	02/03/2014	568055	3952
10	09/03/2014	578027	9972
11	16/03/2014		0
12	23/03/2014		0
13	30/03/2014	589386	11359

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Other data collection issues

- Synchronise data collection frequency between consumption and variables
  - Is the product accounted only at the packaging stage? Beware of storage products, "work in progress", long production processes.
- Monitor each process step separately if possible.
- Monitor storage volumes if possible
  - It can help to solve data timing problems.
- *Gross* throughput, not only saleable

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Data collection plan

- Relevant variables and consumption data are both important:
  - What data do we have?
  - What data do we need?
  - How will I acquire it routinely?
  - Manual v automatic
- Detect gaps, develop a measurement plan to improve data availability in the future

BUT REMEMBER…

It is always possible to start working with the information we already have. Bills are always available.

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Collecting data

- Sources? Electrical, natural gas, propane, hydro, wind?
- What facilities, systems or equipment are using energy?

- What data do we have? Where?
- What data do we need? Where?

- How much energy are we consuming?
- How much did we consume in the past?
- What are likely energy consumption trends for the future?

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Analyze Energy Use & Consumption

- **Collect past and current monthly consumption** data at the facility level (energy bills).
- Determine **what other data** may be **available**.
  - Sub-meter data
  - Interval data
  - Equipment information
  - Other data
- Determine **past and current consumption by use.**

- Note: The time period for data collected will depend on your organization and what data is available.

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Annualised trends

- Moving total of previous 12 months (or 52 weeks, etc)
  - Removes seasonal effects
  - Gives a real view of comparison v budget
  - Effects of a change stay for next 12 periods
  - Absolute numbers
  - No allowance for changing activity levels
- Very useful for forecasting
  - You can quickly judge what next 12 months use will be
  - You need to correct for known changes in output or activity

Note: A large step change in consumption will show as a slow change

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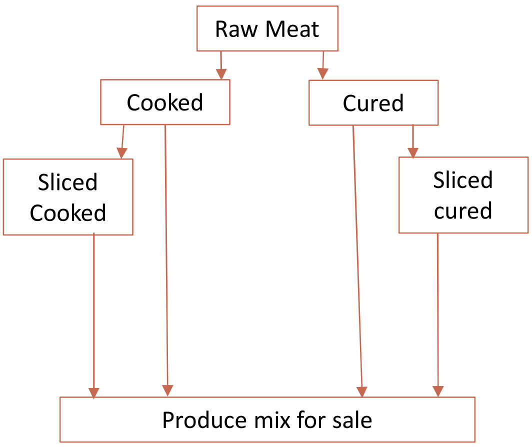
Background to the exercises

- Meat processing plant in Spain
- Large refrigeration systems.
- 3 main types of product:
  - Cured product.
  - Cooked product.
  - Sliced product (all is cooked or cured before slicing).
- We will use this plant for some practical examples and exercises.



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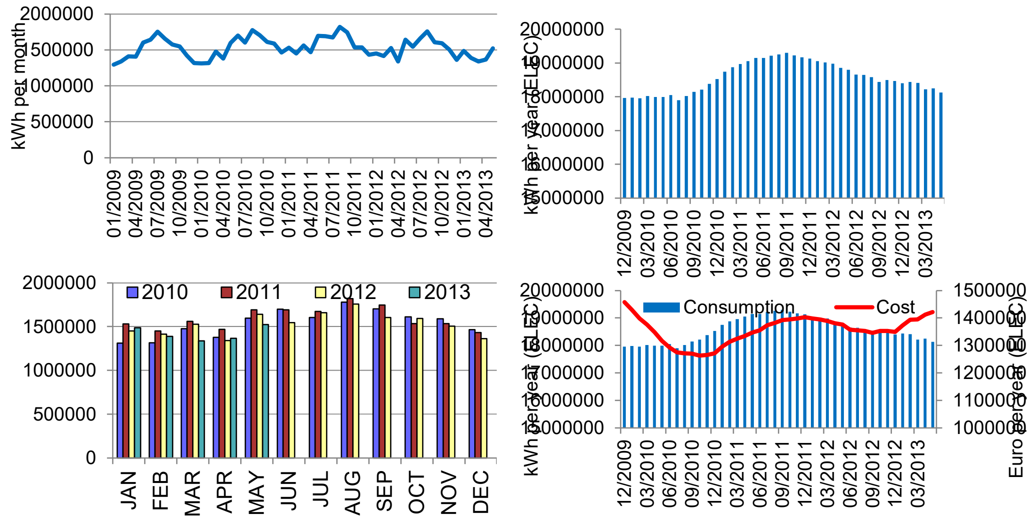
Are we consuming more or less?



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Common mistakes

- Year-to-date reporting
  - Inaccurate near start of year
  - Moving annual totals or averages better, e.g. annualised view
- Calendar has no significance
- Why waste information from prior periods?
- Long-term history gives superior overview

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Exercise 01

Date	Elec kWh/month	Elec kWh/year
01/12	1450461	
02/12	1414145	
03/12	1526610	
04/12	1340280	
05/12	1641128	
06/12	1544644	
07/12	1659025	
08/12	1757326	
09/12	1605133	
10/12	1592016	
11/12	1502998	
12/12	1361331	
01/13	1487662	
02/13	1386564	
03/13	1337163	
04/13	1367378	
05/13	1523203	
06/13	1567576	
07/13	1861774	
08/13	1860107	
09/13	1727270	
10/13	1675044	
11/13	1595225	
12/13	1362289	

- 1. Calculate and represent the annualised trend for 2013
- What is the annual consumption in the year ending July 2013
- 2. What is the % change in consumption in 2013 compared to 2012?

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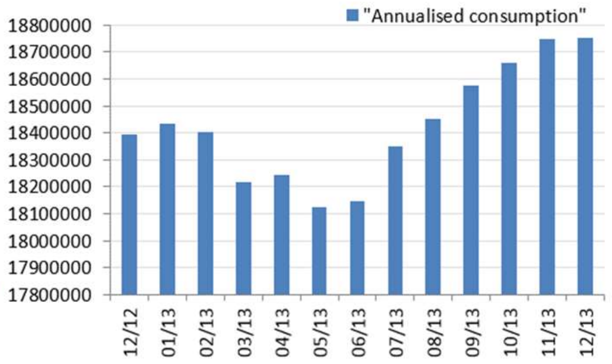
Exercise 01 - Solution

	A	B	C
1		ELECTRICITY	
2		Total Consumption	Annualised
3		kWh	KWh per year
4	01/12	1450461	
5	02/12	1414145	
6	03/12	1526610	
7	04/12	1340280	
8	05/12	1641128	
9	06/12	1544644	
10	07/12	1659025	
11	08/12	1757326	
12	09/12	1605133	
13	10/12	1592016	
14	11/12	1502998	
15	12/12	1361331	18395097
16	01/13	1487662	18432298
17	02/13	1386564	18404717
18	03/13	1337163	18215270
19	04/13	1367378	18242368
20	05/13	1523203	18124443
21	06/13	1567576	18147375
22	07/13	1861774	18350124
23	08/13	1860107	18452905
24	09/13	1727270	18575042
25	10/13	1675044	18658070
26	11/13	1595225	18750297
27	12/13	1362289	18751255

kWh	356158
%	2%



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What do you need to do?

- Identify energy data sources
- Bills – summarize in Excel
- Other meters
  - Where are they?
  - Are they connected?
  - Who has the data?
  - Get access
- Start manual data collection if necessary.

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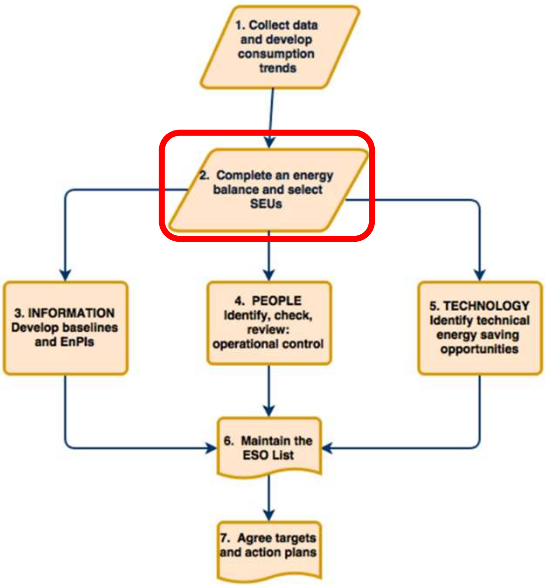
2. Energy Balance & SEUs

- For each source (type):
  - Identify all energy uses
  - Estimate consumptions
  - Sort in order of consumption
  - Select SEUs (approx 80%)

Tool:

- SEU Tab



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What are SEUs?

- What are energy uses (or energy end-use)?
  - *"application of energy"*
  - The service provided
  - e.g. Light, heat, pump, cool, ventilate, convey, etc.
- Significant energy uses
  - Large energy uses
  - Uses with good potential for savings
    - Normally don't use the 2nd part of the definition
    - It adds work without additional benefit
    - You can implement energy savings without something being an SEU.
- SEU is a central and key concept of your EnMS

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SEU - Motor List

SEU - Motors

ID	Purpose	Name plate (kW)	Hours per year	Ave VSD speed (100% if fixed)	% name plate load	Actual Power (kW)	Annual Power (kWh)	Note	When can this be switched off?	% of total	How were estimates made?	Opportunities for improvement	SEU
1	Cooling Water Pump #1	20	4.200	0,5	0,9	4,5	18.900	shares load with #2		0,02	Hours run meter reading, estimate of speed, estimate of nameplate %	insert ref nos from opp list	Cooling water
2	Cooling Water Pump #2	20	4.200	1	0,9	18	75.600			0,08	Hours run meter reading, estimate of speed, estimate of nameplate %		Cooling water
3	Hydraulic pack drive	100	250	1	0,9	90	22.500	used intermittently		0,02	Hours run meter reading, estimate of speed, estimate of nameplate %		Production
4	Seal cooler pump	1	8.400	1	0,9	0,9	7.560		almost always	0,01	review of operator logs, estimate of speed, estimate of nameplate %		Production
5	AHU 1 Fan	10	8.400	0,8	0,9	5,76	48.384		night and weekend	0,05	review of BEMS data, other items estimated		HVAC
6				1	0,9	0	-			0			
7				1	0,9	0	-			0			
8				1	0,9	0	-			0			
9				1	0,9	0	-			0			
	Total						172.944			17%			
	Total electricity consumption						1.000.000	kWh per year					

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SEU - Heat Users

SEU - Heat Users

ID	Purpose	Design (kW)	Hours per year	% of design	Actual Power (kW)	Annual Energy (kWh)	% of total	Notes	When can this be switched off?	How was this estimated?	Opportunities for improvement
1	Process 1	100	4000	0,5	50,00	200.000	25%		Analyse when if can be switched off	position of control valve and design data	
2	Process 2	80	2000	0,7	56,00	112.000	14%		Analyse when if can be switched off	position of control valve and design data	
3	Building 1 heating	120	2080	0,6	72,00	149.760	19%				
4	Building 2 heating	50	2080	0,6	30,00	62.400	8%				
5					-	-	0%				
6					-	-	0%				
7					-	-	0%				
					-	-	0%				
					-	-	0%				
					-	-	0%				
					-	-	0%				
	Total of users					524.160	66%				
	Total fuel used		kWh per year (from bills)			1.000.000					
	Generation efficiency					80%					
	Total heat used		kWh per year			800.000					

SEU - Lighting

SEU - Lighting

ID	Area	Category	Type of Fitting	Number of fittings	Lamp rating (W)	Number of Lamps/ fittings	Hour per Year	kWh per Year	How is the light controlled?	Opportunities for improvement	Are there different lux levels required in the area?	Is there natural light available?	Required Lux Levels	Actual Lux levels
1	General Office	Office	T8	16	60	4	1.000	3.840	On/Off switch	awareness, natural light, task lighting	Yes, some passageways, some desks	Yes, to the south end	400	800
2	Warehouse 2	Storage	High Bay induction					0						
3	Entrance hall	Corridor						0						
4								0						
5								0						
								0						
								0						
								0						
								0						
								0						

SEU – Communication and IT

SEU - CIT						
ID	Area	Number of units	Rating (kW)	Hour per Year	kWh per Year	Can they be switched off?
1	Administration PCs	129	0.06	2,500	19,350	Yes
2	Production PCs	84	0.06	3450	17,388	No
3	Comms building	8	5	8760	350,400	Investigate
4	Data Centre	5	0.1	2,500	1,250	Yes
5	Printers	27	0.06	2000	3,240	Investigate
					0	
					0	
					0	

SEU - Buildings

Significant Energy Uses (SEU) List - For use with Buildings as SEUs												
All fuels												
ID	Name of Building	Lighting (kWh per year)	HVAC pumps, fans (kWh per year)	IT, comms (kWh per year)	Heating fuel (litres per year)	Transport Fuel (litres per year)	What are the main variables?	Is the SEU metered? Auto/ Manual	Total electricity (kWh per year)	% of Overall Usage	Cumulative %	Who influences the energy use?
1	Administration building	54,600	21,840	56,000	10000	0	Weather for heating, occupancy for electricity	No	132,440	18%	18%	Users/ Maintenance
2	Building A	34,944	21,840	3,000	20000	0	Weather for heating, occupancy for electricity	No	59,784	8%	25%	Users/ Maintenance
3	Building B	43,680	21,840	3,000	30000	0	Weather for heating, occupancy for electricity	No	68,520	9%	35%	Users/ Maintenance
4	Building C	14,560	21,840	3,000	35000	0	Weather for heating, occupancy for electricity	No	39,400	5%	40%	Users/ Maintenance
5	Workshops	34,944	21,840	11,000	15000	0	Weather for heating, occupancy for electricity	No	67,784	9%	49%	Workshop staff
6	Laboratories	43,680	21,840	23,000	15000	0	Weather for heating, occupancy for electricity	No	88,520	12%	61%	Users/ Maintenance
7	Training Building	23,400	21,840	24,000	15000	0	Weather for heating, occupancy for electricity	No	69,240	9%	70%	Users/ Maintenance

- This is an alternative in some non-industrial facilities
- Difficult to meter SEUs across many buildings
- Consider the benefits of treating the buildings as the SEUs
- It doesn't fit the definition in the standard but can be effective

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Moroccan Agency for Energy Efficiency

SEU workflow

1. Collect data
   - Nameplates, measurements, meters
2. Estimate kW and hours to give kWh per year
   1. It is ok to use GJ, tonnes, litres or more normal units
3. Group motors by energy use
   - For example pumps and fans related to refrigeration
   - Sub-total by SEU, e.g. pumping, cooling, compressed air, etc.
4. Try to get a balance of where each energy source is used
5. Select largest uses totaling e.g. 80% of total
   a. Beware of having too many SEUs (excessive workload)

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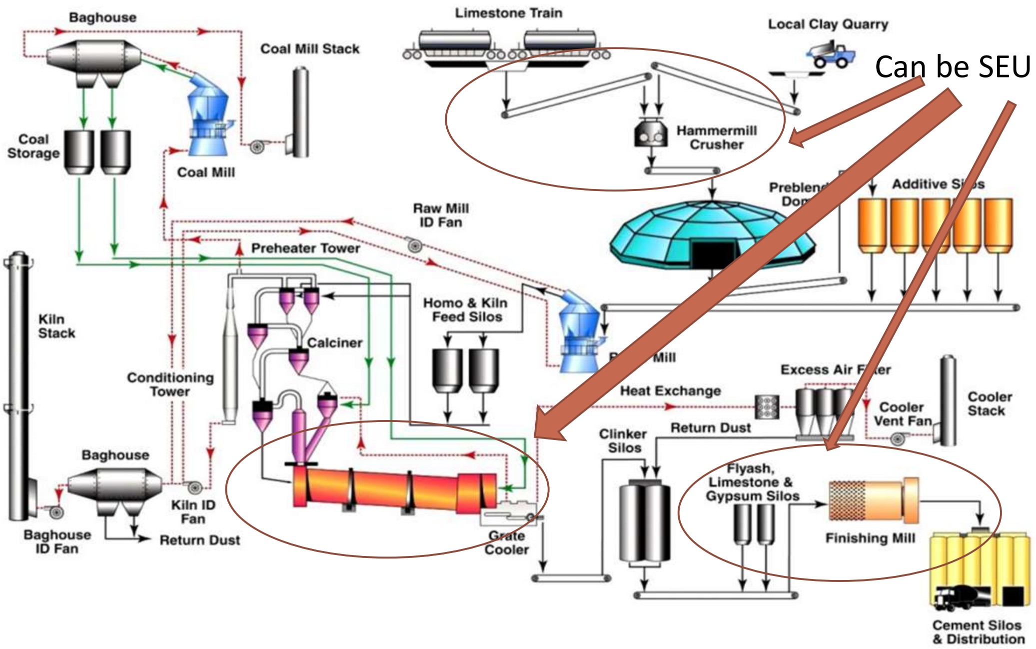

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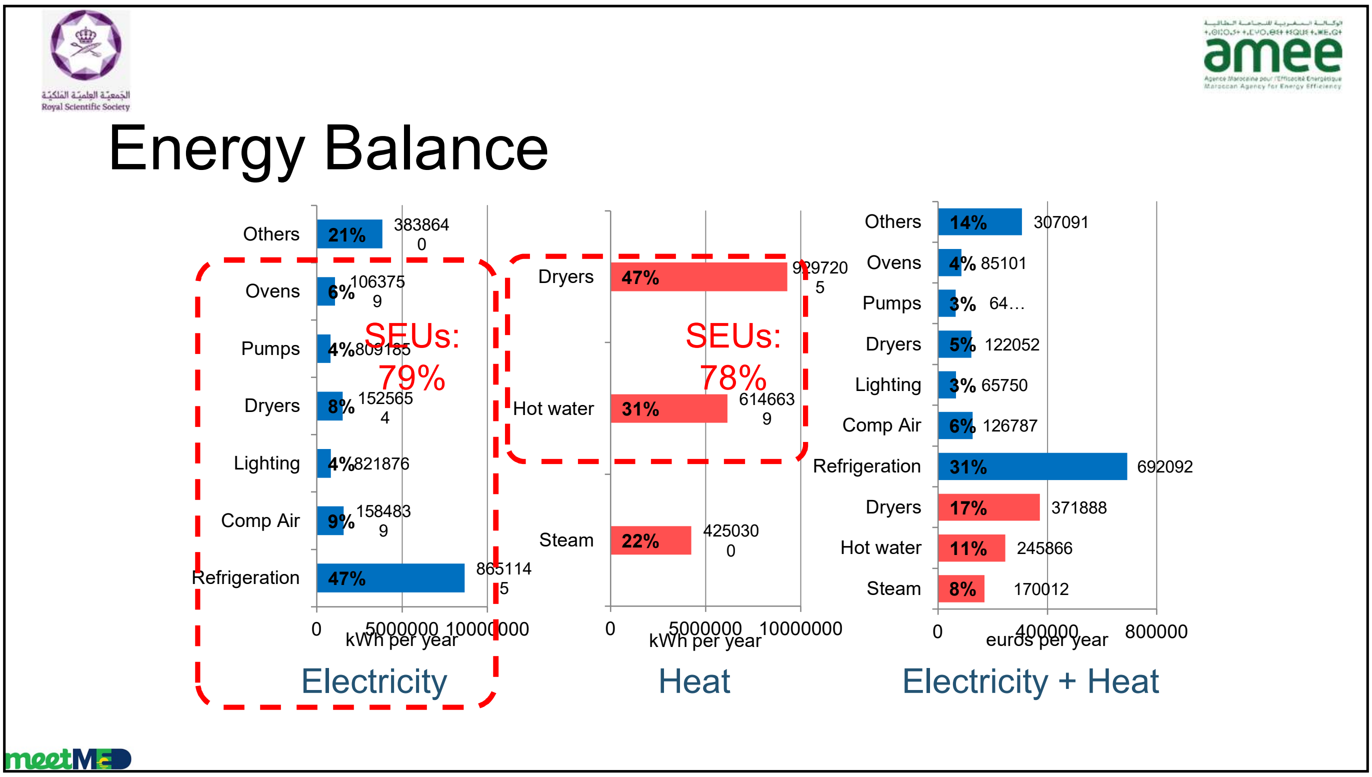
Energy Balance
Others 21% 3838640
Ovens 6% 1063759
Pumps 4% 809185
Dryers 8% 1525654
Lighting 4% 821876
Comp Air 9% 1584839
Refrigeration 47% 8651145
0 5000000 10000000
kWh per year
SEUs: 79%
Electricity
Dryers 47% 9297205
Hot water 31% 6146639
Steam 22% 4250300
0 5000000 10000000
kWh per year
SEUs: 78%
Heat
Others 14% 307091
Ovens 4% 85101
Pumps 3% 64…
Dryers 5% 122052
Lighting 3% 65750
Comp Air 6% 126787
Refrigeration 31% 692092
Dryers 17% 371888
Hot water 11% 245866
Steam 8% 170012
0 400000 800000
euros per year
Electricity + Heat

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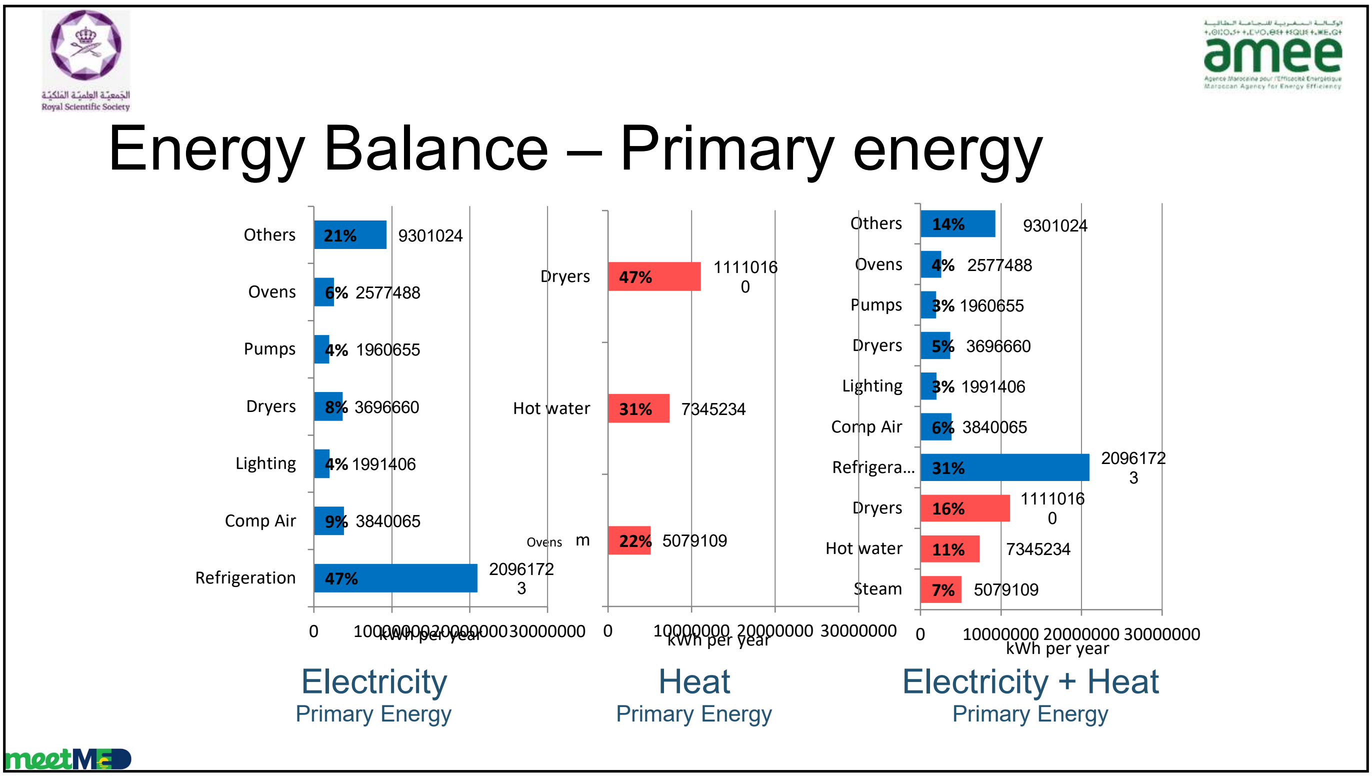
Energy Balance – Primary energy
Others 21% 9301024
Ovens 6% 2577488
Pumps 4% 1960655
Dryers 8% 3696660
Lighting 4% 1991406
Comp Air 9% 3840065
Refrigeration 47% 20961723
0 10000000 20000000 30000000
kWh per year
Electricity
Primary Energy
Dryers 47% 11110160
Hot water 31% 7345234
22% 5079109
0 10000000 20000000 30000000
kWh per year
Heat
Primary Energy
Others 14% 9301024
Ovens 4% 2577488
Pumps 3% 1960655
Dryers 5% 3696660
Lighting 3% 1991406
Comp Air 6% 3840065
Refrigera… 31% 20961723
Dryers 16% 11110160
Hot water 11% 7345234
Steam 7% 5079109
0 10000000 20000000 30000000
kWh per year
Electricity + Heat
Primary Energy

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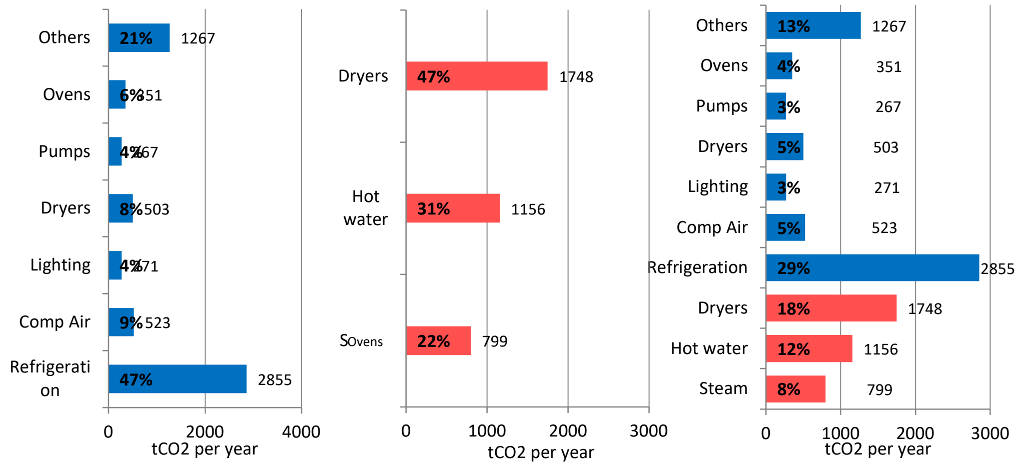
Energy Balance – CO2 emissions



Electricity
CO2 Emissions

Heat
CO2 Emissions

Electricity + Heat
CO2 Emissions

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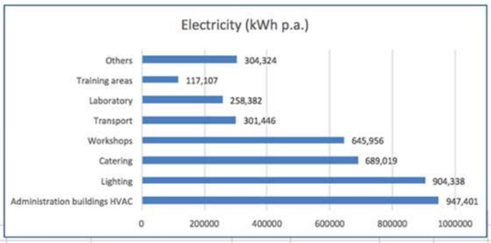
Significant Energy Uses (SEU) List

ID	Name of SEU	What are the main variables?	Is the SEU metered? Auto/ Manual	kWh p.a.	% of Overall Usage	Cumulative %	Who influences the energy use?
			Electricity				
1	Administration buildings HVAC	Weather and occupancy	No	947,401	23%	23%	Users/ Maintenance
2	Lighting	Occupancy	No	904,338	22%	44%	Everyone
3	Catering	Occupancy	Yes	689,019	17%	61%	Maintenance
4	Workshops	Weather and occupancy	No	645,956	15%	76%	Users/ Maintenance
5	Transport	Distance travelled	No	301,446	7%	84%	Maintenance
6	Laboratory	Weather and occupancy	No	258,382	6%	90%	Lab Tech and maintenance
7	Training areas	Weather and occupancy	Yes	117,107	3%	93%	Kitchen staff
8	Others	N.A.	No	304,324	7%	100%	N.A.
	Total consumption (sum of above)			4,167,972	100%		
	Total from bills			4,167,972	100%		
	Note: This total should be the same as the annual data from tab Energy data						



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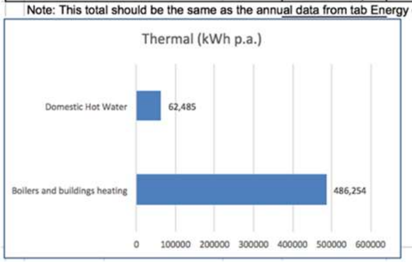
Thermal Energy							
ID	Name of SEU	What are the main variables?	Is the SEU metered? Auto/ Manual	kWh p.a.	% of Overall Usage	Cumulative %	Who influences the energy use?
1	Boilers and buildings heating	Weather and occupancy	Yes	486,254	89%	89%	Users/ Maintenance
2	Domestic Hot Water	Occupancy	No	62,485	11%	100%	
						100%	
						100%	
						100%	
						100%	
						100%	
				548,739	100%		
	Total from bills			548,739	100%		

Note: This total should be the same as the annual data from tab Energy data



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Notes and examples about SEUs

- Consider different approaches to SEUs
  - Normally it is large energy consuming “uses”
  - Buildings in a campus
  - Processes, e.g. painting, kiln
  - Utilities; compressed air, refrigeration
- Make the link from motor list to SEUs
- You may need to change to a common unit to add different energy sources
  - For example: kWh to GJ, $ or primary energy

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Exercise

- For each energy source; think about the SEUs.
- What are the largest energy uses in your EnMS Scope?
- List them
- How will you estimate their energy consumption?
- Sankey

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Demonstrate the concept of EnBs and EnPIs

- Whiteboard or scatter diagram to show the concept
- Demo using Excel
  - Prepared data from a known example
  - Show data layout
  - Show scatter diagram with formula and concept of expected v actual energy consumption
  - Show SEC
  - Show correlation table (including the tool)
  - Show multivariate regression (including the regression tool)
  - Show the difference in results for SEC v regression
- Allow 60 minutes

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How do you measure energy performance?

