Energy Management System (EnMS) Implementation Training

Trainers

UNIDO International Energy Efficiency Expert

Day 1 Afternoon

Based on the contents of the UNIDO EnMS Student Training Manual

Country
Date

Day 1

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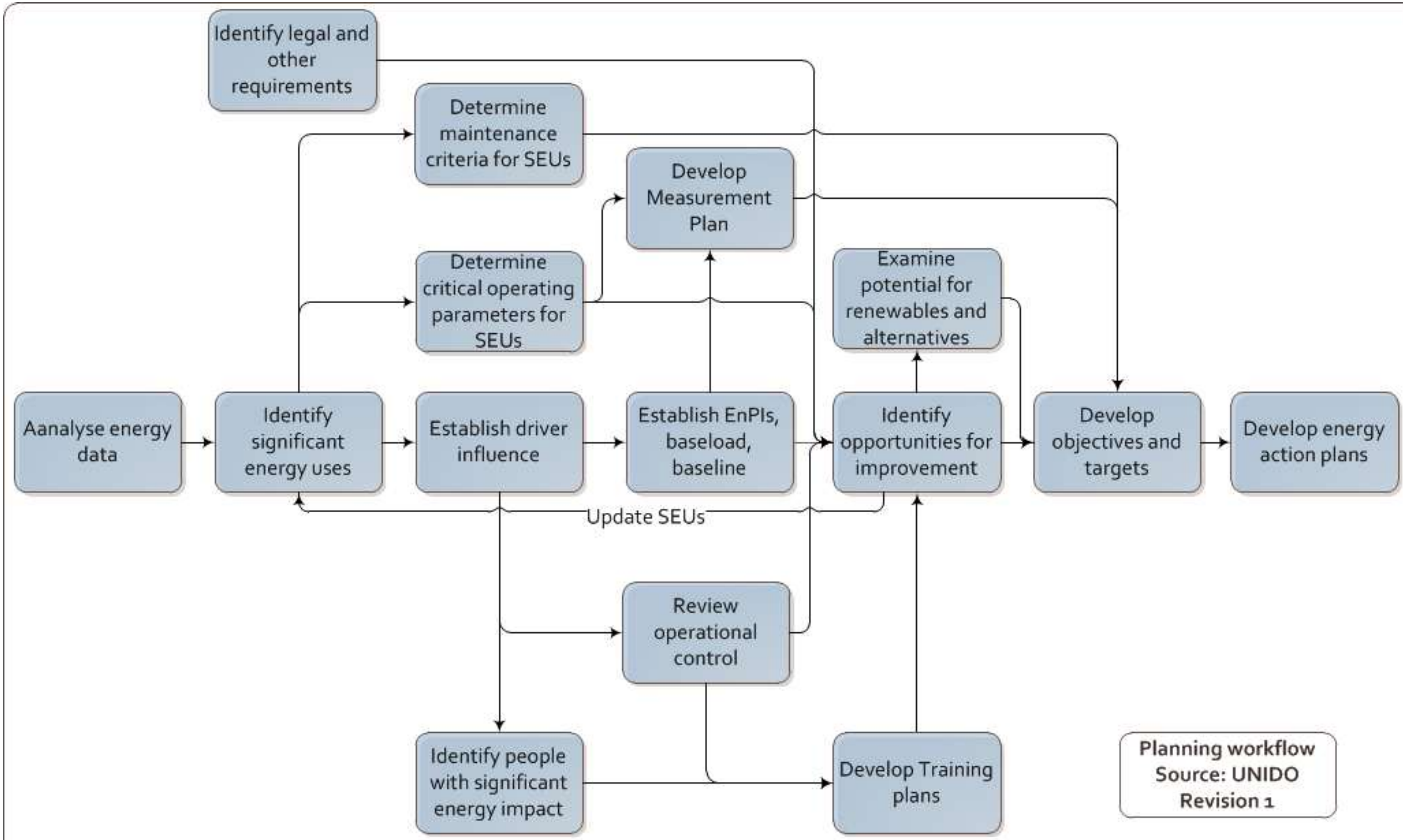

Planning workflow
Source: UNIDO
Revision 1

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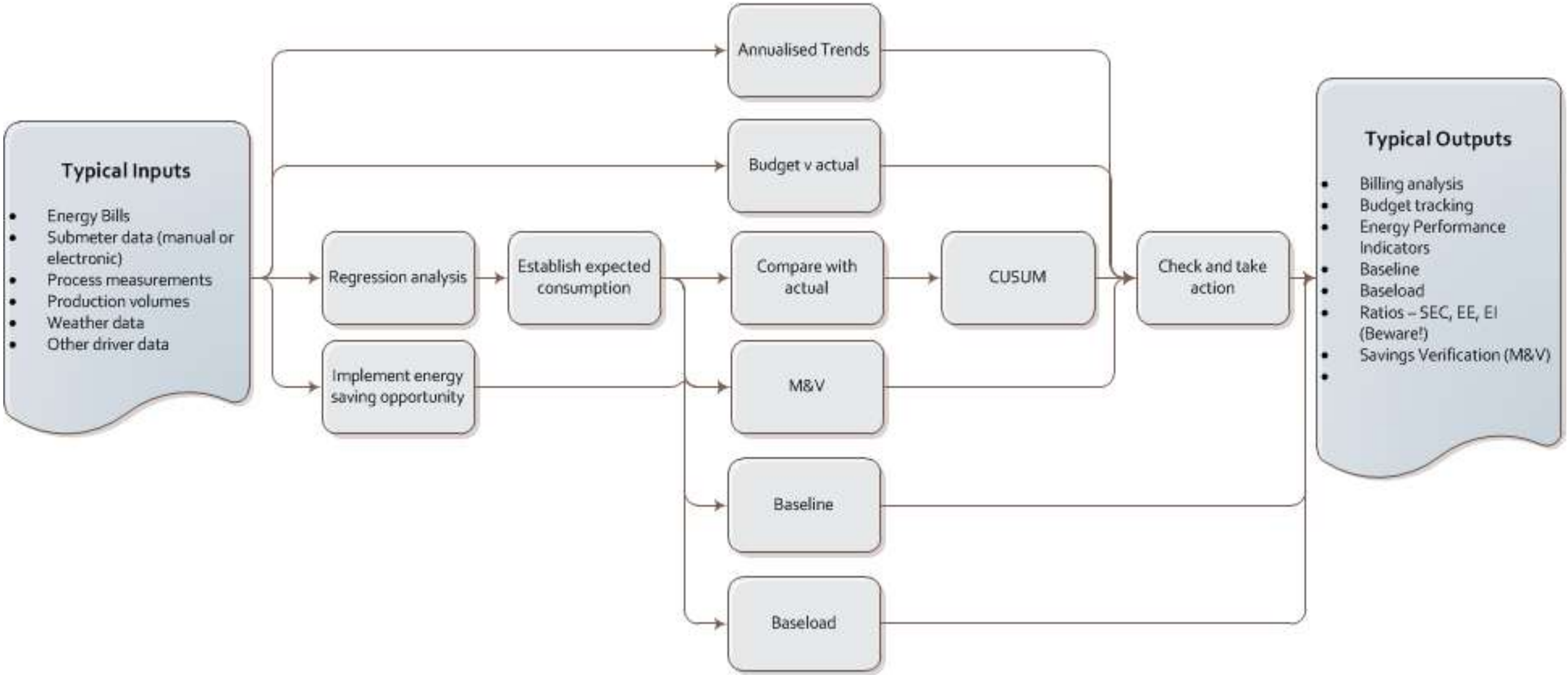
Purpose of energy metrics

