MINISTRY OF INDUSTRY AND TRADE

EU - VIET NAM SUSTAINABLE ENERGY TRANSITION PROGRAMME (SETP)

Global Gateway

Funded by the European Union

UNIDO

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Project "Accelerating energy efficiency (EE) in large industries through energy management system, system optimisation and the promotion and adoption of EE in SMEs" (IEEP)

# TRAINING PROGRAMME

## REQUIREMENTS FOR BODIES PROVIDING AUDIT AND CERTIFICATION OF EnMS - ISO 50003

Ha Noi, 15 - 16/05/2024

# AGENDA

## TRAINING PROGRAMME
## REQUIREMENTS FOR BODIES PROVIDING AUDIT AND CERTIFICATION OF EnMS - ISO 50003

*From 15 to 16 May 2025*

*Adonis Hotel - 55 Quang Trung Street, Nguyen Du Ward, Hai Ba Trung Dist., Ha Noi*

**Day 1: 15/05/2025**

| Time | Contents | Speakers |
| --- | --- | --- |
| 8.00-8.30 | Registration and welcome | |
| 8.30-8.35 | Participants Introduction | UNIDO Project |
| 8.35-8.45 | Opening speech | MOIT/UNIDO Project |
| 8.45-9.30 | Introduction and Course objectives<br>ISO50001, ISO50003, ISO17021 and applicable IAF MD relationships | International Expert |
| 9.30-10.15 | Energy Terminology | International Expert |
| **10.00-10.15** | **Tea break** | |
| 10.30-11.15 | Planning process, energy metrics Baseline and EnPI | International Expert |
| 11.15-11.30 | Significant energy user identification | International Expert |
| 11.30-11.45 | Discussion on site performance planning | International Expert and Trainees |
| 11.45-12.00 | Energy Systems part 1 | International Expert |
| **12.00-13.00** | **Lunch at the Hotel** | |
| 13.00-13.30 | Energy Systems part 1 (continue) | International Expert |
| 13.30-15.00 | Energy Systems part 2 | International Expert |
| **15.00-15.15** | **Tea break** | |
| 15.00-15.30 | Energy Systems part 2 (continue) | International Expert |
| 15.30-17.00 | Discussion Q&A | International Expert and Trainees |

**Day 2: 16/05/2025**

| Time | Contents | Speakers |
|---|---|---|
| 8.00-8.30 | Registration | |
| 8.30-8.45 | Recap from Day 1 | International Expert |
| 8.45-9.15 | Resource + Information requirement | International Expert |
| 9.15-10.00 | Process requirement: Audit time | International Expert |
| **10.00-10.15** | **Tea break** | |
| 10.15-11.00 | Process requirement: Multi sampling process | International Expert |
| 11.00-12.00 | Process requirement: Conducting the audit | International Expert |
| **12.00-13.00** | **Lunch at the Hotel** | |
| 13.00-13.15 | Process requirement: Maintain certification | International Expert |
| 13.15-15.00 | Exercise | International Expert and Trainees |
| **15.00- 15.15** | **Tea break** | |
| 15.15-16.15 | Effective review and Energy performance determination | International Expert |
| 16.15-17.00 | Discussion Q &A and Feedback | International Expert and Trainees |

MINISTRY OF INDUSTRY AND TRADE

EU - VIET NAM SUSTAINABLE ENERGY TRANSITION PROGRAMME (SETP)
Accelerating energy efficiency (EE) in large industries through energy management system, System optimisation and the promotion and adoption of EE in SMEs -(IEEP project)

Global Gateway — Funded by the European Union

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

# ISO 50001/50003
# Technical Training
# Accreditation and certification Body
# Day 1

UNIDO International Energy Efficiency

Training

Delivered by: Richard Morrison, Stefan Walta



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## Today

| Topic | Duration (mins) | Break duration | Start Time | End Time |
|---|---|---|---|---|
| Registration | | 15 | 08:15 | 08:30 |
| Introduction and Course objectives | 45 | | 08:30 | 09:15 |
| ISO50001, ISO50003, ISO17021 and applicable IAF MD relationships | | | | |
| Energy Terminology | 45 | | 09:15 | 10:00 |
| Break | | 15 | 10:00 | 10:15 |
| Planning process, energy metrics Baseline and EnPI | 45 | | 10:15 | 11:00 |
| Significant energy user identification | 15 | | 11:00 | 11:15 |
| Discussion on site performance planning | 15 | | 11:15 | 11:30 |
| Energy Systems part 1 | 45 | | 11:30 | 12:15 |
| Lunch | | 45 | 12:15 | 13:00 |
| Energy Systems part 2 | 120 | | 13:00 | 15:00 |
| Break | | 15 | 15:00 | 15:15 |
| Discussion Q&A and Feedback | 90 | | 15:15 | 16:45 |
| End | | | 16:45 | |

## INTRODUCTIONS

- During your introduction outline:
  - Your name
  - Organisation
  - A key learning objective from the training
  - Level of experience with witnessed auditing
  - A common issue when witnessing an audit



## Course Objectives

- Good understanding of the Technical requirements of an EnMS
- ISO 50003 requirements
- Audit Duration
- Audit Competency
- How to recognize a *"good systems audit"* as opposed to a *"good system"*

## Housekeepig & Logistics

- Restrooms
- Phones
- Food
- Computers
- Emergency Exit



## Why are we here?

The function of the Accreditation process?

- Involves the continuous assessment
- Evaluation of a program and the enhancement of the program's operations using standards.
- This process, through self-evaluation and peer review, is designed to foster collegial relationships among educators and members of the profession.
- Some view to audit the standard?

## Why are we here?

The function of the Accreditation process?

- What can you do to ensure the standards are high?
- ISO17021 **Conformity assessment — Requirements for bodies providing audit and certification of management systems**

- ISO50003 **Conformity assessment — Requirements for bodies providing audit and certification of energy management systems**



## International Accreditation Forum OLD

- IAF Resolution

- The General Assembly, acting on the recommendation of the Technical Committee, recognizes that the ISO 50001 and ISO 50003 are the appropriate standards for certification and accreditation in the energy management systems field.

- The General Assembly agreed that the implementation period for ISO 50003:2014 will be three years from the date of publication.

- The date of publication was 14 October 2014, therefore the deadline for Certification Bodies to conform to it will be **14 October 2017.**

# International Accreditation Forum NOW

- 8 December 2021: transition requirements for ISO 50003:2021
- Transition period was 2,5 years (30 month). Transition period is over now!

- What is changed?

- the definitions have been updated to include the audit time, the duration of the audit and terms related to multi-site audits;

- the phrase “maintained documented information” has been used to represent procedures, work instructions or other forms of documents that provide the who, what, when, how or why information;



# International Accreditation Forum NOW

- What is changed?
- the phrase “retained documented information” or “record of audit evidence” has been used to represent records that demonstrate or provide evidence of the execution of a requirement;
- the structure has been updated to align with ISO/IEC 17021-1:2015;
- the phrase “man-days” has been changed to “audit days”;
- for audit day calculations, the number of energy types have been changed to those that comprise at least 80% of total consumption;

## International Accreditation Forum NOW

- What is changed?
- the weighted values for complexity have been modified;
- the sampling requirements for multi-site EnMS have been updated;
- the information on EnMS effective personnel has been clarified in A.2



## International Accreditation Forum NOW

- What is changed?
- Tables A.3 and A.4 have been modified from audit duration to audit time;
- technical areas have been removed and requirements for technical competency added; and
- related to energy performance improvement the following have changed

  a. The definition in 3.6 of ISO 50003:2014 for “Energy performance improvement” has been removed, but the term is defined in ISO 50001 which is a normative reference

  b. For surveillance audits the focus has switched for an organization to be required to demonstrate “implementation of actions for energy performance improvement” rather than to demonstrate “achievement of energy performance achievement”

# Adjusted Pertinent Terms ISO50003

3.5 EnMS effective personnel

Personnel who materially contribute to the effectiveness of the EnMS or impact energy performance

Note 1: EnMS effective personnel is not necessarily the total number of employees

Note 2: The EnMS effective personnel is a factor used to determine the audit time

Note 3: Annex A contains more information on EnMS effective personnel





# Adjusted Pertinent Terms ISO50003

EnMS improvement is not longer a definition in the standard

Reference to the definition in ISO 50001

3.6 Major nonconformity

EnMS non conformity that affects the capability of the EnMS to achieve the intended results

Note: Classifying nonconformities as major could be as follows:

- Audit evidence that energy performance improvement was not achieved
- A significant doubt that effective process control is in place
- A number of minor non-conformities associated with the same requirement or issue could demonstrate a systematic failure and thus constitute a major nonconformity

## Adjusted Pertinent Terms ISO50003

3.3. Audit time

Time needed to plan and accomplish a complete and effective audit the client organization’s management system

3.2. Duration of the audit

Part of audit time spent conducting audit activities from the opening meeting to the closing meeting, inclusive

Note 1: Audit activities normally include

Conducting the opening meeting

Performing document review while conducting the audit



Adjusted Pertinent Terms ISO50003

Add other definition

3.4

3.7

3.8

3.9

## What are the Requirements:

- ISO 50003 was prepared by Technical Committee TC 242 Energy management, in collaboration with the ISO Committee on conformity assessment. TC 301 is now responsible Energy Management and energy savings.
- ISO 50003:2021 is intended to be used in conjunction with ISO 17021:2015. The requirements of ISO 17021:2015 also apply to ISO 50003.



## What are the Requirements:

- For effectiveness of EnMS auditing the ISO 50003 addresses the auditing process, competence requirements for personnel involved in the certification process for energy management systems, the duration of audits and multi-site sampling.
- ISO 50003 specifies additional requirements to those specified in ISO/IEC 17021:2015 – like ISO/TS 22003 for Food Safety Management Systems, ISO/IEC 27006 for IT-Security Management Systems, etc.

## ISO50003 Structure

1. Scope
2. Normative References
3. Terms and Definitions
4. Principles
5. General requirements
6. Structural requirements
7. Resource requirements
8. Information requirements



## ISO50003 Structure

9. Process Requirements
10. Management system requirements for certification bodies

Annex A EnMS Audits time [Normative]

Annex B Multisite organizations [Normative]

Annex C Energy performance [Normative]

Annes D Examples of audit calculation [Informative]

Energy Terminology
50001/50003



## Definition

ISO 50001 Scope:

"This International Standard specifies requirements for establishing, implementing, maintaining and improving an energy management system, whose **purpose is to enable an organization** to follow a systematic approach in **achieving continual improvement of energy performance,** including energy efficiency, energy use and consumption."

## ISO 50001 Definition

3.4.3 energy performance

- measurable result(s) related to energy efficiency (3.5.3), energy use (3.5.4) and energy consumption (3.5.2)

Note 1: Energy performance can be measured against the organization's energy objectives (3.4.13), targets (3.4.15) and other energy performance requirements.

Note 2: Energy performance is one component of the performance (3.4.2) of the energy management system (3.4.2.)



## ISO 50001 Definition

Difference between energy use (3.5.4) and energy consumption (3.5.2)??

Energy use:

Definition: Energy use generally refers to the process or activity of utilizing energy. It encompasses the manner, in which energy is applied or consumed within a system, process, or facility.

Context in ISO 50001: energy use is a part of the broader concept of energy-related performance, which includes how energy is used to achieve specific outcomes or outputs.

# ISO 50001 Definition

Difference between energy use (3.5.4) and energy consumption (3.5.2)??

Energy consumption:

Definition: Energy consumption specifically refers to the total amount of energy used over a certain period. It is typically measured in units such as kilowatt-hours (kWh) for electricity or liters for fuel.

Context in ISO 50001: Energy consumption is a key metric for assessing energy performance. Improvements in energy-related performance can involve reducing energy consumption or enhancing energy efficiency



# ISO 50001 Definition

Difference between energy use (3.5.4) and energy consumption (3.5.2)??

Summary:

In summary, while both terms relate to the utilization of energy, "energy use" focuses on the application or process of using energy, whereas "energy consumption" quantifies the total amount of energy used over time.

## What is Energy?

- Energy is defined as the capacity of a system to perform work on other physical systems (Joules)
  - Work is defined in force x distance.
- There are many forms of energy including for example Kinetic Energy and Potential energy
  - Kinetic Energy is the energy of motion (waves, wind etc.)
  - Potential energy is stored energy which has the potential to do work.
- Energy cannot be created or destroyed it can only be transformed from one form to another



## What is Power?

- Power: the rate at which energy is converted, used or transferred (J/s or Watts)
  - E.g. the rate at which a light bulb transforms electrical energy into power
- The same amount of energy converted in a shorter time = more power
- Instantaneous electrical power is voltage multiplied by current (VA or W)
- 1 kW of power acting for 1 hour = 1 kWh = 3.6 MJ

# Energy and EnMS terminology

**3.5 Terms related to energy**

**3.5.1**
**energy**
electricity, fuels, steam, heat, compressed air and other similar media

Note 1 to entry: For the purposes of this document, energy refers to the various types of energy, including renewable, which can be purchased, stored, treated, used in an equipment or in a process, or recovered.