- **Absolute Values**
  - Actual cost compared with budget.
  - kWh last month compared with the same month last year.
  - Moving total of 12 months kWh.
- **Ratios**
  - Specific Energy Consumption (kWh/unit of production).
  - kWh/m2 compared with another facility.
  - Coefficient of performance (COP).
  - Energy efficiency (output/input).
  - Energy intensity (GJ/$).
- **Normalization**
  - Normalized consumption taking into account relevant variables.
  - More complex, but much more precise.
  - It is the appropriate way of measuring energy performance in most of the cases.
  - This training program is focused on that methodology.

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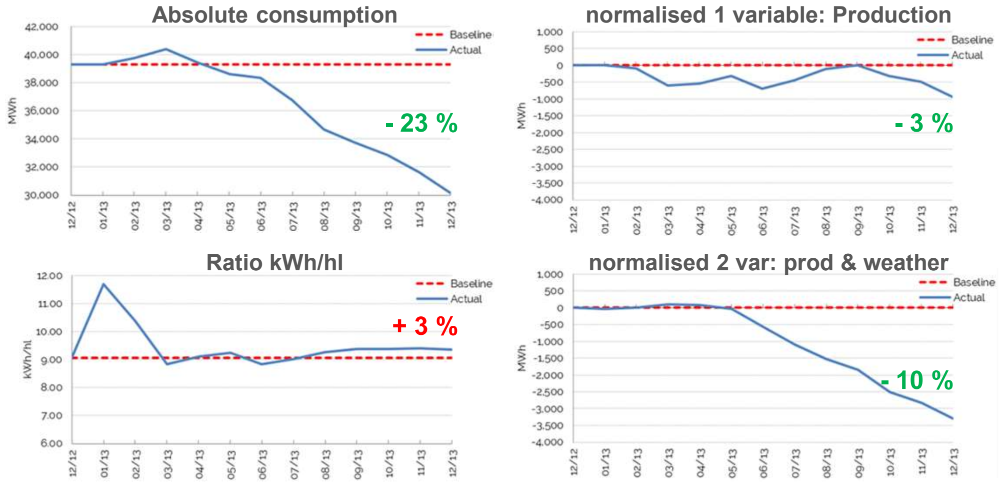
Energy performance in Industry – Which is right?



Beverage industry

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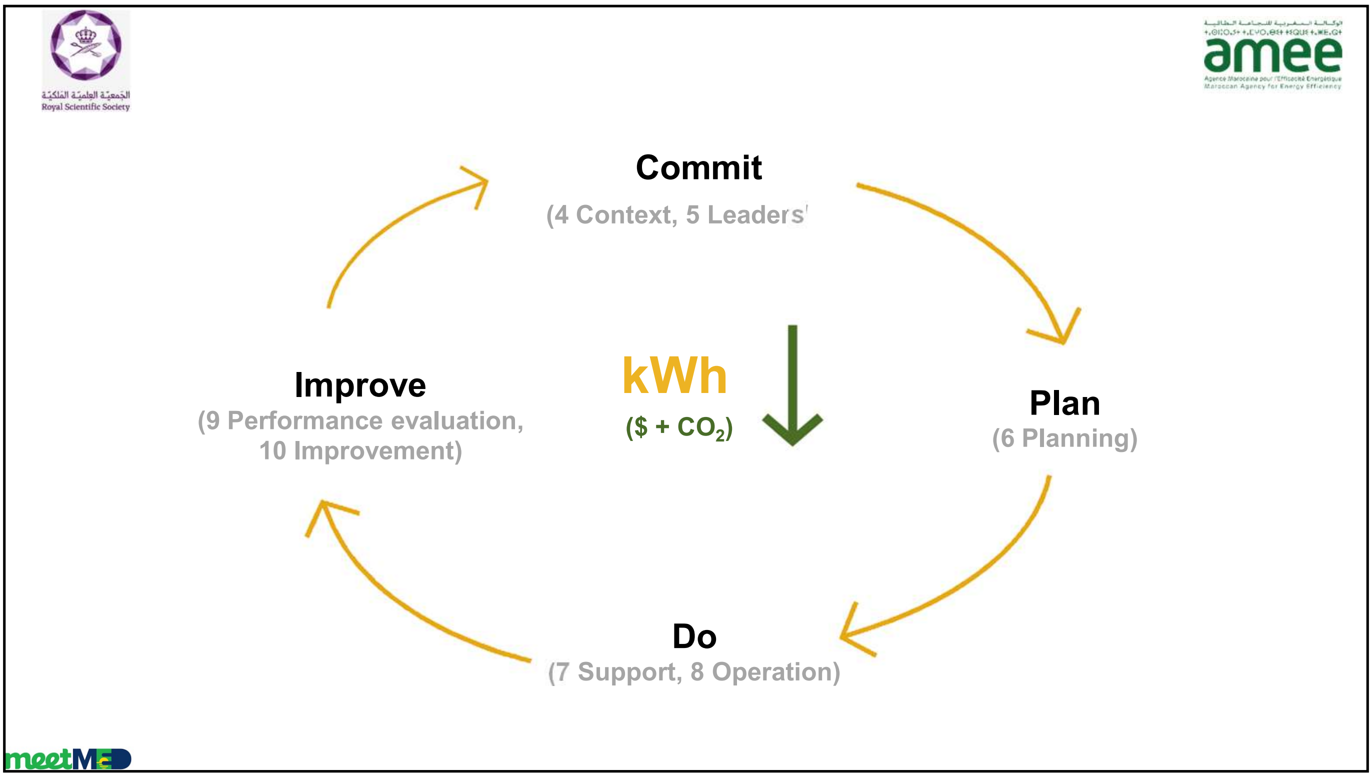
Commit
(4 Context, 5 Leaders
Plan
(6 Planning)
Do
(7 Support, 8 Operation)
Improve
(9 Performance evaluation,
10 Improvement)
kWh
($ + CO2)
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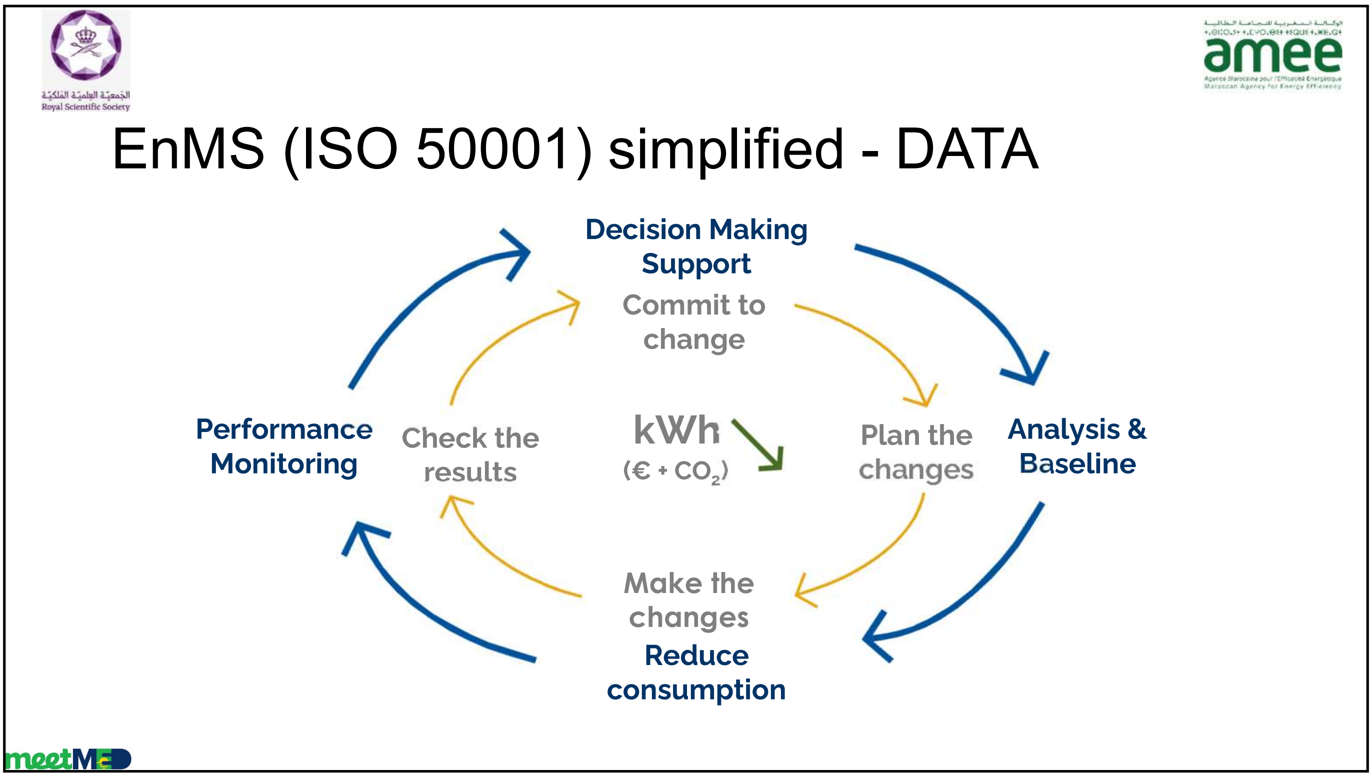
EnMS (ISO 50001) simplified - DATA
Decision Making
Support
Commit to
change
Analysis &
Baseline
Plan the
changes
Make the
changes
Reduce
consumption
Check the
results
Performance
Monitoring
kWh
(€ + CO2)
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Indicators in different parts of an EnMS

Targets-Management review	Absolute, normalised	SEP EnPI tool
Legal & other requirements	Ratios	kWh/t, kWh/$
Budgets and cost control	Absolute	Annualised cost trend
EnBs and EnPIs	Normalised	Regression
Monitoring performance	Absolute, normalised	N.A.
Operational Control	All of the above	Critical op. parameters
M&V Action plans	Absolute, normalised	N.A.
Training & Awareness	All of the above	Count PCs left on
Design and procurement	Others: Life cycle cost	COP new chiller

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Indicators in different parts of an EnMS

Targets-Management review	Absolute, normalised	SEP EnPI tool
Legal & other requirements	Ratios	kWh/t, kWh/$
Budgets and cost control	Absolute	Annualised cost trend
EnBs and EnPIs	Normalised	Regression
Monitoring performance	Absolute, normalised	UNIDO methodology
Operational Control	All of the above	Critical op. parameters
M&V Action plans	Absolute, normalised	IPMVP, ISO50015
Training & Awareness	All of the above	Count PCs left on
Design and procurement	Others: Life cycle cost	COP new chiller

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Basic terminology

- Energy consumption
- Energy use
- Energy efficiency
- Energy conservation
- Energy saving
- Energy budget
- Energy baseload
- Energy baseline
- Energy performance…

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Discussion

Define energy performance?

Is energy performance the same as energy saved?

Could energy performance improvement be defined as:

"The reduction in energy consumption resulting from energy saving activities and measured taking account of the variables that affect consumption"

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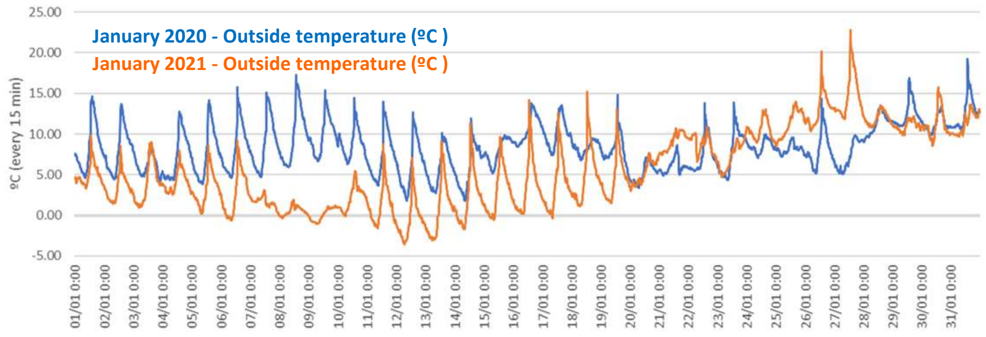
What does normalization mean?



If outside temperature affects energy consumption in one organization…

…Is it fair to measure energy performance in January 2020 and January 2021 without taking into account that variable?

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What does normalization mean?

- **It is not fair** to **compare** the energy **consumption in the past** with the **current consumption in absolute figures** given that the **external factors** were different:
  - Weather.
  - Production volumes (output, raw materials, sub-process volumes, etc)
  - Others.
- **Normalization** is a process that aims to **enable comparison** and assessment of energy performance at different points in time **under equivalent conditions**.
- **A proper normalization** needs to take into account the **weight of the relevant external factors**, also known as **relevant variable**s.
- Since operating, raw material, weather, etc. conditions are constantly changing, normalization process always involve the use of some analytics.

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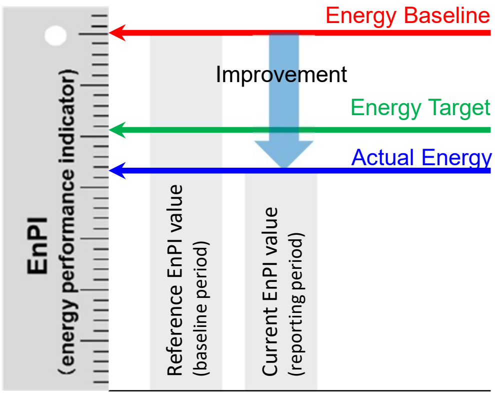
Main concepts in normalization

- Energy Performance Indicator (EnPI)

- Energy Baseline *
- Energy Target
- Actual Energy Consumption

- Energy performance improvement
  (= normalized savings)

- Relevant variable



Source: Adapted from ISO 50006

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Few additional definitions

Relevant variable

Quantifiable factor that significantly influence/affect/drive energy consumption and that changes routinely. Also known as driving factors, explanatory variables, independent variables, drivers).

Baseline period

The period of time, in the past, over which operations, results and performance of the company are taken as reference for assessing whether we have improved our energy performance after taking energy management and efficiency actions.

Monitoring period

The period of time over which operations, results and performance of the company are evaluated to check if we have improved our energy performance.

Energy performance indicator

Indicator used to show energy performance variation through comparing Baseline period and Monitoring period under equal conditions

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Energy performance indicators

1. **Only** responds to **changes** in energy **performance**

1. **Unaffected by relevant variables**, like weather, production outputs or others

1. **Direction and magnitude** of change **consistent** with change of energy **performance**

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Next steps

- Complete any open items related to context and leadership
- Collect energy data; bills and sub-meters
- Develop your energy balance for each incoming energy type
- Select your SEUs

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Single variable regression analysis

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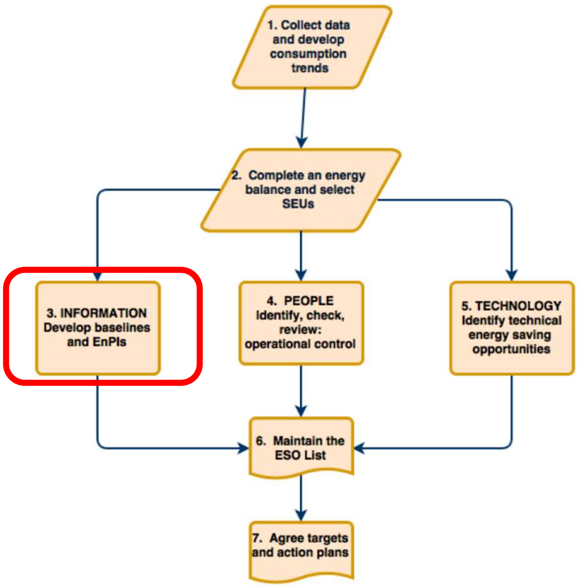
3. Information

- Whole plant & each SEU
  - Consumption
  - Variables
  - Relationship
  - Energy Baseline(s)
  - Energy Performance Indicators (EnPIs)

Tool:

- Baseline tab
- EnPI tab



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Expected consumption (or baseline)

- Expected consumption calculated considering the relevant variables that cause consumption to vary
  - Production throughput?
  - Weather?
  - Etc.
- We must be able to measure these relevant variables variables

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Relevant variables and static factors

- We can calculate expected consumption accurately if we consider the variables that cause consumption to vary
- We must be able to measure these variables and detect the static factors.

QUESTION	RELEVANT VARIABLE	STATIC FACTOR
Is it measurable?	YES	YES
Does it cause a variation in consumption?	YES	YES
Does it routinely vary?	**YES**	**NO**
Examples	Occupancy Weather …	Size of process equipment Size of a building …

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Selecting baseline period

- You need to use a representative range of relevant variable (RV) value
  - The baseline period needs to match the reporting period in terms of RV values
- This means, for example, that production data should range from typical low to typical high production amounts
- The same applies if HDD or CDD are relevant variables, you need a representative range, ideally a full year of data
  - But it may be possible to use 6 months if they represent, more or less, the full range of HDD or CDD.

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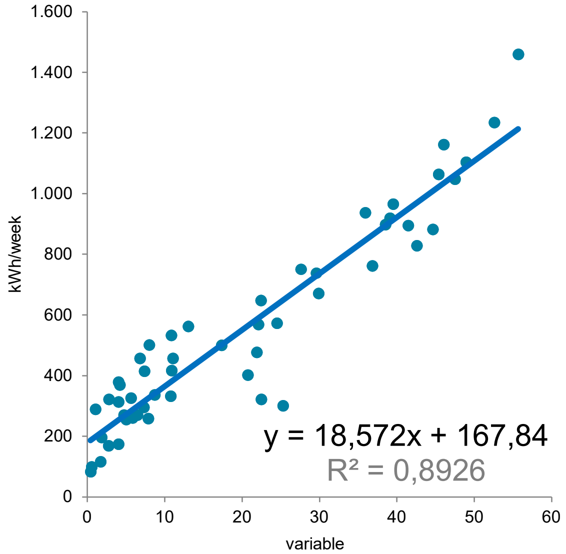
Single regression analysis



- **Represent consumption VS relevant variable**
- **See the trend**
- **Observe the dispersion**
- **Obtain the formula**
- Remember: y= mx + c
  - c and m are constants
  - x is a measured “relevant variable”
- You can also use formulae in excel
  - c =INTERCEPT (known_y's,known_x's)
  - m =SLOPE (known_y's,known_x's)
  - R2 =RSQ(known_y's,known_x's)

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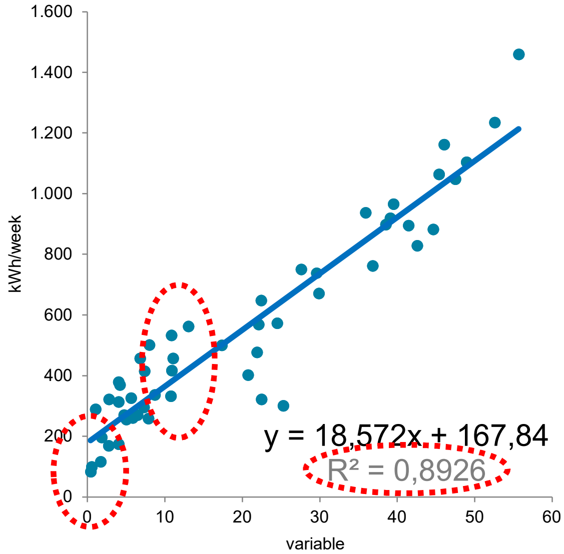
Single regression analysis



- **Intercept:** Consumption when the variable is 0. It can be considered as the baseload in most of the cases.
- **R^2:** % of variation explained by variables
  - **High R2:**
    a) Strong correlation. Not necessarily good performance.
  - **Low R2:**
    a) There are other variables.
    b) Saving Opportunities in operational control.
- **Dispersion**

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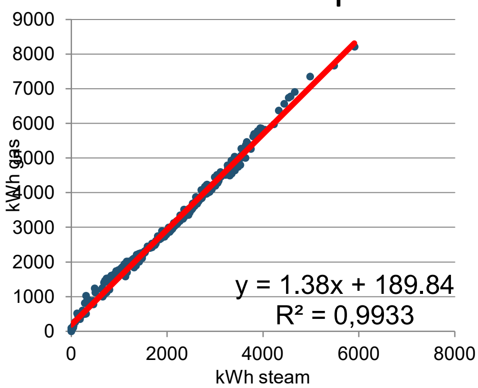
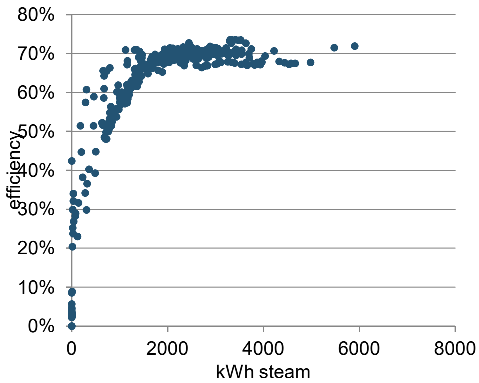
A technical example: boiler





- 1.38 kWh of gas to get each kWh of steam.
- Standing losses of 189.84 kWh of gas
- The efficiency is lower when the output (and input) is lower.

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How to do it in excel?

	ELECTRICITY	
	Sliced (t)	Compressed Air (kWh)
01/12	1373,46	107172
02/12	1512,75	107961
03/12	1560,68	113379
04/12	1292,58	104756
05/12	1686,87	118200
06/12	1300,77	101787
07/12	1480,37	111308
08/12	1471,13	112371
09/12	1474,62	118348
10/12	1488,21	115878
11/12	1426,5	111566
12/12	1042,42	92684

- Select variable data and consumption data.
  - Consumption must be at right

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How to do it in excel?

	ELECTRICITY	
	Sliced (t)	Compressed Air (kWh)
01/12	1373,46	107172
02/12	1512,75	107961
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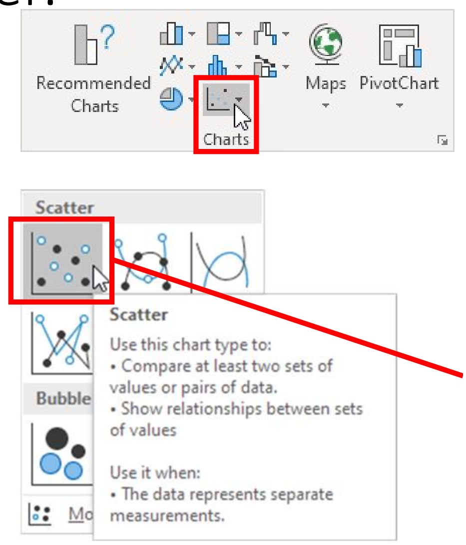

- Select insert scatter diagram

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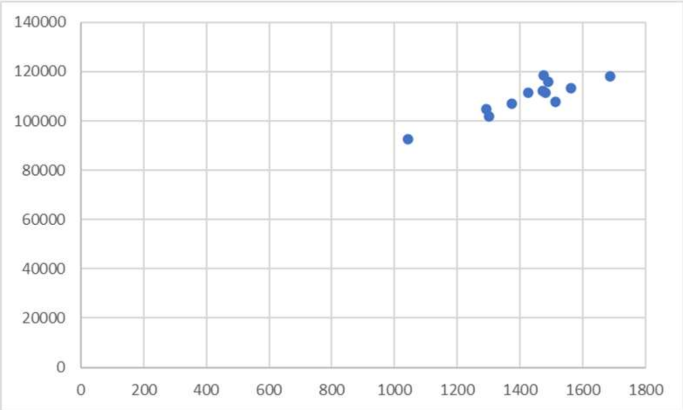
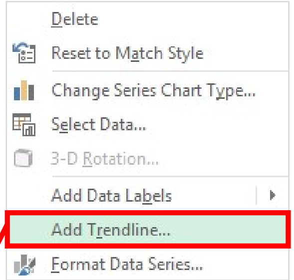
How to do it in excel?





- Click right button on the points and select the option “add trendline”

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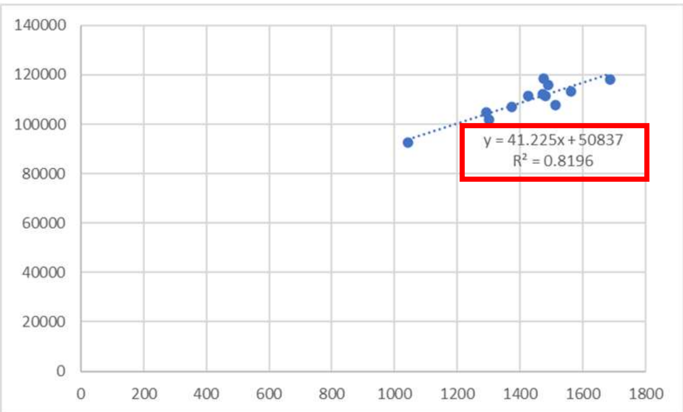
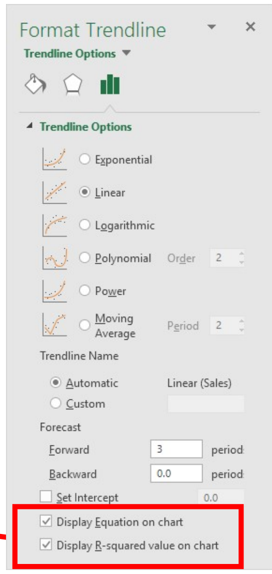
How to do it in excel?





- Select “show equation” and “show R2”

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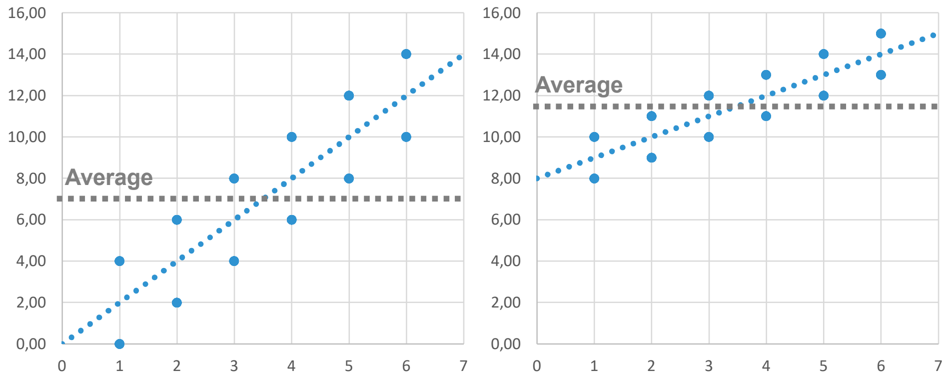
Is R2 enough to decide if a model is usable



Which one has a bigger R2?

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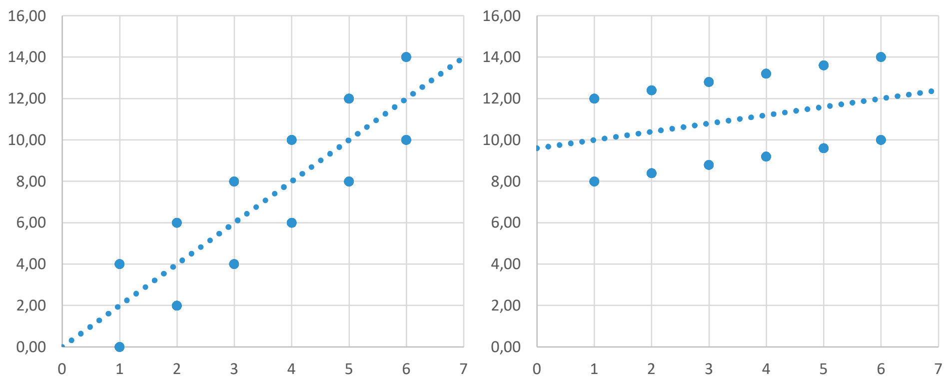
Is R2 enough to decide if a model is usable



Same dispersion. Which one has a bigger R2?

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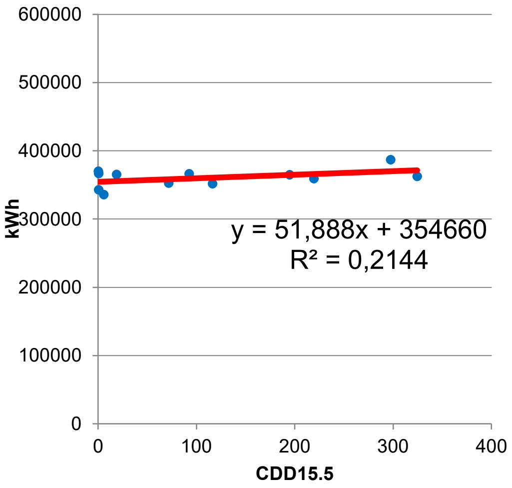
Is R2 enough to decide if a model is usable?

- Electricity data taken from an office building in Spain.
  - Main variable must be CDD.
  - Regression shows low R2.
  - We would have expected high R2 and a higher slope.
  - Saving opportunities in operational control. It consumes the same in winter and in summer.
- R2 is low, but the model can be use as it is accurately showing what is happening.



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Remember…

- Low R2 can show you opportunities to improve

BUT:

- High R2 does NOT mean good performance
- High R2 does NOT mean lack of low-cost saving potential
- High R2 JUST shows a strong correlation.

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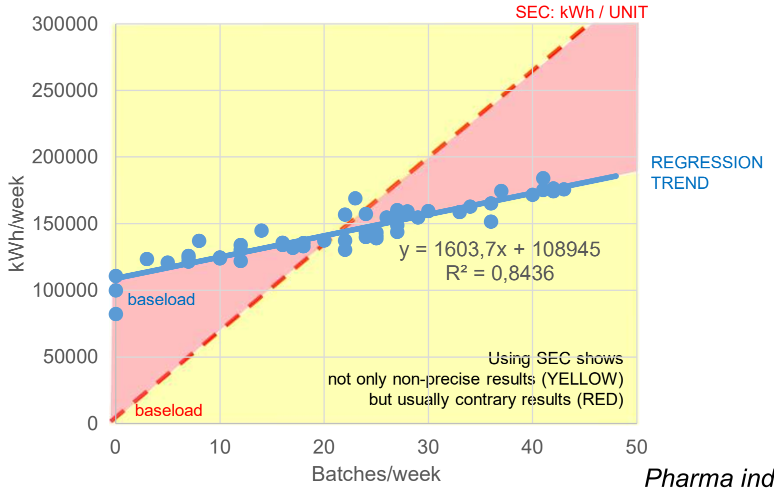
Why is SEC less accurate?