- Objective support for decision making
  Often subjective reasons
- We need to know how much energy we are using
- We need to know if performance is improving or not
- We need to know if we are meeting targets
- We need to be able to verify savings of improvements
- We need to establish the following:
  - Baseline
  - Baseload
  - Performance indicators (EnPIs)
- Numerical basis

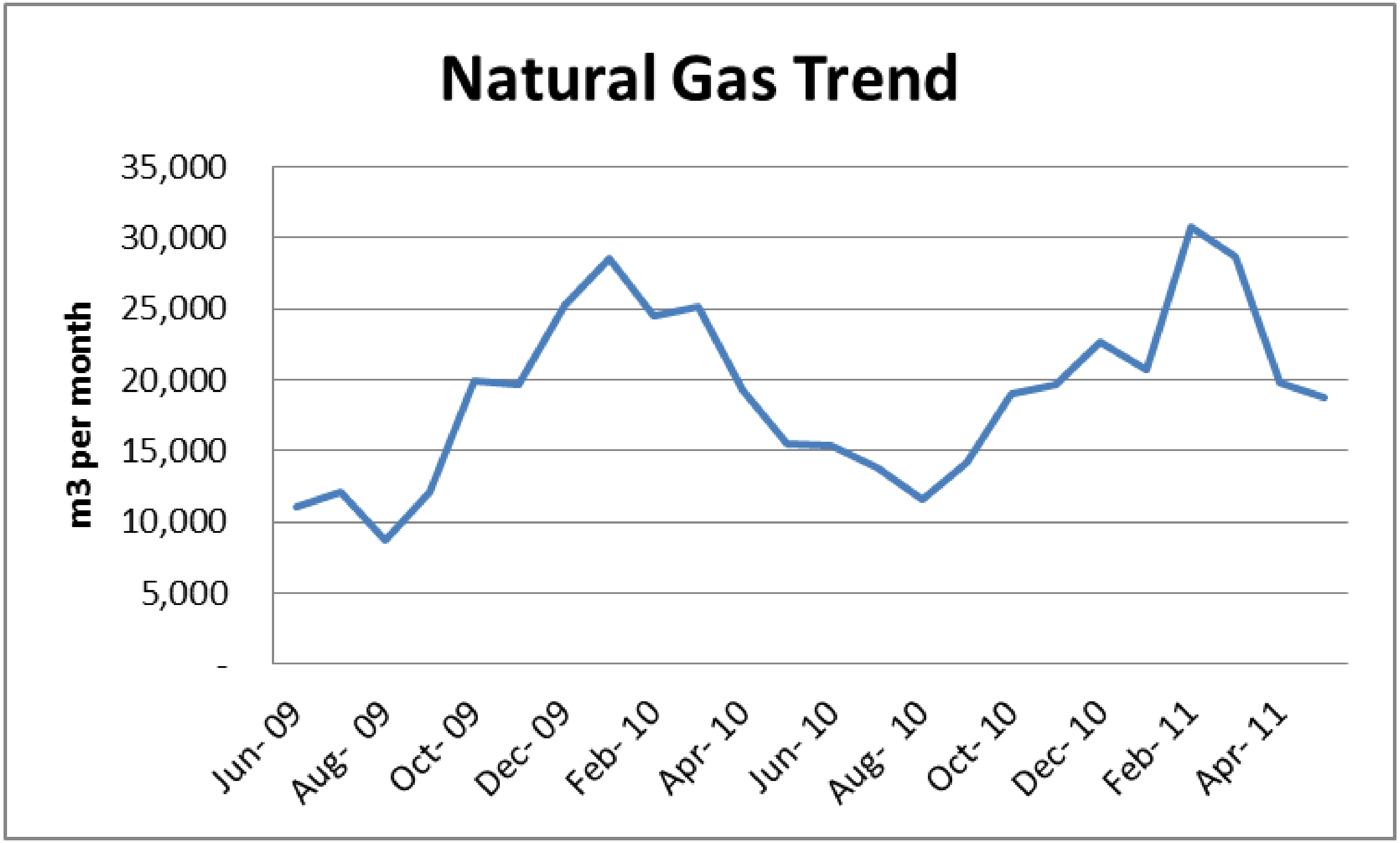
Energy Metrics

- Various levels of complexity
- Simple:
  - Simple: consumption last month v same month last year
  - Simple: compare actual consumption with budget
  - Simple: annualised trend of cost and consumption
- More complex (but beware!)
  - Energy use per unit output
  - Cooling energy per cooling degree day
  - Specific energy consumption (SEC)
- Regression analysis is usually best
- Same principles apply to EnPIs and verification of savings