**3.5.2**
**energy consumption**
quantity of *energy* (3.5.1) applied

**3.5.3**
**energy efficiency**
ratio or other quantitative relationship between an output of *performance* (3.4.2), service, goods, commodities, or *energy* (3.5.1), and an input of energy

EXAMPLE Conversion efficiency; energy required/energy consumed.

Note 1 to entry: Both input and output should be clearly specified in terms of quantity and quality and be measurable.

**3.5.4**
**energy use**
application of *energy* (3.5.1)

EXAMPLE Ventilation; lighting; heating; cooling; transportation; data storage; production process.

Note 1 to entry: Energy use is sometimes referred to as "energy end-use".

**3.5.5**
**energy review**
analysis of *energy efficiency* (3.5.3), *energy use* (3.5.4) and *energy consumption* (3.5.2) based on data and other information, leading to identification of *SEUs* (3.5.6) and opportunities for *energy performance improvement* (3.4.6)

**3.5.6**
**significant energy use**
**SEU**
*energy use* (3.5.4) accounting for substantial *energy consumption* (3.5.2) and/or offering considerable potential for *energy performance improvement* (3.4.6)

Note 1 to entry: Significance criteria are determined by the *organization* (3.1.1).

Note 2 to entry: SEUs can be facilities, systems, processes, or equipment.





# Energy and EnMS terminology

**3.4 Terms related to performance**

**3.4.1**
**measurement**
*process* (3.3.6) to determine a value

Note 1 to entry: See ISO/IEC Guide 99 for additional information on measurement-related concepts.

**3.4.2**
**performance**
measurable result

Note 1 to entry: Performance can relate either to quantitative or qualitative findings.

Note 2 to entry: Performance can relate to the management of activities, *processes* (3.3.6), products (including services), systems or *organizations* (3.1.1).

**3.4.3**
**energy performance**
measurable result(s) related to *energy efficiency* (3.5.3), *energy use* (3.5.4) and *energy consumption* (3.5.2)

Note 1 to entry: Energy performance can be measured against the *organization's* (3.1.1) *objectives* (3.4.13), *energy targets* (3.4.15) and other energy performance requirements.

Note 2 to entry: Energy performance is one component of the *performance* (3.4.2) of the *energy management system* (3.2.2).

**3.4.4**
**energy performance indicator**
**EnPI**
measure or unit of *energy performance* (3.4.3), as defined by the *organization* (3.1.1)

Note 1 to entry: EnPI(s) can be expressed by using a simple metric, ratio, or a model, depending on the nature of the activities being measured.

Note 2 to entry: See ISO 50006 for additional information on EnPI(s).

**3.4.5**
**energy performance indicator value**
**EnPI value**
quantification of the *EnPI* (3.4.4) at a point in or over a specified period of time

**3.4.6**
**energy performance improvement**
improvement in measurable results of *energy efficiency* (3.5.3), or *energy consumption* (3.5.2) related to *energy use* (3.5.4), compared to the *energy baseline* (3.4.7)

**3.4.7**
**energy baseline**
**EnB**
quantitative reference(s) providing a basis for comparison of *energy performance* (3.4.3)

Note 1 to entry: An energy baseline is based on data from a specified period of time and/or conditions, as defined by the *organization* (3.1.1).

Note 2 to entry: One or more energy baselines are used for determination of *energy performance improvement* (3.4.6), as a reference before and after, or with and without implementation of energy performance improvement actions.

Note 3 to entry: See ISO 50015 for additional information on measurement and verification of energy performance.

Note 4 to entry: See ISO 50006 for additional information on EnPIs and EnBs.

**3.4.8**
**static factor**
identified factor that significantly impacts *energy performance* (3.4.3) and does not routinely change

Note 1 to entry: Significance criteria are determined by the *organization* (3.1.1).

EXAMPLE Facility size; design of installed equipment; number of weekly shifts; range of products.

[SOURCE: ISO 50015:2014, 3.22, modified — Note 1 to entry and EXAMPLE 1 have been modified and EXAMPLE 2 has been deleted.]

**3.4.9**
**relevant variable**
quantifiable factor that significantly impacts *energy performance* (3.4.3) and routinely changes

Note 1 to entry: Significance criteria are determined by the *organization* (3.1.1).

EXAMPLE Weather conditions, operating conditions (indoor temperature, light level), working hours, production output.

[SOURCE: ISO 50015:2014, 3.18, modified — Note 1 to entry has been added and wording of examples has been modified.]

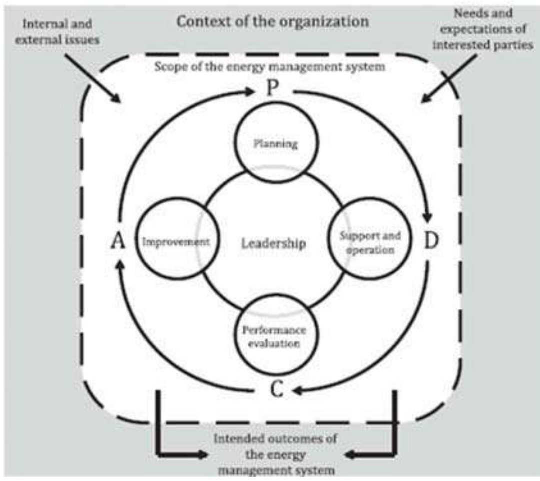
**3.4.10**
**normalization**
modification of data to account for changes to enable comparison of *energy performance* (3.4.3) under equivalent conditions

## See you in 15 minutes!



# Planning process, energy metrics
# Baseline and EnPI

# ISO 50001 Connections




- ISO 50001 based on the Plan-Do-Check-Act continual improvement framework.
- Incorporates energy management into everyday organizational practices.
- What **objective evidence** would you look for to confirm energy performance improvements?



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# Energy Planning

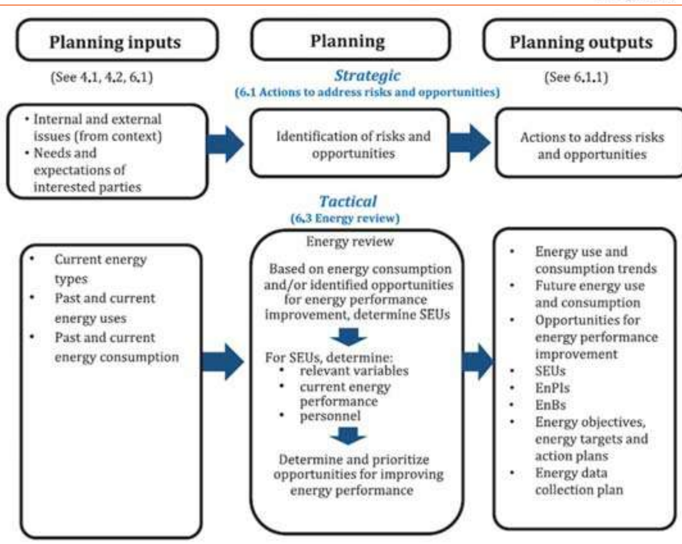
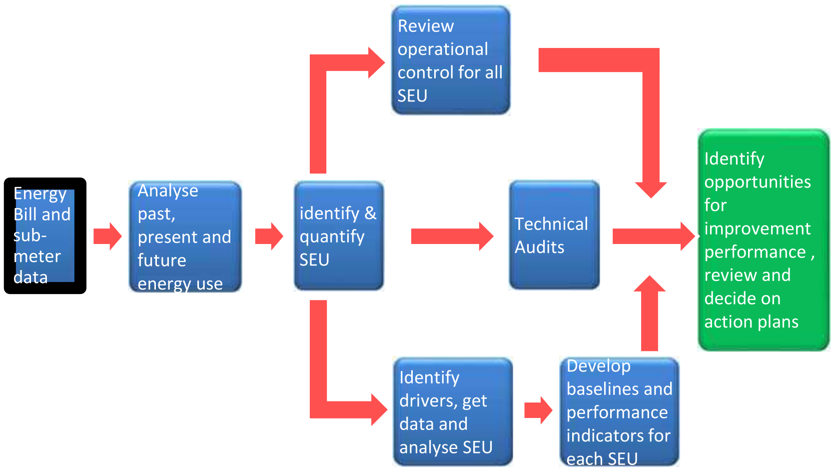



Figure A.2 — Energy planning process

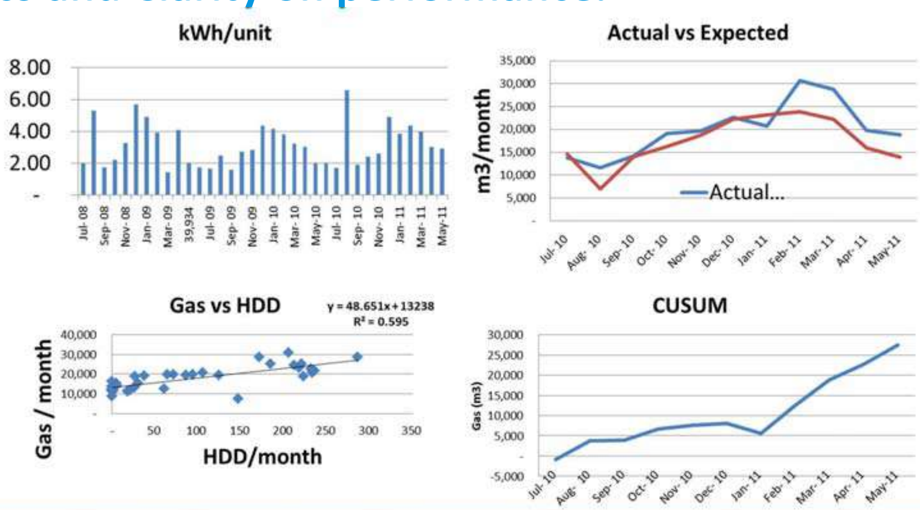
# Planning workflow tactical








# Metrics and Clarity on performance.



# Information Communication for EnPIs

- Tabular
- Simple trends
- Annualised trends
- Trend of annualised use vs target
- Actual V Predicted
- CUSUM
- Etc.



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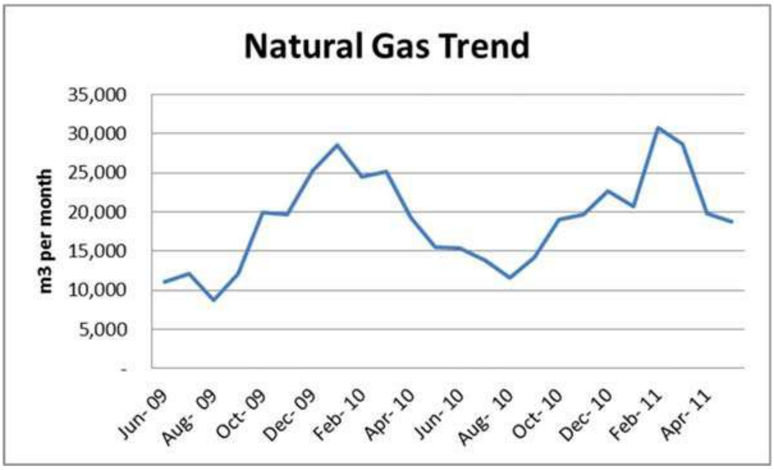
# Tabular Information