Pharma industry

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Excel alternative - formulae

- If you use the scatter diagram and showing the R2 and the equation, then the numbers are really text and have to be retyped into your "expected consumption" column.
- An alternative is to use:
  - **c:** =INTERCEPT (known_y's,known_x's)
  - **m:** =SLOPE (known_y's,known_x's)
  - **R2** =RSQ(known_y's,known_x's)
- The results of this can be used directly in formulae and will be more accurate as they will contain all decimal places.

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Static factors

- Some things influence consumption but do not routinely vary…
- For example:
  - Size of process equipment
  - Number of luminaires in a lighting system
  - Size of a building
- We can ignore these until they change and then we may need to recalculate the baseline

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Exercise 02

	A	B	C
1		ELECTRICITY	
2		Sliced (t)	Compressed Air (kWh)
3	01/12	723.66	129124
4	02/12	770.11	130074
5	03/12	789.71	136602
6	04/12	740.96	126213
7	05/12	871.84	142410
8	06/12	710.94	122635
9	07/12	858.71	134107
10	08/12	842.25	135387
11	09/12	819.41	142589
12	10/12	823.94	139613
13	11/12	784.28	134417
14	12/12	621.49	111668

- Look at these data, from a SEU (compressed air) in the demo plant.
- Use a scatter diagram to analyse the relation between sliced products volume (t) and consumption.
- Questions
  1. What is the slope of the line?
  2. What is the intercept value ?
  3. How many kWh do we need to produce 800 t?

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Exercise 02 - Solution

	A	B	C
1		ELECTRICITY	
2		Sliced (t)	Compressed Air (kWh)
3	01/12	723.66	129124
4	02/12	770.11	130074
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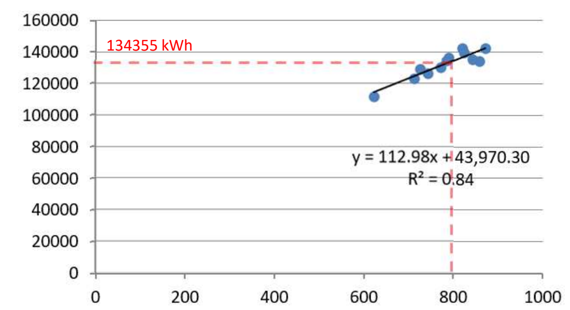
11	09/12	819.41	142589
12	10/12	823.94	139613
13	11/12	784.28	134417
14	12/12	621.49	111668

Sliced (t) VS Compressed Air (kWh)



M	N
Intercept	43970.30
Slope	112.98
If production is 800 t	
kWh=	134355

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The importance of weather

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Weather-related energy demand

- Energy consumption varies because of the temperature in many industries
  - Building heating and cooling energy
  - Refrigeration as an SEU
  - Food and drink industries
  - Industries with critical indoor environmental conditions
  - Microelectronics
  - Car assembly (painting is a SEU)

- Humidity can have a similar effect

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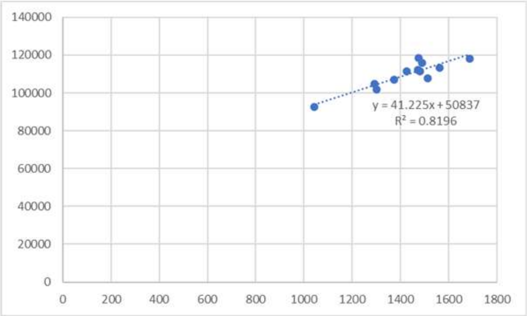
What about weather-related demand?

- We did this for an energy-intensive process…



- Can we do something similar for weather-related energy consumption?

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Degree Days (heating and cooling)

- It is a measure of heating/cooling demand.
- "Base temperature":
  - HDD base: outside temp. above which no artificial heating is required.
  - CDD base: outside temp. below which no artificial cooling is required.

  - Default HDD in the UK & IRL 15.5ºC (Austria is 12C)
  - Other countries differ: Lower HDD base in countries with high standards of weatherisation
  - Depends on the building construction and internal heat gains
  - Can be calculated in a daily/monthly/yearly basis.

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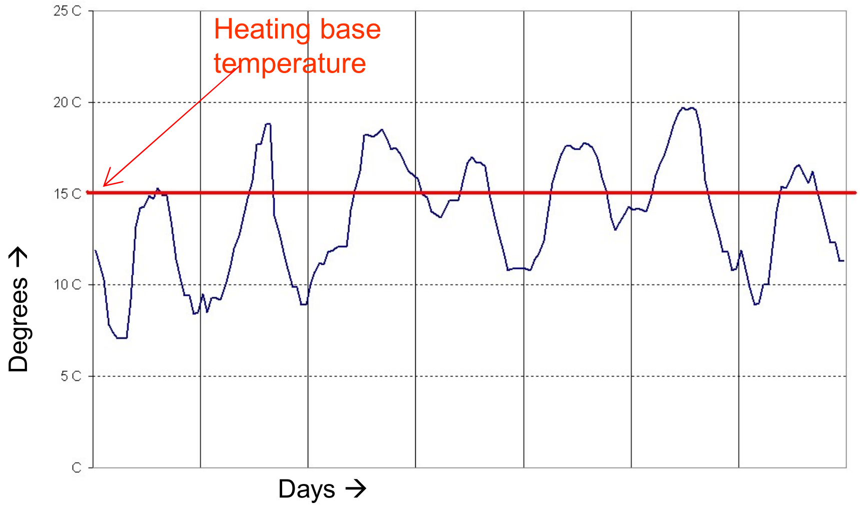
Temperature-related demand



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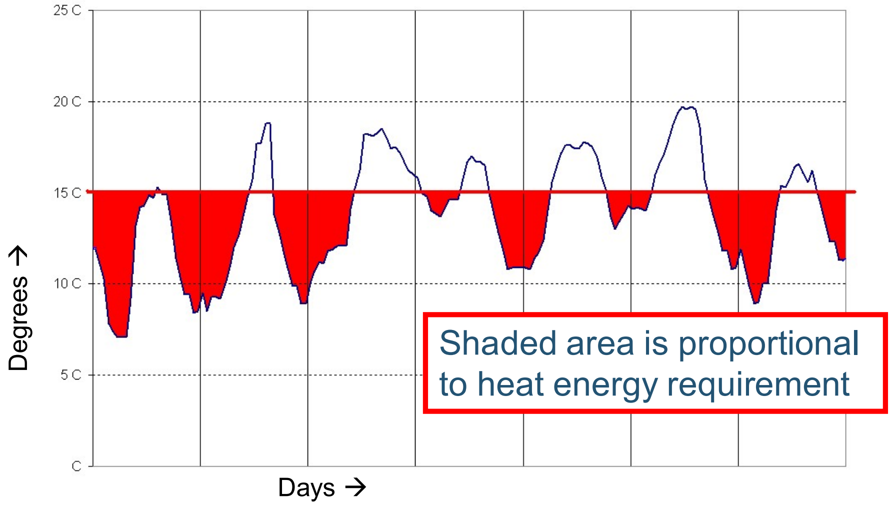
Temperature-related demand



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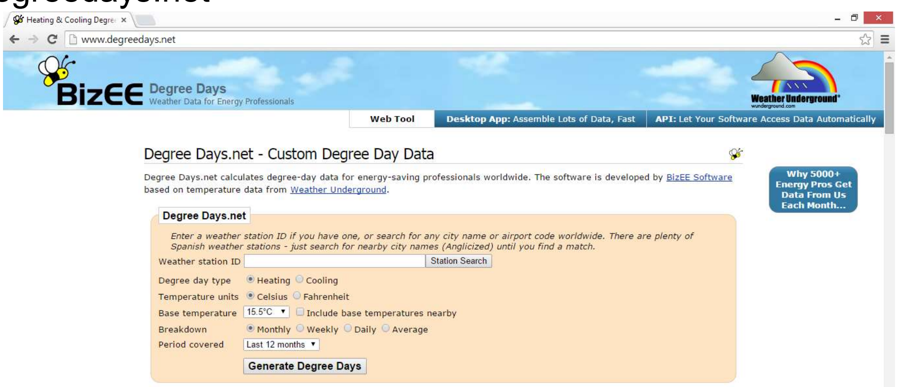
How to get HDD and CDD?

- www.degreedays.net



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How to get HDD and CDD?

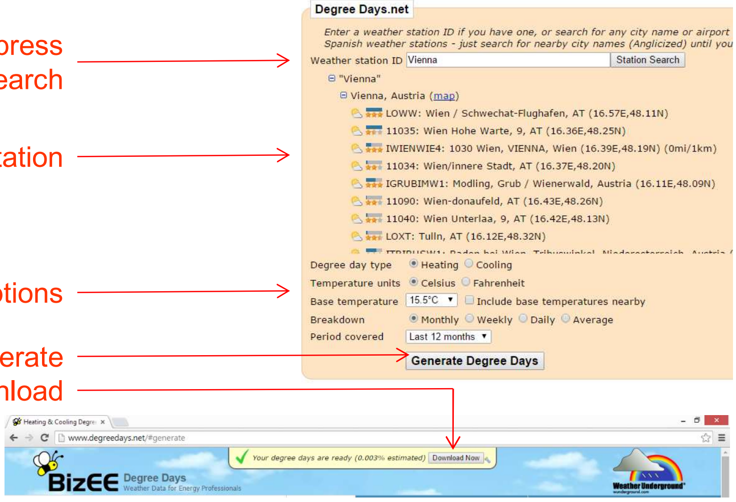
City name and press Station Search

Choose station

Choose data options

Generate

Wait and download



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How to get HDD and CDD?

	A	B	C	D	E	F	G	H	I
1	Description:	Celsius-based heating degree days for a base temperature of 15,5C							
2	Source:	www.degreedays.net (using temperature data from www.wunderground.com)							
3	Accuracy:	Estimates were made to account for missing data: the "% Estimated" column shows how much each figure							
4	Station:	Madrid / Barajas, Spain (3.56W,40.47N)							
5	Station ID:	LEMD							
6									
7	Month starting	HDD	% Estimated						
8	01/02/2014	232	0						
9	01/03/2014	162	0						
10	01/04/2014	60	0						
11	01/05/2014	36	0,03						
12	01/06/2014	5	0						
13	01/07/2014	2	0						
14	01/08/2014	0	0						
15	01/09/2014	5	0						
16	01/10/2014	33	0						
17	01/11/2014	148	0						
18	01/12/2014	305	0						
19	01/01/2015	347	0						
20	01/02/2015	258	0						
21	01/03/2015	185	0						
22	01/04/2015	84	0						
23	01/05/2015	27	0						

This can be used as the relevant variable that represents the heating demand (HDD)

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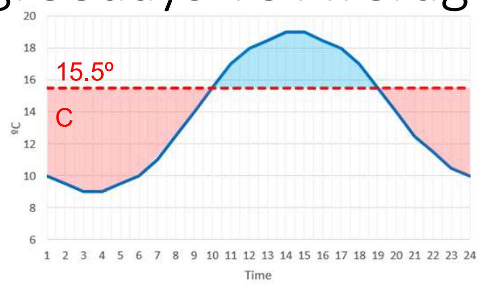
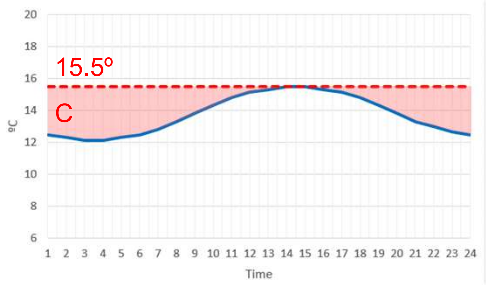
Degreedays VS Averages





- ✓ Average T: 13.7ºC
- ✓ Heating demand
- ✓ Cooling demand

- ✓ Average T: 13.7ºC
- ✓ Lower heating demand
- ✓ No cooling demand

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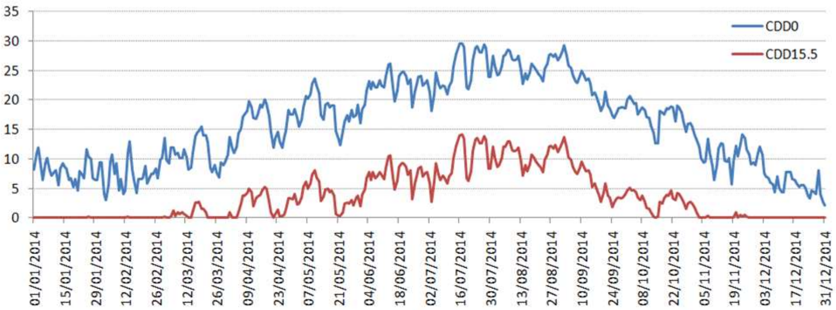
Changing base temperature

- Sometimes another base temperature is needed to represent the real cooling demand.
  - E.g. many zeros at the traditional base.
  - Typical in industries with refrigeration operational all year
  - In those cases, the energy demand is not 0 in winter. We need a base temperature that let us see different degree days also during winter



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Sources of degree-day data?

- Available online sources
  - Degreedays.net
  - Subscription services
- Calculate your own degree-days from:
  - Weather station
  - SCADA system
  - Building energy management system

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Daylight in regression models

- Significant variation in some latitudes
- Prolonged overcast also possible
- Affects photocell-controlled lighting
- Possible sources of data
  - Real values from weather stations (W/m2)
  - Standard tables (daylight hours and darkness hours)
  - Photocell controlling hours-run meter

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Some figures

- The following table shows the impact of baseload and different variables in 3 pharma companies.

COMPANY	BASELOAD CONSUMPTION (%)	CONSUMPTION DUE TO WEATHER (%)	CONSUMPTION DUE TO PRODUCTION (%)
PHARMA 1	9 %	21 %	70%
PHARMA 2	51 %	10 %	39 %
PHARMA 3	71 %	29 %	0 %

- The impact of baseload and weather is usually high in this sector.
- Similar results can be found in other sectors: food, beverage, cars, etc.
- This shows why Specific Energy Consumption cannot be used to monitor performance, as it is not including the impact of baseload and weather.

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Discussion

- Is weather a potentially relevant variable in your operations?

- HDD – heating demand?
- CDD – cooling demand?
- Humidity?
- Atmospheric pressure?

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See you in 45 minutes!

- Lunch TIME

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Multi-variate regression analysis

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Expected-consumption formulae

- **Straight-line models are most common**
  - More complex models could be developed if they have sense from the technical point of view
- **Expected consumption =**
  - C kWh per week (or per day, month etc)
  - + M_1 kWh per tonne of product A
  - + M_2 kWh per tonne of product B
  - + M_3 kWh per tonne of product C

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How to build a multivariate regression model

- The following example shows how to build a multivariate regression, using data from the food company in Spain.
- We will build the model using data from 2011. That regression model would be used to monitoring performance in 2012.
- At the end of 2012, they will have enough data to update the model.
- In the next exercise, you will need to build the new regression model using the new data they had from 2012.

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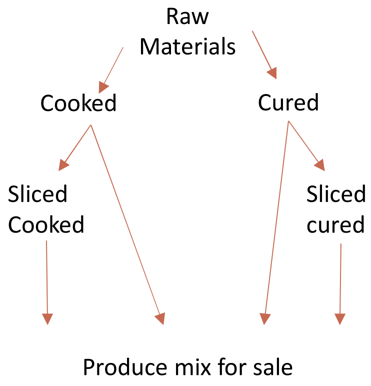
Background to the exercises

- Meat processing plant in Spain
- Large refrigeration systems.
- 3 main types of product:
  - Cured product.
  - Cooked product.
  - Sliced product (all is cooked or cured before slicing).
- We will use this plant for some practical examples and exercises.



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Choosing appropriate relevant variables

	A	B	C	D	E	F
1		ELECTRICITY				
2		CDD5	Cured	Cooked	Sliced	Total Consumption
3	01/11	26	164.59	1481.63	694.09	1531228
4	02/11	49	180.89	1526.45	694.98	1450494
5	03/11	83	212.56	1624.06	757.15	1560932
6	04/11	209	169.59	1425.18	692.53	1466743
7	05/11	290	209.68	1685.38	799.97	1692976
8	06/11	346	235.66	1531.36	780.59	1692700
9	07/11	396	214.72	1566.15	793.54	1671369
10	08/11	486	240.99	1529.46	750.53	1820530
11	09/11	402	210.34	1446.36	764.36	1746080
12	10/11	229	152.22	1462.95	714.92	1534139
13	11/11	122	206.57	1567.48	761.59	1532500
14	12/11	23	180.19	1164.1	638.54	1430632

- Use technical knowledge and common sense
- List theoretical relevant variables

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Correlation test (R)

	A	B	C	D	E	F
1		ELECTRICITY				
2		CDD5	Cured	Cooked	Sliced	Total Consumption
3	01/11	26	164.59	1481.63	694.09	1531228
4	02/11	49	180.89	1526.45	694.98	1450494
5	03/11	83	212.56	1624.06	757.15	1560932
6	04/11	209	169.59	1425.18	692.53	1466743
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9	07/11	396	214.72	1566.15	793.54	1671369
10	08/11	486	240.99	1529.46	750.53	1820530
11	09/11	402	210.34	1446.36	764.36	1746080
12	10/11	229	152.22	1462.95	714.92	1534139
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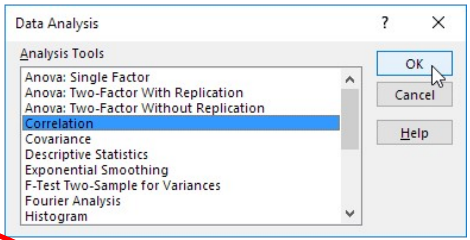
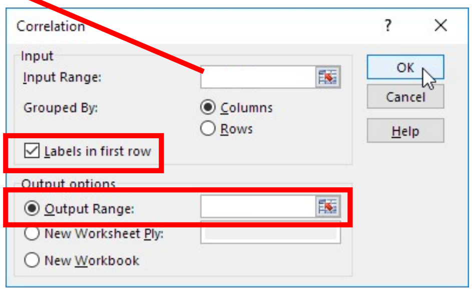
14	12/11	23	180.19	1164.1	638.54	1430632





Correlation test (R)

	A	B	C	D	E	F
1		ELECTRICITY				
2		CDD5	Cured	Cooked	Sliced	Total Consumption
3	01/11	26	164.59	1481.63	694.09	1531228
4	02/11	49	180.89	1526.45	694.98	1450494
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10	08/11	486	240.99	1529.46	750.53	1820530
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12	10/11	229	152.22	1462.95	714.92	1534139
13	11/11	122	206.57	1567.48	761.59	1532500
14	12/11	23	180.19	1164.1	638.54	1430632

	CDD5	*Cured (t)*	*Cooked (t)*	*Sliced (t)*	*Total Consumption (kWh)*
CDD5	1.00				
Cured (t)	0.77	1.00			
Cooked (t)	0.30	0.26	1.00		
Sliced (t)	0.56	0.54	0.89	1.00	
Total Consumption (kWh)	0.86	0.86	0.60	0.79	1.00

- This is “R”. But we can easily calculate “R^2”.

	CDD5	*Cured (t)*	*Cooked (t)*	*Sliced (t)*	*Total Consumption (kWh)*
CDD5	1.00				
Cured (t)	0.59	1.00			
Cooked (t)	0.09	0.07	1.00		
Sliced (t)	0.31	0.29	0.79	1.00	
Total Consumption (kWh)	0.75	0.73	0.36	0.62	1.00

- Main variable is CDD5
- Cured production Is also relevant
- Cooked production is correlated to sliced production

- This step is not essential, but helps to know more about your data and might help to explain why some of the variables will be finally out from the model

Testing significance of relevant variables

	A	B	C	D	E	F
1		ELECTRICITY				
2		CDD5	Cured	Cooked	Sliced	Total Consumption
3	01/11	26	164.59	1481.63	694.09	1531228
4	02/11	49	180.89	1526.45	694.98	1450494
5	03/11	83	212.56	1624.06	757.15	1560932
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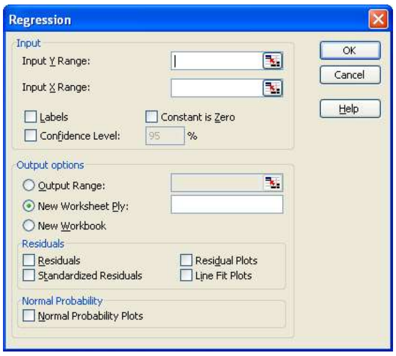
11	09/11	402	210.34	1446.36	764.36	1746080
12	10/11	229	152.22	1462.95	714.92	1534139
13	11/11	122	206.57	1567.48	761.59	1532500
14	12/11	23	180.19	1164.1	638.54	1430632

- Use Excel's regression analysis tool



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Testing significance of relevant variables

	A	B	C	D	E	F
1		ELECTRICITY				
2		CDD5	Cured	Cooked	Sliced	Total Consumption
3	01/11	26	164.59	1481.63	694.09	1531228
4	02/11	49	180.89	1526.45	694.98	1450494
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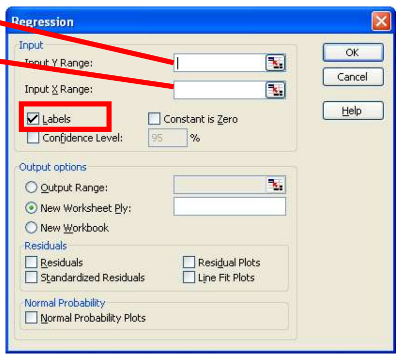

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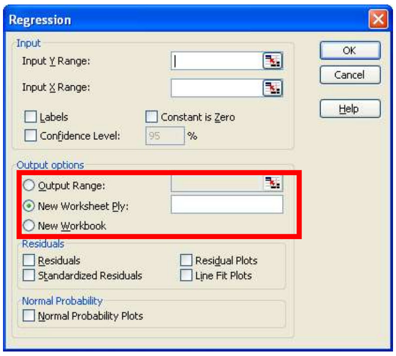
Testing significance of relevant variables

		ELECTRICITY				
		CDD5	Cured	Cooked	Sliced	Total Consumption
	01/11	26	164.59	1481.63	694.09	1531228
	02/11	49	180.89	1526.45	694.98	1450494
	03/11	83	212.56	1624.06	757.15	1560932
	04/11	209	169.59	1425.18	692.53	1466743
	05/11	290	209.68	1685.38	799.97	1692976
	06/11	346	235.66	1531.36	780.59	1692700
	07/11	396	214.72	1566.15	793.54	1671369
	08/11	486	240.99	1529.46	750.53	1820530
	09/11	402	210.34	1446.36	764.36	1746080
	10/11	229	152.22	1462.95	714.92	1534139
	11/11	122	206.57	1567.48	761.59	1532500
	12/11	23	180.19	1164.1	638.54	1430632



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Testing significance of relevant variables

Regression Statistics	
Multiple R	0.93863699
R Square	0.88103941
Adjusted R S	0.81306192
Standard Err	54665.9459
Observation	12

P-value < 0.10?

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	1.54926E+11	3.8731E+10	12.9607537	0.002371145
Residual	7	20918559526	2988365647		
Total	11	1.75844E+11			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1028575.16	344730.1124	2.98371139	0.02040728	213417.9804	1843732.35	213417.98	1843732.35
CDD5	512.72498	163.7113722	3.13188371	0.01656603	125.6090992	899.840861	125.609099	899.840861
Cured	1368.34499	902.0271538	1.51696652	0.1730609	-764.610294	3501.30027	-764.61029	3501.30027
Cooked	113.95378	264.1554979	0.43138901	0.67915965	-510.674717	738.582276	-510.67472	738.582276
Sliced	13.2044398	966.0946728	0.01366785	0.98947636	-2271.24645	2297.65533	-2271.2465	2297.65533

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Testing significance of relevant variables

	A	B	C	D	E	F
1		ELECTRICITY				
2		CDD5	Cured	Cooked	Sliced	Total Consumption
3	01/11	26	164.59	1481.63	694.09	1531228
4	02/11	49	180.89	1526.45	694.98	1450494
5	03/11	83	212.56	1624.06	757.15	1560932
6	04/11	209	169.59	1425.18	692.53	1466743
7	05/11	290	209.68	1685.38	[illegible]	1692976
8	06/11	346	235.66	1531.36	780.59	[illegible]
9	07/11	396	214.72	1566.15	793.54	1671369
10	08/11	486	240.99	1529.46	750.53	1820530
11	09/11	402	210.34	1446.36	764.36	1746080
12	10/11	229	152.22	1462.95	714.92	1534139
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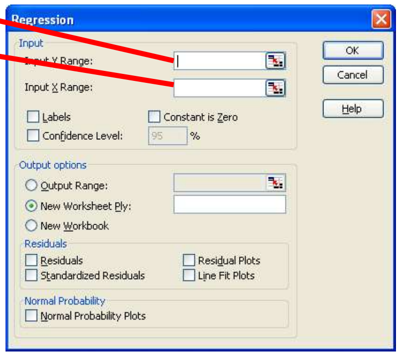

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Testing significance of relevant variables

Regression Statistics	
Multiple R	0.9386353
R Square	0.88103623
Adjusted R S	0.83642482
Standard Err	51135.9924
Observation	12

P-value < 0.10?

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	1.54925E+11	5.1642E+10	19.7491217	0.000468833
Residual	8	20919117783	2614889723		
Total	11	1.75844E+11			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1032333.18	194514.1295	5.30724006	0.00072205	583782.7943	1480883.57	583782.794	1480883.57
CDD5	514.048136	123.496374	4.16245529	0.00315457	229.2649864	798.831285	229.264986	798.831285
Cured	1373.90425	753.129375	1.82426061	0.10556114	-362.815203	3110.6237	-362.8152	3110.6237
Cooked	117.003493	132.2594164	0.88465151	0.40214946	-187.987268	421.994254	-187.98727	421.994254

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Testing significance of relevant variables

	A	B	C	D	E	F
1		ELECTRICITY				
2		CDD5	Cured	Cooked	Sliced	Total Consumption
3	01/11	26	164.59	1481.63	694.09	1531228
4	02/11	49	180.89	1526.45	694.98	1450494
5	03/11	83	212.56	1624.06	757.15	1560932
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9	07/11	396	214.72	1566.15	793.54	1671369
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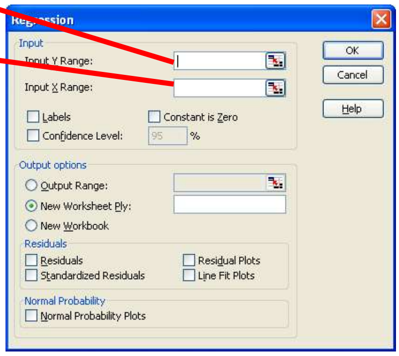
11	09/11	402	210.34	1446.36	764.36	1746080
12	10/11	229	152.22	1462.95	714.92	1534139
13	11/11	122	206.57	1567.48	761.59	1532500
14	12/11	23	180.19	1164.1	638.54	1430632



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Testing significance of relevant variables

Regression Statistics	
Multiple R	0.9324154
R Square	0.86939848
Adjusted R S	0.84037592
Standard Err	50514.6317
Observation	12

P-value < 0.10?

Coefficients

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	1.52879E+11	7.6439E+10	29.9559534	0.00010514
Residual	9	22965552186	2551728021		
Total	11	1.75844E+11			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1163449.22	124441.2278	9.34938717	6.2458E-06	881943.6041	1444954.83	881943.604	1444954.83
CDD5	517.273212	121.9425858	4.24194065	0.00216808	241.4199189	793.126505	241.419919	793.126505
Cured	1594.81428	701.8919392	2.27216498	0.04918865	7.024408189	3182.60416	7.02440819	3182.60416

Model consumption = 1163449.22+(517.27*CDD5)+(1594.81*Cured)

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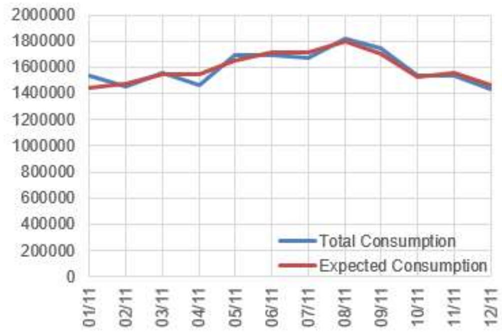
Expected Vs Actual consumption

- This can give you an impression of how accurate the model is

	ELECTRICITY					Model Consumption
	CDD5	Cured	Cooked	Sliced	Total Consumption	
01/11	26	164.59			1531228	1439389
02/11	49	180.89			1450494	1477282
03/11	83	212.56			1560932	1545377
04/11	209	169.59			1466743	1542024
05/11	290	209.68			1692976	1647859
06/11	346	235.66			1692700	1718260
07/11	396	214.72			1671369	1710728
08/11	486	240.99			1820530	1799178
09/11	402	210.34			1746080	1706846
10/11	229	152.22			1534139	1524667
11/11	122	206.57			1532500	1555997
12/11	23	180.19			1430632	1462716



Model consumption = 1163449.22+(517.27*CDD5)+(1594.81*Cured)

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Interpret results: P-value

- What does the P-value mean?: Probability of NOT being significant.

- Low P-value:
  a) The variable is significant.
- High P-value:
  a) The variable is not significant.
  b) Some variables are correlated. Colinearity. Check it.
  c) The variable might be significant but there are other variables that need to be added.
  d) Saving Opportunities in operational control.