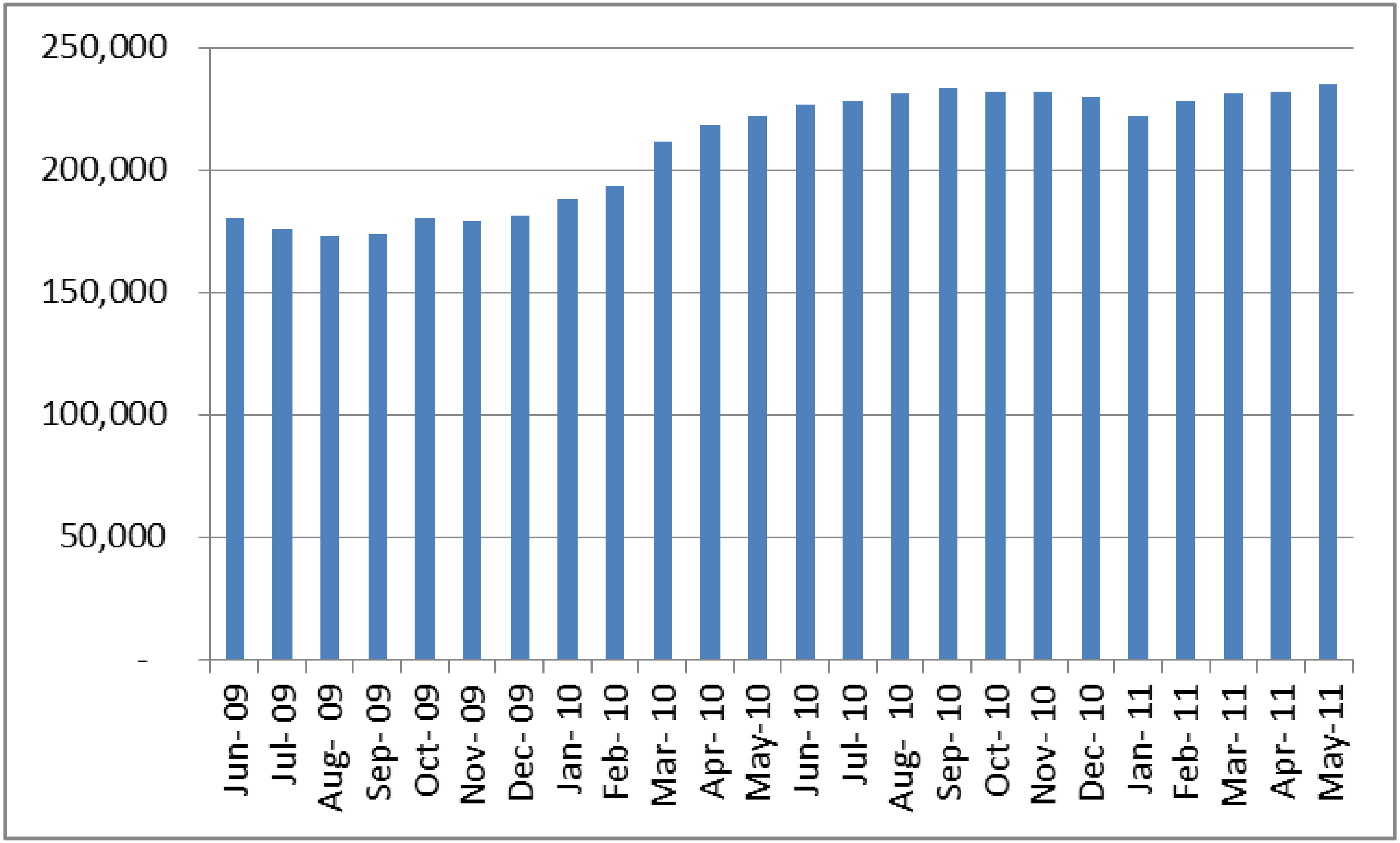
Overview of metrics



What does this tell us?



Same gas data in annualised view



Annualised trend

- 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 drivers or 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 other

Beware of simple ratios

- Energy use per unit of output (Energy Intensity)
  - e.g. kWh/T of product
  - Useful in energy intensive industries for benchmarking internally and externally
  - Beware in others, especially in cases with large baseloads
  - Almost of no value in judging energy performance
  - Usually tracks output better than energy
- Energy Efficiency (energy in compared with energy out)
  - E.g. boiler efficiency is a useful indicator but beware:
  - Decreasing boiler load through pipe insulation, leak repair or demand management will almost always result in reduced efficiency due to lower loads
  - Overall system efficiency will improve but not the boiler efficiency

Other indicators to be careful of

- Specific Energy Consumption (SEC)
  - For example air compressor SEC will usually increase if leaks are repaired or demand reduced.
  - This does not mean you shouldn't reduce demand
  - It means that care is needed in the use of this indicator
- Coefficient of Performance (COP)
  - Used as a measure of refrigeration plant performance
  - = cooling load (kW) / electrical power to compressor (kW)
  - COSP = cooling load (kW) / power to compressors plus auxiliaries loads such as fans and pumps
  - Often reduces as load reduces (centrifugal compressors can be an exception)

Checking performance

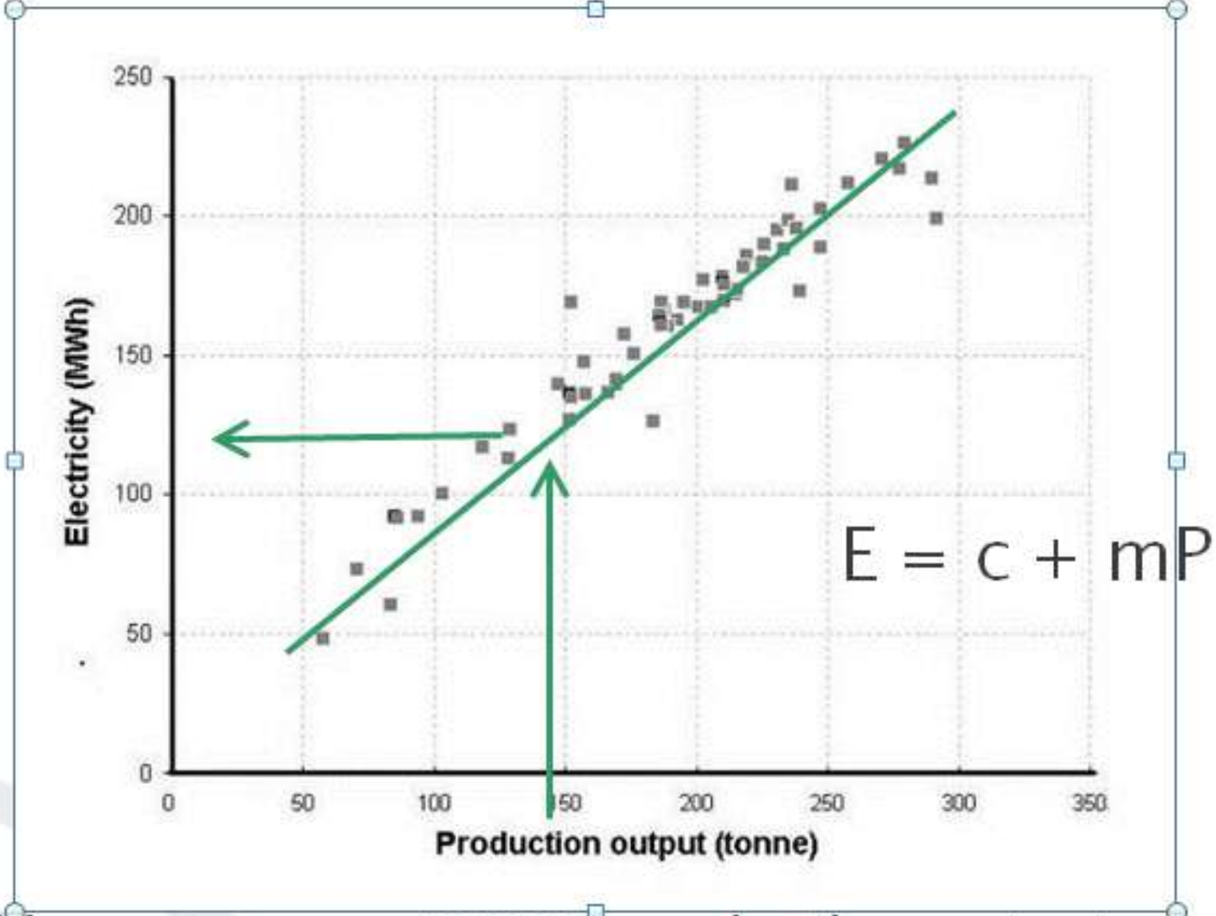
- You cannot manage what you do not measure
- This is not the whole story
- It’s not enough to know how much you used
- CRITICAL QUESTION: was it more than necessary?

Problem: things make consumption vary

- Weather
- Daylight availability
- Production throughputs
- Mileages
- Occupancy
- …*etc*