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1,166,440 | 26.7 | 161,840 | - | 28,530 | - | 74,633 | 46,485 | - | 46,485 | 4985985 | 133250 | 336920 | 1166440 | 26.7249 | 161840 | -28530.5 | -74693.4 | 46,485 | - | 46,48 |
| 1,292,500 | 36.9 | 156,199 | | 19,886 | - | 54,807 | 46,485 | - | 46,485 | 4774756 | 176085 | 298920 | 1292500 | 36.8783 | 156199 | 19886.3 | -54807.2 | 46,485 | - | 46,48 |
| 1,195,920 | 33.6 | 149,579 | | 2,303 | - | 52,504 | 46,485 | - | 46,485 | 4526917 | 151992 | 294000 | 1195920 | 33.5509 | 149579 | 2302.84 | -52504.3 | 46,485 | - | 46,48 |
| 1,098,020 | 33.5 | 152,292 | | 2,908 | - | 49,596 | 46,485 | - | 46,485 | 4628490 | 155200 | 331200 | 1098020 | 33.5315 | 152292 | 2907.91 | -49596.4 | 46,485 | - | 46,48 |
| 1,102,200 | 34.3 | 148,324 | | 5,434 | - | 44,163 | 46,485 | - | 46,485 | 4479929 | 153758 | 297000 | 1102200 | 34.3215 | 148324 | 5433.85 | -44162.6 | 46,485 | - | 46,48 |
| 1,102,200 | 35.9 | 146,593 | | 11,797 | - | 32,365 | 46,485 | - | 46,485 | 4414736 | 158380 | 307800 | 1102200 | 35.8753 | 146593 | 11797.1 | -32365.5 | 46,485 | - | 46,48 |
| 1,881,440 | 33.2 | 141,720 | - | 1,179 | - | 33,545 | 46,485 | - | 46,485 | 4232682 | 140541 | 304200 | 1881440 | 33.2038 | 141720 | -1179.41 | -33544.3 | 46,485 | - | 46,48 |
| 1,200,000 | 35.7 | 129,774 | | 5,226 | - | 28,319 | 46,485 | - | 46,485 | 3785417 | 135000 | 275000 | 1200000 | 35.6632 | 129774 | 5226.65 | -28319.2 | 46,485 | - | 46,48 |
| 1,191,720 | 40.2 | 130,676 | | 22,953 | - | 5,467 | 46,485 | - | 46,485 | 3819187 | 153529 | 301400 | 1191720 | 40.1994 | 130676 | 22952.7 | -5466.5 | 46,485 | - | 46,48 |
| 934,780 | 36.3 | 126,518 | | 6,419 | | 352 | 46,485 | - | 46,485 | 3663515 | 132937 | 277400 | 934780 | 36.2867 | 126518 | 6418.54 | 352.0 | 46,485 | - | 46,48 |
| 781,000 | 32.4 | 153,322 | - | 2,207 | - | 1,255 | 46,485 | - | 46,485 | 4667053 | 161116 | 294100 | 781000 | 32.3791 | 153322 | 2207.07 | -1255.1 | 46,485 | - | 46,48 |
| 746,000 | 36.2 | 131,439 | | 7,956 | | 6,701 | 46,485 | - | 46,485 | 3947747 | 139395 | 253600 | 746000 | 36.2277 | 131439 | 7955.87 | 6700.8 | 46,485 | - | 46,48 |
| 1,320,000 | 28.9 | 129,530 | - | 20,344 | - | 13,643 | 46,485 | - | 46,485 | 3776257 | 109166 | 273600 | 1320000 | 28.9138 | 129530 | -20343.7 | -13642.3 | 46,485 | - | 46,48 |
| 1,130,140 | 38.3 | 126,565 | | 13,643 | - | 0 | 46,485 | - | 46,485 | 3665261 | 140208 | 264800 | 1130140 | 38.2632 | 126565 | 13642.9 | 0.0 | 46,485 | - | 46,48 |
| 1,000,000 | 37.7 | 63,764 | - | 14,257 | - | 14,257 | 46,485 | - | 46,485 | 1313963 | 49507 | 134440 | 1000000 | 37.6776 | 63764 | -14257 | -14257.001 | 46485.464 | | -46485.46 |
| 665,720 | 53.4 | 69,507 | | 12,080 | - | 2,177 | 46,485 | - | 46,485 | 1528978 | 81587 | 148400 | 665720 | 53.3605 | 69506.3 | 12080.1 | -2176.8633 | 46485.464 | | -46485.46 |
| 956,120 | 42.9 | 78,276 | | 1,374 | - | 902 | 46,485 | - | 46,485 | 1857282 | 79650 | 174000 | 956120 | 42.8952 | 78275.6 | 1374.43 | -902.43479 | 46485.464 | | -46485.46 |
| 965,800 | 37.3 | 92,958 | - | 3,158 | - | 3,960 | 46,485 | - | 46,485 | 2406982 | 89800 | 180400 | 965800 | 37.3081 | 92957.6 | -3157.57 | -3960.0074 | 46485.464 | | -46485.46 |
| 1,796,960 | 32.4 | 117,063 | - | 9,992 | - | 13,952 | 46,485 | - | 46,485 | 3309715 | 107077 | 224100 | 1796960 | 32.3523 | 117063 | -9991.77 | -13951.78 | 46485.464 | | -46485.46 |
| 953,040 | 35.1 | 139,526 | | 6,349 | - | 7,603 | 46,485 | - | 46,485 | 4150500 | 146874 | 271300 | 953040 | 35.1461 | 139526 | 6348.6 | -7603.1774 | 46485.464 | | -46485.46 |
| 1,276,000 | 32.0 | 173,327 | - | 159 | - | 7,763 | 46,485 | - | 46,485 | 5416059 | 173168 | 315100 | 1276000 | 31.9731 | 173327 | -159.359 | -7762.5365 | 46485.464 | | -46485.46 |
| 1,270,000 | 27.0 | 204,029 | - | 27,029 | - | 34,792 | 46,485 | - | 46,485 | 6565549 | 177000 | 315900 | 1270000 | 26.9589 | 204029 | -27029.2 | -34791.757 | 46485.464 | | -46485.46 |
| 1,046,000 | 37.1 | 222,126 | | 46,566 | | 11,774 | 46,485 | - | 46,485 | 7243118 | 268692 | 366300 | 1046000 | 37.0962 | 222126 | 46565.5 | 11773.753 | 46485.464 | | -46485.46 |
| 1,690,920 | 30.0 | 201,295 | - | 7,307 | | 4,467 | 46,485 | - | 46,485 | 6463186 | 193988 | 344560 | 1690920 | 30.0143 | 201295 | -7307.2 | 4466.5571 | 46485.464 | | -46485.46 |
| 1,480,160 | 32.1 | 200,468 | | 5,883 | | 10,349 | 46,485 | - | 46,485 | 6432224 | 206351 | 342060 | 1480160 | 32.0808 | 200468 | 5882.77 | 10349.323 | 46485.464 | | -46485.46 |
| 1,363,340 | 30.7 | 214,136 | - | 934 | | 9,416 | 46,485 | - | 46,485 | 6943941 | 213202 | 350060 | 1363340 | 30.7033 | 214136 | -933.737 | 9415.6924 | 46485.464 | | -46485.46 |
| 1,296,660 | 33.4 | 179,798 | | 8,920 | | 18,336 | 46,485 | - | 46,485 | 5658315 | 188718 | 368720 | 1296660 | 33.3523 | 179798 | 8920.2 | 18335.79 | 46485.464 | | -46485.46 |
| 1,277,100 | 25.3 | 189,230 | - | 37,020 | - | 18,685 | 46,485 | - | 46,485 | 6011474 | 152210 | 345020 | 1277100 | 25.3199 | 189230 | -37020.4 | -18684.578 | 46485.464 | | -46485.46 |
| 1,267,200 | 34.2 | 177,468 | | 12,822 | | 5,963 | 46,485 | - | 46,485 | 5671104 | 190290 | 347800 | 1267200 | 34.1666 | 177468 | 12821.6 | 5963.0518 | 46485.464 | | -46485.46 |
| 1,240,600 | 30.6 | 178,180 | - | 7,139 | - | 13,002 | 46,485 | - | 46,485 | 5597737 | 171041 | 349800 | 1240600 | 30.5554 | 178180 | -7138.82 | -13001.87 | 46485.464 | | -46485.46 |
| 1,171,720 | 31.5 | 153,653 | - | 6,478 | - | 19,480 | 46,485 | - | 46,485 | 4879459 | 147175 | 319800 | 1171720 | 31.4513 | 153653 | -6478.42 | -19480.294 | 46485.464 | | -46485.46 |
| 1,329,020 | 32.4 | 157,587 | - | 1,172 | - | 20,653 | 46,485 | - | 46,485 | 4926743 | 156415 | 303800 | 1329020 | 32.4059 | 157587 | -1172.25 | -20652.644 | 46485.464 | | -46485.46 |
| 1,136,080 | 30.4 | 160,428 | - | 10,392 | - | 31,044 | 46,485 | - | 46,485 | 4933089 | 150036 | 298000 | 1136080 | 30.4142 | 160420 | -10391.7 | -31044.201 | 46485.464 | | -46485.46 |
| 1,031,800 | 32.6 | 154,798 | - | 874 | - | 31,918 | 46,485 | - | 46,485 | 4722306 | 153924 | 295200 | 1031800 | 32.5951 | 154798 | -873.83 | -31918.031 | 46485.464 | | -46485.46 |
| 1,057,640 | 29.6 | 162,109 | - | 14,185 | - | 46,103 | 46,485 | - | 46,485 | 4996037 | 147924 | 296100 | 1057640 | 29.6093 | 162109 | -14184.9 | -46102.974 | 46485.464 | | -46485.46 |
| 1,166,440 | 26.7 | 161,840 | - | 28,530 | - | 74,633 | 46,485 | - | 46,485 | 4985985 | 133250 | 336920 | 1166440 | 26.7249 | 161840 | -28530.5 | -74693.437 | 46485.464 | | -46485.46 |
| 1,292,500 | 36.9 | 156,199 | | 19,886 | - | 54,807 | 46,485 | - | 46,485 | 4774756 | 176085 | 298920 | 1292500 | 36.8783 | 156199 | 19886.3 | -54807.16 | 46485.464 | | -46485.46 |
| 1,195,920 | 33.6 | 149,579 | | 2,303 | - | 52,504 | 46,485 | - | 46,485 | 4526917 | 151992 | 294000 | 1195920 | 33.5509 | 149579 | 2302.84 | -52504.322 | 46485.464 | | -46485.46 |
| 1,098,020 | 33.5 | 152,292 | | 2,908 | - | 49,596 | 46,485 | - | 46,485 | 4628490 | 155200 | 331200 | 1098020 | 33.5315 | 152292 | 2907.91 | -49596.409 | 46485.464 | | -46485.46 |
| 1,102,200 | 34.3 | 148,324 | | 5,434 | - | 44,163 | 46,485 | - | 46,485 | 4479929 | 153758 | 297000 | 1102200 | 34.3215 | 148324 | 5433.85 | -44162.584 | 46485.464 | | -46485.46 |
| 1,102,200 | 35.9 | 146,593 | | 11,797 | - | 32,365 | 46,485 | - | 46,485 | 4414736 | 158380 | 307800 | 1102200 | 35.8753 | 146583 | 11797.1 | -32365.471 | 46485.464 | | -46485.46 |
| 1,881,440 | 33.2 | 141,720 | - | 1,179 | - | 33,545 | 46,485 | - | 46,485 | 4232682 | 140541 | 304200 | 1881440 | 33.2038 | 141720 | -1179.41 | -33544.876 | 46485.464 | | -46485.46 |
| 1,200,000 | 35.7 | 129,774 | | 5,226 | - | 28,319 | 46,485 | - | 46,485 | 3785417 | 135000 | 275000 | 1200000 | 35.6632 | 129774 | 5225.65 | -28319.229 | 46485.464 | | -46485.46 |
| 1,191,720 | 40.2 | 130,676 | | 22,953 | - | 5,467 | 46,485 | - | 46,485 | 3819187 | 153529 | 301400 | 1191720 | 40.1994 | 130676 | 22952.7 | -5466.5649 | 46485.464 | | -46485.46 |
| 934,780 | 36.3 | 126,518 | | 6,419 | | 352 | 46,485 | - | 46,485 | 3663515 | 132937 | 277400 | 934780 | 36.2867 | 126518 | 6418.54 | 351.99277 | 46485.464 | | -46485.46 |

# What does this tell us?

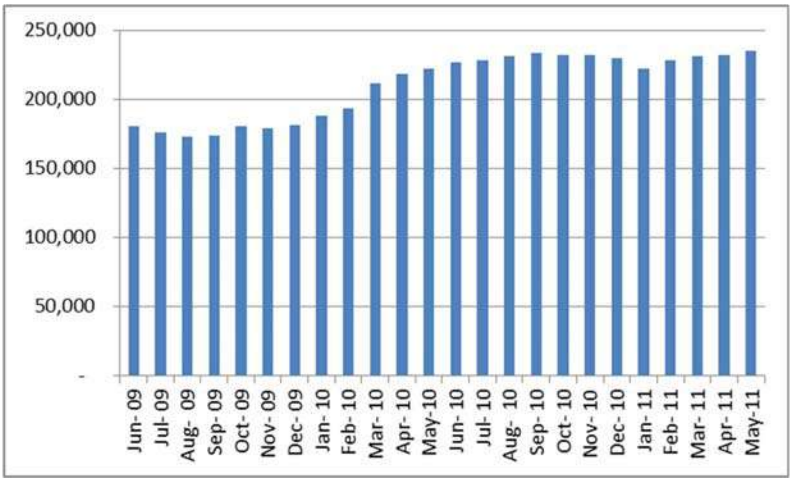





# Annualised Trend

- 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 months 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