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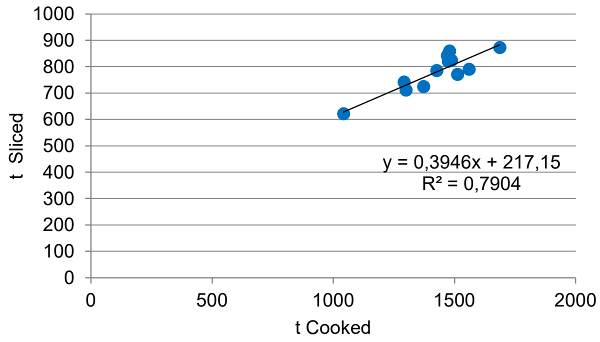
Interpret results: Collinearity

- **Why sliced production was not relevant?**
  - Sliced product volume is related to the cooked product volume.
  - That is collinearity: Two or more variables consistently change together.
  - Use the one that has a greater impact on consumption i.e. lowest p-value.



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Interpret results: Saving opportunities

- **Why cooked production was not relevant?**
  - We expected to find a correlation, but the regression showed that cooked production volume was not relevant.
  - It means that, producing a bit more or producing a bit less was not affecting energy consumption.
  - Did it have sense? In this case, it did not. So, something was wrong in that production line, and needed to be investigated.
  - **"Switch off" opportunities were found.**

  - After implementing the changes, we expect that cooked production will have an impact on energy consumption.
  - Regression will help to check again (next exercise).

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Weather in multivariate regression

- In general, HDD is used in heating analysis and CDD in cooling analysis
- But in some cases, both need to be included
  - When the same system is used for heating or cooling:
    - Heat pump
    - Boiler combined with absorption chiller
    - Electrical heaters and cooling
    - ...

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Weather in multivariate regression

Month 2012	Electricity kWh	CDD15,5 ºC	HDD15,5 ºC	OCC
01/2012	120,058	0	387	3
02/2012	135,067	5	248	4
03/2012	107,550	28	183	4
04/2012	88,026	12	154	4
05/2012	92,249	156	17	4
06/2012	131,703	291	3	4
07/2012	120,943	337	0	3
08/2012	81,834	367	0	2
09/2012	98,946	185	15	4
10/2012	90,691	63	107	4
11/2012	111,838	2	182	4
12/2012	94,761	0	261	3

Regression Statistics	
Multiple R	0.90
R Square	0.82
Adjusted R Square	0.75
Standard Error	8862.19
Observations	12

Total consumption

Building with electrical heating + cooling

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-104796.15	3.62E+04	-2.90E+00	0.062709861
CDD15,5	316.09	5.68E+01	5.56E+00	0.000532739
HDD15,5	326.30	5.65E+01	5.78E+00	0.000416607
OCC	36415.95	6.72E+03	5.42E+00	0.000632422

ELEC= (316.09*CDD15.5) + (326.30*HDD15.5) + (36,415.95*OCC) – 104,796.15

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Categorical variables and weather

Date	Working days	CDD15.5 Working days	CDD15.5 Weekends	Batches	HR (%)	Electricity (kWh)
01/01/2019	0	0	0	0	52	10725
02/01/2019	1	0	0	1	58	18449
03/01/2019	1	0	0	1	54	17501
04/01/2019	1	0	0	0	55	17649
05/01/2019	0	0	0	0	54	11880
01/08/2019	1	12	0	3	38	27814
02/08/2019	1	13	0	2	21	26668
03/08/2019	0	0	13	0	20	16842
04/08/2019	0	0	13	0	12	16955
05/08/2019	1	14	0	3	14	29693
06/08/2019	1	13	0	4	12	29254
07/08/2019	1	10	0	2	35	25838
08/08/2019	1	11	0	3	41	26955
09/08/2019	1	11	0	2	50	25544
10/08/2019	0	0	10	0	40	15231
11/08/2019	0	0	10	0	20	15007
12/08/2019	1	7	0	5	18	23676
13/08/2019	1	8	0	3	24	24169
14/08/2019	1	10	0	3	15	25723
15/08/2019	0	0	13	0	15	20369
27/12/2019	1	0	0	1	68	16545
28/12/2019	0	0	0	0	46	10825
29/12/2019	0	0	0	0	51	10699
30/12/2019	1	0	0	0	66	17437
31/12/2019	1	0	0	0	79	11359

Regression Statistics	
Multiple R	0.94
R Square	0.88
Adjusted R Square	0.88
Standard Error	1945.35
Observations	365

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept (Weekend days)	13679.30	515.71	26.53	1.32E-86	12665.11	14693.50
Working days	6346.90	393.85	16.12	2.40E-44	5572.36	7121.44
CDD15.5 Working days	620.15	35.22	17.61	1.84E-50	550.88	689.42
CDD15.5 Weekends	310.19	45.57	6.81	4.21E-11	220.57	399.82
Batches	374.19	112.90	3.31	1.01E-03	152.16	596.21
HR	-33.61	7.09	-4.74	3.11E-06	-47.56	-19.66

- **Calendar is included** as a variable using “0” for weekends and “1” for weekdays.
- **CDD15.5 is separated in “CDD15.5 working days” and “CDD15.5 weekends”**. This is needed, given that the cooling demand in the site is lower at weekends.
- As a result, **regression results** show that:
  - Intercept is 13679 kWh
  - Additional consumption every working day is 6347 kWh
  - Consumption due to cooling demand on working days is twice as big as it is on weekends.
  - Production and HR are also relevant variables in this site.

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Regression analysis: key points

- Regression analysis IS ONLY A TOOL
  - It is just a statistical estimate of the effect of each relevant variable
- Technical understanding of the process is critical
  - To predict variables
  - To interpret regression results
- Operational control is an un-measurable relevant variable
  - Important concept
  - Often very significant

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How to develop the model?

1. **Choose variables based on technical understanding**
   - There could be strong models with wrong variables. Don't use them.
   - ...or weak models with the right variables (saving potential)
2. **Low p-values confirm that the variables are relevant**
3. **R2 shows % of variation explained by the variables**
   - There could be precise models with low R2
4. **Precision can help to decide**
   - Compare actual consumption and model consumption in a graph.
   - Calculate Standard Error. M&V? Big investments?
5. **Interpret monitoring results based on all the above**

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And, what if the models are very weak?

- Big saving potential! Let's start working!
- Use regression models to detect saving opportunities
- Don't get stuck on data. Focus on action plans

- OK, but, how can I measure performance?
  - Variables are not significant, so SEC will be a worse solution!
  - Use annualised consumption until improving enough to find a correlation between consumption and theoretical variables

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	AGENDA
Part 1	Energy Baselines: multivariate regression continued
Part 2	Relevant variables Uncertainty
	Break
Part 3	Energy Performance indicators (EnPIs)

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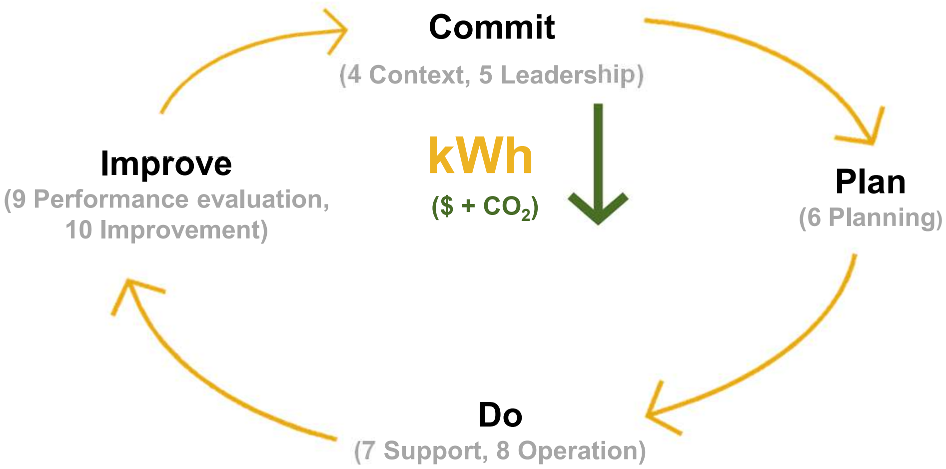
EnMS Cycle



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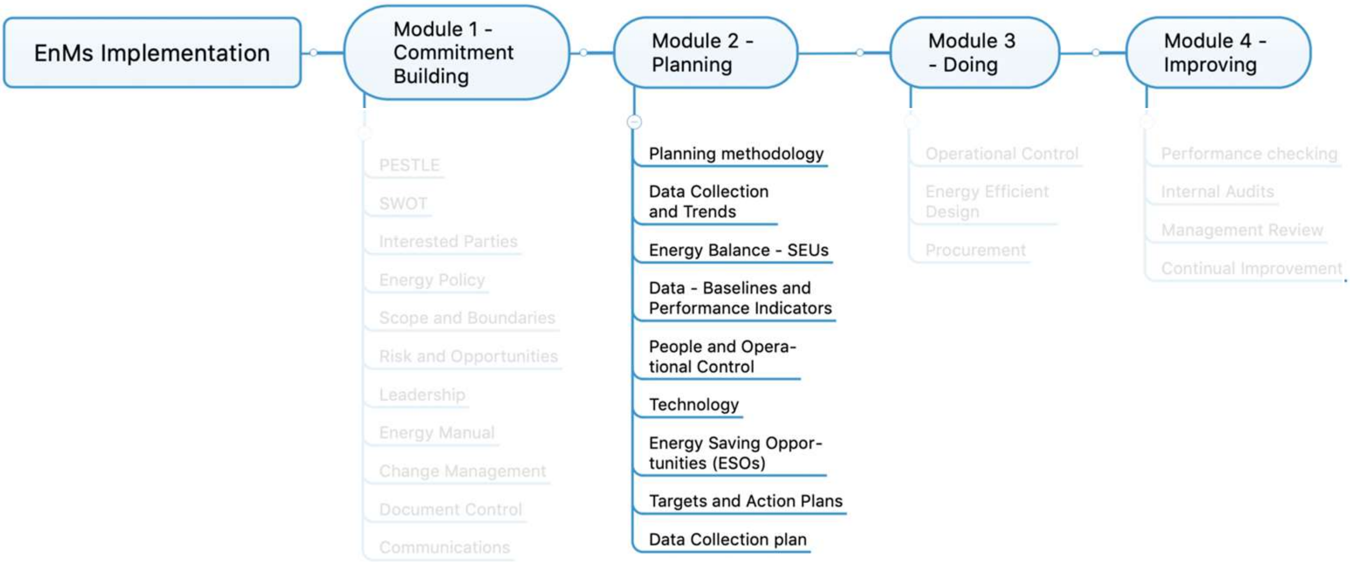

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Exercise 03

- We have already built the regression model for the food plant, using data from 2011.
  - We detected a saving potential in the cooked product line.
  - That regression was used to monitoring performance in 2012.
- At the end of 2012, they have enough data to update the models.
  - They have implemented saving measures in the cooked line, so they expect changes in the regression model.
- In this exercise, you will need to build the new model using the new data they had from 2012.

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Exercise 03 - 30 minutes

- **These are data from the demo plant**

1. What is the baseline model?
2. Which variables are significant?
3. Which variables are not significant?
4. Which model should we use?
5. What are the R2, P-value, intercept and the coefficients telling us?
6. Draw the trend of actual and expected for 2012

	ELECTRICITY				
	CDD5	Cured	Cooked	Sliced	Total Consumption
01/12	20	160.75	1373.46	723.66	1450461
02/12	30	144.00	1512.75	770.11	1414145
03/12	132	201.63	1560.68	789.71	1526610
04/12	68	149.44	1292.58	740.96	1340280
05/12	286	189.17	1686.87	871.84	1641128
06/12	411	186.50	1300.77	710.94	1544644
07/12	439	223.36	1480.37	858.71	1659025
08/12	505	317.88	1471.13	842.25	1757326
09/12	335	218.82	1474.62	819.41	1605133
10/12	201	224.80	1488.21	823.94	1592016
11/12	72	185.62	1426.50	784.28	1502998
12/12	40	174.60	1042.42	621.49	1361331

Exercise 03 - Solution

	ELECTRICITY				
	CDD5	Cured	Cooked	Sliced	Total Consumption
01/12	20	160.75	1373.46	723.66	1450461
02/12	30	144.00	1512.75	770.11	1414145
03/12	132	201.63	1560.68	789.71	1526610
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10/12	201	224.80	1488.21	823.94	1592016
11/12	72	185.62	1426.50	784.28	1502998
12/12	40	174.60	1042.42	621.49	1361331

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.9784203
R Square	0.9573062
Adjusted R S	0.941296
Standard Err	30578.465
Observation	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	1.67729E+11	5.591E+10	59.793624	8.035E-06
Residual	8	7480340251	935042531		
Total	11	1.75209E+11			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	830128.88	93715.99594	8.8579209	2.083E-05	614019.4	1046238.3	614019.4	1046238.3
CDD5	298.52202	82.77912493	3.6062476	0.0069193	107.63301	489.41102	107.63301	489.41102
Cured	1193.0621	311.7367741	3.8271458	0.0050383	474.19581	1911.9284	474.19581	1911.9284
Cooked	282.88169	59.75347348	4.7341463	0.001475	145.08993	420.67344	145.08993	420.67344

SLICED vs COOKED

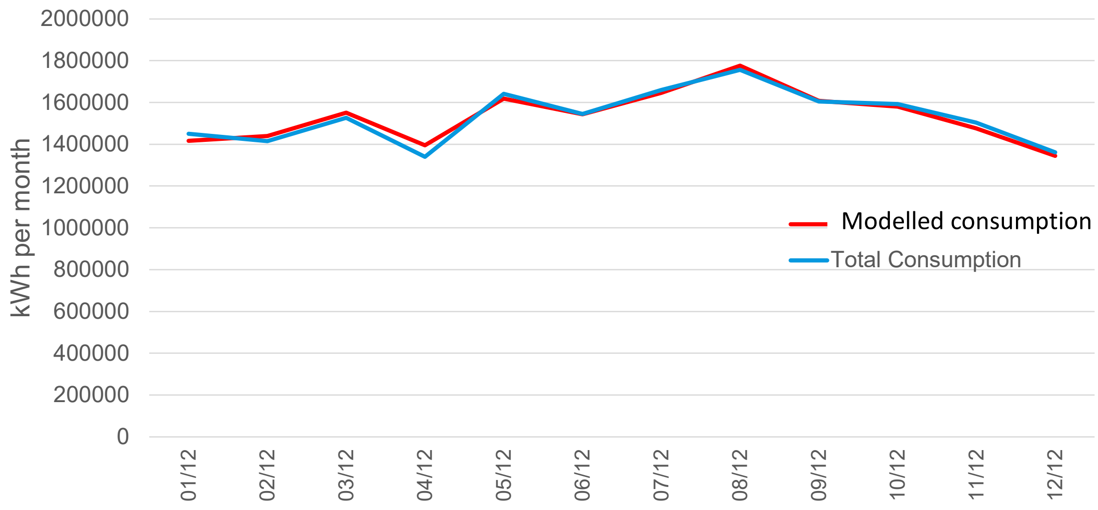
Regression Statistics	
R Square	0.79044036
Observations	12

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	217.154132	92.148079	2.35657796	0.04018719
Cooked	0.3945826	0.064247644	6.14158872	0.00010953

COLINEARITY

Reason why p-value is high for sliced production

Exercise 03 - Solution



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Identification of potentially relevant variables

Exercise

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Exercise: Potentially relevant variables

Consider a car

- What are all the relevant variables for fuel consumption?
- Which are practical to measure?
- Which are economical to measure?

Source: Tim Mossholder, unsplash

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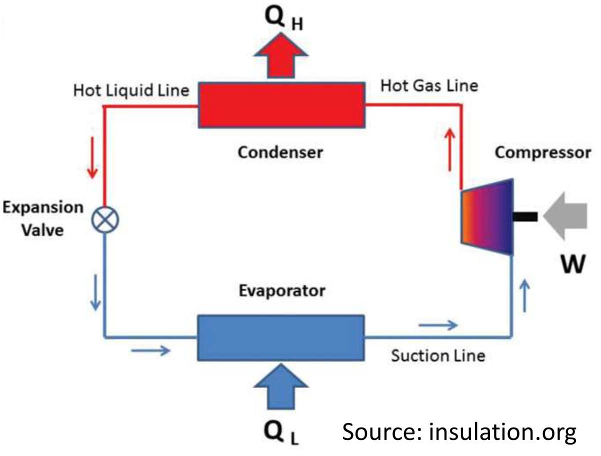
Exercise: Potentially relevant variables

Consider a refrigeration system

- What is the energy input?
- What are all the relevant variables for electricity consumption?
- Which are practical to measure?
- Which are economical to measure?



Source: insulation.org

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Discussion

What happens if an unexpected variable is significant?

What happens if an expected variable is not significant?

What can cause these situations?

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Energy Performance Indicators (EnPIs)

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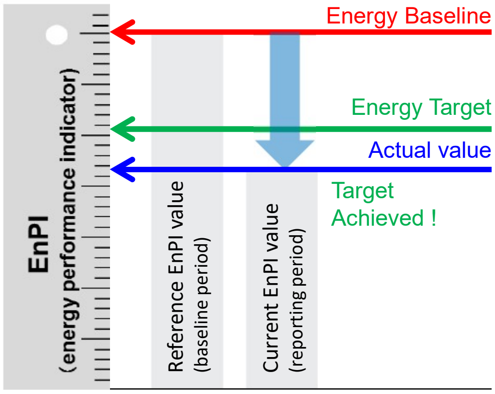
Basic terminology

- Energy performance indicator (EnPI)
- Energy Baseline (EnB)
- Energy Target
- Energy Improvement



Source: Adapted from ISO 50006

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EnPI & EnB

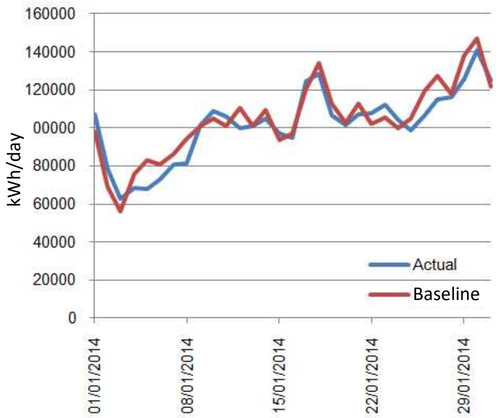
- EnPI = A comparison of energy baseline (EnB) and actual energy consumption
- EnB = Expected energy consumption

	A	B	C	D	E	F	G
1	SUMMARY OUTPUT						
2							
3	*Regression Statistics*						
4	Multiple R	0.96					
5	R Square	0.92					
6	Adjusted R Square	0.92					
7	Standard Error	11467.43					
8	Observations	357					
9							
10		*df*	*SS*	*MS*	*F*	*Significance F*	
11	Regression	12	5.33E+11	4.44E+10	337.4629313	4.83E-182	
12	Residual	344	4.52E+10	1.32E+08			
13	Total	356	5.78E+11				
14							
15		*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
16	Intercept	56042.3321	1.69E+03	3.31E+01	6.4909E-109	5.27E+04	5.94E+04
17	CDD0	1092.1375	1.02E+02	1.07E+01	4.1633E-23	8.91E+02	1.29E+03
18	Volum _ line_3_PET	341.1980	3.89E+01	8.78E+00	7.96694E-17	2.65E+02	4.18E+02
19	Volum _ line_6_KEG	280.4946	6.55E+01	4.29E+00	2.374E-05	1.52E+02	4.09E+02
20	Volum _GB	204.7169	3.59E+01	5.71E+00	2.46218E-08	1.34E+02	2.75E+02
21	Volum _CAN	124.1628	2.64E+01	4.71E+00	3.58282E-06	7.23E+01	1.76E+02
22	Volum_Filtration	59.7760	1.71E+01	3.50E+00	0.000524591	2.62E+01	9.34E+01
23	Beer in CKT	29.7719	5.40E+00	5.51E+00	6.88665E-08	1.92E+01	4.04E+01
24	Volum_non_alc_beer	984.9315	1.79E+02	5.51E+00	7.05868E-08	6.33E+02	1.34E+03
25	Count of brewing	802.2374	1.17E+02	6.84E+00	3.68161E-11	5.71E+02	1.03E+03
26	Volum syrup	66.3940	9.97E+00	6.66E+00	1.0809E-10	4.68E+01	8.60E+01
27	Count of preform	25.3723	5.00E+00	5.07E+00	6.44968E-07	1.55E+01	3.52E+01
28	Count_dry_grain_in_work	4277.4592	1.55E+03	2.76E+00	0.006004484	1.23E+03	7.32E+03

153

Different views, same story

Day	KWh	Expected	Act-Exp	Act-Exp CUSUM	EnPC
31/12/201		0	0	0	0
01/01/201	107423	98376	9,047	9,047	1.09
02/01/201	78543	69251	9,292	18,339	1.13
03/01/201	62766	56042	6,724	25,063	1.12
04/01/201	68589	75803	-7,214	17,849	0.90
05/01/201	68019	82903	-14,884	2,964	0.82
06/01/201	72858	80875	-8,017	-5,052	0.90
07/01/201	80909	86417	-5,508	-10,561	0.94
08/01/201	81574	94189	-12,615	-23,175	0.87
09/01/201	101414	101077	337	-22,839	1.00
10/01/201	109003	104834	4,169	-18,669	1.04
11/01/201	106208	101084	5,124	-13,546	1.05
12/01/201	100070	110332	-10,262	-23,808	0.91
13/01/201	100870	101218	-348	-24,156	1.00
14/01/201	104885	109333	-4,448	-28,604	0.96
15/01/201	97125	93507	3,618	-24,985	1.04
16/01/201	94610	97057	-2,447	-27,433	0.97
17/01/201	124637	120398	4,239	-23,194	1.04
18/01/201	128703	134224	-5,521	-28,715	0.96
19/01/201	106501	112781	-6,280	-34,995	0.94
20/01/201	101758	102596	-838	-35,833	0.99
21/01/201	107399	112698	-5,299	-41,132	0.95
22/01/201	107817	102179	5,638	-35,495	1.06
23/01/201	112199	105480	6,720	-28,775	1.06
24/01/201	104549	100088	4,460	-24,315	1.04
25/01/201	98829	104897	-6,068	-30,383	0.94
26/01/201	106536	119637	-13,100	-43,483	0.89
27/01/201	115323	127389	-12,067	-55,550	0.91
28/01/201	116232	117619	-1,387	-56,937	0.99
29/01/201	125486	137932	-12,446	-69,382	0.91
30/01/201	141070	146880	-5,810	-75,192	0.96
31/01/201	124989	122034	2,954	-72,238	1.02



Drink industry

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Different views, same story

Day	KWh	Expected	Act-Exp	Act-Exp CUSUM	EnPC
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01/01/2014	107423	98376	9,047	9,047	1.09
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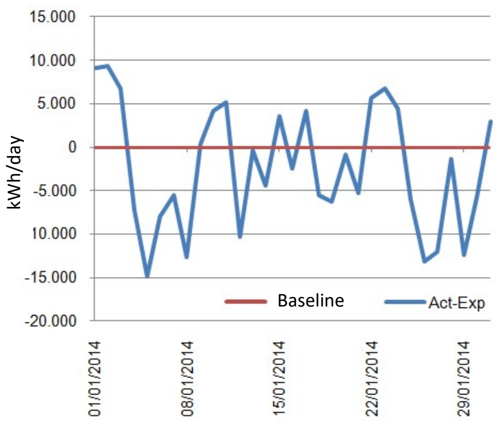
31/01/2014	124989	122034	2,954	-72,238	1.02



Drink industry

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Different views, same story

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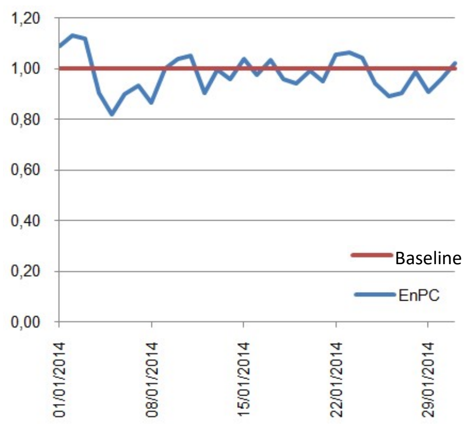
31/01/2014	124989	122034	2,954	-72,238	1.02



Drink industry

CUSUM

- CUmulative SUM of deviation from expected consumption
- Equals the sum of the residuals

- Key technique for…
  - Target-setting
  - Diagnosing changes in performance
  - Tracking savings achieved

	A	B	C	D	E
1				Act. – Exp.	
2		Expected	Actual	Difference	Cusum
4		442	449	7	7
5		341	338	-3	4
6		261	274	13	17
7		136	137	1	18
8		81	83	2	20
9		120	115	-5	15
10		120	120	0	15

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Different views, same story

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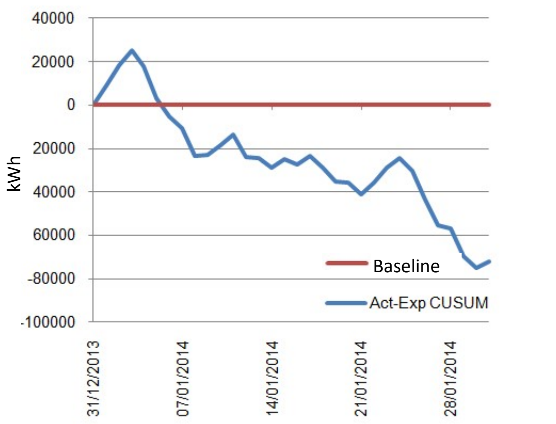

Drink industry

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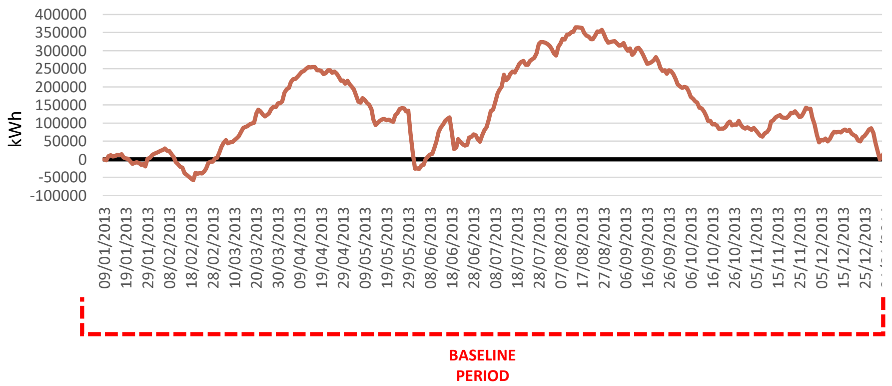
More about CUSUM

- CUSUM always starts at zero and ends at zero when you compare actual and modelled (or expected) consumption in the baseline period



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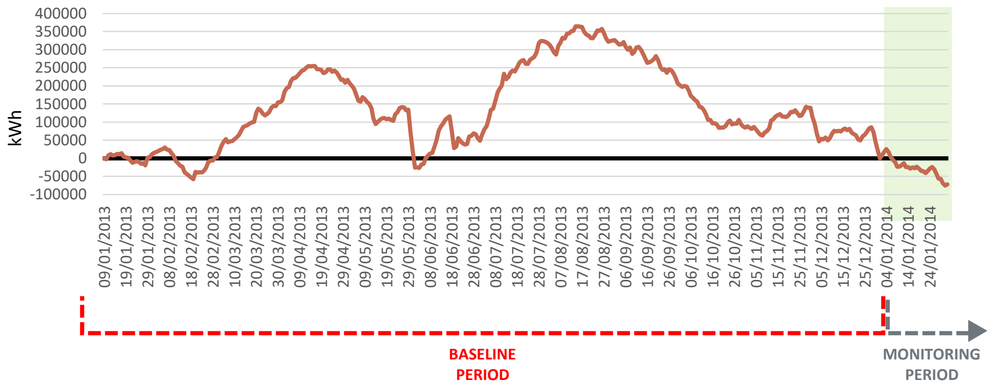
More about CUSUM

- In the monitoring period, CUSUM always starts at zero. The value at the end of the line represents the total savings (if negative) or excess consumption (if positive).



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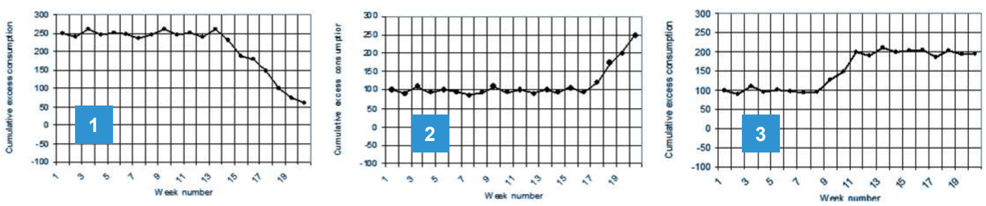
Understanding CUSUM



- Which chart(s)…

1. indicate a single fault has recently occurred and not yet been cured?
2. indicate a short period of waste, which has now been corrected? How much energy was wasted during that period?
3. indicate a successful energy-saving measure has been implemented during this period?

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Adjusting baselines, updating models

- If a static factor changes. What to do?

1. Estimate changes and adjust baseline to continue monitoring

OR

2. Develop a new regression model as soon as there is enough data to develop a new baseline.

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A little bit of homework ☺

- Collect data for the relevant variables for the past year or more
  - Same data interval as energy consumption from Day 1
  - Consider the factors that routinely change and affect your energy consumption
  - Production volumes, occupancy, product mix, weather, etc.
- Tabulate in vertical columns in Excel
- Experiment with multi-variate regression to test potential variables

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Target setting

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Long term targets

- Mostly based on carbon emissions nowadays.
- Clear targets – probably top down.
  - For example, 55% reduction in emissions by 2030 against a base year of 1990 or later.
- Action plans – specific quantifiable actions to reduce emissions.
  - Estimate future level of activity. Regression can help to better estimate.
  - Energy Efficiency.
  - Electrification (where the grid is lower carbon intensity).
  - Embedded renewable energy sources.
  - Impact of reduction in carbon intensity in the grid.
  - Offsetting.
  - Carbon capture/utilization/storage (CCUS).