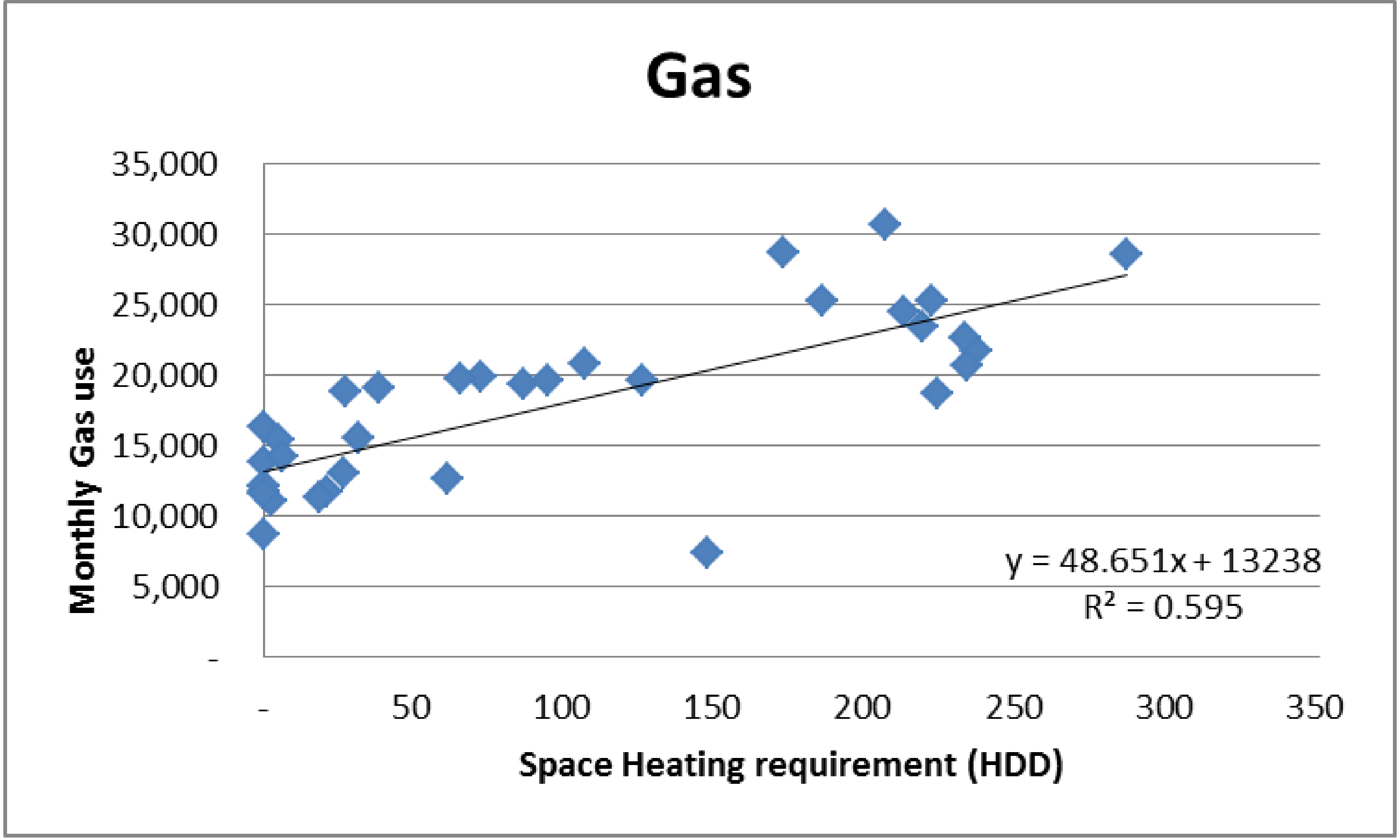
- *“driving factors”*
- *Terminology: drivers, independent variables, energy factors*
    - *All mean the same, decide which you will use*

Simple process



- Weekly energy use *versus* production output

Previous gas data vs heating degree days (HDD)