## Same gas data in annualised view



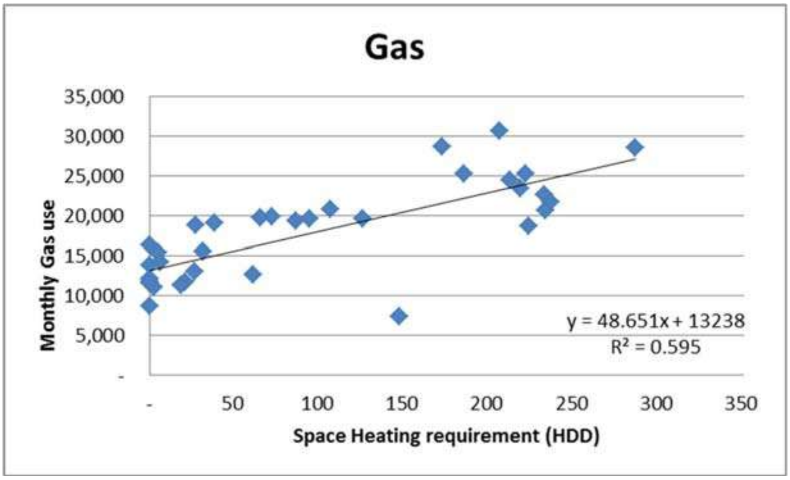



## Problem: energy consumption varies due to....

- 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

## 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 vs. actual usage to indicate performance!**

# In general

- Expected energy consumption can be any function of relevant driving factors, D

$$E = f(D1, D2, \cdots\cdots. Dn)$$

- Use the simplest effective model
- A straight-line relationship is often good enough



BỘ CÔNG THƯƠNG Global Gateway Funded by the European Union TỔ CHỨC PHÁT TRIỂN CÔNG NGHIỆP LIÊN HỢP QUỐC

# Other models

Multivariate linear regression:

$$Y = b + m_1X_1 + m_2X_2$$

Polynomial linear regression:

$$Y = b + m_1X_1 + m_2(X_2)^2$$

Nonlinear regression (energy use in cement industry):

$$E_i = \beta_0 + \beta_1 \ln(capacity) + \beta_2 \ln(labor\ hours) + \beta_3 \ln(total\ cement\ production)$$
$$+ \beta_4 \ln(number\ of\ kilns) + \beta_5(\%\ masonry) + \beta_6(\%\ 4\ or\ other)$$
$$+ \beta_7(\%\ wet) + \varepsilon_i$$

Courtesy of Argonne National Laboratory and EPA, ANL/DIS -06-3

## Statistics Terms

Interpretation

1. Review the p-values at the bottom of the data entry chart. Ensure the p-value for each variable is less than 0.05. Variables that have high p-values should be removed from the analysis (remove the variable as an input and rerun the analysis).

2. The F-test is a test of model significance. Ensure the p-value for the model is less than 0.05.

3. Review the R2 value for the regression equation. (The R2 value quantifies the amount of variation in the dependent variable, Y, which is explained by the regression equation. Ideally, you would like for the R2 value to be high, indicating that you have a model that explains a large portion of the variation in energy consumption.)

4. If the R2 value for the model is low, review the factors to determine if a factor that can impact energy usage has been overlooked.

5. Determine, based on process knowledge, whether the regression makes sense.



## Multi-variable linear regression

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.940601644 |
| R Square | 0.884731453 |
| Adjusted R Square | 0.85911622 |
| Standard Error | 4910.773928 |
| Observations | 12 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 2 | 1665877415 | 8.33E+08 | 34.53927 | 5.99375E-05 |
| Residual | 9 | 217041305.1 | 24115701 | | |
| Total | 11 | 1882918720 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 24848.98769 | 15881.10198 | 1.564689 | 0.152095 | -11076.56091 | 60774.54 | -11076.56091 | 60774.53629 |
| tons | 2.549170827 | 0.494038127 | 5.159867 | 0.000595 | 1.431578939 | 3.666763 | 1.431578939 | 3.666762715 |
| CDD | 33.58479232 | 9.093848921 | 3.693133 | 0.004973 | 13.01307684 | 54.15651 | 13.01307684 | 54.15650779 |

## 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



## Regression

## Step-by-step Demonstration

# Purpose of energy metrics

- Objective support for decision making
  - too often subjective reasons are used!
- We need to know how much energy we are using
- We need to know if **performance** is improving
- We need to know if we are meeting targets
- We need to be able to **verify savings** of improvements

$$E_S = B_{peu} - R_{peu} \pm A$$



# Example Performance Indicators

- Facility-wide EnPIs
- Process-unit level
  - Product specific
  - Process specific
- Energy System level
  - Compressed Air – kW / $m^3$/sec
  - Steam systems – kWh / kg/hr
  - Furnace – kWh / unit

## Energy Metrics – 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



## Simple ratios – beware!

- 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 - be careful!

- 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)

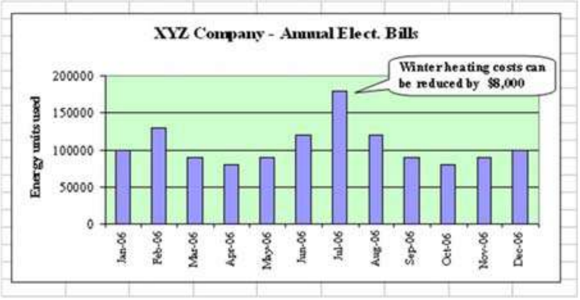


## Performance checking with EnPI

- 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

# Energy Baseline

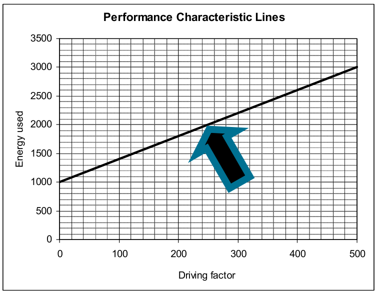
- Basis of comparison for evaluating energy performance
  - Facility-wide
  - Systems and equipment
  - Significant energy uses
- Uses pieces of initial energy review
  - Energy use data
  - Energy consumption data
- Facility-determined time period
  - Point in time
  - Period of time
- Measure energy performance improvement against the baseline





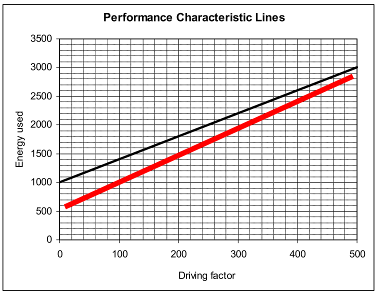

# Targets and baselines

- "Target" characteristic
  - For management control
  - Base on best achievable performance
  - Keep continually adjusting



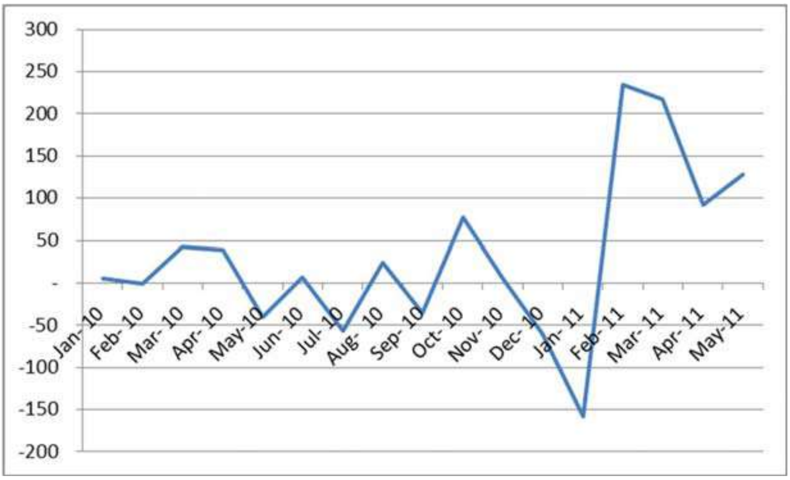
# Targets and baselines

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

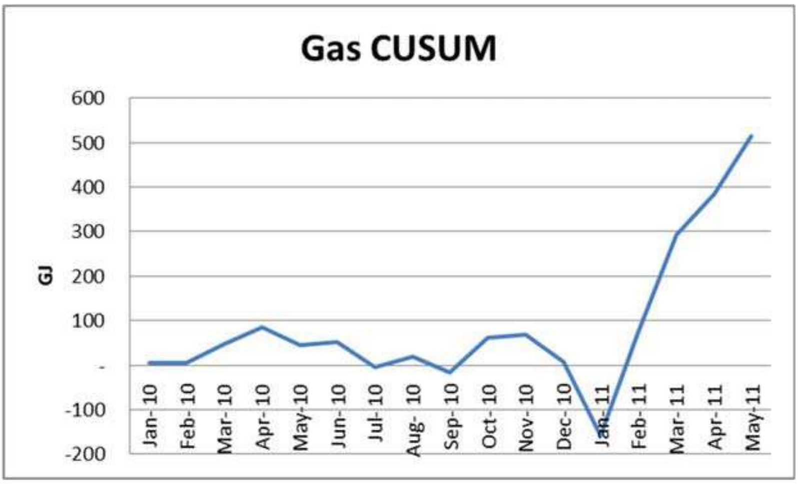





# Difference between expected and actual



## CUmulative SUM of difference (CUSUM)



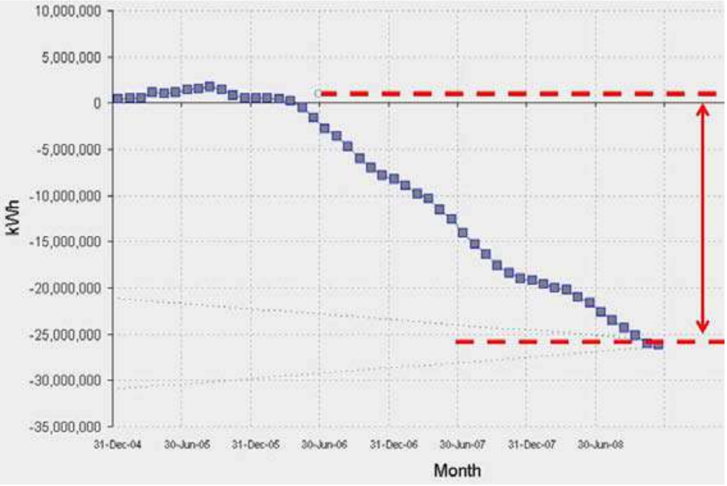



## Historical baseline characteristic

- 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

## 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

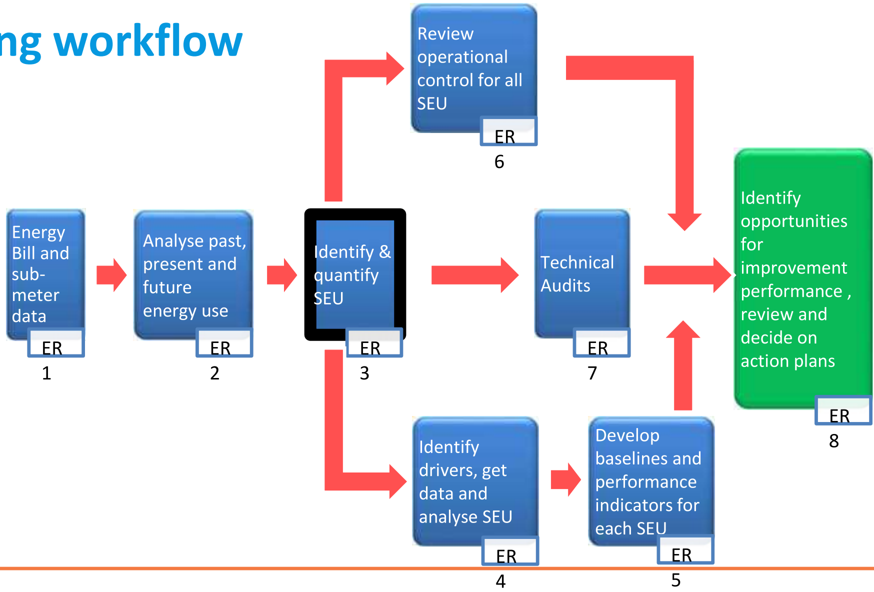
## Adjust Energy Baseline

- Major process changes
- Major operational changes
- Major energy system changes
- When EnPIs no longer reflect organizational use
- As determined by the organization (predetermined method)



Significant energy uses identification

# Planning workflow








# Significant Energy Uses

- Significant component of the organization consumption
- Equipment, processes, facilities, systems
- Considerable opportunity for improvement
- Determined by organization!
- Document methods and criteria

## Significant Energy Use Identification

- Use facility and process flow diagrams to identify energy uses and interactions
- Show primary and secondary energy streams
- Use previously collected data to determine energy use
- Is additional data required?
- Group equipment and processes into logical systems
- Which people affect the energy use of that item/system?