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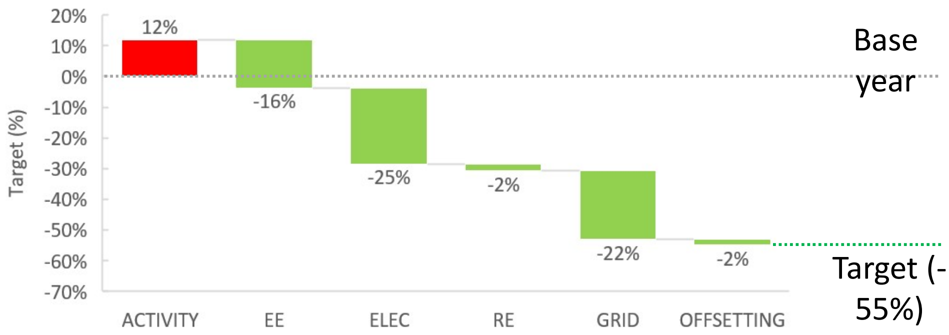
Overview of CO_2 target and action plans

	%
TCO2 from activity levels	12%
TCO2 from Energy Efficiency	-16%
TCO2 from Electrification	-25%
TCO2 from RE on site	-2%
TCO2 from grid improvement	-22%
TCO2 from offsetting	-2%



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Short term planning

- They should be aligned with and support long-term targets.

- Energy Performance targets can be set in different ways:
  1. Top-down targets
  2. Bottom-up targets, based on action plans.
  3. Based on previous best performance.

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1. Aspirational targets

- **Top down: to challenge and drive improvement**
  - Corporate target, e.g. 5%
  - Based on national targets
  - e.g. EU 55% emissions reduction by 2030
  - Often arbitrary
- **Should be reflected in budgets**
  - Excessive budgets are a license to waste energy
- **Should be reflected in performance monitoring**
  - i.e. reduce expected consumption by x%

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2. Bottom up approach

- **Identify all energy saving opportunities**
- **Decide which you will action**
- **The total of these is the target savings**
  - Consider the effect of operational control
  - And reaction to deviations
  - Consider also that all opportunities will not be operational on 1st of January
  - Consider interactive effects, some can't be added together
- **Subtract from expected consumption**

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3. Previous best performance

- Previous best performance based on regression model(s)
  - Not necessarily best possible performance

- Has been achieved with existing equipment and people
  - No investment required

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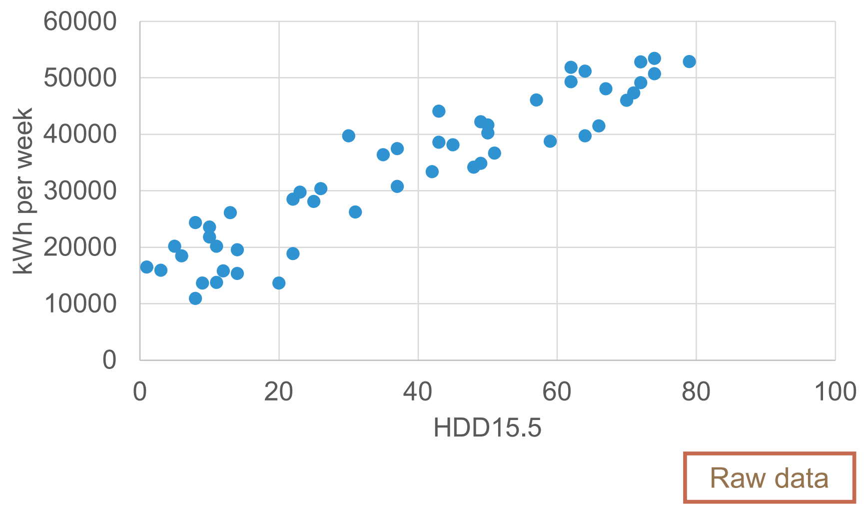
Setting aggressive but achievable targets



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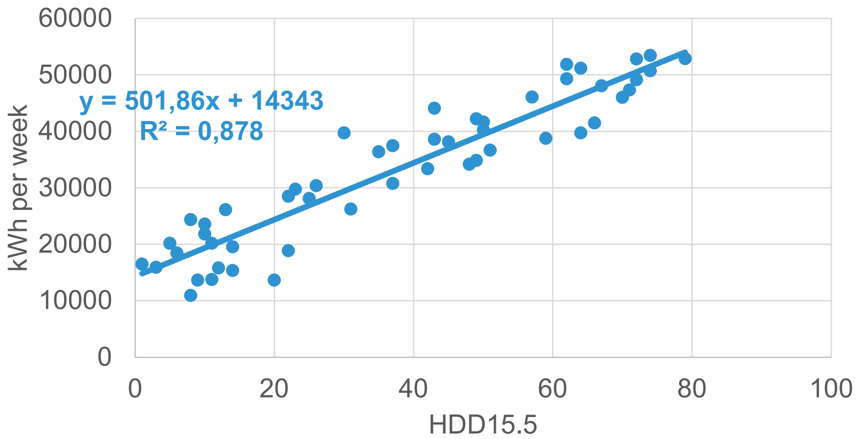
Setting aggressive but achievable targets



Regression line

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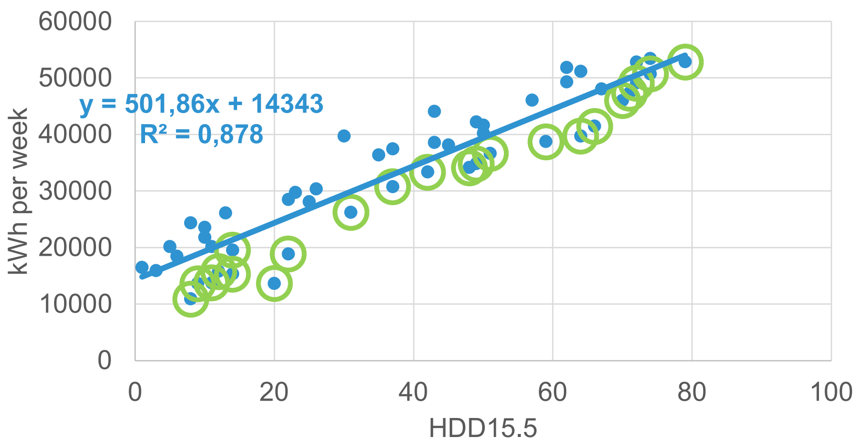
Setting aggressive but achievable targets



Best are below the line

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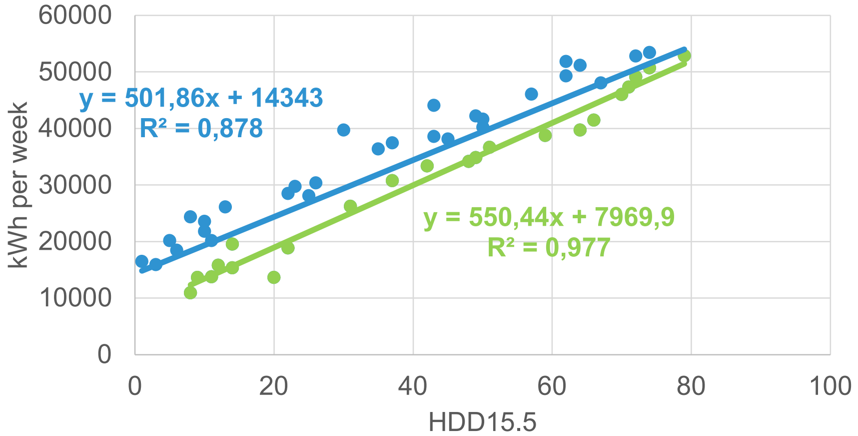
Setting aggressive but achievable targets



Regression of best performance period only

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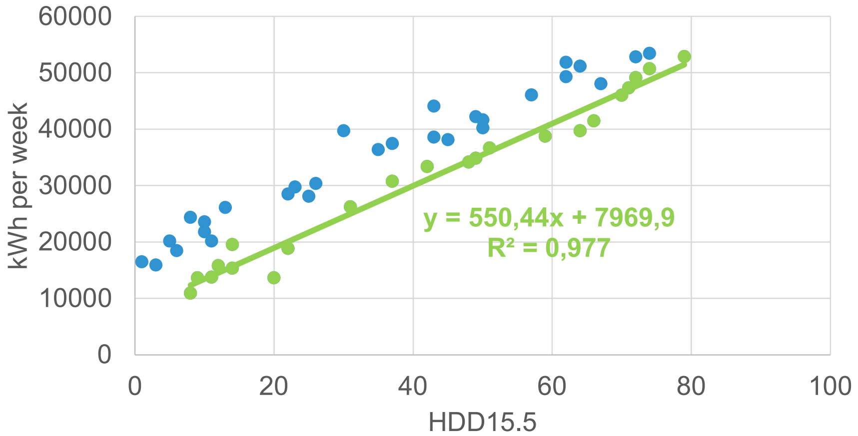
Setting aggressive but achievable targets



Best performance adopted as target

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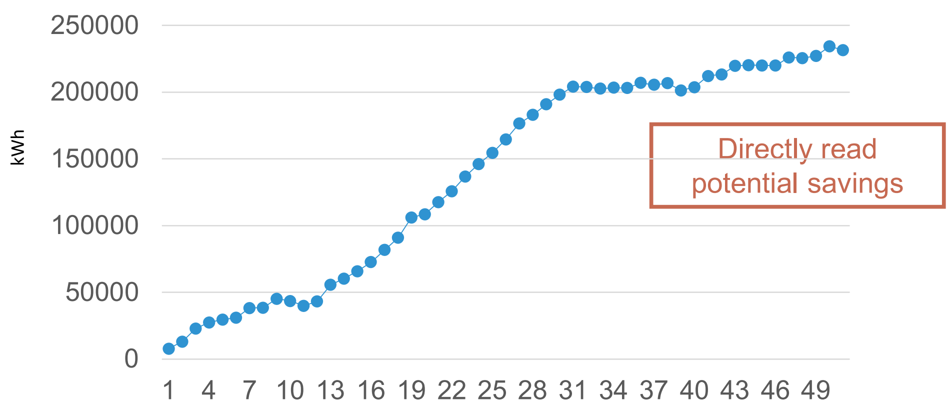
Setting aggressive but achievable targets



CUSUM relative to best performance

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Agence Marocaine pour l'Efficacité Energétique

Moroccan Agency for Energy Efficiency

Thank you for your attention

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Agence Marocaine pour l'Efficacité Energétique
Moroccan Agency for Energy Efficiency

Energy Management System according to the ISO 50001 standard

16/05/2025

Amine AHMARRAS
Head of training within AMEE

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Forecasting

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Forecasting

- Predicting or estimating future energy consumption
- Forecasting future energy prices
- Estimating savings from:
  - Energy saving projects.
  - Operational control.
  - Monitoring and corrective actions.

3

Forecasting consumption

- Option A: Use annualised trends.
  - But, it does not take into account known changes in variables (production, etc.)
- Option B: Use your regression model
  - Estimate changes in variables
  - Insert the forecast values for each variable
  - The result is the forecast energy consumption

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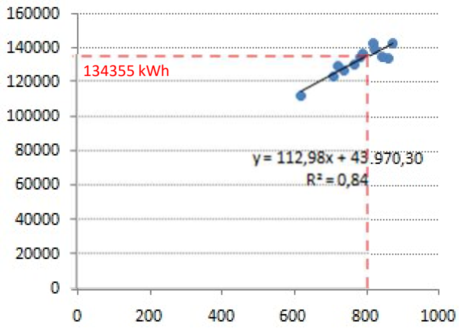
Forecasting consumption

- We have seen this already.



- We can forecast future consumption if we estimate the future variable values.

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Exercise 04

- We did a regression exercise, and we found that the expected consumption was:

kWh=830128.88+(298.52*CDD5)+(1193.06*Cured)+(282.88*Cooked)

	A	B	C	D	E	F
1						ELECTRICITY
2		CDD5	Cured	Cooked	Sliced	Total Consumption
3		ºC	t	t	t	kWh
4	01/12	20	160.75	1373.46	723.66	1450461
5	02/12	30	144.00	1512.75	770.11	1414145
6	03/12	132	201.63	1560.68	789.71	1526610
7	04/12	68	149.44	1292.58	740.96	1340280
8	05/12	286	189.17	1686.87	871.84	1641128
9	06/12	411	186.50	1300.77	710.94	1544644
10	07/12	439	223.36	1480.37	858.71	1659025
11	08/12	505	317.88	1471.13	842.25	1757326
12	09/12	335	218.82	1474.62	819.41	1605133
13	10/12	201	224.80	1488.21	823.94	1592016
14	11/12	72	185.62	1426.50	784.28	1502998
15	12/12	40	174.60	1042.42	621.49	1361331

1. Forecast the monthly consumption in 2013 if the expected production is 25% higher than in 2012.
2. What is the budget for 2013 if electricity is 12c/kWh?

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Exercise 04 - Solution

- As we expect an increase of 25% in production volumes, the forecast formula is:

kWh=830128.88+(298.52*CDD5)+(1193.06*Cured*1.25)+(282.88*Cooked*1.25)

	A	B	C	D	E	F	G
1		ELECTRICITY					
2		CDD5	Cured	Cooked	Sliced	Total Consumption	Forecast Consumption 2013
3		ºC	t	t	t	kWh	kWh
4	01/12	20	160.75	1373.46	723.66	1450461	1561489
5	02/12	30	144.00	1512.75	770.11	1414145	1588747
6	03/12	132	201.63	1560.68	789.71	1526610	1722090
7	04/12	68	149.44	1292.58	740.96	1340280	1530351
8	05/12	286	189.17	1686.87	871.84	1641128	1794101
9	06/12	411	186.50	1300.77	710.94	1544644	1690909
10	07/12	439	223.36	1480.37	858.71	1659025	1817745
11	08/12	505	317.88	1471.13	842.25	1757326	1975140
12	09/12	335	218.82	1474.62	819.41	1605133	1777895
13	10/12	201	224.80	1488.21	823.94	1592016	1751616
14	11/12	72	185.62	1426.50	784.28	1502998	1632856
15	12/12	40	174.60	1042.42	621.49	1361331	1471057

Total consumption	20313998
€/kWh	0.12
Total expected cost	€ 2,437,680

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Performance monitoring

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Performance monitoring

- Budget Vs actual spending
  - Use annualised view
- Expected Vs actual consumption
  - Actual minus expected
- Target savings Vs actual savings
  - Actual minus target
- CUSUM

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Routine monitoring

ISO 50001 9.1.1 a) 4

- Requires regular comparison of actual and expected consumption
- This is the same as comparing actual consumption with the calculated EnB consumption.

Our interpretation:

- Initially most people do this monthly due to available data
- Consider once a week
- Daily is better but is unusual
- Monthly is too long – waste will accumulate
- We need rapid detection and prioritization of unexpected excess consumption

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Monitoring Performance example

- Remember we had already built the regression model for the food plant, using data from 2011.
  - We detected a saving potential in the cooked product line.
  - That regression was going to be used to monitoring performance in 2012, while the saving measures were going to be implemented.
  - The following sequence explains how to monitor performance using that example.

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Monitoring Performance

	A	B	C	D	E	F
1		ELECTRICITY				
2		CDD5	Cured	Cooked	Sliced	Total Consumption
3	01/11	26	164.59	1481.63	694.09	1531228
4	02/11	49	180.89	1526.45	694.98	1450494
5	03/11	83	212.56	1624.06	757.15	1560932
6	04/11	209	169.59	1425.18	692.53	1466743
7	05/11	290	209.68	1685.38	799.97	1692976
8	06/11	346	235.66	1531.36	780.59	1692700
9	07/11	396	214.72	1566.15	793.54	1671369
10	08/11	486	240.99	1529.46	750.53	1820530
11	09/11	402	210.34	1446.36	764.36	1746080
12	10/11	229	152.22	1462.95	714.92	1534139
13	11/11	122	206.57	1567.48	761.59	1532500
14	12/11	23	180.19	1164.1	638.54	1430632

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.9324154
R Square	0.86939848
Adjusted R S	0.84037592
Standard Err	50514.6317
Observation	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	1.52879E+11	7.6439E+10	29.9559534	0.00010514
Residual	9	22965552186	2551728021		
Total	11	1.75844E+11			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1163449.22	124441.2278	9.34938717	6.2458E-06	881943.6041	1444954.83
CDD5	517.273212	121.9425858	4.24194065	0.00216808	241.4199189	793.126505
Cured	1594.81428	701.8919392	2.27216498	0.04918865	7.024408189	3182.60416

This is the model we build before implementing saving opportunities.

EnB: Expected consumption= 1163449.22+(517.27*CDD5)+(1594.81*Cured)
EnPI: A comparison of baseline (expected consumption) and **actual** consumption

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Monitoring Performance

		CDD5	Cured	Total Consumption
1				
2				
3				
4	01/11	26	164.59	1531228
5	02/11	49	180.89	1450494
6	03/11	83	212.56	1560932
7	04/11	209	169.59	1466743
8	05/11	290	209.68	1692976
9	06/11	346	235.66	1692700
10	07/11	396	214.72	1671369
11	08/11	486	240.99	1820530
12	09/11	402	210.34	1746080
13	10/11	229	152.22	1534139
14	11/11	122	206.57	1532500
15	12/11	23	180.19	1430632
16	01/12	20	160.75	1450461
17	02/12	30	144.00	1414145
18	03/12	132	201.63	1526610
19	04/12	68	149.44	1340280
20	05/12	286	189.17	1641128
21	06/12	411	186.50	1544644

Data from 2011 used to develop the expected consumption formula

Expected consumption = 116344.22+(517.27*CDD5)+(1594.81*Cured)

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Monitoring Performance

		CDD5	Cured	Total Consumption
1				
2				
3				
4	01/11	26	164.59	1531228
5	02/11	49	180.89	1450494
6	03/11	83	212.56	1560932
7	04/11	209	169.59	1466743
8	05/11	290	209.68	1692976
9	06/11	346	235.66	1692700
10	07/11	396	214.72	1671369
11	08/11	486	240.99	1820530
12	09/11	402	210.34	1746080
13	10/11	229	152.22	1534139
14	11/11	122	206.57	1532500
15	12/11	23	180.19	1430632
16	01/12	20	160.75	1450461
17	02/12	30	144.00	1414145
18	03/12	132	201.63	1526610
19	04/12	68	149.44	1340280
20	05/12	286	189.17	1641128
21	06/12	411	186.50	1544644

Actual consumption in 2012

Expected consumption = 116344.22+(517.27*CDD5)+(1594.81*Cured)

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Monitoring Performance

		CDD5	Cured	Total Consumption	Expected
1					
2					
3					
4	01/11	26	164.59	1531228	
5	02/11	49	180.89	1450494	
6	03/11	83	212.56	1560932	
7	04/11	209	169.59	1466743	
8	05/11	290	209.68	1692976	
9	06/11	346	235.66	1692700	
10	07/11	396	214.72	1671369	
11	08/11	486	240.99	1820530	
12	09/11	402	210.34	1746080	
13	10/11	229	152.22	1534139	
14	11/11	122	206.57	1532500	
15	12/11	23	180.19	1430632	
16	01/12	20	160.75	1450461	1430161
17	02/12	30	144.00	1414145	1408621
18	03/12	132	201.63	1526610	1553292
19	04/12	68	149.44	1340280	1436953
20	05/12	286	189.17	1641128	1613080
21	06/12	411	186.50	1544644	1673481

Expected consumption is the **BASELINE.** It is the consumption that we should have if the performance is the same as last year, based on the relevant variables

Expected consumption = 116344.22+(517.27*CDD5)+(1594.81*Cured)

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Monitoring Performance

		CDD5	Cured	Total Consumption	Expected	EnPC	Actual Savings (Act-Exp)
1							
2							
3							
4	01/11	26	164.59	1531228			
5	02/11	49	180.89	1450494			
6	03/11	83	212.56	1560932			
7	04/11	209	169.59	1466743			
8	05/11	290	209.68	1692976			
9	06/11	346	235.66	1692700			
10	07/11	396	214.72	1671369			
11	08/11	486	240.99	1820530			
12	09/11	402	210.34	1746080			
13	10/11	229	152.22	1534139			
14	11/11	122	206.57	1532500			
15	12/11	23	180.19	1430632			
16	01/12	20	160.75	1450461	1430161	1.014	20300
17	02/12	30	144.00	1414145	1408621	1.004	5524
18	03/12	132	201.63	1526610	1553292	0.983	-26682
19	04/12	68	149.44	1340280	1436953	0.933	-96673
20	05/12	286	189.17	1641128	1613080	1.017	28048
21	06/12	411	186.50	1544644	1673481	0.923	-128837

The actual savings are the difference between actual consumption and expected consumption

For example, in March we saved 26682 kWh

Expected consumption = 116344.22+(517.27*CDD5)+(1594.81*Cured)

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Monitoring Performance

		CDD5	Cured	Total Consumption	Expected	EnPC	Actual Savings (Act-Exp)	Actual Savings CUSUM
4	01/11	26	164.59	1531228				
5	02/11	49	180.89	1450494				
6	03/11	83	212.56	1560932				
7	04/11	209	169.59	1466743				
8	05/11	290	209.68	1692976				
9	06/11	346	235.66	1692700				
10	07/11	396	214.72	1671369				
11	08/11	486	240.99	1820530				
12	09/11	402	210.34	1746080				
13	10/11	229	152.22	1534139				
14	11/11	122	206.57	1532500				
15	12/11	23	180.19	1430632				0
16	01/12	20	160.75	1450461	1430161	1.014	20300	20300
17	02/12	30	144.00	1414145	1408621	1.004	5524	25824
18	03/12	132	201.63	1526610	1553292	0.983	-26682	-857
19	04/12	68	149.44	1340280	1436953	0.933	-96673	-97530
20	05/12	286	189.17	1641128	1613080	1.017	28048	-69483
21	06/12	411	186.50	1544644	1673481	0.923	-128837	-198320

The actual savings CUSUM are the cumulative savings from the beginning

For example, from January to June we saved 198320 kWh

Expected consumption = 116344.22+(517.27*CDD5)+(1594.81*Cured)

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Monitoring Performance

		CDD5	Cured	Total Consumption	Expected	EnPC	Actual Savings (Act-Exp)	Actual Savings CUSUM	2.5% Target consumption
4	01/11	26	164.59	1531228					
5	02/11	49	180.89	1450494					
6	03/11	83	212.56	1560932					
7	04/11	209	169.59	1466743					
8	05/11	290	209.68	1692976					
9	06/11	346	235.66	1692700					
10	07/11	396	214.72	1671369					
11	08/11	486	240.99	1820530					
12	09/11	402	210.34	1746080					
13	10/11	229	152.22	1534139					
14	11/11	122	206.57	1532500					
15	12/11	23	180.19	1430632				0	
16	01/12	20	160.75	1450461	1430161	1.014	20300	20300	1394407
17	02/12	30	144.00	1414145	1408621	1.004	5524	25824	1373405
18	03/12	132	201.63	1526610	1553292	0.983	-26682	-857	1514459
19	04/12	68	149.44	1340280	1436953	0.933	-96673	-97530	1401029
20	05/12	286	189.17	1641128	1613080	1.017	28048	-69483	1572753
21	06/12	411	186.50	1544644	1673481	0.923	-128837	-198320	1631644

The target consumption is the consumption we want to have.

For example, the target here is to save 2.5%

Expected consumption = 116344.22+(517.27*CDD5)+(1594.81*Cured)

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Monitoring Performance

		CDD5	Cured	Total Consumption	Expected	EnPC	Actual Savings (Act-Exp)	Actual Savings CUSUM	2.5% Target consumption	Target Savings (Tgt-Exp)	Target Savings CUSUM
4	01/11	26	164.59	1531228							
5	02/11	49	180.89	1450494							
6	03/11	83	212.56	1560932							
7	04/11	209	169.59	1466743							
8	05/11	290	209.68	1692976							
9	06/11	346	235.66	1692700							
10	07/11	396	214.72	1671369							
11	08/11	486	240.99	1820530							
12	09/11	402	210.34	1746080							
13	10/11	229	152.22	1534139							
14	11/11	122	206.57	1532500							
15	12/11	23	180.19	1430632				0			0
16	01/12	20	160.75	1450461	1430161	1.014	20300	20300	1394407	-35754	-35754
17	02/12	30	144.00	1414145	1408621	1.004	5524	25824	1373405	-35216	-70970
18	03/12	132	201.63	1526610	1553292	0.983	-26682	-857	1514459	-38832	-109802
19	04/12	68	149.44	1340280	1436953	0.933	-96673	-97530	1401029	-35924	-145726
20	05/12	286	189.17	1641128	1613080	1.017	28048	-69483	1572753	-40327	-186053
21	06/12	411	186.50	1544644	1673481	0.923	-128837	-198320	1631644	-41837	-227890

We can also compare our consumption with the target.

For example, from January to June the target savings were 227890 kWh and we have saved 198320 kWh, so it is less than the target.

Expected consumption = 116344.22+(517.27*CDD5)+(1594.81*Cured)

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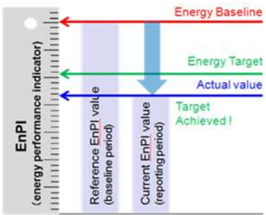
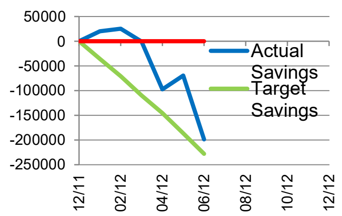
Monitoring Performance





		CDD5	Cured	Total Consumption	Expected	EnPC	Actual Savings (Act-Exp)	Actual Savings CUSUM	2.5% Target consumption	Target Savings (Tgt-Exp)	Target Savings CUSUM
4	01/11	26	164.59	1531228							
5	02/11	49	180.89	1450494							
6	03/11	83	212.56	1560932							
7	04/11	209	169.59	1466743							
8	05/11	290	209.68	1692976							
9	06/11	346	235.66	1692700							
10	07/11	396	214.72	1671369							
11	08/11	486	240.99	1820530							
12	09/11	402	210.34	1746080							
13	10/11	229	152.22	1534139							
14	11/11	122	206.57	1532500							
15	12/11	23	180.19	1430632				0			0
16	01/12	20	160.75	1450461	1430161	1.014	20300	20300	1394407	-35754	-35754
17	02/12	30	144.00	1414145	1408621	1.004	5524	25824	1373405	-35216	-70970
18	03/12	132	201.63	1526610	1553292	0.983	-26682	-857	1514459	-38832	-109802
19	04/12	68	149.44	1340280	1436953	0.933	-96673	-97530	1401029	-35924	-145726
20	05/12	286	189.17	1641128	1613080	1.017	28048	-69483	1572753	-40327	-186053
21	06/12	411	186.50	1544644	1673481	0.923	-128837	-198320	1631644	-41837	-227890

Expected consumption = 116344.22+(517.27*CDD5)+(1594.81*Cured)

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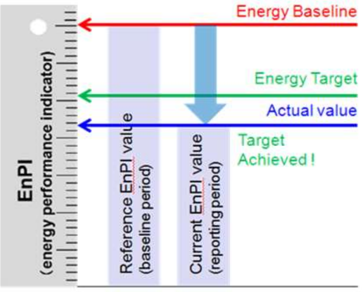
Terminology

- Actual energy consumption: from the meter
- Expected energy consumption = the baseline: calculated from the baseline formula using the actual variable values.
- Energy savings = actual consumption minus expected consumption
- Target consumption = calculated from expected consumption
- Target savings = Target consumption minus expected consumption



All of the above are based on past data

- Forecast consumption (predicted?) = estimated future consumption

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Exercise 05

- We have already built the regression model for the food plant, using data from 2011.
- We have already checked performance in 2012, and we saw the savings.
- We have also calculated the regression model for 2012, that also included cooked production volumes as a relevant variable.
- In this exercise, you will check performance in 2013.

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Exercise 05

	A	B	C	D	E	F	G	H	I	J	K	L
1		ELECTRICITY										
2		CDD5	Cured	Cooked	Sliced	Total Consumption	Expected	Actual Savings	Actual Savings	Target	Target Savings	Target Savings
3								(Act-Exp)	CUSUM	consumption	(Tgt-Exp)	CUSUM
4		ºC	t	t	t	kWh				2.5%		
5									0			0
6	01/13	26	186.04	1491.82	813.15	1487662						
7	02/13	21	155.68	1172.28	735.36	1386564						
8	03/13	70	146.98	1166.62	721.74	1337163						
9	04/13	116	170.38	1486.95	802.17	1367378						
10	05/13	132	200.67	1659.13	874.10	1523203						
11	06/13	267	243.04	1643.38	966.75	1567576						
12	07/13	478	288.44	1904.17	983.69	1861774						
13	08/13	429	422.85	1786.97	1210.68	1860107						
14	09/13	330	305.21	1848.96	1213.42	1727270						
15	10/13	228	285.42	1818.81	1039.42	1675044						
16	11/13	73	243.59	1834.90	976.44	1595225						
17	12/13	19	213.96	1267.06	807.31	1362289						

1. Did the demo plant meet the target in 2013 (2.5%)?
2. How many kWh did they save to the end of July? And in the whole 2013? Which was the best month in terms of energy saved?
3. Compare results with annualised results (Exercise 01)

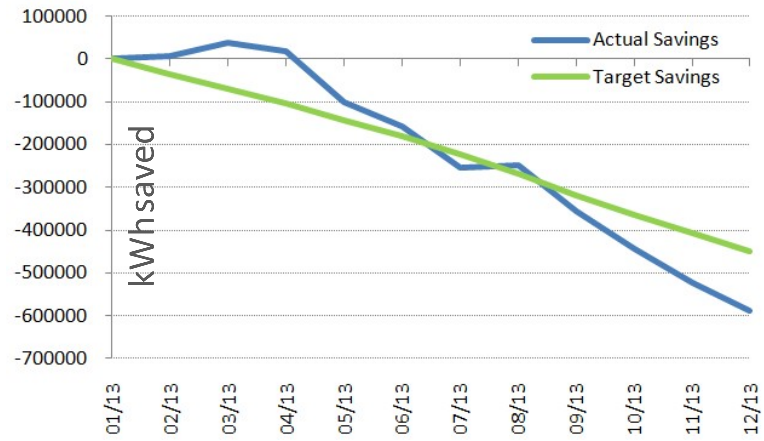
Exercise 05 - Solution

	A	B	C	D	E	F	G	H	I	J	K	L
1		ELECTRICITY										
2		CDD5	Cured	Cooked	Sliced	Total Consumption	Expected	Actual Savings	Actual Savings	Target	Target Savings	Target Savings
3								(Act-Exp)	CUSUM	consumption	(Tgt-Exp)	CUSUM
4		ºC	t	t	t	kWh				2.5%		
5									0			0
6	01/13	26	186.04	1491.82	813.15	1487662	1481856	5806	5806	1444810	-37046	-37046
7	02/13	21	155.68	1172.28	735.36	1386564	1353750	32814	38619	1319907	-33844	-70890
8	03/13	70	146.98	1166.62	721.74	1337163	1356397	-19234	19385	1322487	-33910	-104800
9	04/13	116	170.38	1486.95	802.17	1367378	1488662	-121284	-101899	1451446	-37217	-142017
10	05/13	132	200.67	1659.13	874.10	1523203	1578283	-55080	-156979	1538826	-39457	-181474
11	06/13	267	243.04	1643.38	966.75	1567576	1664678	-97102	-254081	1623061	-41617	-223091
12	07/13	478	288.44	1904.17	983.69	1861774	1855604	6170	-247911	1809214	-46390	-269481
13	08/13	429	422.85	1786.97	1210.68	1860107	1968182	-108075	-355986	1918978	-49205	-318685
14	09/13	330	305.21	1848.96	1213.42	1727270	1815813	-88543	-444529	1770417	-45395	-364081
15	10/13	228	285.42	1818.81	1039.42	1675044	1753224	-78180	-522709	1709393	-43831	-407911
16	11/13	73	243.59	1834.90	976.44	1595225	1661599	-66374	-589082	1620059	-41540	-449451
17	12/13	19	213.96	1267.06	807.31	1362289	1449496	-87207	-676290	1413259	-36237	-485689

The annualised results (exercise 01) showed an increase in absolute consumption (2%). This shows more than 3% of savings!