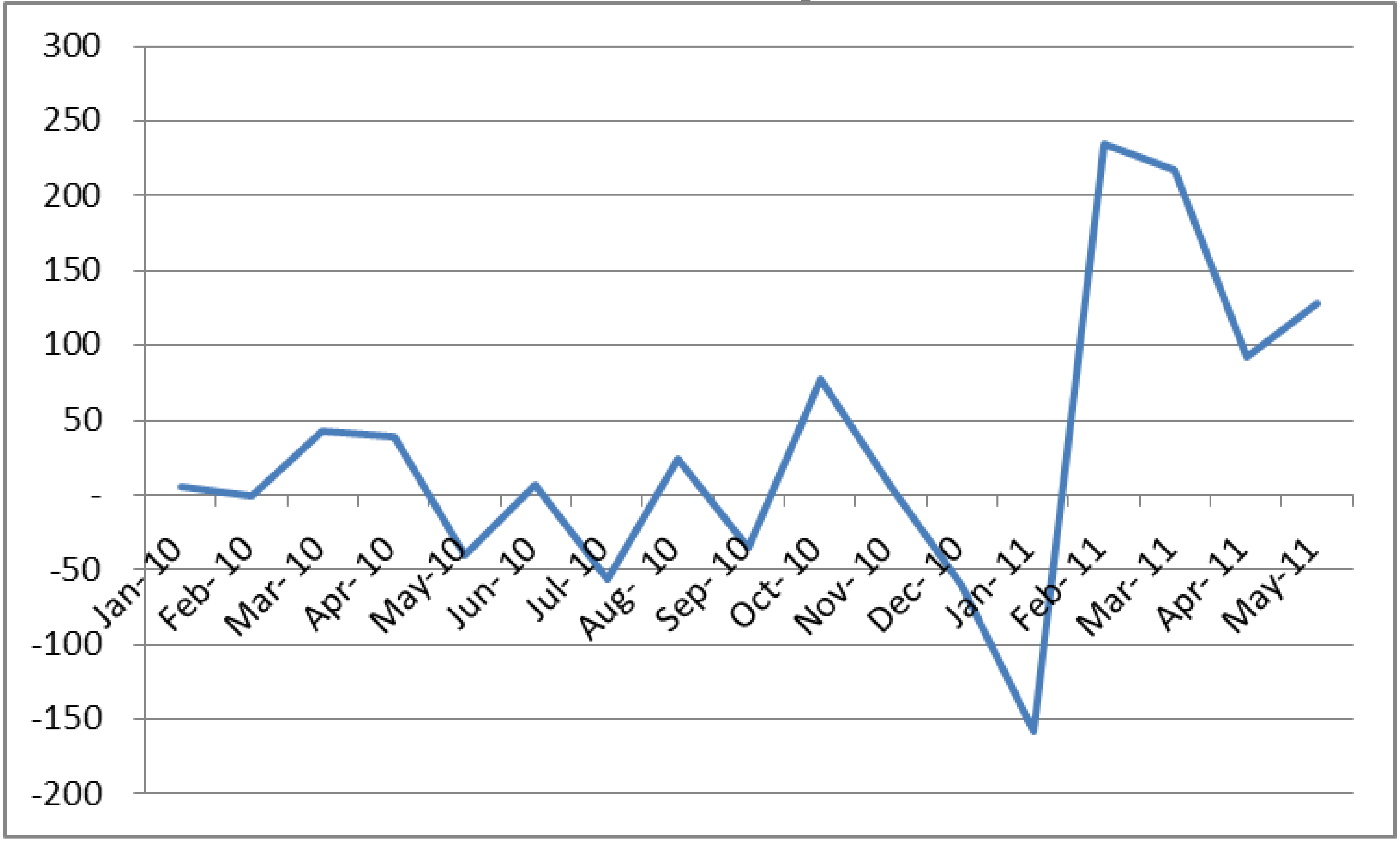


Straight line formula

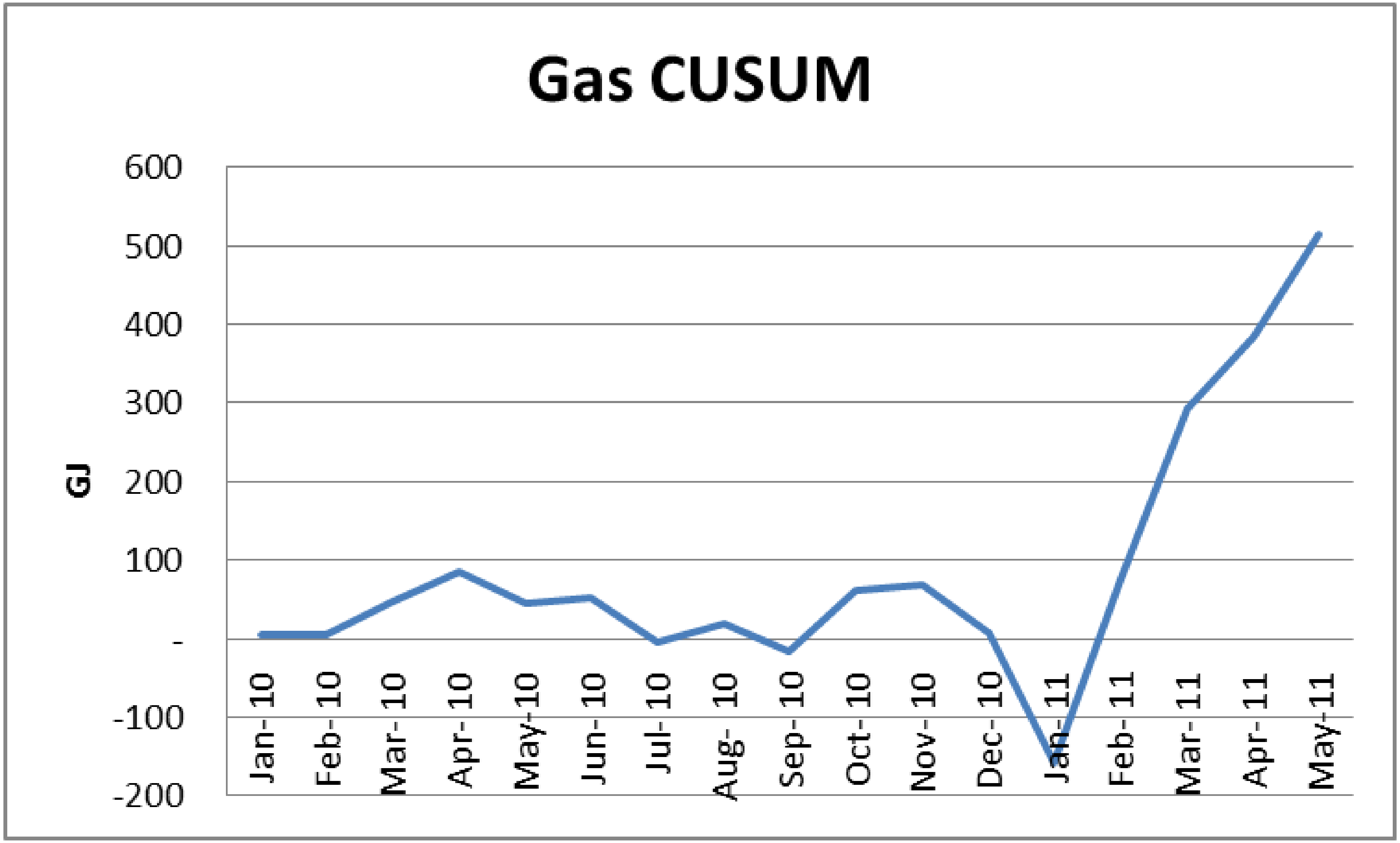
- Y = mX + C
- Energy (E) = Factor (F) * Driver (D) + Constant (c)
- E = FD+c
- In the previous case:
- Gas = 48.651 * HDD + 13238

- This formula can be used to predict expected consumption for any given driver
- We can compare predicted v actual usage to indicate performance

Difference between expected and actual



CUmulative SUM of difference (CUSUM)



Multiple factor case

Fixed	123,000 kWh per week	1 weeks	123,000 kWh
Bread	190 kWh per tonne	93 tonnes	17,670 kWh
Tarts	310 kWh per tonne	5 tonnes	1,550 kWh
Rolls	250 kWh per tonne	75 tonnes	18,750 kWh
Space heating	1,200 kWh per degree day	20 degree days	24,000 kWh
		Total:	**184,970 kWh**

$$E = c + m_1 D_1 + m_2 D_2 + \ldots + m_n D_n$$

Source: Vilnis Vesma

In general

- Expected energy consumption can be any function of relevant driving factors D
- E = f(D1, D2, ……. Dn)
- Use the simplest effective model
- A straight-line relationship is often good enough

The main message

- Establish relationships between energy consumptions and appropriate energy (driving) factors
- Sometimes called "performance characteristics"
- Use these to **calculate *expected* consumption** based on production activity, prevailing weather etc.
- Thereby detect unexplained deviations

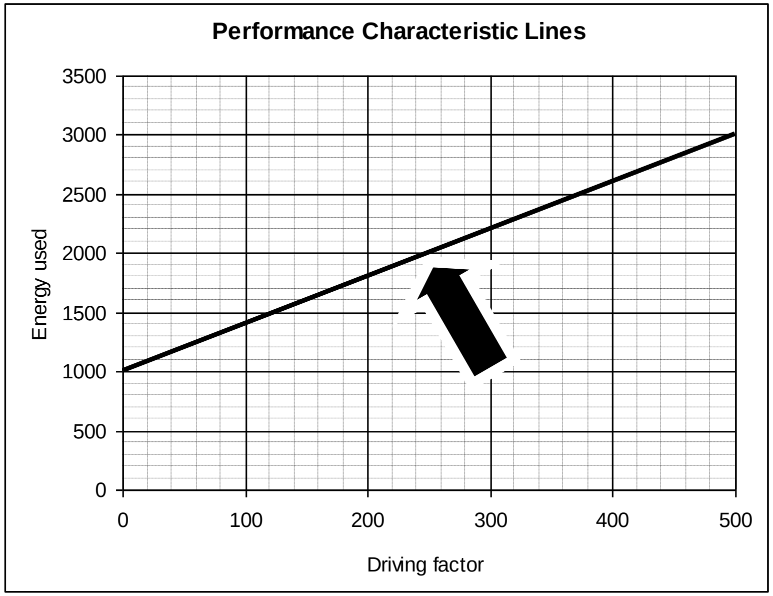
Targets and baselines

- “Target” characteristic

  For management control

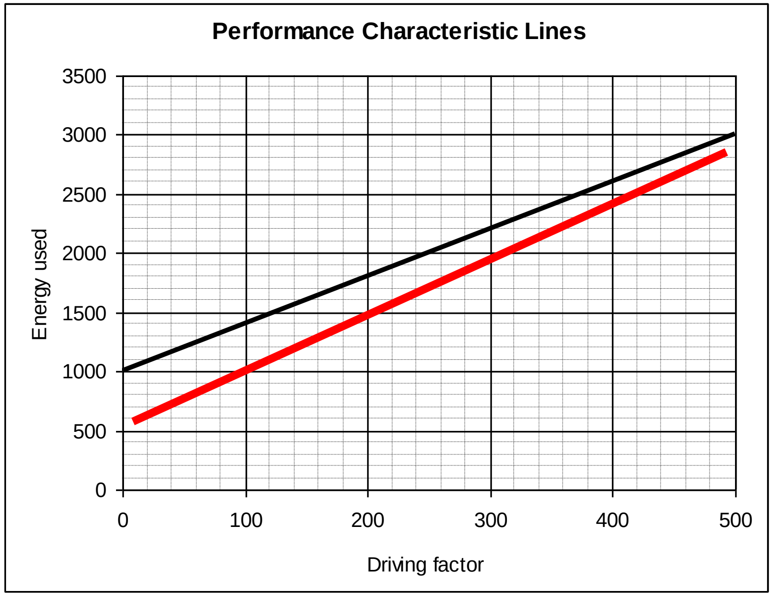
  Base on best achievable performance

  Keep continually adjusting



Targets and baselines

- Historical baseline characteristic
  - For assessing savings
  - Usually derived from ‘base year’ data
  - Leave unchanged