## How to quantify each energy user

- Do you have sub-metering?
  - Automatically logged to a database
  - Manual readings
  - Meters accurate and working
  - Data collection process working, consistent and accurate
- Do you have local meters?
  - These can be read manually and calculated/estimated
  - Care with time of readings
- Motor List, Heat Balance, Sankey Diagram
- Ideally identify at least 80% of energy use
- SEU list is the basis of much of the EnMS

## Heat (energy) balance

- Use what you know:
  - Steam flow
  - Feedwater flow (= steam flow approximately)
  - Fuel flow (heat flow = fuel flow * efficiency)
  - Gas bills
  - Hot water flow and temperature difference (dT) (Q=m*Cp*dT)
- Build up a balance
  - Heat in = heat out
  - If you have a significant gap, you may need to measure it
  - Ultrasonic flow meters, portable heat meters
- More challenging than electrical power
  - Typically fewer measuring points



## Significant Energy Use Identification

- Organize data in energy balance or other method to identify equipment and processes
- Use internal knowledge to add to list
- Techniques
  - Energy balance
  - Ranking methods
  - Six sigma tools
  - Other data analyses
- Remember Pareto Rule (80/20)
- **Start with a few**

## Rank Uses

| Description | kW | % | Annual $ |
|---|---|---|---|
| Melter | 9,634 | 53.4% | $2,959,879 |
| Hi Press Air Compressor | 2,330 | 12.9% | $715,852 |
| Med Press Air Compressor | 780 | 4.3% | $239,641 |
| Med Freq. | 545 | 3.0% | $167,442 |
| Forming Fans | 494 | 2.7% | $151,773 |
| Oven Scrubber | 450 | 2.5% | $138,255 |
| Scrubber | 414 | 2.3% | $127,194 |
| Cooling Water | 407 | 2.3% | $125,044 |
| Filtered Air | 373 | 0.0% | $114,598 |
| Fans | 336 | 1.9% | $103,230 |
| Med Freq | 320 | 1.8% | $98,314 |
| East Scrubber | 255 | 1.4% | $78,344 |
| Forming Fans | 150 | 0.8% | $46,085 |
| F. Fans West 4,5 | 122 | 0.7% | $37,482 |
| Line Drive | 69 | 0.4% | $21,199 |
| Other loads and misc. | 1,241 | 6.9% | $381,276 |
| **100% Load Factor kW** | **18,042** | **100.0%** | **$5,543,090** |

66% of total load



## Another Method to Determine Significance

| | Rating Description | | | |
|---|---|---|---|---|
| **Criteria** | **1** | **2** | **3** | **4** |
| **Percentage of total plant energy consumption** | **0-10%** | **11-25%** | **26-50%** | **51-100%** |
| **Value of anticipated opportunity** | **Less than $10,000/year** | **$10,000-$25,000/year** | **$25,000-$100,000/year** | **Greater than $100,000/year** |

# Connections to Significance




Discussion

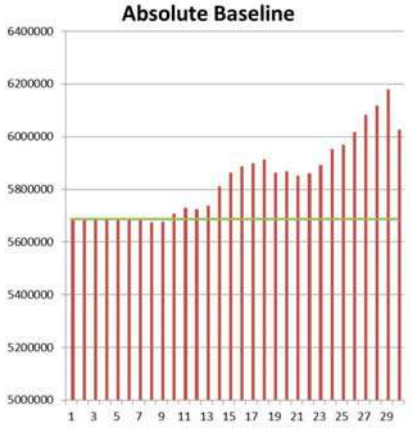
## Discussion

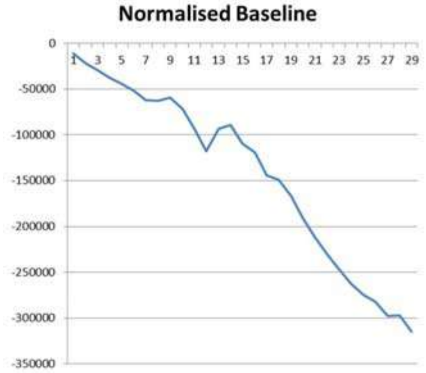
- The following slide uses the same data from the site
- The graph on the left establishes a baseline based on absolute kWh
- The graph on the right establishes a baseline normalised against production

- **Does this site demonstrate energy performance improvement?**
- **What additional information do you need to make a determination?**



## Baseline Example



Energy systems part I



## Overview of energy using systems

- Compressed air
- Steam boiler
- Pumps
- Fans
- HVAC
- Heating and cooling systems
- Power systems
- etc

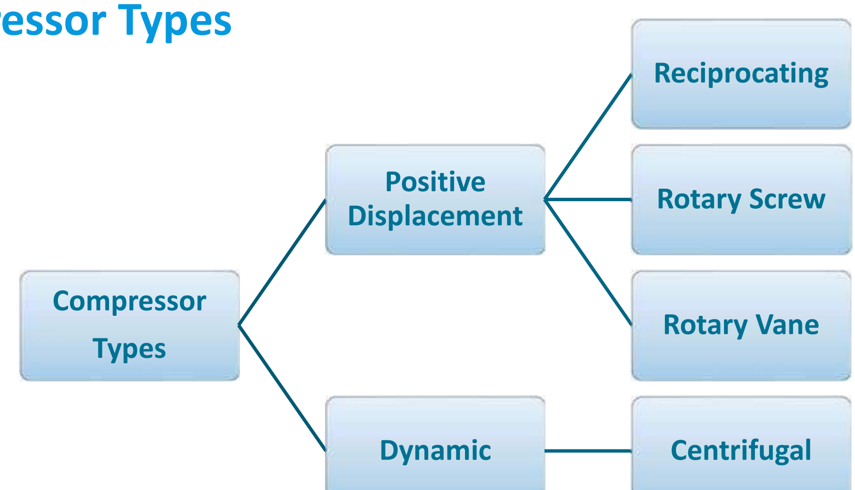
# Compressed Air Systems

General Characteristics

- Cost savings potential of 20-50%
- Improvement opportunities on both supply and demand side
- Widely used and high cost

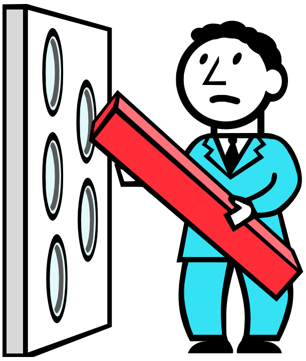


# Compressor Types



## Potentially Inappropriate Applications

- Open blowing
- Sparging
- Aspirating
- Atomizing
- Padding
- Dilute phase transport
- Vacuum generation
- Personnel cooling and cleaning
- Cabinet cooling





## Operating Characteristics and Inefficient Applications of Compressed Air Systems

Geo Manufacturing currently uses compressed air to mix paint in the process line for its Orange Grove, CA plant. When designing its newest facility in Houston, TX, the system designer must choose between a compressed air motor or an electric motor to mix paint in the process line. The electric motor has an initial purchase price which is 10% more than the compressed air motor. Why should the designer choose the electric motor?

A. Electric motors weigh less than air motors

B. Using a compressed air system to mix paint is less efficient than using an electric motor for this application

C. Electric motors provide more uniform mixing

D. Electric motors require less maintenance than air motors and last longer

## Opportunities for Improved Efficiency

Operation and Maintenance

- Eliminate air leaks
- Reduce compressed air pressure
- Use synthetic oil
- Reduce wasteful applications
- Intake outside air
- Provide air quality appropriate to application



## Opportunities for Improved Efficiency

Capital Investment

- Install sequencer control
- Install VFD compressor as trim unit
- Install small dedicated air compressor
- Increase air storage and turnoff trim compressor
- Use blowers for certain applications
- Recover waste heat

## Data Integration & Relevant Variables

- Air pressure
- Inlet air temperature
- Compressor loading
- Control method
- Compressor type



## Reduce Operating Pressure

- Determine minimum required pressure
- Adjust pressure setting
- Consider when operating pressure 10 psi higher than required for equipment

***Cost savings approximation:***

$1.80 per psi reduction per hp of compressor power per year.

Example: a 10 psi reduction of a fully loaded 2000 hp compressor.

Annual Savings = $1.80/(psi-hp) x 10 psi x 2000 hp = $36,000 per year

## Improve Compressor Controls

- Screw compressors may consume 60% to 80% of rated power idling at
  no-load (i.e., 0 cfm)
- Shut down extra units when not required
- Replace with modular units of small compressors
- Install integrated sequence controls to improve system operating efficiency

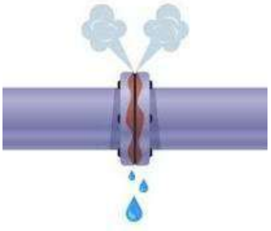
A compressed air management system could save 20% or more of the compressor's electrical cost



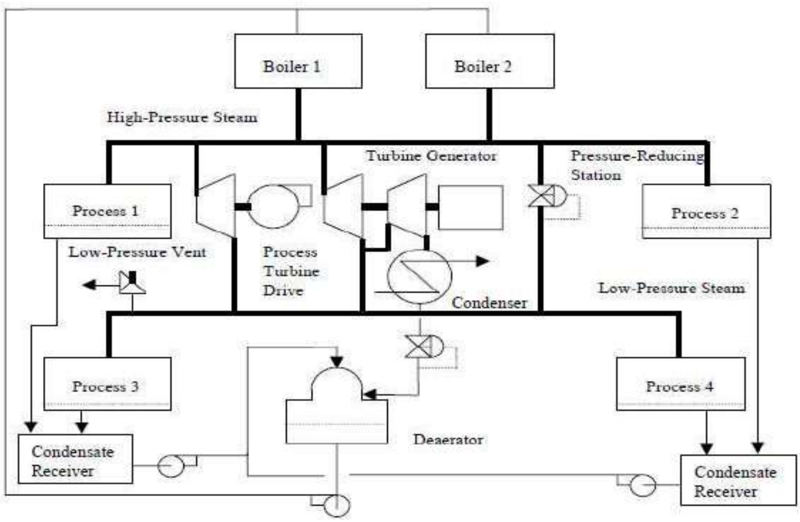
## Opportunities for Improved Efficiency of Air Compressor Systems

Air leaks cannot normally be surveyed in a plant that operates 24/7 because of the background noise.

- True or
- False



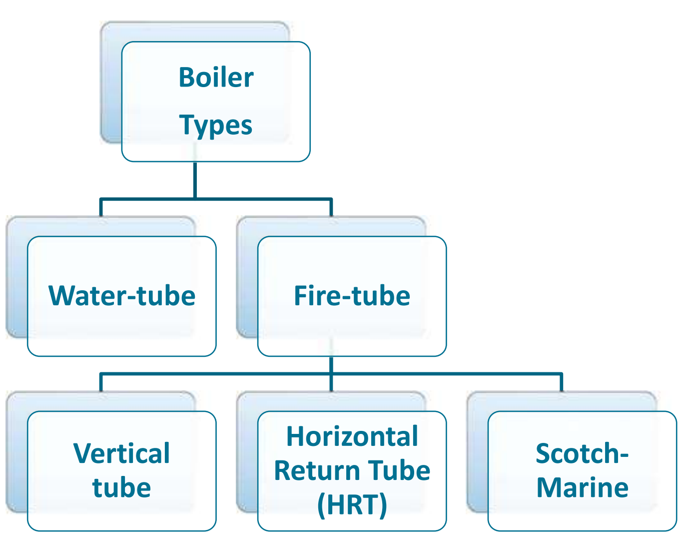
## Steam Systems (scheme of major components)








## Boiler Types



## Factors Affecting Steam System Performance

- Boiler design
- Combustion system type
- Fuel type
- System conditions: pressure, condensate recovery, makeup water quality
- Condition of heat transfer surfaces



## Potentially Inappropriate Applications

- Direct Sparging
- Humidification
- Hot water via mixing valve
- Vacuum generation

## Operating Characteristics and Inefficient Applications of Steam Systems

Which of the following is an appropriate use of steam as energy in a manufacturing plant?