Exercise 05 - Solution

- ISO 50001 Shalls:
  1. Demonstrate performance improvement by comparing EnPI values with EnBs
  2. Current energy performance
  3. Energy Baselines
  4. Energy Performance Indicators
  5. Actual v expected consumption
  6. Monitor EnPIs
  7. Targets



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Monitoring and Reporting

EDIFICIO	OBJETIVO		REAL	AHORRO			AHORRO		COSTE	CO2
	%	último mes	último mes	2015			último mes		2015	2015
Edif 1	5.00%	322,081 kWh	327,160 kWh	-6.0%	-85134 kWh	-€ 6,913	-3.5%	-11873 kWh	€ 134,702	547 t
Edif 2	5.00%	80,237 kWh	71,457 kWh	-11.8%	-41235 kWh	-€ 3,348	-15.4%	-13003 kWh	€ 31,380	128 t
Edif 3	5.00%	1,308 kWh	1,139 kWh	-9.2%	-876 kWh	-€ 71	-17.3%	-238 kWh	€ 874	4 t
Edif 4	5.00%	26,654 kWh	29,430 kWh	-0.8%	-747 kWh	-€ 61	4.9%	1373 kWh	€ 9,160	37 t
Edif 5	5.00%	68,241 kWh	60,753 kWh	-10.3%	-28399 kWh	-€ 2,306	-15.4%	-11080 kWh	€ 24,988	102 t
Edif 6	5.00%	13,135 kWh	12,588 kWh	-4.0%	-1866 kWh	-€ 152	-9.0%	-1239 kWh	€ 4,520	18 t
Edif 7	5.00%	58,710 kWh	63,787 kWh	0.6%	1367 kWh	€ 111	3.2%	1987 kWh	€ 24,029	98 t
Edif 8	5.00%	40,582 kWh	41,168 kWh	-3.9%	-6566 kWh	-€ 533	-3.6%	-1550 kWh	€ 16,522	67 t
Edif 9	5.00%	50,036 kWh	61,530 kWh	8.0%	20242 kWh	€ 1,644	16.8%	8861 kWh	€ 27,865	113 t
Edif 10	5.00%	450,748 kWh	502,141 kWh	-2.4%	-46028 kWh	-€ 3,737	5.8%	27669 kWh	€ 192,745	783 t
Total		**1,111,731 kWh**	**1,171,151 kWh**	**-5.8%**	**-189241 kWh**	**-€ 15,366**	**-3%**	**908 kWh**	**€ 466,785**	**1,897 t**

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Utilities report

Target Savings: 5%

End Date: 20/03/2018

SERVICE	TARGET	ACTUAL	SAVINGS		COST		AVERAGE
	last week	last week	YTD	last week	YTD	last week	last week
Chilled Water	3,007 kWh	1,971 kWh	-48% -€ 3,706	-€ 128	€ 4,055	€ 211	12 kW
Compressed Air	79,557 kWh	82,587 kWh	-1% -€ 919	-€ 124	€ 97,031	€ 8,822	492 kW
Cold Glycol	39,899 kWh	43,683 kWh	3% € 1,445	€ 180	€ 48,724	€ 4,666	260 kW
Steam	42,691 Nm^3	38,367 Nm^3	-8% -€ 22,229	-€ 2,852	€ 267,684	€ 4,098	228 Nm^3/h

Utility Electricity	**-2% -€ 3,180**	**-€ 71**	**€ 149,810**
Utility Gas	**-8% -€ 22,229**	**-€ 2,852**	**€ 267,684**

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CO_2 Reporting System

Target Reduction: 5% per year

Report End Date: 18/02/2021

Facility	Primary Energy (MWh) 7 day Target	Primary Energy (MWh) 7 day Actual	CO2 Reduction (t) Year to Date	CO2 Reduction (t) Past 7 days	Cost Reduction Year to Date	Cost Reduction Past 7 days	Expenditure (€ in 7 days) Energy	Expenditure (€ in 7 days) CO2
Location 1	840	820	86.1	12.3	€ 2,870	€ (410)	€ 82,000	€ 8,610
Location 2	790	830	87.2	12.5	€ 2,905	€ (415)	€ 83,000	€ 8,715
Location 3	467	456	47.9	6.8	€ 1,596	€ (228)	€ 45,600	€ 4,788
Location 4	567	579	60.8	8.7	€ 2,027	€ (290)	€ 57,900	€ 6,080
Location 5	678	678	71.2	10.2	€ 2,373	€ (339)	€ 67,800	€ 7,119
Location 6	123	120	12.6	1.8	€ 420	€ (60)	€ 12,000	€ 1,260
Location 7	1234	1230	129.2	18.5	€ 4,305	€ (615)	€ 123,000	€ 12,915
Location 8	998	850	89.3	12.8	€ 2,975	€ (425)	€ 85,000	€ 8,925
Total	5697	5563	584	83	€ 19,470.50	€ (2,781.50)	€ 556,300	€ 58,412

- This is where we need to get to, to have an objective overview
- We will build it from the bottom-up

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Energy Saving calculation

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Why is measurement of savings important?

- To demonstrate progress with saving energy
- Check target achievement.
- Comply with ISO 50001
- Comply with good management practice
- Gets backing for further similar projects
- Confirm return on investment
- May reveal *avoidable* underperformance
- Improves trust in results

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Monitoring, Verification and Reporting

SERVICE	TARGET	ACTUAL	SAVINGS				COST		AVERAGE
	7 days	7 days	YTD		7 days		YTD	7 days	7 days
Chilled Water	38,960 kWh	24,273 kWh	36%	€ 10,188	-€	1,788	€ 38,730	€ 2,593	144 kW
Compressed Air	60,962 kWh	68,206 kWh	6%	€ 12,829	€	431	€ 215,368	€ 7,286	406 kW
Cold Glycol	57,645 kWh	66,901 kWh	-5%	-€ 13,019	€	665	€ 238,002	€ 7,146	398 kW
Steam	31,668 Nm^3	32,874 Nm^3	0%	€ 684	-€	49	€ 709,889	€ 3,512	196 Nm^3/h
Utility Electricity			2%	€ 9,999	-€	692	€ 492,100		
Utility Gas			0%	€ 684	-€	49	€ 709,889		

- **The three things can be done at the same time.**
- **Reporting** is essential to **get support and to trigger action**
- The **objective is to improve**, not to write reports
- It can be **automated**, reducing time spent. **Be focused on action**

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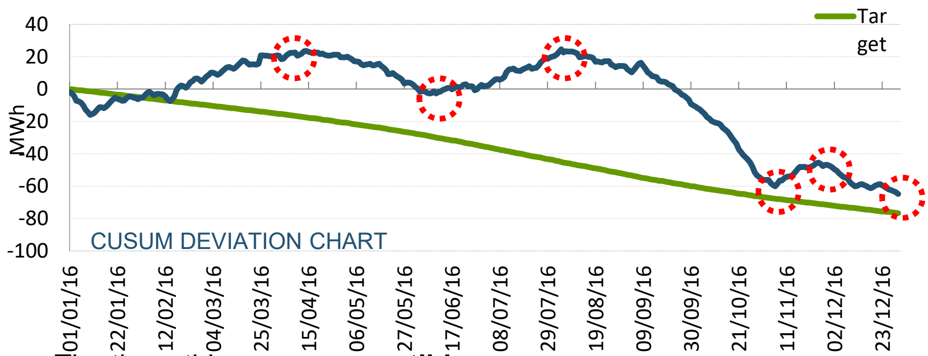
Monitoring, Verification and Reporting



- The three things are **compatible**
- **Reporting** is essential to **get support and to trigger action**
- The **objective is to improve**, not to write reports
- It can be **automated**, reducing time spent. **Be focused on action**

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Different approaches to calculate savings

- **Absolute savings:** Typically used to calculate cost savings and CO_2 reduction.
- **Normalized savings:** Typically used to calculate performance improvement (avoided consumption). Essential inside the ENMS.
- **Based on implemented measures:** When normalized methodology is not possible or reliable.

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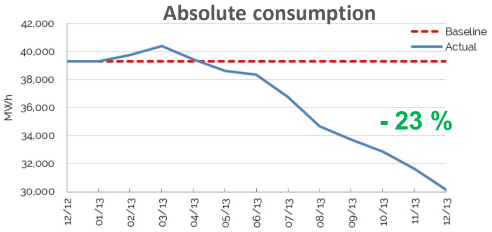
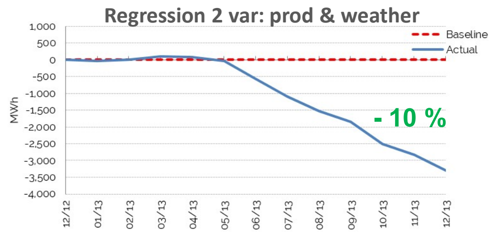
Absolute compared to Normalized savings





- We have already seen this example (brewing industry):
  - Absolute savings were 23%.
  - 10% are related to performance improvement (right-hand diagram above).
  - The other 13% is a result of production reduction and the weather.
  - Production caused a 3% reduction, thus weather caused a 10% reduction

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Multi-year CUSUM with updated Baselines

- To promote continual improvement, it is recommendable to update models every year to compare your performance against last year's performance.
- In the long term, this creates a multiple saving calculation:
  - Every year, you are calculating normalized savings in comparison with last year.
  - Additionally, you are interested in calculating energy savings since the beginning of the EnMS implementation. That requires using the first year 0 as the baseline.
  - It is always very difficult to calculate savings if the number of variables changes or if some static factors change. In those cases, a case-by-case calculation needs to be done, making some assumptions.

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Multi-year CUSUM with updated Baselines

METHOD 1:
Total savings = 3 * Savings year 1 + 2* Savings year 2 + Savings year 3
Total savings = 2,637,988 kWh

METHOD 2:
Total savings = Savings year 3 (baseline year 0)
Total savings = 2,669,077 kWh

		Electricidad	
		Consumo	CDD15.5
	Mes	kWh	degree days
Year 0	ene-13	416,303	0
	feb-13	390,824	-
	mar-13	401,650	0
	abr-13	429,624	34
	may-13	420,959	62
	jun-13	419,821	203
	jul-13	468,197	375
	ago-13	430,165	351
	sep-13	423,333	208
	oct-13	441,817	75
	nov-13	373,191	11
	dic-13	369,924	0
Year 1	ene-14	366,920	0
	feb-14	342,731	0
	mar-14	365,211	19
	abr-14	352,592	72
	may-14	351,989	116
	jun-14	359,511	219
	jul-14	386,845	297
	ago-14	362,552	324
	sep-14	364,940	194
	oct-14	366,573	92
	nov-14	335,652	6
	dic-14	350,854	-
Year 2	ene-15	341,550	0
	feb-15	314,943	0
	mar-15	337,272	24
	abr-15	320,748	43
	may-15	344,379	163
	jun-15	368,396	271
	jul-15	418,351	452
	ago-15	372,960	328
	sep-15	362,302	164
	oct-15	343,808	57
	nov-15	320,927	19
	dic-15	322,336	1
Year 3	ene-16	313,194	1
	feb-16	315,013	0
	mar-16	325,336	5
	abr-16	313,615	15
	may-16	318,806	71
	jun-16	360,465	255
	jul-16	370,103	393
	ago-16	371,031	369
	sep-16	357,950	228
	oct-16	325,070	76
	nov-16	281,651	5
	dic-16	206,470	0

Method 1:

Mes	Expected (baseline 2013)	Act-Exp (baseline 2013)	CUSUM savings (baseline 2013)
ene-14	400,246	- 33,326	- 33,326
feb-14	400,246	- 57,515	- 90,841
mar-14	402,777	- 37,566	- 128,407
abr-14	410,148	- 57,556	- 185,963
may-14	416,351	- 64,362	- 250,325
jun-14	430,690	- 71,179	- 321,504
jul-14	441,565	- 54,720	- 376,224
ago-14	445,306	- 82,754	- 458,978
sep-14	427,241	- 62,301	- 521,279
oct-14	413,027	- 46,454	- 567,733
nov-14	400,969	- 65,317	- 633,050
dic-14	400,204	- 49,350	- 682,400

Savings in year 1 (baseline year 0)

Mes	Expected (baseline 2014)	Act-Exp (baseline 2014)	CUSUM savings (baseline 2014)
ene-15	351,575	- 10,025	- 10,025
feb-15	351,569	- 36,626	- 46,651
mar-15	353,099	- 15,827	- 62,478
abr-15	354,375	- 33,627	- 96,105
may-15	362,191	- 17,812	- 113,917
jun-15	369,267	- 871	- 114,788
jul-15	381,138	37,213	- 77,575
ago-15	373,015	- 55	- 77,630
sep-15	362,269	33	- 77,597
oct-15	355,271	- 11,463	- 89,060
nov-15	352,785	- 31,858	- 120,918
dic-15	351,608	- 29,272	- 150,190

Savings in year 2 (baseline year 1)

Mes	Expected (baseline 2015)	Act-Exp (baseline 2015)	CUSUM savings (baseline 2015)
ene-16	324,341	- 11,147	- 11,147
feb-16	324,231	- 9,218	- 20,364
mar-16	325,036	300	- 20,064
abr-16	326,865	- 13,250	- 33,314
may-16	337,055	- 18,249	- 51,564
jun-16	370,754	- 10,289	- 61,853
jul-16	396,111	- 26,008	- 87,861
ago-16	391,592	- 20,561	- 108,422
sep-16	365,943	- 7,993	- 116,415
oct-16	337,988	- 12,918	- 129,334
nov-16	325,017	- 43,366	- 172,700
dic-16	324,176	- 117,706	- 290,406

Savings in year 3 (baseline year 2)

Method 2:

Mes	Expected (baseline 2013)	Act-Exp (baseline 2013)	CUSUM savings (baseline 2013)
ene-14	400,246	- 33,326	- 33,326
feb-14	400,246	- 57,515	- 90,841
mar-14	402,777	- 37,566	- 128,407
abr-14	410,148	- 57,556	- 185,963
may-14	416,351	- 64,362	- 250,325
jun-14	430,690	- 71,179	- 321,504
jul-14	441,565	- 54,720	- 376,224
ago-14	445,306	- 82,754	- 458,978
sep-14	427,241	- 62,301	- 521,279
oct-14	413,027	- 46,454	- 567,733
nov-14	400,969	- 65,317	- 633,050
dic-14	400,204	- 49,350	- 682,400
ene-15	400,232	- 58,682	- 741,082
feb-15	400,218	- 85,275	- 826,357
mar-15	403,472	- 66,200	- 892,558
abr-15	406,184	- 85,436	- 977,994
may-15	422,804	- 78,425	- 1,056,419
jun-15	437,852	- 69,456	- 1,125,875
jul-15	463,094	- 44,743	- 1,170,619
ago-15	445,821	- 72,861	- 1,243,480
sep-15	422,971	- 60,669	- 1,304,149
oct-15	408,090	- 64,282	- 1,368,430
nov-15	402,805	- 81,878	- 1,450,308
dic-15	400,302	- 77,966	- 1,528,274
ene-16	400,343	- 87,149	- 1,615,423
feb-16	400,260	- 85,247	- 1,700,670
mar-16	400,872	- 75,536	- 1,776,206
abr-16	402,263	- 88,648	- 1,864,853
may-16	410,009	- 91,203	- 1,956,056
jun-16	435,627	- 75,162	- 2,031,218
jul-16	454,903	- 84,800	- 2,116,018
ago-16	451,468	- 80,437	- 2,196,454
sep-16	431,969	- 74,019	- 2,270,474
oct-16	410,718	- 85,648	- 2,356,122
nov-16	400,858	- 119,207	- 2,475,329
dic-16	400,218	- 193,748	- 2,669,077

Savings in year 3 (baseline year 0)

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Multi-year CUSUM with updated Baselines

- You have a baseline based in 2018
  - The CUSUM shows savings of 100,000 kWh in 2019.
- Then you set a new baseline for 2019, using the same variables.
  - The CUSUM shows savings of 200,000 kWh in 2020 compared with 2019 baseline.
- What is the cumulative savings in 2019 and 2020 compared with the 2018 baseline?

a) 200,000 kWh b) 300,000 kWh c) 400,000 kWh

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Savings based on implemented measures

- Sometimes, it is not possible to verify savings using a model:
  - Lack of data to develop a model.
  - The model is not strong enough.
  - Etc.
- In those cases it is possible to verify savings based on the implemented saving measures.

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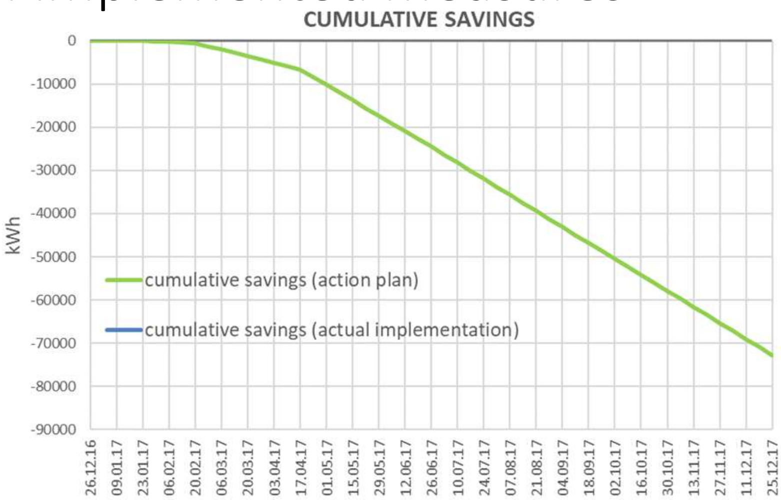
Savings based on implemented measures

Measure	Weekly savings (kWh)	Expected competion date
Measure 2	35	01/02/17
Measure 10	97	01/02/17
Measure 3	17	01/03/17
Measure 4	69	01/03/17
Measure 5	96	01/03/17
Measure 6	28	01/03/17
Measure 7	15	01/03/17
Measure 11	95	01/03/17
Measure 12	95	01/03/17
Measure 13	953	01/03/17
Measure 14	191	01/03/17
Measure 1	84	01/04/17
Measure 8	20	01/06/17
Measure 9	58	01/07/17



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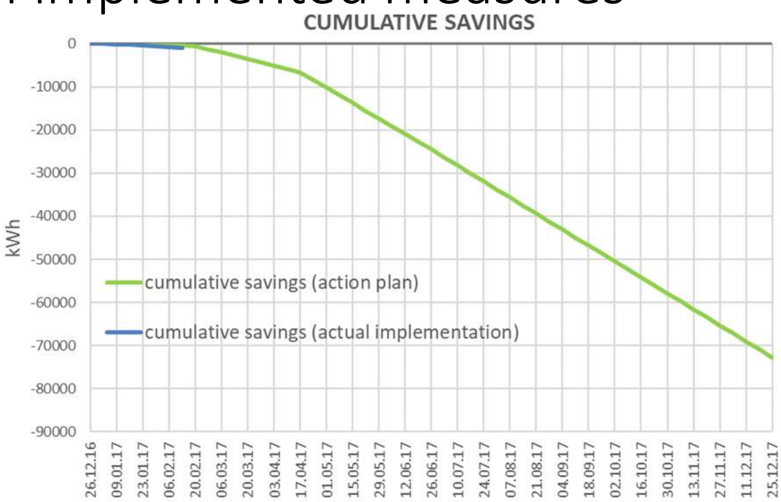
Savings based on implemented measures

Measure	Weekly savings (kWh)	Expected competion date	Date of completion
Measure 2	35	01/02/17	30/01/17
Measure 10	97	01/02/17	16/01/17
Measure 3	17	01/03/17	
Measure 4	69	01/03/17	
Measure 5	96	01/03/17	
Measure 6	28	01/03/17	
Measure 7	15	01/03/17	
Measure 11	95	01/03/17	
Measure 12	95	01/03/17	
Measure 13	953	01/03/17	
Measure 14	191	01/03/17	
Measure 1	84	01/04/17	
Measure 8	20	01/06/17	
Measure 9	58	01/07/17	02/01/17



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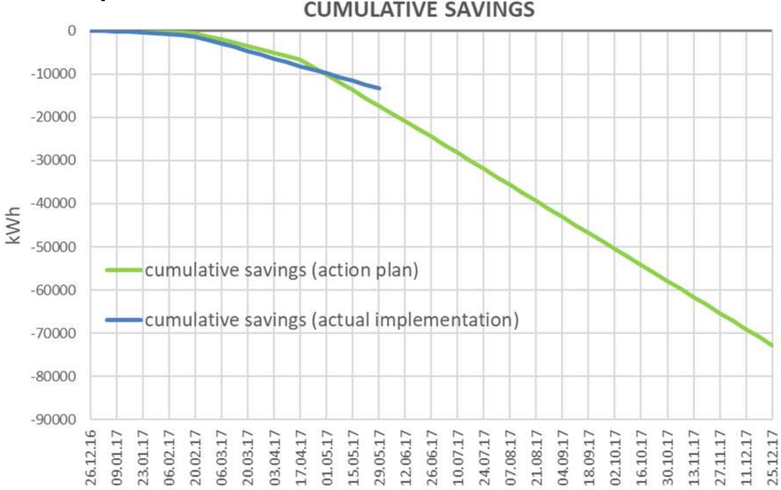
Savings based on implemented measures

Measure	Weekly savings (kWh)	Expected competion date	Date of completion
Measure 2	35	01/02/17	30/01/17
Measure 10	97	01/02/17	16/01/17
Measure 3	17	01/03/17	06/03/17
Measure 4	69	01/03/17	20/02/17
Measure 5	96	01/03/17	20/02/17
Measure 6	28	01/03/17	27/02/17
Measure 7	15	01/03/17	06/03/17
Measure 11	95	01/03/17	27/02/17
Measure 12	95	01/03/17	27/02/17
Measure 13	953	01/03/17	
Measure 14	191	01/03/17	27/02/17
Measure 1	84	01/04/17	20/03/17
Measure 8	20	01/06/17	
Measure 9	58	01/07/17	02/01/17



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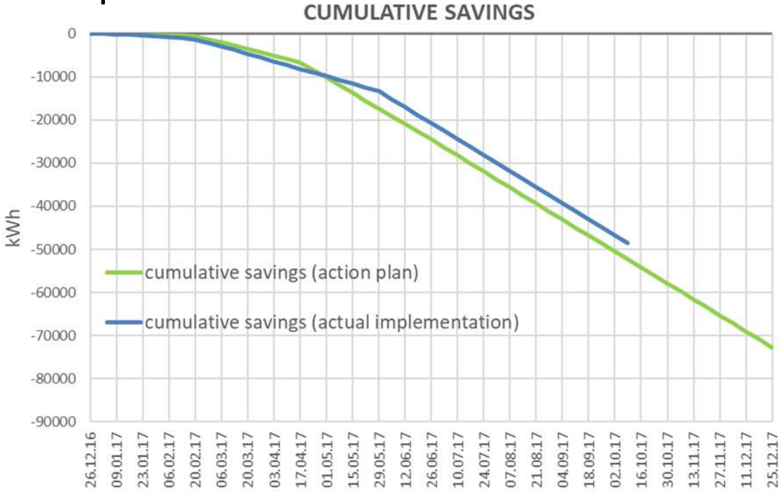
Savings based on implemented measures

Measure	Weekly savings (kWh)	Expected competion date	Date of completion
Measure 2	35	01/02/17	30/01/17
Measure 10	97	01/02/17	16/01/17
Measure 3	17	01/03/17	06/03/17
Measure 4	69	01/03/17	20/02/17
Measure 5	96	01/03/17	20/02/17
Measure 6	28	01/03/17	27/02/17
Measure 7	15	01/03/17	06/03/17
Measure 11	95	01/03/17	27/02/17
Measure 12	95	01/03/17	27/02/17
Measure 13	953	01/03/17	05/06/17
Measure 14	191	01/03/17	27/02/17
Measure 1	84	01/04/17	20/03/17
Measure 8	20	01/06/17	26/06/17
Measure 9	58	01/07/17	02/01/17



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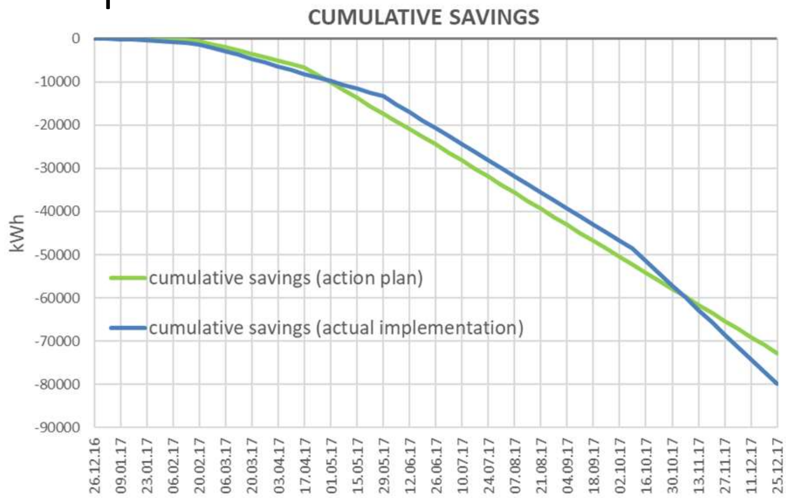
Savings based on implemented measures

Measure	Weekly savings (kWh)	Expected competion date	Date of completion
Measure 2	35	01/02/17	30/01/17
Measure 10	97	01/02/17	16/01/17
Measure 3	17	01/03/17	06/03/17
Measure 4	69	01/03/17	20/02/17
Measure 5	96	01/03/17	20/02/17
Measure 6	28	01/03/17	27/02/17
Measure 7	15	01/03/17	06/03/17
Measure 11	95	01/03/17	27/02/17
Measure 12	95	01/03/17	27/02/17
Measure 13	953	01/03/17	05/06/17
Measure 14	191	01/03/17	27/02/17
Measure 1	84	01/04/17	20/03/17
Measure 8	20	01/06/17	26/06/17
Measure 9	58	01/07/17	02/01/17
Measure 15 (extra)	1000	-	16/10/17