Historical baseline characteristic

- Answers the question "*how much would I have used in the absence of my energy-saving measures?*"
- Allows absolute kWh savings to be computed
  - Gives clean, objective view
  - Production, weather, *etc*. already accounted for

Performance checking summary

- We use energy for known purposes ("outputs")
- If we can measure useful output, we should be able to estimate *expected* energy consumption
- Thus we can gauge actual consumption…
  - *Waste* relative to target characteristic
  - *Savings* relative to historical baseline

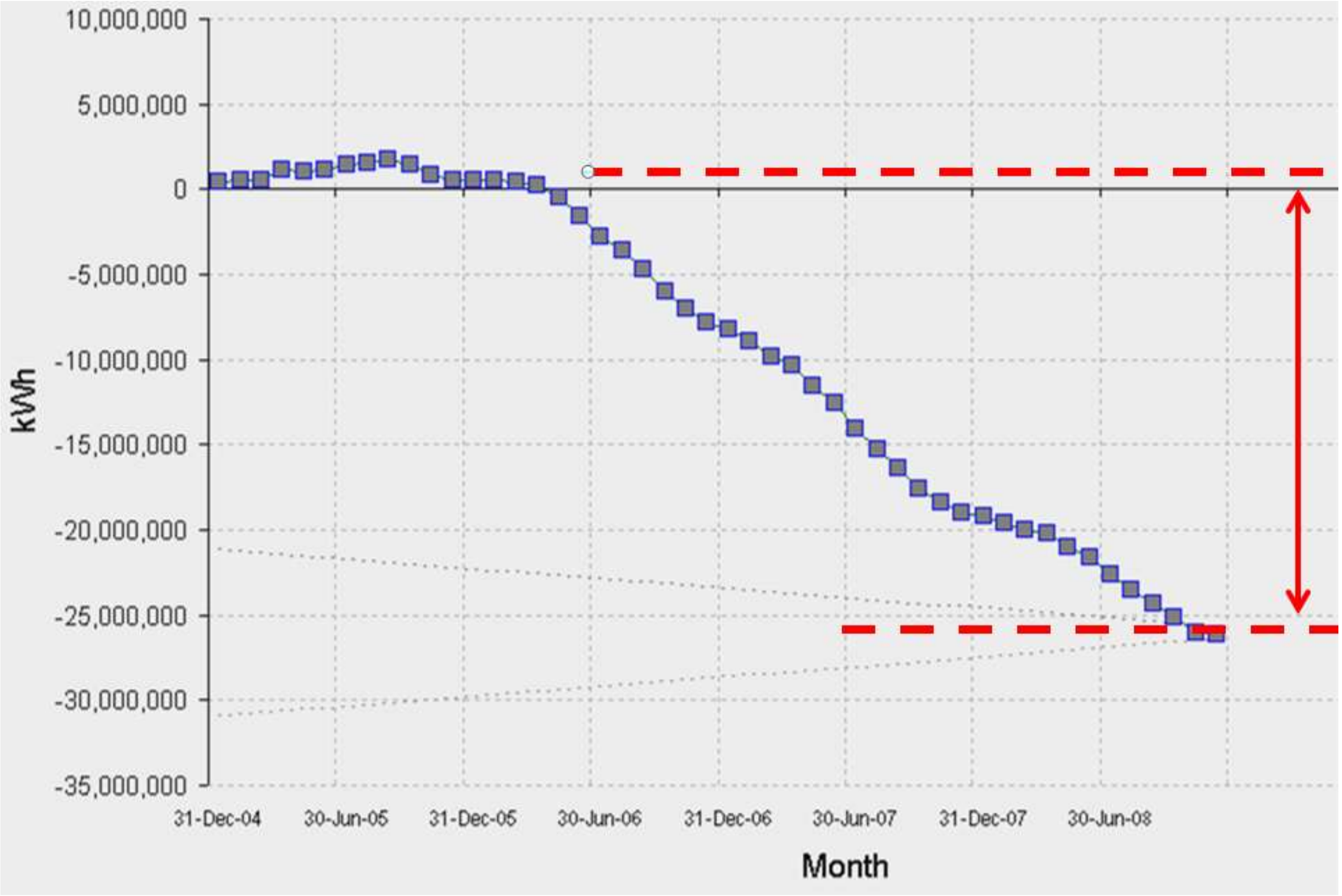
Savings Verification (action plan and program)

- Simple estimates for simple items
- Cost of verification commensurate with savings
- Simple measurements – spot checks
- Temporary continuous monitoring over a period
- Permanent continuous monitoring
    - For example ESCO financed

Simple cases

- We have 20 lights
  - Each consumes 100W
  - Each runs 12 hours per day, 365 days per year
- We fit a more efficient lamp in each
  - New lamps consume 20W
- Use before = 20 X 100 X 12 X 365 = 8,760 kWh p.a.
- Use after = 20 X 20 X 12 X 365 = 1,759 kWh p.a.
- Saving = 7001 kWh p.a.
- We probably don’t need to take any measurements, calculation is sufficient
- The level of effort (cost) in measuring a saving should be related to the level of savings

Cumulative savings can be tracked



Baseline alternatives

- Baseline will be used for future comparison of improvements
- Ideally based on regression analysis as shown
- Can be absolute consumption, e.g. 1 GWh per annum
- SEC: kWh per unit of output

Baseload

- The energy you use when there is no productive activity
- Very often a major opportunity for improvement
- Measure and analyse baseload if it is significant

Energy Performance Indicators (EnPI)

- Budget v actual consumption
- CUSUM of total energy and of each SEU

Further information

- www.degreedays.net
- www.vesma.com
- www.evo-world.org
- Google:
  - CUSUM
  - IPMVP
  - Lean Energy Analysis

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What is financial appraisal?

- All organisations need to control spending
  - Current spending (expenses)
  - Capital spending (investment)
- Need to make choices of where to spend
  - Spend; Yes or No?
  - Choose between options for investment in savings project
  - Choose between options using life cycle cost (LCC)
- Need tools to help with these choices
- This is a basic introduction
- We will ignore the effects of taxes
- We will consider the effects of inflation and interest rates

Some financial choices

- Do you buy bread at $1.20 or $1?
- Two motors are the same
  - One costs $300 and the other $250
- Two motors are not the same
  - One costs $300 and the other $250
- I will give you $1 now or $2 in 12 months time?
- Two compressors:
  - One costs $5,000 to buy and $10,000 p.a. to operate
  - The other $6,000 to buy and $9,000 to operate
  - Which is best?

Simple payback (SPB)

- SPB = Cost in \$ / Savings in \$ p.a.
- Usually organisations have a limit e.g. only opportunities with a payback of less than 2 years will be considered

- Advantages
  - Simple
  - Quick
  - Good rule of thumb
  - Useful as a quick estimate
  - Useful for low cost opportunities

- Disadvantages
  - Too simple
  - What is the effect of the life of the item?
  - Should not be used for major decisions, either high cost or organisationally critical

Simple payback (SPB) – Example 1

- Energy Savings that will be made = $1000 p.a.
- Cost of modification = $2000
- What is the payback?

Simple payback (SPB) – Example 1

- Energy Savings that will be made = $1000 p.a.
- Cost of modification = $2000
- What is the payback?