A. Using steam to add moisture to a space

B. Using steam for vacuum generation

C. Using steam in a heat exchanger to raise the temperature of air, water or solutions

D. Generating hot water by direct mixing of cold water and steam



## Opportunities for Improved Efficiency

Operation and Maintenance

- Eliminate steam leaks
- Reduce boiler pressure
- Boiler combustion tune-up
- Inspect and repair failed steam traps
- Minimize deaerator venting
- Minimize blowdown
- Shutoff backup boiler

## Opportunities for Improved Efficiency

<u>Capital Investment</u>

- Install automatic blowdown control
- Insulate steam and condensate return lines
- Install stack economizer
- Increase condensate recovery
- Recover heat from boiler blowdown
- Flash steam vent condenser
- Install oxygen trim control



## Data Integration & Relevant Variables

- Boiler operating pressure
- Excess combustion air
- Stack temperature
- Boiler load, i.e. steaming rate
- Condensate return temperature and amount
- Makeup water quality
- Makeup water temperature

## Shutdown Backup Boiler

- Backup boiler on standby is high cost for rare occurrence
- High turndown burner improves efficiency and limits loss
- Standby losses for 500 hp boiler are around $12,000 to $25,000 per year



## Opportunities for Improved Efficiency – Steam Systems

- Reducing boiler pressure improves operating efficiency by:
  A. Lowering steam temperature
  B. Reducing losses from steam leaks and condensate flash
  C. Reducing stack temperature
  D. All - A, B and C

## See you in 45 minutes!



Energy systems part II

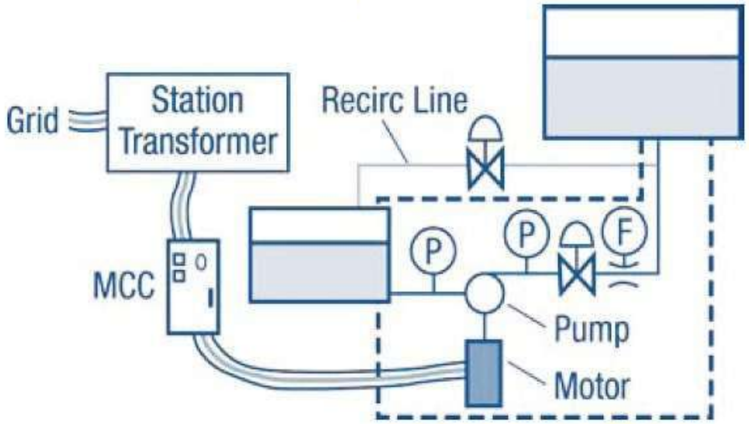
# Pumping Systems

Factors Affecting Pump performance

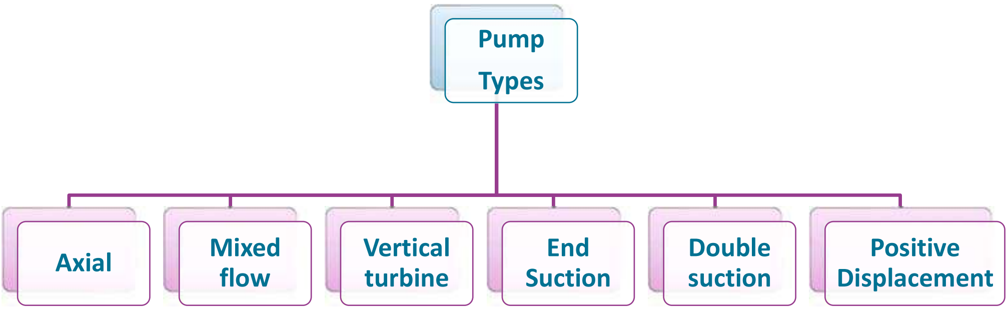
- Liquid flowrate
- Differential pressure
- Liquid density
- Pump suction head
- Operating speed



# Pump System Components



# Pump Types



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# Pump Types

Double suction

End suction

Axial flow

Vertical turbine

## Pump Applications

| | |
|---|---|
| End-suction centrifugal | applications such as condenser, chilled, and hot water systems in HVAC and process secondary pumping |
| API double suction | for use in both pipeline and general refinery applications; petrochemical and heavy-duty chemical processing; boiler-feed booster and other high temperature services; water and general Industrial |
| Multi-stage boiler feed | suitable for domestic water supply, boiler feeding, condensate water circulation, and handling mineral and vegetable oils |
| Axial flow | Typical applications for the Axial Flow pump include high volume, low head duties like evaporators, crystallizers, heat recovery, and high-volume mixing |
| Vertical turbine | Cooling towers, pressure boosting and general water service |



## Indicators of Inappropriate Applications

- Throttle-valve control for system
- Cavitation noise or damage
- Continuous operation in batch process
- Bypass line normally open
- High system maintenance
- Systems that have changed function

# Opportunities for Improved Efficiency

## Operation and Maintenance

- Repair pump leaks
- Turn off pumps when not in use
- Trim or replace impellers on oversized pumps
- Reduce or eliminate by-pass flow and control (throttling) valves
- Optimize parallel pumping systems

## Capital Investment

- Optimize piping size
- Match pump size to requirements
- Install VFD on pump



# Data Integration & Relevant Variables

- Pump differential pressure
- Pump head
- Fluid density
- Pump flowrate
- Pump speed

## Measure: Repair Pump Leaks

- Liquid pumps have seals between rotating shaft and housing and leaks frequently occur
- Additional leaks can occur at couplings, flexible hose connections
- Pump seals and pipe washers and gaskets should be replaced at shutdown when leaks are present



## Install VFD on Pump

- Pumps are constant speed devices and transfer a fixed amount of fluid
- Processes have varying loads and demand
- Most processes use by-pass valves
- More efficient approach would be to install a variable speed drive on the pump motor

## Opportunities for Improved Efficiency – Pumping Systems

Which of the following is a valid way to improve the efficiency of a pumping system that involves very little capital expense?

A. Install a VFD

B. Reduce production

C. Turn off pump when not in use

D. Decrease pump size to match requirement



## Fan Systems

General Characteristics

- In manufacturing, fans use about 78.7 billion kilowatt-hours of energy each year.
- Consumption represents roughly 15% of electricity used in motors.
- Oversized fans cost more to operate and create avoidable system problems.

# Fan Types

Fan Types

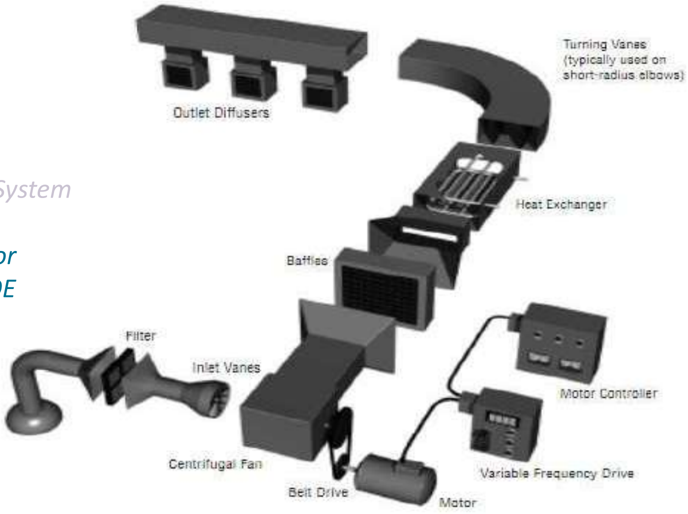
- Axial
- Centrifugal





# Fan System Components

*Source:*
*Improving Fan System Performance:*
*A Sourcebook for Industry: US DOE*



## Potentially Inefficient Applications

- Fan Degradation
- Re-Adjustment
- Contaminant Build Up
- Leakage
- Ductwork geometry
- Oversize fans



## Opportunities for Improved Efficiency

Operation and Maintenance

- Maintenance items- bearing lube, belt tightening, filter cleaning/replacement, blade cleaning, ductwork repair
- Turn off fans when not in use
- Replace standard v-belts with cogged v-belts

Opportunities for Improved Efficiency

- Increase duct size and include flow straighteners, splitters and turning vanes
- Replace oversize fans with correct size
- Two-speed motors for fan drive
- VFD fan control

## Data Integration & Relevant Variables

- Airflow and Pressure Requirements
- Fan Design and Materials
- Size of fan
- Size of motor
- Fan Rotational Speed
- Contaminant Build-up on Fan Blades
- Ductwork geometry: diameter, length, turns



## Opportunities for Improved Efficiency of Fan Systems

When implementing a plan for energy performance improvement of fan systems, it is best to concentrate only on large fans that consume a significant amount of energy.

- True or
- False

## HVAC Systems

General Characteristics

- Heating, ventilation and air conditioning (HVAC) is the process to provide comfort and environmental control in a facility
- Largest energy user in a big commercial facility is (HVAC) system
- Chilled water systems may be used for both process cooling and environmental control
- Chiller systems can account for 35% of electrical energy use in a large commercial facility
- Many manufacturing facilities do not require additional heating for comfort
- Manufacturers often have specific ventilation requirements



## Factors Affecting Performance

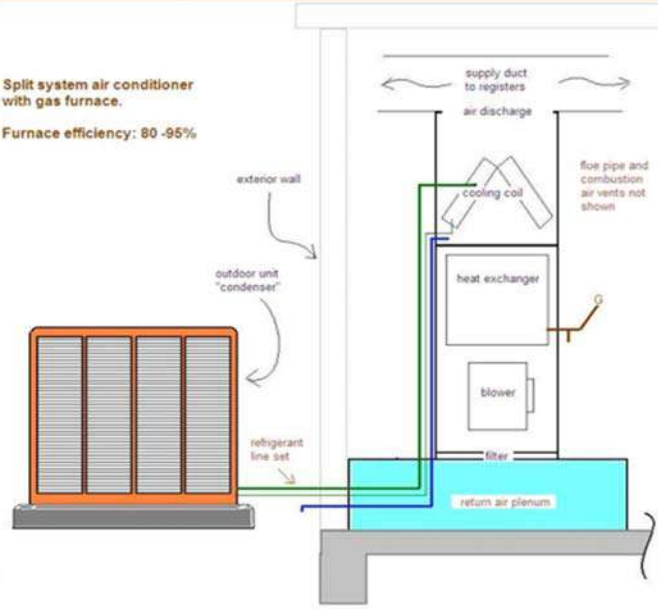
COOLING
- Head pressure
- Suction pressure
- Refrigerant type
- Compressor control method
- Condenser tower fan control

HEATING
- Fuel Type
- Exhaust Temp.
- Supply Air Temp.
- Excess Combustion Air

# Cooling System Components

Split System HVAC Components

- Condenser/ compressor
- Air handler unit with blower
- Cooling coil
- Heater heat exchanger






# Cooling System Types

- Cooling Systems
  - Window unit
  - Split system
  - PTAC (ex. = RTU)
  - Central system
- Heating Systems
  - Forced air
  - Hydronic
  - Radiant
  - Steam
  - Heat pump

## Potentially Inefficient Applications

- Improperly sized cooling coils and control valves
- Short-circuiting chilled water
- Excessively low chilled water temperature
- Excessively high condenser water temperature
- Fouled heat exchanger in furnace
- Poor combustion efficiency
- Dirty furnace or air conditioner filters
- Exhausting heated/cooled air to satisfy air quality requirements
- Maintaining set-point temperature 24/7
- Running ventilation fans 24/7



## Operating Characteristics and Inefficient Applications – HVAC Systems

In major facilities, HVAC systems can account for up to _____ of a facility's electrical energy consumption?