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Other uses for regression

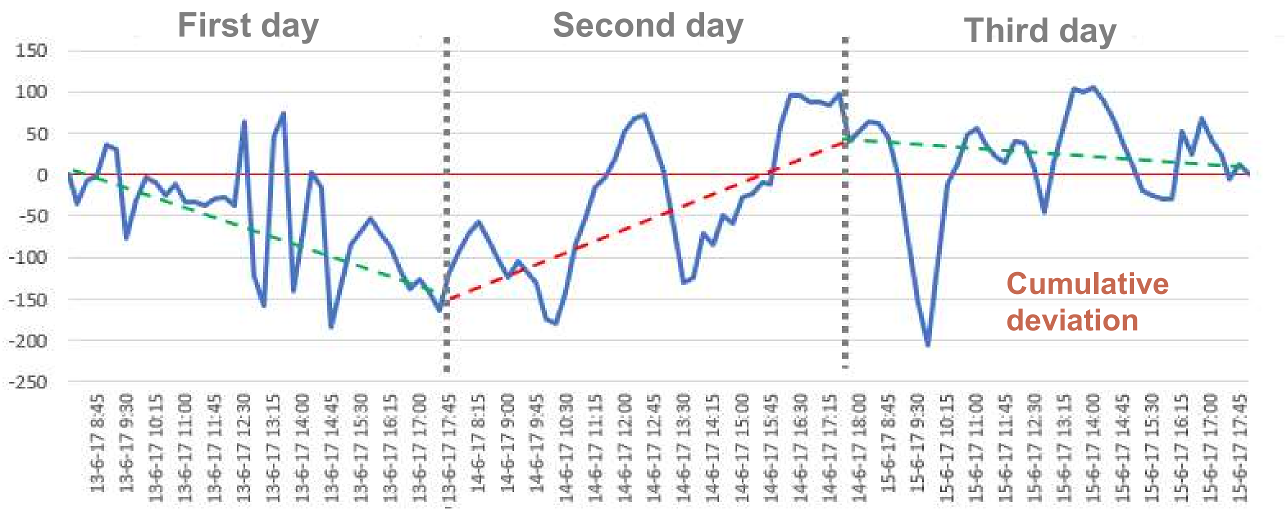
44

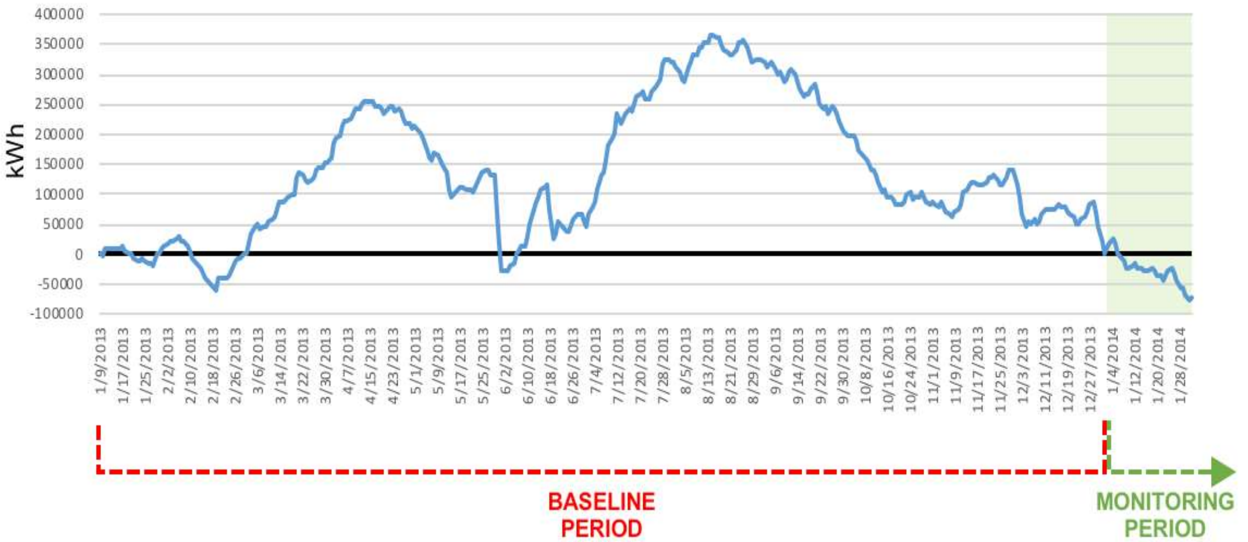
5 pharmaceutical steps, regression result

Adj R2	0.87

	Coefficients	P-value
Intercept	46226.40	2.124E-44
	2678.35	6.8194E-06
	1509.17	0.00734594
	2594.21	4.5297E-06
	2290.86	0.08203344
	1238.05	0.00986137
CCD10	159.08	0.00041744

Energy Saving trial – chiller automation





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Benchmarking

- What is it?
  - Comparing with others
- If you can't use kWh/m2 or kWh/unit of production, what can you do?
- For similar facilities or similar processes:
  - Compare regression coefficients; intercept and others

  OR

  - Regression using location in place of date; only one data point need for each location

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Next steps

- Review your current energy performance monitoring practices
- Challenge your current performance metrics
- Review data; sources and quality
- Communicate the performance monitoring results to decision makers and performance influencers
- Take action to improve performance
- Monitor absolute annualised CO_2 and normalised energy and CO_2

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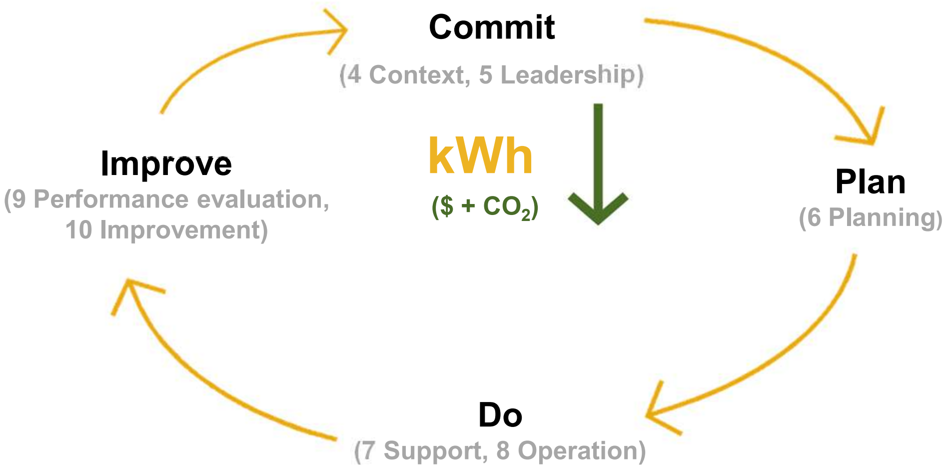
EnMS Cycle



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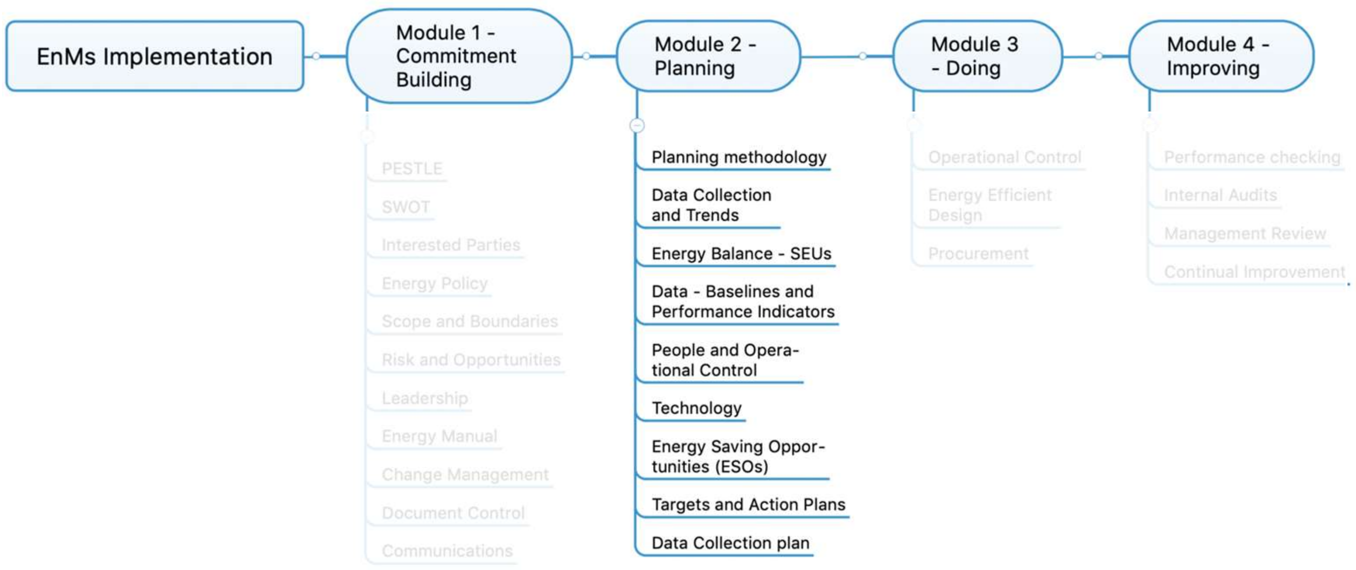

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	AGENDA
Part 1	Step 5 – Technology ESOs
Part 2	Step 4 – People and operational control
	Break
Part 3	Workshop

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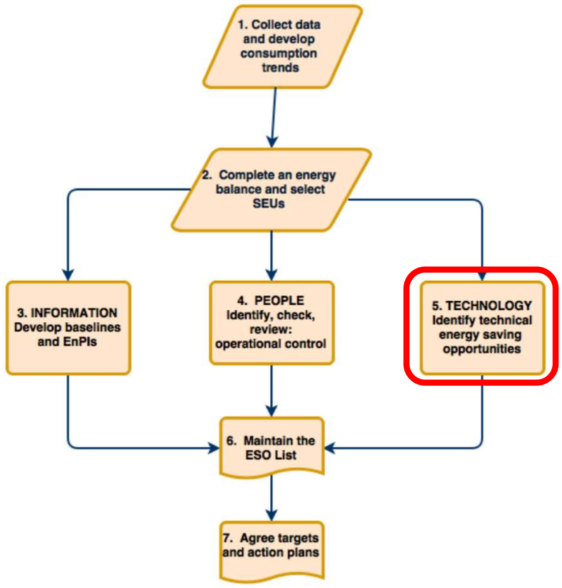
Planning workflow

Identify energy saving opportunities related to tecnology



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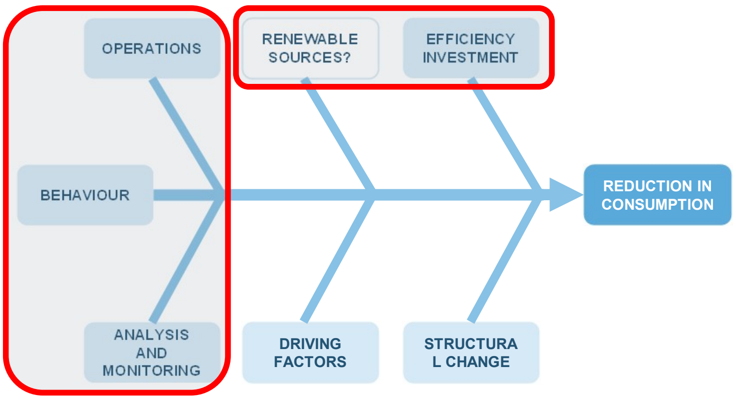
Planning reduction in energy consumption



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Identify technical ESOs

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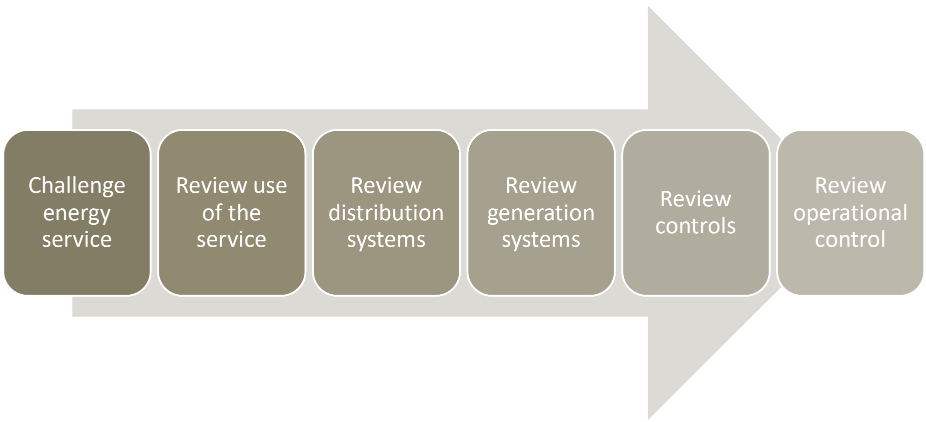
Identify energy saving opportunities



Note: review of energy consumption data and trends can help with all steps

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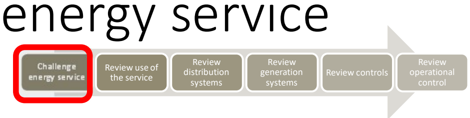
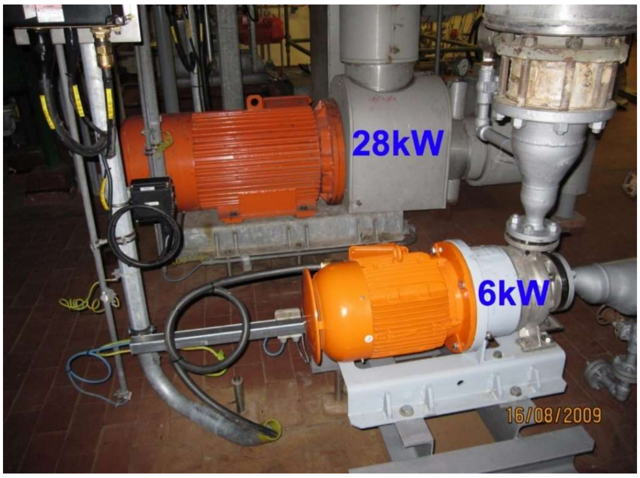
Step 1 – Challenge the energy service



- What is required by the end user?
- Why is it required?
- Is it really required?
- Why is it really required?
- Why? Why? Why?
- Buildings example
  - Temperature (heating and cooling)
  - Humidity
  - Light levels
  - Fresh air



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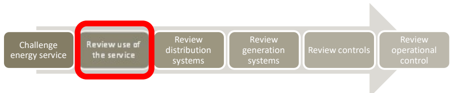
Step 2 – Review use of the service



- This will be covered in another session

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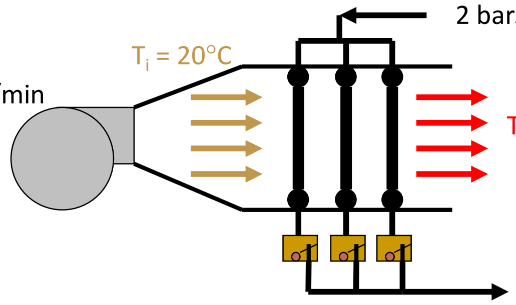
Example Steam Demand (Pre-heat air)



$$Q_{air} = m_{air} C_{p\_air} \left(T_{out} - T_{in}\right)_{air}$$

$$Q_{air} = 2{,}000 \times 1.188 \times 1.006 \times (80 - 20) \times \frac{1}{60}$$

$$Q_{air} = 2{,}391\, kW$$

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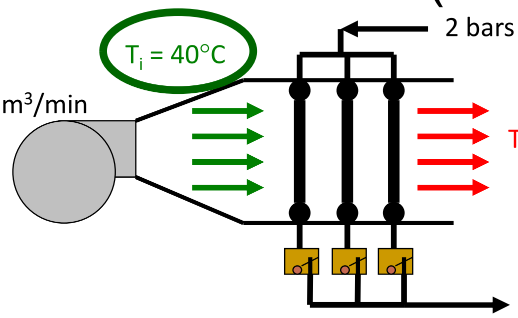
Example Steam Demand (Pre-heat air)



$$Q_{air} = m_{air} C_{p\_air} \left(T_{out} - T_{in}\right)_{air}$$

$$Q_{air} = 2{,}000 \times 1.188 \times 1.006 \times (80 - 40) \times \frac{1}{60}$$

$$Q_{air} = 1{,}594\, kW$$

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Example Steam Demand (Pre-heat air)

- Energy Savings = 2,391 – 1,594 ≈ 796 kW

$$m_{steamsaved} = \frac{EnergySavings}{\left(h_{steam} - h_{condensate}\right)}$$

$$m_{steamsaved} = \frac{796}{\left(3{,}181 - 561.5\right)} \times 3{,}600$$

$$m_{steamsaved} = 1{,}094 \frac{kg}{\text{hr}}$$

- Steam saved = 1.094 * 8,760 = 9,582 tonnes/yr
- Unit cost of steam generation: $91.67 per tonne
- Annual cost savings = $878,000

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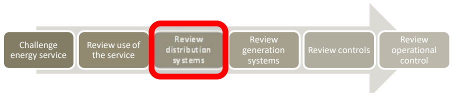
Step 3 – Review distribution systems

- Insulation



- Pressure drops, bends, restrictions, pipe size, etc.
- Leaks
- Transformers
- Losses
- Pumping and pump control
  - 3 port control valves
  - Variable speed drives (VSDs)

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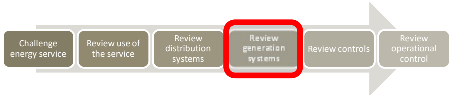
Step 4 – Review generation systems



- Boilers
- Chillers
- Generators
- Co-generation
- Pumps
- Compressors

Magnetic levitation refrigeration compressor

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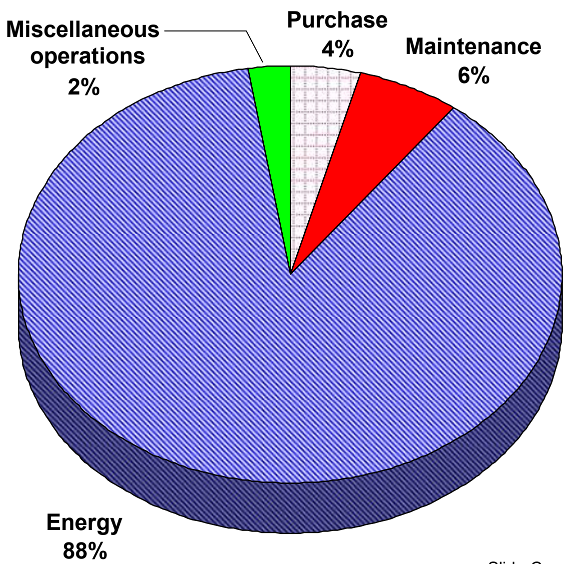
Life cycle cost - 200kW pump and motor



Slide Courtesy of Oak Ridge National Laboratory

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Pumps equation

- The power of a pump is proportional to the product of the head (H) and the flow (Q), divided by the efficiency of the pump. If flow in l / min and H in meters, the pump power in kW is:

$$kW_P = \frac{Q \times H \times 9.8}{60{,}000 \times Ef}$$

- Significant savings can be achieved:
  - Decreasing the flow
  - Reducing pressure

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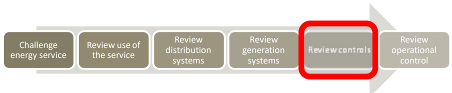
Step 5 – Review control systems



- Automation of use
  - Temperature control
  - PIR for lighting
- Automation of distribution
  - Pump pressure control
  - Reset of pump pressure
- Automation of generation
  - Boiler/Chiller/Generator controls
  - Sequencing of multiple units
  - Start/Stop
  - Reset of supply temperature and pressure

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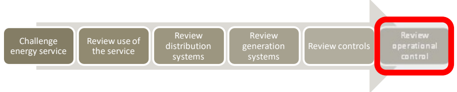
Step 6 – Review operational control



- Covered in another session

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ISO 50002: Energy audit process flow

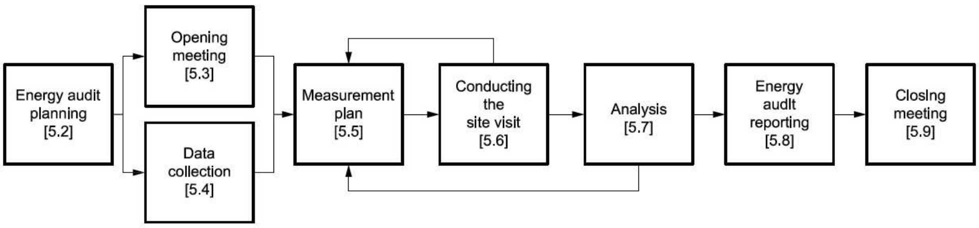

Figure 1 — Energy audit process flow diagram

Source: ISO 50002:2014

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ISO 50002 Energy audit types

Type 1
- Preliminary
- Low cost
- SME

Type 2
- More detailed
- Data profile
- Basic design

Type 3
- Comprehensive
- Single system or whole facility
- Investment grade

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Examine potential for renewables and alternative energy sources

- Which renewable sources are available?
  - Solar PV or solar thermal
  - Biomass or biofuel
  - Wind
- Which renewable technologies are economical with these resources?
- Which alternative energy sources are available?
  - Waste heat
  - Free cooling
- Co-generation (Combined Heat and Power (CHP)
- Tri-generation (Heat, cooling and electricity using absorption chilling)
- Which alternative technologies are economical?
- Heat Pumps to aid electrification

ENERGY EFFICIENCY FIRST!

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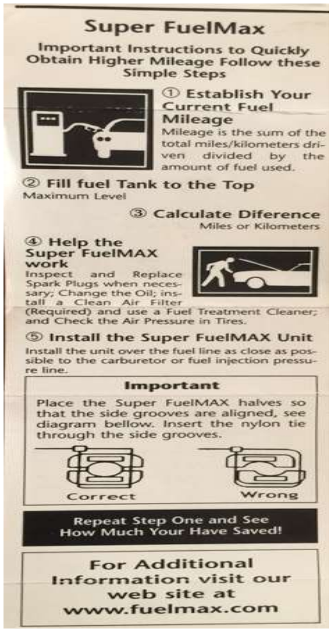
What about “magic” solutions?

- Lubricants for refrigeration
- Controllers for refrigeration
- Controllers for boilers
- Magnets for fuel pipes
- Voltage optimisation
- Power Factor Correction as an energy saving tool (reduce Amps but not much kWh)



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Planning Notes

- Continual improvement v planning “phase”
- Continually develop energy saving ideas
- Typically complete data analysis (EnB’s) annually
- Ideally monitor performance weekly (monthly if only billing data is available)
- Future Energy Consumption
  - Financial budgets

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Exercise

Pick one of your SEUs:

1. Challenge specifications
2. Consider distribution
3. Consider generation
4. Consider controls
5. Start to add items to your ESO list
   a. What technology related items can you think of?
   b. How will you estimate cost and savings?
   c. What risks might you encounter for each?
   d. How will you measure the actual savings?

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Review people and operational control

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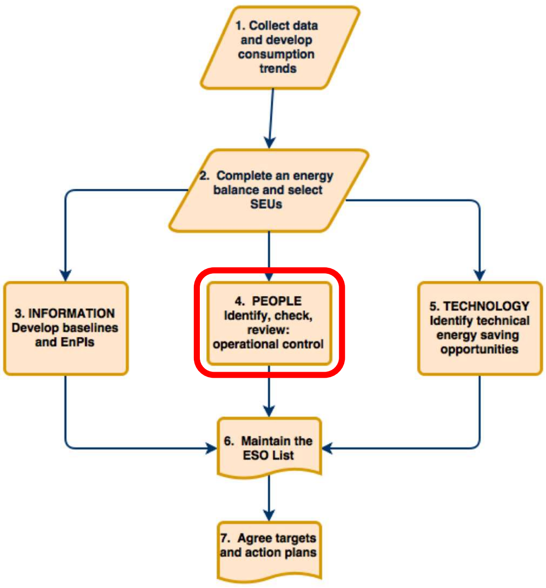
People

- Operational Control
  - Operations
  - Maintenance
- Critical operating parameters
- Competence
- Training



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Critical Operating parameters

SEU (inc use)	Parameter	Eng Units	Normal set point or value	Upper Limit	Lower Limit	Measuring Instrument Designation	Accuracy/Calibration Frequency	Who needs to be informed of these values?	Who needs to be informed of deviations?	Note
Steam system	Total Dissolved Solids	ppm	3500	3800	3400	TDS001	3 months	operators	supervisor	
Steam system	Boiler Pressure	bar	9.5	10	9	PT123	12 months	operators	supervisor	
Steam system	Exhaust Oxygen	% O2	3	3.5	2	Portable 123	6 months	operators	supervisor	
Steam system	Stack Temperature	DegC	N.A.	300	N.A.	TT124	12 months	operators	supervisor	Varies with firing rate
Pump 28	Differential pressure	bar	3	3.3	2.7	P28	24 months	Refrigeration	supervisor	
Refrigeration	Temperature Lift	DegC	25+/-10	35	15	T12 and T16	12 months	operators	supervisor	Varies with the ambient wet bulb temperature
Refrigeration	Condenser approach temperature	DegC	5	6	N.A.	T12	12 months	operators	supervisor	
Refrigeration	Evaporator approach temperature	DegC	5	6	N.A.	T12	12 months	operators	supervisor	
Compressed Air	Compressor discharge pressure	bar	6	6.4	6	PT124	12 months	operators	supervisor	
Compressed Air	Compressor vs system pressure difference	bar	0.5	0.7	N.A.	PT127	12 months	operators	supervisor	

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Operation Control - examples

ID	SEU	Check	Method	Expectations	Corrective Action
1	Steam	Uninsulated pipes, valves, fittings, boiler fittings	Infra red thermometer, thermal imaging camera, surface temperature probe, your hand (don't touch hot surfaces!)	It should be possible to keep ypur hand on all insulated surfaces without pain	Repair, replace, upgrade insulation
2	Steam	Condensate return rate	Compare make up water flow rate with steam rate. Steam rate can be estmamted from fuel flow rate if a steam meter is not available	Dependent on the process conditions. If steam is not lost to the process e.g. by sparging, humifdification ,etc. then over 80% condensate return is achievable	Check condensate return units, flash steam (are there visible steam plumes), repair traps, are there condensate or steam leaks, open drains, ???
3	Steam	Steam leaks	Usually very visible and noisy	There should be none	Repair, check gaskets and seal materials for suitability, warm steam lines slowly

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Cold Rooms

- ✓ Keep the door closed as much as possible
- ✓ Do not obstruct evaporator airflow
- ✓ Minimise heat sources in the cold store
  - ✓ Lights, people
- ✓ Report ice on the floor and walls of the store
- ✓ Indicates air is entering the room, bringing with it moisture
- ✓ Do not keep the room colder than necessary
- ✓ Reduce the number of cold rooms

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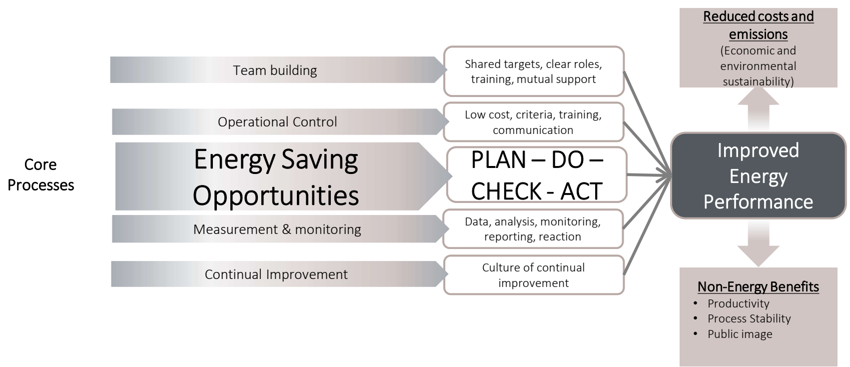
EnMS processes – the importance of the ESO list



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Energy Management Systems (EnMS)

Module 3 – Doing

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	AGENDA
Part 1	Communications and awareness
	Break
Part 2	Communications exercise
	Break
Part 3	Data collection plans

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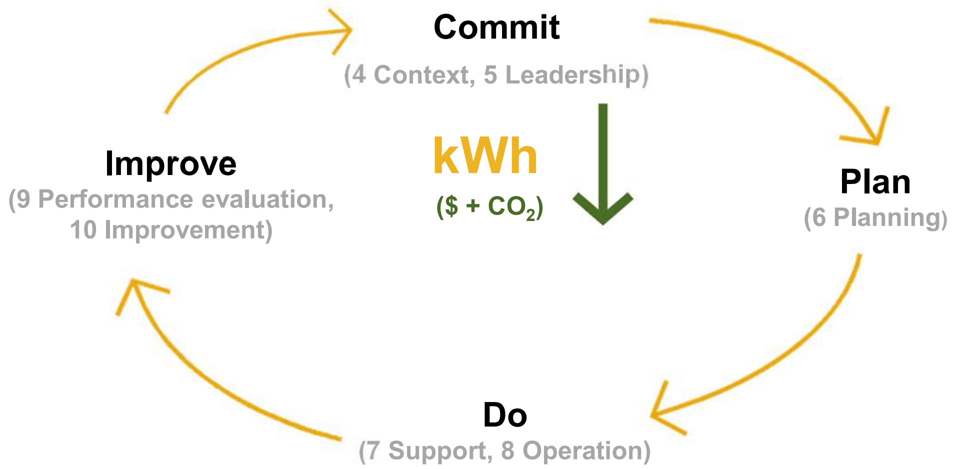
EnMS Cycle



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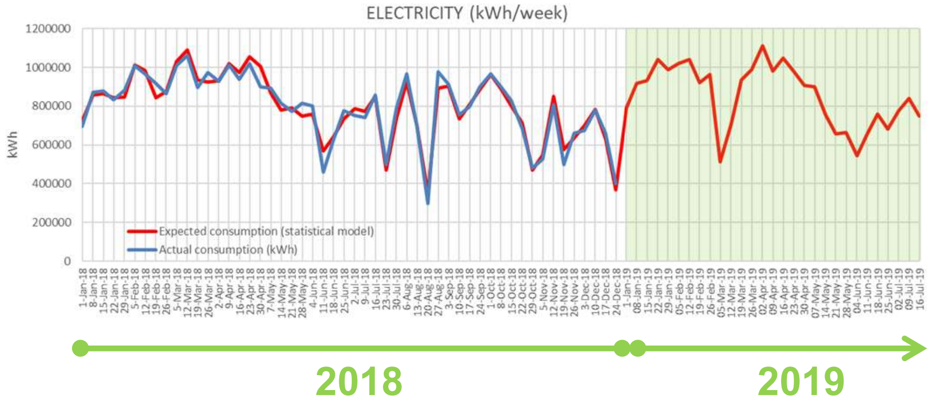
LML1

ELECTRICITY: Using the model to predict values in 2019



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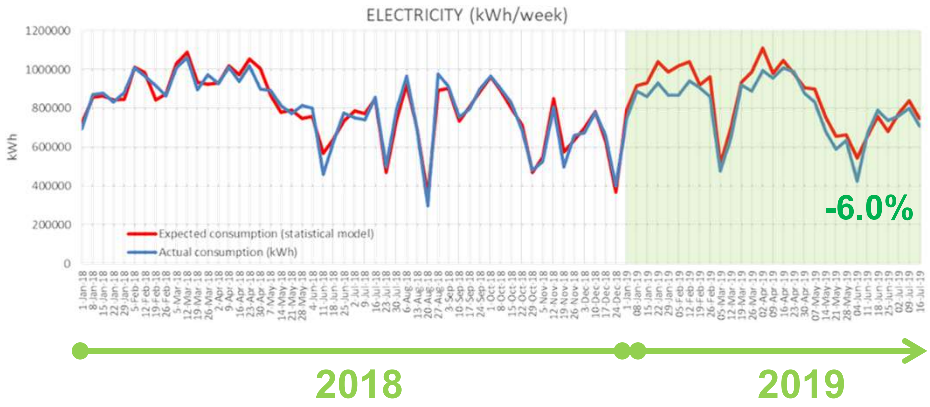
ELECTRICITY: Calculating real savings



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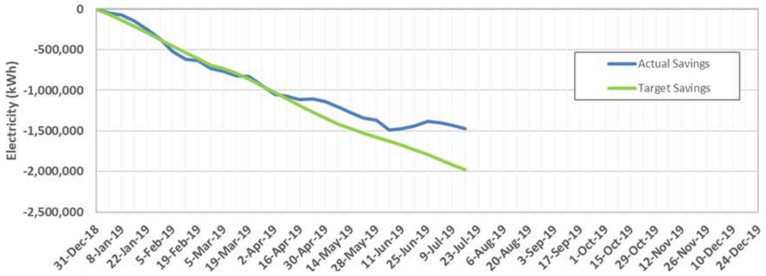
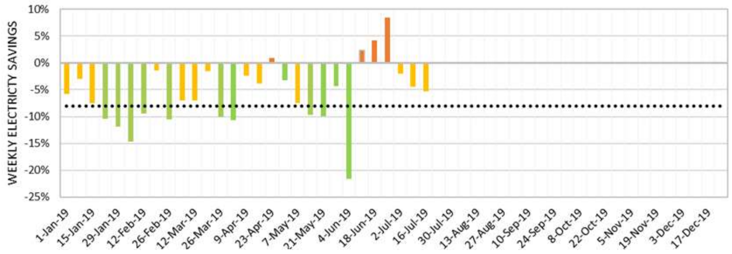
LML1 Develop this idea of predicting future energy consumption somewhere else with different data
Liam Mc Laughlin; 2021-11-15T12:13:46.925

ELECTRICITY: Showing the results



Cumulative savings VS cumulative target



Weekly savings (%) VS Weekly target

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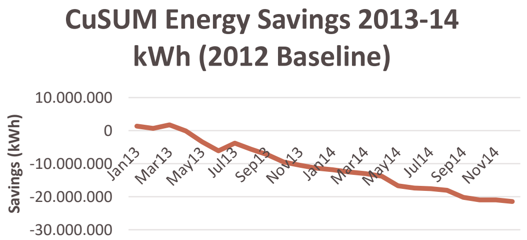
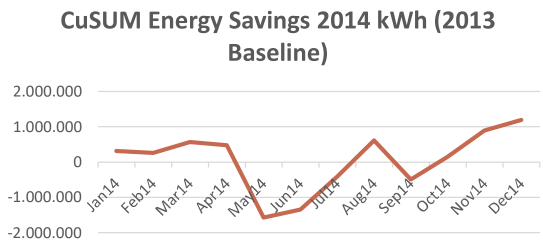
Updating Baselines

- Different results depending on which year is selected as baseline
- Using 2012 baseline 2014 looks good
- Using 2013 baseline 2014 is not good
- Select based on which is the most representative,





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Different aspects of performance measurement

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eg1

Section	Common application
Legal and other requirements	In some countries there is a legal requirement to measure and report specific energy consumption (SEC). The same applies in some organisations. If this requirement exists, it must be conformed with. This a not substitute for monitoring the energy performance of the organisation itself as required in the planning and checking parts of an EnMS.
Planning	Part of the planning process is to develop energy baselines and energy performance indicators. These will be used to monitor the energy performance of the organisation. In order to be effective these need to be normalised for any relevant variables that affect energy consumption.
Awareness and training	The effectiveness of awareness campaigns could be measured by comparing behaviour before and after the campaign. For example one could count the number of personal computers left on when not in use before and after an awareness campaign.
Operational control	In developing operational controls for SEUs critical operating parameters will be established. Monitoring these parameters is a form of energy performance measurement.