- 2 years

Simple payback (SPB) – Example 2

- Energy Savings that will be made = $1000 p.a.
- Additional maintenance cost = $500 p.a.
- Cost of modification = $500
- What is the payback?

Simple payback (SPB) – Example 2

- Energy Savings that will be made = $1000 p.a.
- Additional maintenance cost = $500 p.a.
- Cost of modification = $500
- What is the payback?

1 year

Time value of money

- Very important concept
- If I offer you the choice of $5,000 now or $800 p.a. for 10 years which would you choose?
  - You need to take into account the option of putting the $5,000 in the bank and earning interest at say 10%
- Due to inflation money is worth less in the future than it is now
  - Assume 5% inflation
  - $100 now is worth $95 in one year
- We need to take this into account
  - Future savings are worth less than they are now
  - The reverse may be the case with respect to energy savings if energy prices continue to rise

Discount rate (or hurdle rate)

- Need to know discount rate
  - This is the return the organisation will decide to invest at
  - Sometimes increased for more risky projects
  - Related to the cost the organisation incurs in raising the capital
  - Weighted average cost of capital (WACC) (debt and equity)
  - Usually your accountant will know the discount rate

Net Present Value (NPV)

- Present Value (PV) or present worth (PW)
  - The value now of a future amount of money
  - E.G. $100 in 1 year at 5% inflation has a present value of $95
- NPV is the value now of a future stream of cash flows
  - Can be incoming or outgoing and is typically a combination of both
  - Spreadsheets have an NPV function
  - Typically we spend money now to make a saving
  - Then we save money in the future on an ongoing basis
  - In energy terms we save energy each year
  - We may have extra maintenance costs (or less!)
  - We may have a salvage value at the end
- If NPV > 0 then it is a viable idea
  - If you have the money and it is the best NPV available

Internal Rate of return (IRR)

- Very similar to NPV
- Doesn't use discount rate
- IRR is the rate of return of the projected cash flows

Financial Appraisal

	A	B	C	D	E	F	G	H
1	Life (years)	Discount Rate	Annual Inflation					
2	15	11%	2%					
3								
4	Option	Capital Cost (€)	Annual Savings (€)	Payback (years)	NPV	IRR		
5	A	10,000	1,500	6.7	€1,782	14%		
6	B	10,000	10,000	1.0	€62,934	102%		
7	C	10,000	3,000	3.3	€12,574	31%		
8								
9								
10								
11	Notes:							
12	1. To use this to compare life cycle costs, use negative values for annual savings							
13	2. Inflation is the annual increase in operating costs or savings							
14	3. The values for entry are those in yellow							

Life cycle cost (LCC)

- Similar to NPV but all cash flows are negative
- For example

Two options

Buy a fixed speed pump for $5,000 and annual running costs of $7,000

OR

Buy a variable speed pump for $8,000 and annual running costs of $3,000

Life Cycle Cost (LCC)

	A	B	C	D	E	F
1	Life (years)	Discount Rate	Annual Inflation			
2	15	11%	2%			
3						
4	Option	Capital Cost (€)	Annual Savings (€)	Payback (years)	NPV	IRR
5	A	5,000	- 7,000	- 0.7	-€54,864	#NUM!
6	B	8,000	- 3,000	- 2.7	-€28,790	#NUM!

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What is this step

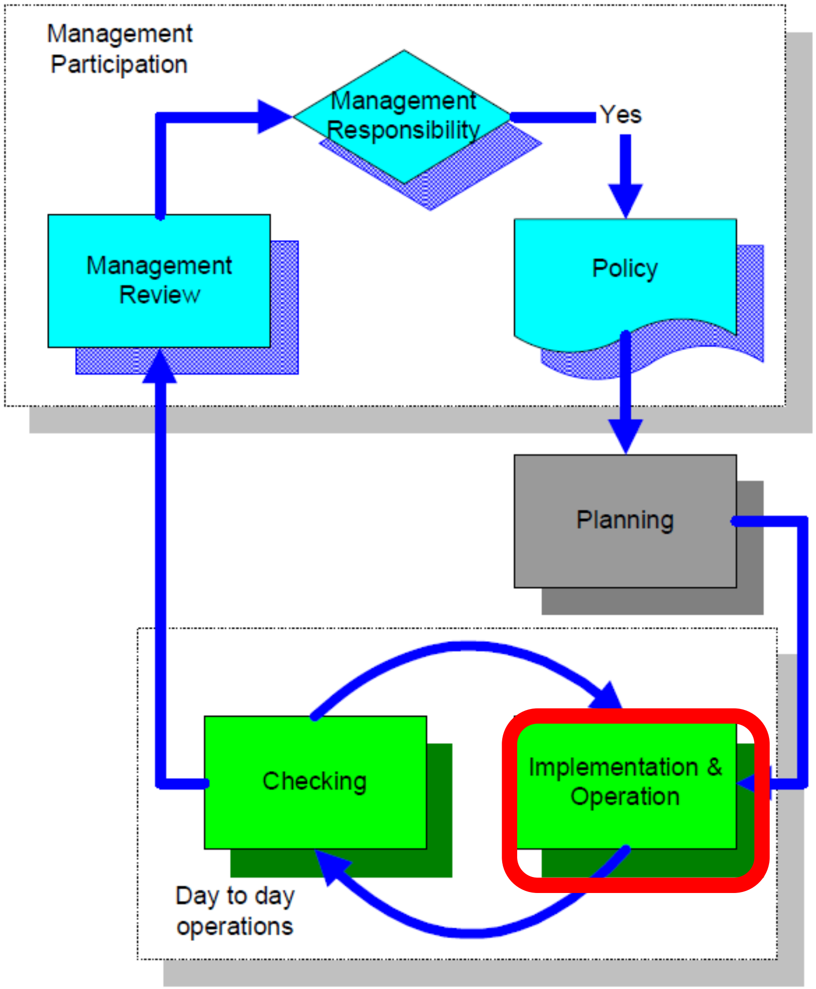
Doing - *Daily activities to improve energy performance*

We have a policy with management support, resources, strategic direction and committed team members

We also have objectives, targets and action plans

Now, we must implement the day to day control and continuous improvement of our energy usage

Implementation & Operation



- Competence, training and awareness
- Documentation
- Operational control
  - Key Area
  - Operation and Maintenance
  - Service Contractors
  - Training
- Communication
- Design

  Energy Efficient Design (EED)
- Purchasing energy, services, goods
- Action plans