A. 60%

B. 5%

C. 90%

D. 35%

The components of an HVAC split-system include:

A. Condenser/compressor

B. Blower

C. Cooling Coil

D. All - A, B and C

## Opportunities for Improved Efficiency

Operation and Maintenance

- Regularly clean or replace air filters
- Clean coils as needed
- Set-forward temperature when space is unoccupied
- Maintain proper refrigerant charge
- Tighten v-belts regularly
- Tune-up heater burner regularly



## Opportunities for Improved Efficiency

Capital Investment

- Replace refrigerant
- Use “free cooling” when possible
- Install VFD controls
- Install geothermal heat pump
- Install chiller sequencer
- Install high efficiency condensing furnace

## Data Integration and Relevant Variables

- Space temperature
- Ambient temperature
- Cooling system performance
- Furnace efficiency
- Run hours and occupied hours
- Cooling system capacity and load
- Heating system capacity and load

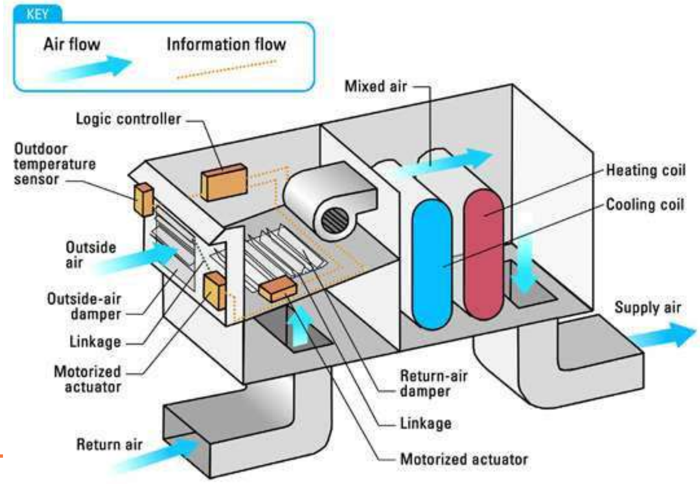


## Set-forward space temperature

- When unoccupied, space temperature can be increased
- Savings depends on geographic location and degrees set-forward

## Use free cooling when possible

- Free cooling can also be used with process cooling




When outside air is cooler than return air (space temperature), using it will reduce cooling load and save energy



## Plan for Energy Performance Improvement

- Check air flow , clean coils and replace filter if needed
- Increase/decrease set-point temperature
- Consider changing refrigerant
- Analyze VFD control on pumps, fans and compressors
- Install sequencer control on chillers
- Consider condensing furnace

## Opportunities for Improved Efficiency – HVAC Systems

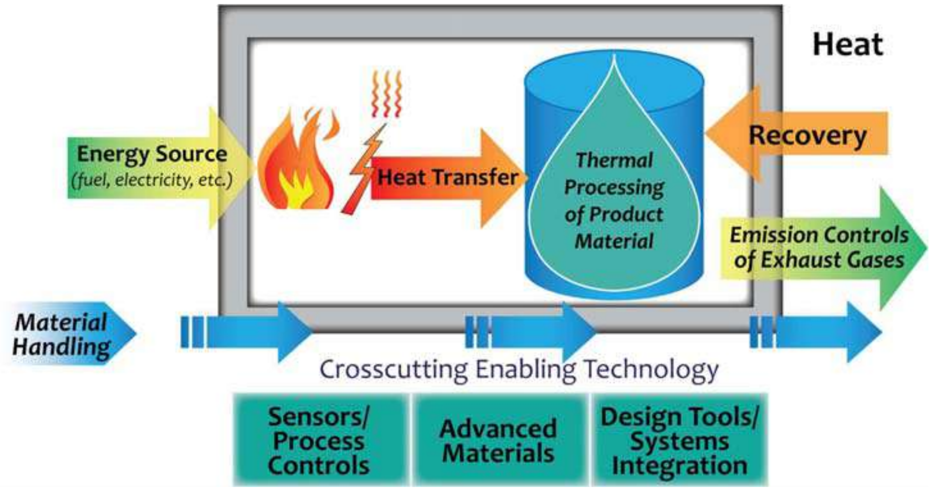
It is best to leave facility temperature settings at a constant, especially during the summer months.  Setting thermostats at a higher temperature when the building is unoccupied causes the HVAC system to use more energy to cool the space once the settings are changed.  This measure actually uses more energy rather than improving efficiency.

True

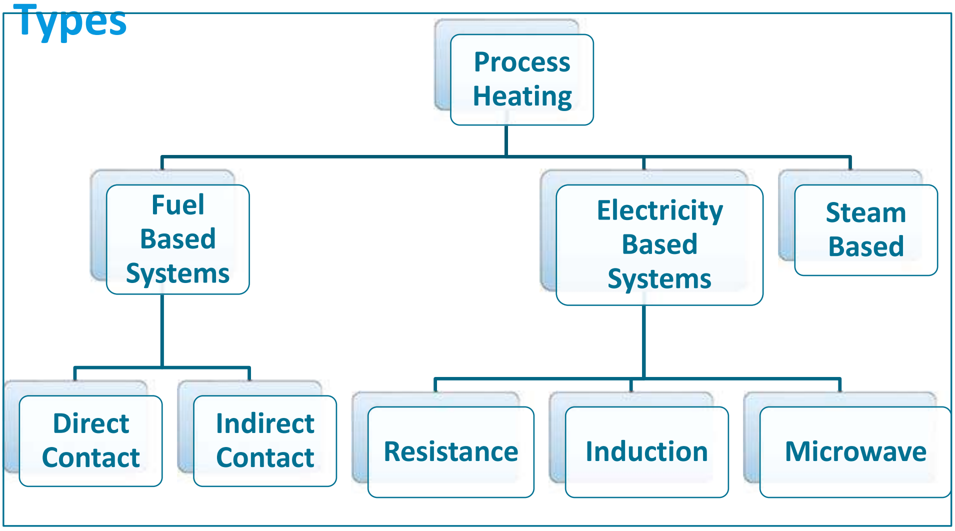
False



# Process Heating



## System Types






## Factors Affecting Performance

- Heating method: direct vs. indirect
- Operating temperature
- Heating element: simple burner, radiant tube burner, heating panel, band or drum
- Air balance
- Insulation losses
- Operating method: batch vs. continuous

## Potentially Inefficient Operations

- Inefficient combustion
- Oven/furnace Leakage
- Fouled heat transfer surfaces
- Ineffective insulation
- Stack heat losses
- Ineffective controls



## Operating Characteristics and Inefficient Applications – Process Heat Systems

Process Heat Systems can be:

A. Fuel-based

B. Electricity-based

C. Steam-based

D. All of these

## Opportunities for Improved Efficiency

Operation and Maintenance

- Tune-up burner
- Clean heat transfer surfaces
- Eliminate air leaks
- Install seals/curtains to reduce losses
- Minimize support items that absorb heat
- Heat only to required temperature
- Match firing rate to load



## Opportunities for Improved Efficiency

Capital Investment

- Oxygen enrichment
- Pre-heat combustion air
- Replace damaged or failed insulation
- Recover waste heat
- Install advanced controls
- Furnace pressure control

## Data Integration & Relevant Variables

- Operating temperature
- Surface temperature
- Combustion air temperature
- Material throughput
- Material input and output temperature
- Material moisture content



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## Control Losses at Entry/Exit

- Seal openings with strip doors, air curtains to reduce heat loss
- Excessive furnace pressure increases loss

## Process Cooling

General Characteristics

- When cooling is part of the manufacturing process and is directed to a product, raw material or piece of processing equipment
- Facilities may use simple direct expansion or chilled water systems to provide process cooling
- Process cooling also encompasses refrigeration and ice production.

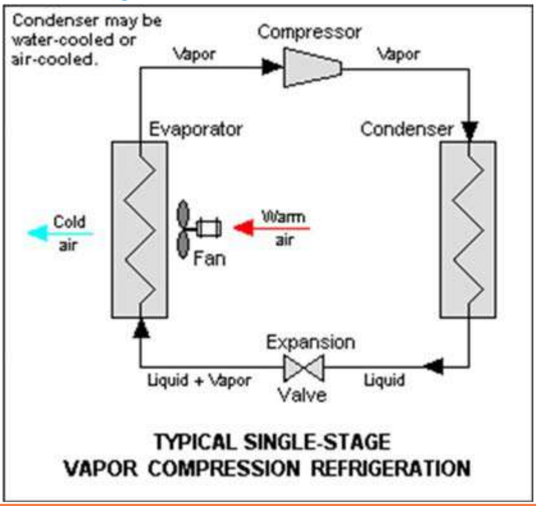


## Factors Affecting Performance

- Head pressure
- Suction pressure
- Refrigerant type
- Compressor control method
- Condensing method
- Compressor loading


**Vilter**
**Ammonia Compressor**

## Systems components




- Components
  1. Compressor
  2. Condenser
  3. Expansion valve
  4. Evaporator



## Potentially Inefficient Applications

- Operating compressor with non-condensable gases in system
- Operating system with excessive refrigerant charge
- Excessively low suction pressure
- Excessively high head pressure
- Parasitic loads from failed insulation infiltration through openings or exhaust flow
- Operating with fouled coils

## Operating Characteristics and Inefficient Applications – Process Cooling Systems

Which of the following is an inefficient application for a process cooling system?

A. Operating at too high a temperature

B. Operating with excess refrigerant in the system

C. Operating the system with an evaporative condenser

D. Operating the system just after cleaning the evaporator coils



## Opportunities for Improved Efficiency

Operation and Maintenance

- Clean coils
- Purge non-condensable gases from system
- Seal space: close doors
- Increase cooling set-point
- Decrease condensing temperature

## Opportunities for Improved Efficiency

<u>Capital Investment</u>

- Compressor sequencer control
- VFDs
- Demand -based defrost control
- Eliminate heat gain
- Heat recovery from compressor superheat or lubricating oil



## Data Integration and Relevant Variables

- Evaporator temperature
- Ambient temperature
- Product entering and exit temperature
- Product flow rate
- Infiltration into refrigerated space

## Seal Refrigerated Spaces

- Openings in  coolers and freezers gaskets, air curtains, strip doors, automatic closers and high-speed doors.

- Analyze traffic patterns, cost of sealing method and energy savings to arrive at preferred solution.



## Plan for Energy Performance Improvement

- Inspect insulation and openings
- Check refrigerant pressures
- Inspect heat transfer coils
- Look for extra compressors operating at low loads
- VFDs

## Opportunities for Improved Efficiency – Process Cooling Systems

If the entry and exit openings on a blast freezer are sealed with strip curtains, the energy consumed for product cooling system will decrease because:

A. Freezer heat gain will be reduced

B. Infiltration of outside air will speed up coil defrosting

C. Space temperature will decrease

D. Increased air turnover improves cooling efficiency



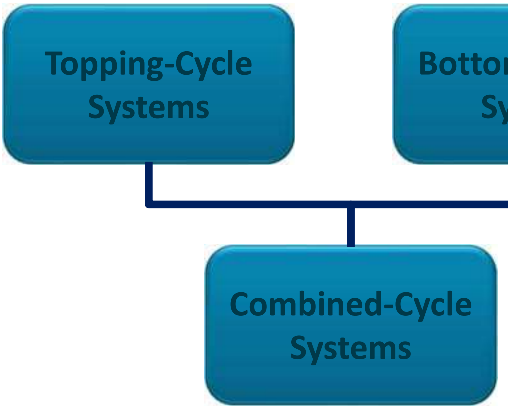


## Combined Heat & Power [CHP] Systems

Factors Affecting Performance

- Fuel or fuel combination types
- Fuel availability, price, handling, transportation and storage costs
- Thermal and electric load patterns
- Environmental regulations
- Individual component performance

# System Types








# System Components

- Topping-Cycle Schematic


- Bottoming-Cycle Schematic

## Potentially Inefficient Applications

- Burning of fuels containing impurities can erode turbine blades.
- Fuels such as residual oil or fuels derived from coal cannot be fired without an auxiliary cleaning system.
- Electric generating efficiency for gas turbine systems is reduced significantly by part-load operation.



## Operating Characteristics and Inefficient Applications – Combined Heat & Power Systems

Most power generation systems discharge up to 65% of input energy as waste heat.

- True or
- False

## Opportunities for Improved Efficiency

Operation and Maintenance

- Burn relatively clean fuels
- Increase inlet temperature and pressure ratio
- Clean fouled gas turbine compressors

Capital Investment

- Install CHP system
- If exhaust from a gas turbine contains 15% or more oxygen, it will support additional combustion for heat recovery steam generators (HRSGs)
- Use an open cycle gas turbine for systems with generation capacities of less than 25 MW



## Data Integration and Relevant Variables

- Air temperature
- Fuel type
- Heat recovery requirement
- Engine load

## Clean Gas Turbine Compressor

- CHP maintenance costs are a significant ongoing financial burden
- Fouled gas turbine compressors can reduce efficiency and output.
- Compressors can be water washed and sand or shot blasted to remove deposits



## Install CHP System

- Well suited to industries with combination of both heavy thermal and electrical demand
- Selection of generator driver depends on the ratio between electric and heat required
- Access to waste or low-cost fuel source improves economic payback
- CHP systems are capital intensive

## Plan for Energy Performance Improvement

- Compressor condition
- Quality of fuel
- Turbine entry temperature



## Opportunities for Improved Efficiency – Combined Heat & Power Systems

- Fouled gas turbine compressors have no effect on efficiency and output.