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Diapositive 88

eg1 what is the header here ? intentsion of the slide
erik gudbjerg; 2021-11-12T09:52:27.109

Section	Common application
Design and Procurement	When selecting equipment and designs that will affect energy consumption or performance take account of the efficiency of the equipment and systems. This includes such factors as boiler efficiency, pump and motor efficiency, coefficient of performance of refrigeration systems, etc. These and other performance indicators should be used in combination with the cost of ownership over the life of the equipment and system.
Action plans	Completed action plan items need to have their actual savings measured and verified. This M&V activity is a form of energy performance measurement. It is a valid method where regression models are not possible.
Budgets and forecasting	Trends in absolute energy consumption are required to develop financial budgets and to monitor actual spending compared to budget.
Checking	All of the above need to be checked and compared with expected results

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Checking of savings from completed action plans

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Checking of savings from action plan items

- Has each item achieved its intended savings?
- Actual savings are always different to estimated savings
- Decide how to do this in advance of implementation

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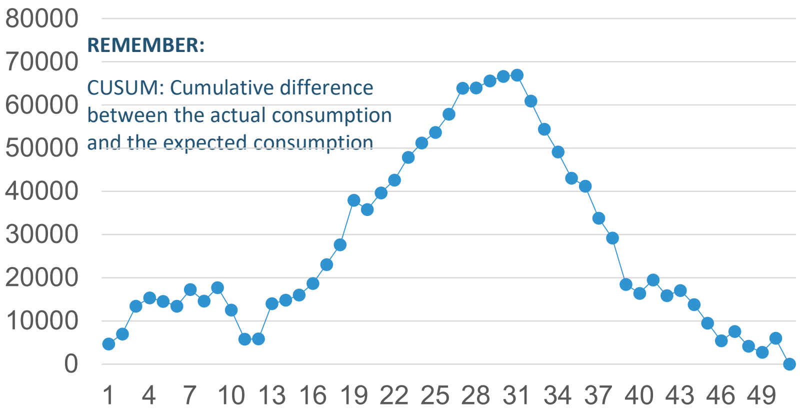
Setting an “aggressive but achievable” target



Initial CUSUM

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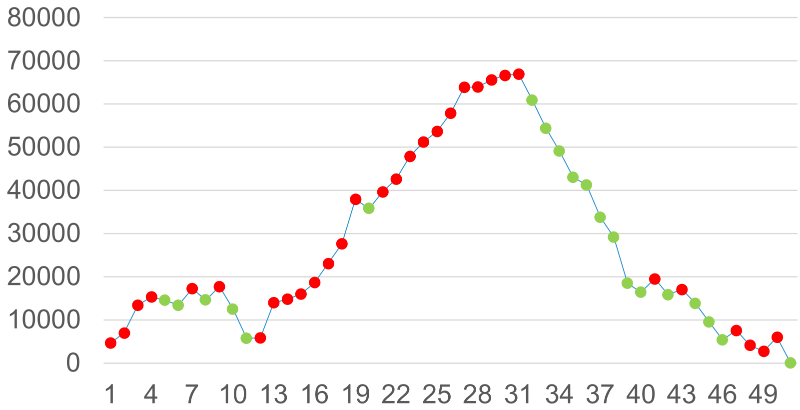
Setting an “aggressive but achievable” target



Period of best performance identified in Green

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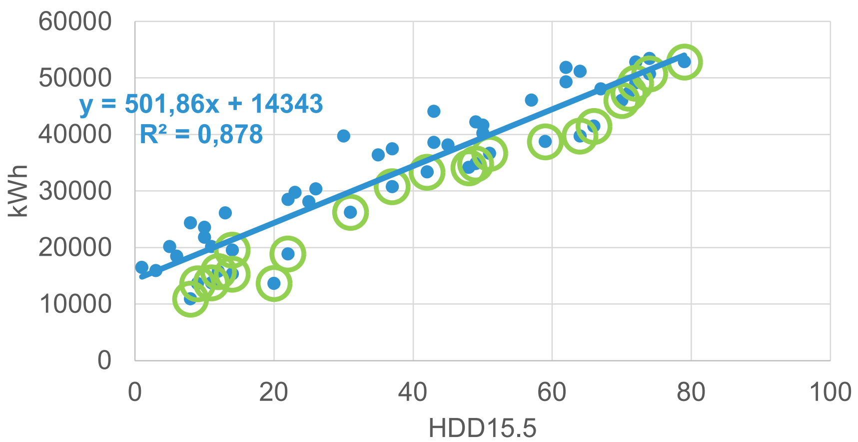
Setting an “aggressive but achievable” target



Raw data

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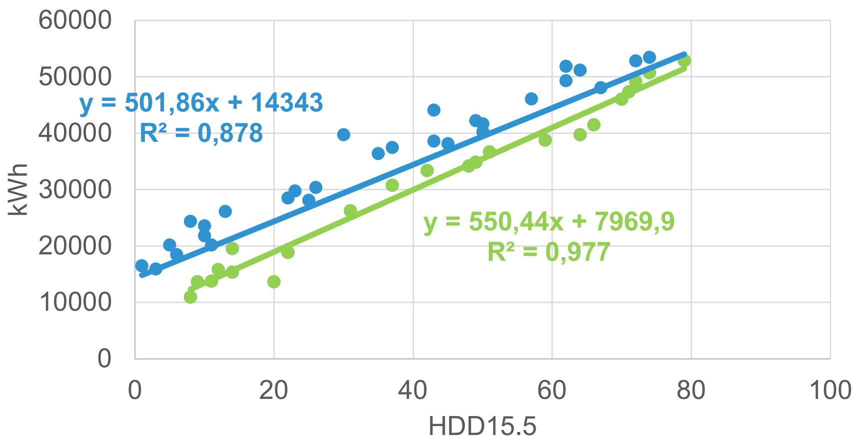
Setting an “aggressive but achievable” target



Regression of best performance period only

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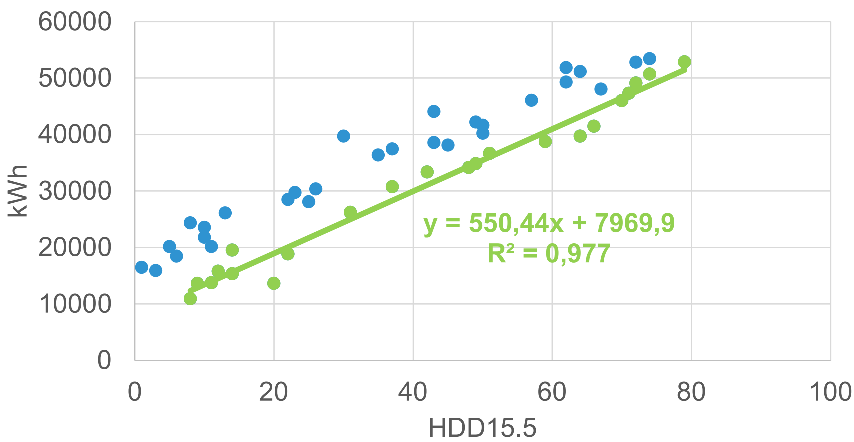
Setting an “aggressive but achievable” target



Best performance adopted as target

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Targets

Specific	• What is the task to be done, use action words • What are the details?
Measurable	• How will we know if the task is complete and how well?
Achievable	• Is it possible and fair? • Is training or personal development required?
Relevant	• Which objective is it supporting? • In what way is it improving our energy performance?
Timed	• When will it be completed or how often? • Does it need sub steps and are these SMART?

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Energy Management Systems (EnMS)

Online version

Module 4 – Improving

Day 2

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Internal Audits

Planning the audit

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Three Stages of Audit Activity

- **Planning for audits**
  - Schedules
  - Notifying auditors and auditees
  - Preparing checklist
  - Preparing an agenda
- **Conducting the audit**
  - Coordination with auditee
  - Interviews, observations and records
  - Auditor notes
- **Follow-up activities**
  - Reporting the findings (positive and negative)
  - Corrective actions

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Internal audit plan or schedule

Internal Audits plans					
Section	**SEU**	**Jan**	**Feb**	**Mar**	**Apr**
Context	Full scope of the EnMS	Charles Dickens			
Leadership	Operations		Agatha Chrisitie		
Planning	Facilities			Charles Dickens	
Support	Maintenance				
Operations	Facilities				
Performance evaluation	Full scope of the EnMS				
Improvement	Operations				

It is common to audit the full EnMS in one or two days annually

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Audit agenda

DAY 1

Start	End	Duration	Topic	People involved
08:30	09:00	00:30	Opening meeting	Top management and energy team
09:00	09:45	00:45	Site and EnMS overview	Energy manager (EM)
09:45	10:45	01:00	Context	EM and MR
10:45	11:00	00:15	Coffee Break	
11:00	12:00	01:00	Leadership	EM and MR
12:00	13:00	01:00	Roles & Responsibilities	EM and energy team
13:00	14:00	01:00	Lunch	
14:00	16:00	02:00	Site tour	EM
16:00	16:15	00:15	Coffee Break	
16:15	17:00	00:45	Planning process	EM

DAY 2

Start	End	Duration	Topic	People involved
08:30	09:15	00:45	Energy review: Data collection	EM and data person
09:15	09:45	00:30	Energy review: Energy balance and SEUs	EM and data person
09:45	10:00	00:15	Coffee Break	
10:00	11:00	01:00	Visit SEUs, check operations	EM and operations personnel
11:00	11:30	00:30	ESO list, action plans, objectives and targets	EM
11:30	12:00	00:30	Baselines and EnPis	EM and data person
12:00	12:45	00:45	Design and procurement	EM and responsible people
12:45	13:45	01:00	Lunch	
13:45	14:30	00:45	Support	EM and responsible people
14:30	15:15	00:45	Performance evaluation and improvement	EM
15:15	15:30	00:15	Coffee Break	
15:30	16:00	00:30	Prepare for closing meeting	Auditor(s)
16:00	16:45	00:45	Closing meeting and next steps	Top management and energy team

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Audit Methods

- Horizontal
  - By department plus interfaces
  - By section of ISO 50001
- Vertical
  - Downstream
    - [SEU(energy use and consumption) to Monitoring and Measurement (evaluation)]
  - Upstream
    - (monitoring and measurement to energy use and consumption)
- Process Audit
  - Significant energy uses
  - Objectives and targets
  - Internal auditing
- Combination

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Nonconformity

Nonconformity is a non-fulfillment of a requirement

Requirements can come from many places.

- ✓ ISO 50001
- ✓ Procedures
- ✓ Forms
- ✓ Records
- ✓ Verbal statements
- ✓ Legal and other requirements
- ✓ UNIDO requirements

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Internal Audit (IA) Checklist in the EnMS Tools

IA Checklist							
ID	Task	Interviewee	Questions	Explanation of what is required	Evidence required	Evidence received	Non-conformities/Improvement Opportunities

- For each requirement:
  - What is required?
  - Who should be able to answer?
  - What evidence is expected?
  - What evidence is seen during the audit?
  - Is there a non-conformity (NC) or an improvement opportunity (IO)
  - How will NCs and IOs be addressed?

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Context checklist

ID	Task	Interviewee	Questions
	4. Context		
1	External Context	Energy Manager	What are the external issues that relate to your current and future use of energy and your EnMS
2	Internal Context	Energy Manager	What are the internal issues that relate to your current and future use of energy and our EnMS
3	Interested Parties	Energy Manager	Who are the parties with needs, expectations and requirements related to your use of energy?
4	Identify all legal requirements applicable to the organisation's use of energy and comply with them	Energy Manager	Review legal requirements and check evidence of compliance
5	Define the boundaries of the EnMS	Energy Manager	What are the geographical and organisational boundaries of the EnMS?
6	Define the scope of the EnMS	Energy Manager	What are the energy sources in the scope of the EnMS? What activities are included and excluded?

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Leadership checklist

ID	Task	Interviewee	Questions
	5. Leadership		
7	Develop, publish and periodically review the energy policy	Energy Manager/Management Representative	Review the policy. Is it approved and communicated?
8	Define the different roles and responsibilities in the EnMS	Energy Manager and sample of personnel with energy roles.	Who is responsible for what? Does each person know and understand their role?
9	Ensure resources are available	Sample of energy personnel and the energy manager	Are there enough resources to implement the EnMS? Sample individuals to check if they have enough time to fulfil their roles
10	Top management will communicate the importance of the EnMS	Energy Manager	Review a sample of top management communications
11	Report EnMS and energy performance to top management	Energy Manager	Review a sample of the repo

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Planning checklist Part 1

ID	Task	Interviewee	Questions
	6. Planning		
12	Consider context (PESTLE and SWOT) in planning	Energy Manager	Where has the context been taken into account in developing energy plans?
13	Develop the methodology used for the energy review and what criteria are used	Energy Manager	What is the methodology used for the energy review and what criteria are used?
14	Collect energy data and develop consumption trends	Energy Manager	Review past, present and future energy use and consumption
15	Complete an energy balance and select the SEUs	Energy Manager	Review SEU list
16	Develop the energy saving opportunities (ESO) list including investments and operational control improvements	Energy Manager	Review ESO list including investments and operational control improvements

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Planning checklist Part 2

ID	Task	Interviewee	Questions
17	Develop the baseline and EnPIs for each energy source and each SEU.	Energy Manager	Review relevant variables affecting SEUs and review the current performance of SEUs. How is the baseline set and adjusted? How are EnPIs established?
18	Identify the personnel affecting energy use and consumption	Energy Manager	Which are the personnel affecting energy use and consumption
19	Investigate opportunities to reduce energy consumption in your technical systems	Energy Manager	What technical reviews have been carried to identify ESOs?
20	Develop action plans from the ESO list	Energy Manager	What are the action plans?
21	Set the objectives and energy targets taking account of the action plans	Top management	What are the objectives and/or targets?
22	Develop energy data collection plan	Energy Manager	What are the plans for measurement and data collections?

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Support checklist

	7. Support		
23	Ensure that relevant personnel understand their roles, responsibilities and are competent for their own role in the EnMS implementation	Energy Manager	How is it ensured that relevant people (RnR and others) are competent with respect to their impact on energy performance and the EnMS
24	Implement training plans and maintain training records	Energy Manager	Review training plans and training records
25	Ensure people are aware of EnMS, benefits, roles, impacts, link of behaviour to objectives and targets, consequences of departure from procedures	Energy Manager and sample of relevant people.	How are people aware of EnMS, benefits, roles, impacts, link of behaviour to objectives and targets, consequences of departure from procedures.
26	Ensure energy performance and the EnMS are communicated internally	Energy Manager	How are energy performance and the EnMS communicated internally?
27	All personnel need to be given an opportunity to comment and make suggestions to improve the EnMS.	Energy Manager	How can personnel comment or make suggestions to improve the EnMS?
28	Decide if there will be external communication.	Energy Manager	How is external communication managed and documented?
29	Develop a process to manage and control documented information	Energy Manager	How are documents and records controlled?

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Operation checklist

	8. Operation		
30	Ensure operational and maintenance criteria for SEUs are met	EM/operational and maintenance personnel	Review operational and maintenance criteria for SEUs and how they are documented, communicated and controlled. Review records to show that critical instruments are accurate
31	Ensure that new projects (including modified or renovated systems) with a significant energy impact are evaluated from an energy perspective	EM/Design personnel	How is energy performance considered in design of new, modified or renovated systems?
32	Decide the criteria for assessing energy use, consumption and efficiency over the lifetime of products, equipment and services	EM/procurement personnel	Have suppliers been informed that procurement is partly evaluated based on energy performance. What are the criteria for assessing energy use, consumption and efficiency over the lifetime of products, equipment and services?
33	Investigate opportunities related to the procurement of energy	EM/procurement personnel	Review samples of energy purchasing specifications and saving opportunities related to energy tariffs.

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Performance evaluation and improvement checklist

	9. Performance evaluation		
34	Monitor and evaluate energy performance	Energy Manager	How are actual and expected energy consumption compared and what action is taken when unexpected results are found?
35	Ensure that the objectives and energy targets are being achieved	Energy Manager/top management	What are they for the current year and the coming year if the review is late in the year? How are they set? Are objectives and targets being achieved?
36	Evaluate compliance with legal and other requirements	Energy Manager	What is the status of compliance?
37	Schedule and organise internal audits of the EnMS	Energy Manager	Review the internal audit plan and schedule
38	Attend the management review meeting	Energy Manager	Review previous management review meeting minutes, notes, presentations, and plans.
	10. Improvement		
39	Manage non-conformities and corrective actions related to the EnMS.	Energy Manager	Review non-conformity management and corrective actions

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Audit Evidence

- Based on facts and not opinion
- Evidence
  - Direct observation
  - Statement of fact
  - Documents, data, and records
- First-hand, verifiable
- Recorded

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Internal Audits

Conducting the audit and follow up

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Three Stages of Audit Activity

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  - Coordination with auditee
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  - Auditor notes
- **Follow-up activities**
  - Reporting the findings (positive and negative)
  - Corrective actions

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Interview Protocol

- Introductions
- Explain purpose
- Ask for relevant documentation
- Satisfy sample defined in checklist
- Consider any additional trails

(Cont'd)

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Interview Protocol (Cont'd)

- If no problems – continue audit
- If problems – establish the facts
- Get agreement on facts
- Inform auditee of findings
- Thank auditee

BE POLITE

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Interviewing Techniques

- Avoid questions that lead to useless information or no information
- Be a good listener
- Reflect information back to auditee to check understanding
- Coordinate and cross-check with other auditors
- Control the agenda
- Don't be led into areas that are not of intertest

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Evidence

- Evidence is collected typically through three methods:
  1. interviews;
  2. observations;
  3. review of documentation
- Evidence should be related to the intent, implementation or effectiveness of the system.
- Only information that is verifiable should be accepted as audit evidence.
  - Can include verbal or observed evidence
- Evidence relevant to the audit topics should be recorded.

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Taking Notes

- Auditors must take clear, complete, and accurate notes
- Notes should not be secret from the auditee

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Following Audit Trails

- Consider significance of leads
  - Assess effects on audit plan
  - Inform lead auditor (if applicable) of changes
  - Let organization know
- Actions on new audit trails
  - May follow immediately
  - May pass to another auditor
  - May audit next time/later

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Auditee Reactions to Findings

- Asks for solutions
- Persists in arguing the facts
- Volunteers other facts
- Complains about others
- Questions significance of findings

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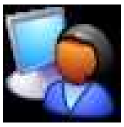
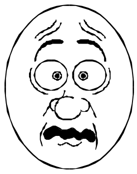
REMEMBER!

Purpose of the audit is to provide information to management. It is also to help employees get changes made and remove barriers.

It's not the people; it's the system!



Auditors have a great reputation;



but terror never provides good information!

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Three Stages of Audit Activity

- Planning for audits
  - Schedules
  - Notifying auditors and auditees
  - Preparing checklist
  - Preparing an agenda
- Conducting the audit
  - Coordination with auditee
  - Interviews, observations and records
  - Auditor notes
- Follow-up activities

  Reporting the findings (positive and negative)

  Corrective actions

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What is a Positive Finding?

- Practice matches requirements (criteria)
- Records demonstrate conformance
- Targets are achieved and demonstrated
- Beyond

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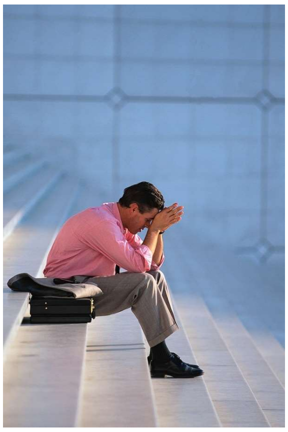
What is a Negative Finding?

- Practice does not match requirements (criteria)
- Records do not support requirements
- Inconsistent answers
- System is not effective



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Definition: Nonconformity

"non-fulfillment of a requirement"

Source: Definition 3.3.3

ISO 50001:2018

Failure to demonstrate energy performance improvement is a major non-conformity

This is related to certification

Source: Definition

ISO 50003:2014

"Confirmation of energy performance improvement is required for ….. granting certification"

ISO 50003:2014

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Nonconformity Occurs When

- Organization does not meet the requirements of the ISO 50001 standard
- Organization does not meet the criteria it has established itself
- Management system is not effective
- Energy performance is not improving

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Identifying Nonconformities

- What are the specific facts?
- What department, line, activity...
- What was observed?
- What was said? By whom?
- What does it not meet?
- Which paragraph of ISO?

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Corrective Action Processes

- Identify the problem and take immediate actions
- Investigate and determine the root cause
- Evaluate the need for action and develop a solution
- Implement the solution
- Record results
- Review for effectiveness

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Root Cause Analysis

- 5 Whys
  - A technique that involves asking why until the question cannot be answered any further
- Fishbone diagram
  - A pictorial technique clearly showing cause and effect relationships
- IS/IS NOT
  - A technique that involves the comparison of two situations, one that exhibits the problem and one that does not, in order to determine the differences in the two situations

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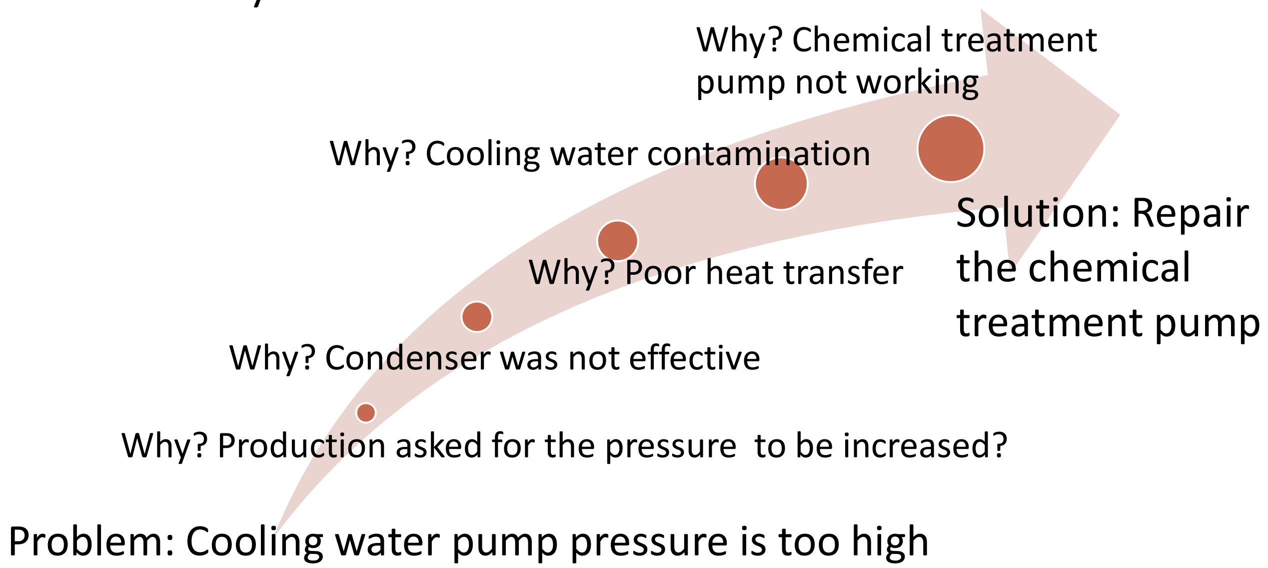
Five Whys



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Is/Is not analysis

	Is	Is not
What	Heating on in warm weather	Heating is not off in summer
Symptoms	Boiler is operating	Boiler is not off in summer
When	All year around	One season only
Where	Specific offices	Not all offices
Who	Occupants of specific offices	Occupants of all offices

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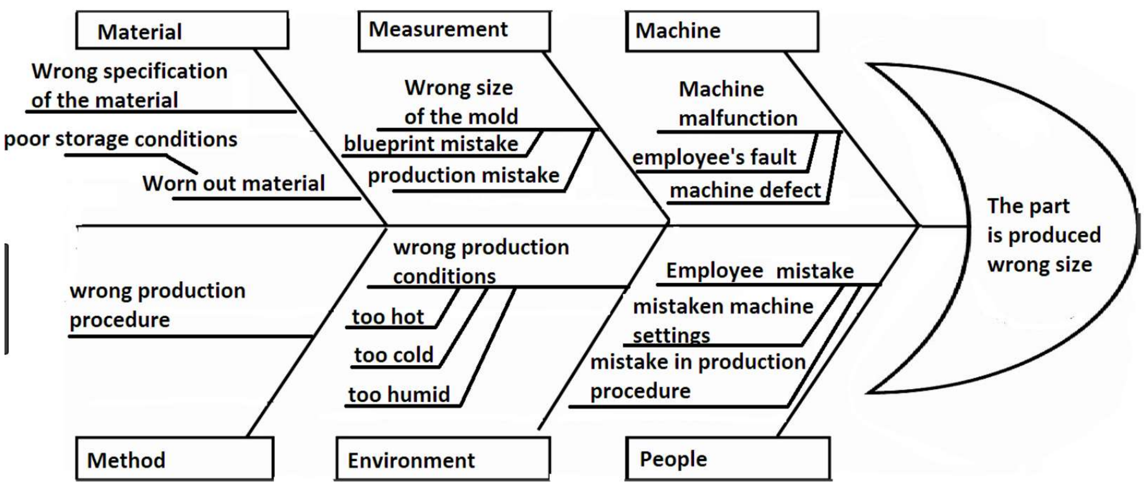
Fishbone or Ishikawa diagram – cause and effect



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Corrective Actions

- Resolve the immediate or potential problem.
- Consider whether the same or similar problems exist elsewhere in the organization.
- Prevent the problem from recurring.
  - Correct the root cause.
- Define the responsibilities and schedules for actions.
- Evaluated regularly for effectiveness.
- Monitor until they are closed.

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Success Factors

- If you have an effective corrective action system in use for another management system and it is effective, use it or replicate it!
- Ensure root cause process is thorough and appropriate.
- Corrective action detailed tracking is important to ensure issues across a facility are evaluated for similarities.
- Corrective action tracking is key to ensure timely resolution of issues.

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Audit Report Content

- Audit scope
- Audit criteria
- Audit objectives
- Identification of audit team
- Identification of auditee
- Dates and places of audit

- General observations
- Non-conformities
- Opportunities for improvement
- Good practice identified
- Processes/areas not audited
- Distribution list

Source: ISO 19011

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Closure with Management

Successful verification

↓

Effective implementation

↓

Report audit results at management review

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