Implementation & 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

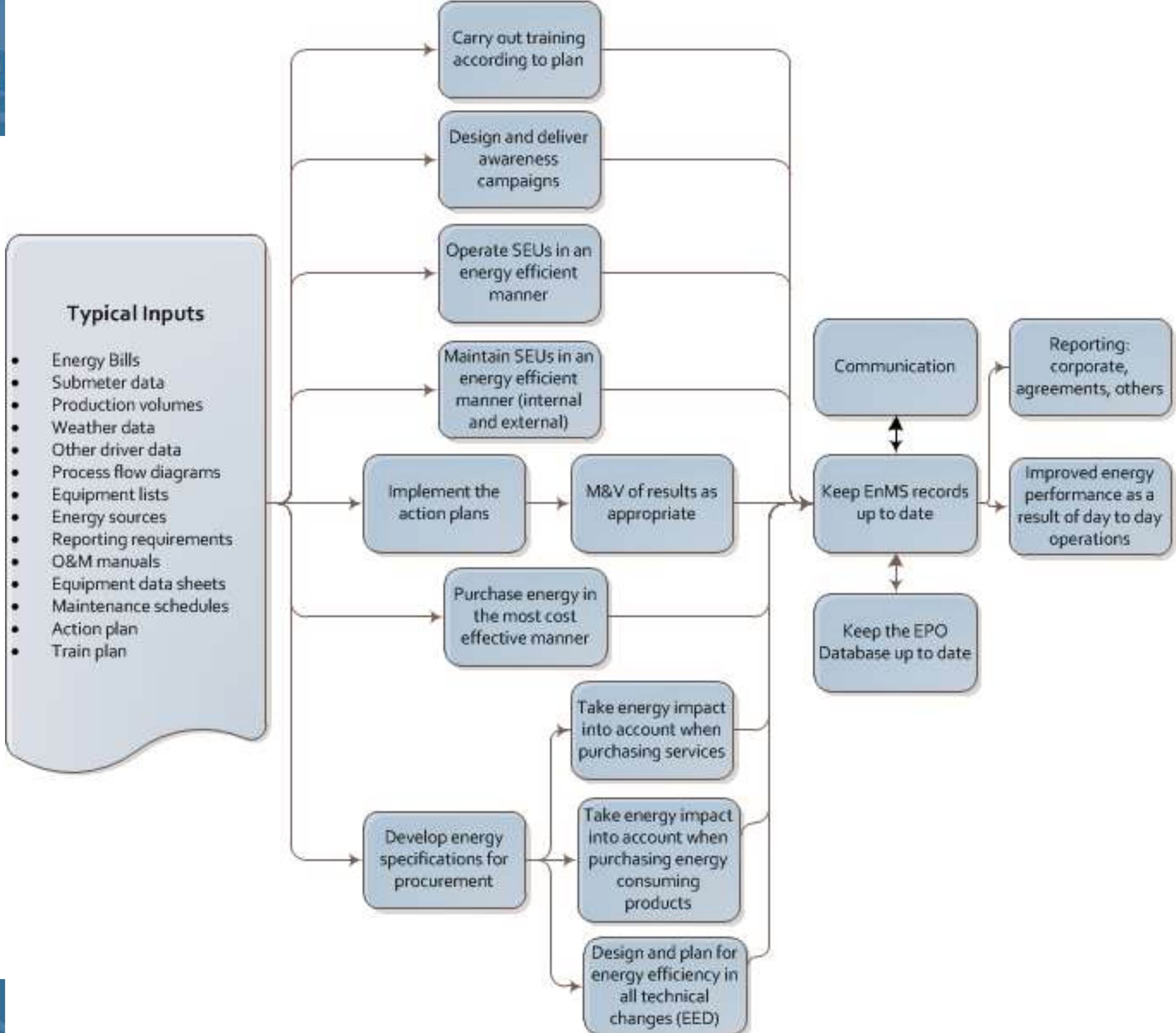
  All other parts of the system support this

- If it doesn't save energy, don't do it (in this context)
- 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

Change Management Discussion

- Do people have examples of change management in their jobs?
- Examples of successful changes
- Examples of failed or less successful changes
- What were the main difference between the successful and the failures


Typical Inputs
Energy Bills
Submeter data
Production volumes
Weather data
Other driver data
Process flow diagrams
Equipment lists
Energy sources
Reporting requirements
O&M manuals
Equipment data sheets
Maintenance schedules
Action plan
Train plan
Carry out training according to plan
Design and deliver awareness campaigns
Operate SEUs in an energy efficient manner
Maintain SEUs in an energy efficient manner (internal and external)
Implement the action plans
M&V of results as appropriate
Purchase energy in the most cost effective manner
Take energy impact into account when purchasing services
Develop energy specifications for procurement
Take energy impact into account when purchasing energy consuming products
Design and plan for energy efficiency in all technical changes (EED)
Communication
Keep EnMS records up to date
Keep the EPO Database up to date
Reporting: corporate, agreements, others
Improved energy performance as a result of day to day operations

Awareness

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

Training & Competence

- Staff with a significant impact on energy use need to be competent
  - Education
  - Training
  - Experience
  - Skills
- Training plans are to be implemented
- Potential consequences of departure from procedures

Training implementation

- During planning we established who were the people with a significant impact on our energy use
  - We established who needed to do what training and when, in our training plan
- During the year we need to carry out that training
  - Schedule training sessions
  - Scope of training
  - Training providers – internal v external. Consider sending one or two people to external training and then using them to deliver internally if expertise and resource is not available in the beginning.
  - Keep records of who has completed training
  - Do you need to test if training was understood?
  - Is refresher or on-going training required?

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
- An energy manual is a good idea, electronic or hard copy
  - Overall guide to the system

Energy Manual

- This can be either hard copy or electronic
- See document list as an example
- You need a map of where all documents are located
- It is not necessary (or desirable) that all documents be copied and included
    - Extra work in maintaining extra copies
    - Potential for error if duplicate copies in circulation

Document requirements

- The following should be maintained for each official procedure or process:
  - Author
  - Name or title of the document
  - Revision version and date
  - Approval, usually a signature
  - Who does the process apply to
  - Description of the process and actions to be followed
  - Reference to other documents, records or monitoring activities associated with the process
- Beware of having too many documented procedures
  - Consider workflows and diagrams if possible

Documents
(expectations – who, what, etc)

- Energy policy
- Objectives, targets and action plans
- Energy Manual
- Workflows

- External Document examples
  - Technical drawings of systems and equipment including process and instrumentation diagrams (P&IDs), and/or process flow diagrams, single line diagrams
  - Technical specifications of equipment

Records
(demonstrates what you do)

- EnPIs and Baseline
- Training plans
- Roles and responsibilities
- Energy review results
- Copies of energy audit reports
- Operator logs
- Maintenance and service records
- Minutes of energy meetings
- Communications with corporate, management, external agencies
- List of critical operating parameters

LOTS MORE

Documents and Records list

	A	B	C	D	E
1	ID	**Description**	**Location**	**Revision**	**Revision Date**
2	1	Energy Manual	Energy Manager Office	2	01/10/2010
3	2	Energy Bills	Finiance Office	N.A.	N.A.
4	3	Boiler Operating Manual	Boiler control room	N.A.	23/04/2004
5	4	Planning Spreadsheet	S:/energy/records	N.A.	01/12/2010
6	5	Checking Spreadsheet	S:/energy/records	N.A.	N.A.
7	6	Energy Policy	S:/energy/documents	1	01/12/2010
8	7	Energy Audit reports - hard copies	Energy Manager Office	N.A.	N.A.
9	8	Energy Audit reports - electronic copies	S:/energy/reports	N.A.	N.A.
10	9	Training plans	Operating Spreadsheet	N.A.	N.A.
11	10	SEU Operator logs	relevant control room	N.A.	N.A.
12	11	Management review minutes	S:/energy/records	N.A.	N.A.
13	12	Minutes of energy team meetings	S:/energy/records	N.A.	N.A.
14	13	Maintenance records	Maintenance management system		
15	14	SEU Process diagrams			
16	15	SEU operating procedures			
17	16	SEU maintenance procedures			
18	17				

The task for tomorrow……

- Group 1
  - Prepare a presentation on how your organisation should go about developing an EnMS, main components, barriers to success, target areas for particular focus
- Group 2
  - Complete as much as possible of the planning stage of the EnMS. Where data is not available either make valid assumptions or describe exactly what data you need to fill in the gaps
- Group 3
  - As above for day to day operations
- Group 4
  - As above for checking and management review