- True or
- False

## Q&A

- How many SEUs should a management system have?
- What is an acceptable percentage of unknown energy be following the completion of an energy review?
- How would you determine of floor area was a driver of energy performance of a shopping mall?
- How would you determine if weather is a determinant of energy consumption of a call centre?



**Day 1 End**

**Thank you**

EU - VIET NAM SUSTAINABLE ENERGY TRANSITION PROGRAMME (SETP)
Accelerating energy efficiency (EE) in large industries through energy management system, System optimisation and the promotion and adoption of EE in SMEs -(IEEP project)

# ISO 50001/50003
# Technical Training
# Accreditation and certification Body
# Day 2

UNIDO International Energy Efficiency

Training

Delivered by: Richard Morrison, Stefan Walta



# Today

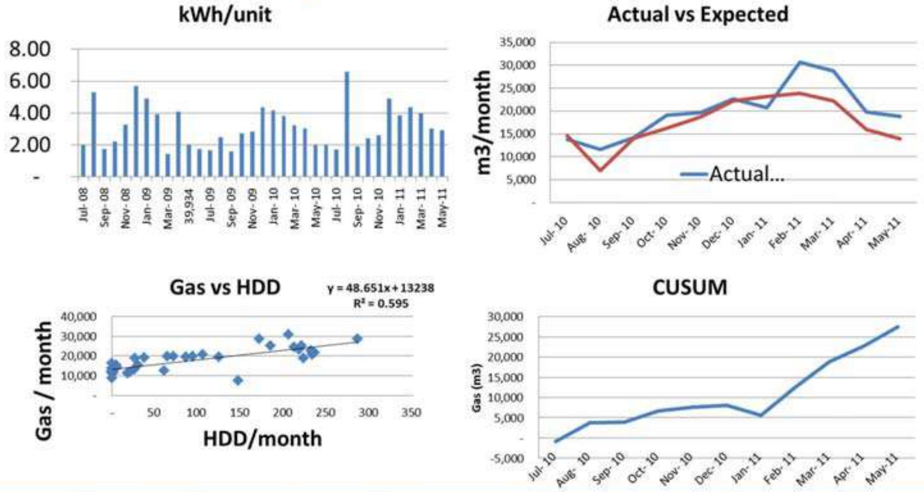
| Topic | Duration (mins) | Break duration | Start Time | End Time |
|---|---|---|---|---|
| Registration | | 15 | 08:15 | 08:30 |
| Recap from Day 1 | 15 | | 08:30 | 08:45 |
| Resource + Information requirement | 30 | | 08:45 | 09:15 |
| Process requirement: Audit time | 45 | | 09:15 | 10:00 |
| Break | | 15 | 10:00 | 10:15 |
| Process requirement: Multi sampling process | 45 | | 10:15 | 11:00 |
| Process requirement: Conducting the audit | 60 | | 11:00 | 12:00 |
| Lunch | | 60 | 12:00 | 13:00 |
| Process requirement: Maintain certification | 15 | | 13:00 | 13:15 |
| Exercise | 105 | | 13:15 | 15:00 |
| Break | | 15 | 15:00 | 15:15 |
| Effective review and Energy performance determination | 60 | | 15:15 | 16:15 |
| Discussion Q&A and Feedback | 30 | | 16:15 | 16:45 |
| End | | | 16:45 | |

# Recap From Yesterday

- Determination of Energy Performance Improvements
- Advantages and Disadvantages of the following metrics
- Tabular Data
- Monthly comparison
- Annualised
- COP, Efficiency, SEC
- Regression analysis
- Multiregression analysis
- CUSUM
- EII



# Recap From Yesterday



# ISO50003 Structure

1. Scope
2. Normative References
3. Terms and Definitions
4. Principles
5. General requirements
6. Structural requirements
7. Resource requirements
8. Information requirements



# ISO50003 Structure

9. Process Requirements
10. Management system requirements for certification bodies

Annex A EnMS Audits time [Normative]
Annex B Multisite organizations [Normative]
Annex C Energy performance [Normative]
Annes D Examples of audit calculation [Informative]

# Resource Requirements



## 7.0 Resource Requirements

- General Competence Defined in ISO 17021
- Technical competence for the audit team and personnel involved in the EnMS certification are defined in ISO50003

  EnMS general knowledge is required for the following certification functions:

✓ Conducting the application review to determine required audit team competence, to select the audit team members, to determine the audit time

✓ Reviewing audit reports and making certification decisions

✓ Auditing

## Competency

- What is it?
- ISO 17021 Definition
- **3.8 competence**
- ability to **apply** knowledge and skills to achieve intended results

- According to ISO/IEC 17021, competency refers to the combination of knowledge, skills, and experience required for personnel involved in auditing and certifying management systems. The standard emphasizes the importance of defining and assessing competency for each technical area and function within the certification process.



## Competency discussion

- What defines a certification auditor to be competent to audit the management system?

- What defines a certification auditor to be competent to audit the technical elements of a steel mill or a glass furnace?

- What would you need to see at head office?

- What would you want to observe during a witnessed audit?

## Technical Competence and knowledge

- The competencies will include a level of generic competence described in ISO 17021:2015 as well the EnMS technical knowledge
- The certification body shall define criteria, including the knowledge and skills of the audit team that is necessary for the client
- Some elements in next slide will be declared



## Technical Competence and knowledge

Table 1 — Required EnMS technical knowledge

| Knowledge | Certification functions: Conducting the application review to determine the required audit team competence, to select the audit team members and to determine the audit time | Reviewing audit reports and making certification decisions | Auditing |
|---|---|---|---|
| Energy specific terminology | X (7.2.2.3) | X (7.2.2.2) | X (7.2.2.1) |
| Energy principles | X (7.2.3.3) | X (7.2.3.2) | X (7.2.3.1) |
| Energy-related legal requirements | — | X (7.2.4.2) | X (7.2.4.1) |
| Knowledge of ISO 50001 requirements | X (7.2.5.3) | X (7.2.5.2) | X (7.2.5.1) |
| Energy performance indicators (EnPIs), energy baseline (EnB), relevant variables and static factors | — | X (7.2.6.2) | X (7.2.6.1) |
| Common energy using systems | — | X (7.2.7.2) | X (7.2.7.1) |
| Energy performance improvement | — | X (7.2.8.2) | X (7.2.8.1) |
| Principles of data collection and of monitoring, measuring and evaluating data | — | X (7.2.9.2) | X (7.2.9.1) |

## Technical Competence and knowledge

Energy principle means

- Knowledge of
  - Types of energy
  - Energy uses
  - Energy conservation
  - Calculation in different units (i.e kWh to GJ)
- Knowledge of following principles
  - Fuel combustion
  - Energy flow
  - Energy losses
  - Energy efficiency
  - Energy balance



## Technical Competence and knowledge

Energy performance Indicators

- Auditor will have knowledge of
  - EnPI
  - EnB
  - Relevant variables
  - Static factor
  - **Demonstrating energy performance improvement including normalization techniques!**
- Also knowledge of the use of models such as
  - Ratios
  - Regression

## Technical Competence and knowledge

Energy performance Improvement

- Auditor will have knowledge of potential energy performance improvement in energy using systems
- Auditor will have knowledge of the application of current technology used to achieve energy performance improvement



## Information Requirements

## 8.2 Certification documents

Scope of certification

- Organisation to define the scope
- Certification body to check for suitability (is applicable)
- Can be part of a building, part of a site, single site, multisite, or any combination defined by the organisation

- Note: When defining the boundaries an organisation shall **not** exclude energy sources



Process Requirements Audit time

## Audit activities

- Pre-certification activities (determining audit time)
- Planning audits
- Initial certification
- Conducting Audits
- Certification decision
- Maintaining certification



## 9.1.1.4 EnMS Effective Personnel

- Process to be defined by the certification body
- Consider the following
- Senior management and management representative
- Energy team
- People who can affect energy performance
- Example Commercial building complex

The EnMS effective personnel are those related to the district heating and cooling systems, maintenance and engineering, procurement, energy team etc.…
Administrative staff working in the building are not considered as EnMS effective personnel

## 9.1.4.2 Duration of the audit

- Duration of audit must be minimum 80% of the audit time
- Max 20% of the audit time for audit reporting, audit planning and communication with client



## 9.1.4. Determining Audit Time

- Considerations:

✓ Number of energy types
✓ Number of Significant Energy Uses
✓ The annual Energy Consumption
✓ Number of EnMS Effective personnel

} EnMS complexity calc

- Audit time defined by audit complexity and number of EnMS personnel
- The audit time includes on site time, audit planning, document reviewing and audit reporting
- If audit time reduced then justification needs to be documented
- Max 20% reduction in audit time if integrated with other certified systems

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## Determining EnMS Complexity

Based on weighted factor of the following three factors

- Annual Energy Consumption 25%: where to find ?
- Number of Energy Types 25%: where to find?
- Number of Significant Energy Users 50%: where to find?

Table A.1 — EnMS complexity factors for determination of audit time

| Criteria | Weighted value | Range | Complexity factor |
|---|---|---|---|
| Annual energy consumption (TJ) | 25 % | ≤ 20 TJ | 1,0 |
| | | 20 TJ ≤ 200 TJ | 1,2 |
| | | 200 TJ ≤ 2 000 TJ | 1,4 |
| | | > 2 000 TJ | 1,6 |
| Number of energy types | 25 % | 1 to 2 energy types | 1,0 |
| | | 3 energy types | 1,2 |
| | | ≥ 4 energy types | 1,4 |
| Number of significant energy uses (SEUs) | 50 % | 1 to 3 SEUs | 1,0 |
| | | 4 to 6 SEUs | 1,2 |
| | | 7 to 10 SEUs | 1,3 |
| | | 11 to 15 SEUs | 1,4 |
| | | ≥ 16 SEUs | 1,6 |



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## Determining EnMS Complexity

- Complexity Factor
- $C = (F_{EC} * W_{EC}) + (F_{ES} * W_{ES}) + (F_{SEU} * W_{SEU})$
- Fec: annual consumption complexity factor form Table A1
- Fet: number of energy types complexity factor form Table A1
- Fseu: dumber of SEU complexity factor form Table A1
- Calculated C check with Table A.2

Table A.2 — Level of the EnMS complexity

| Complexity value | Level of the EnMS complexity |
|---|---|
| > 1,35 | High |
| 1,15 to 1,35 | Medium |
| < 1,15 | Low |

## Complexity Calculation

- Example Energy consumption of this building, 30GWh, 2 energy sources and six SEU's and 30 effective personnel
- Complexity Factor
- $C = (F_{EC} * W_{EC}) + (F_{ES} * W_{ES}) + (F_{SEU} * W_{SEU})$
- C = (1 * 25%) + (1 * 25%) + (1.2 * 50%)
- C = 1.10
- We therefore have a low level of complexity for building

Table A.2 — Level of the EnMS complexity

| Complexity value | Level of the EnMS complexity |
|---|---|
| > 1,35 | High |
| 1,15 to 1,35 | Medium |
| < 1,15 | Low |





## Complexity and Effective Personnel

- Low level complexity and 30 Effective Personnel
- How many audit days?

Table A.3 — Initial certification audit time (audit days)

| Number of EnMS effective personnel | Level of EnMS complexity | | |
|---|---|---|---|
| | Low | Medium | High |
| 1 to 8 | 2,5 | 4 | 5 |
| 9 to 15 | 4 | 6 | 7 |
| 16 to 25 | 5 | 7 | 9 |
| 26 to 65 | 6,5 | 8 | 10 |
| 66 to 85 | 8 | 9,5 | 11,5 |
| 86 to 175 | 8,5 | 11 | 12 |
| 176 to 275 | 9 | 11,5 | 12,5 |
| 276 to 425 | 10 | 13 | 15 |
| ≥ 426 | The certification body provides the audit time for a number of EnMS effective personnel exceeding 425. The certification body shall retain documented information on decisions made to calculate the audit time. | | |

## Number of days for Recertification

- Table A.4 used for calculating Surveillance and recertification requirements and in previous example :
- 2,5 Surveillance days and 5 Recertification days required

**Table A.4 — Surveillance and recertification audit time (audit days)**

| Number of EnMS effective personnel | Level of EnMS complexity | | | | | |
|---|---|---|---|---|---|---|
| | Low | | Medium | | High | |
| | Surveillance | Recertification | Surveillance | Recertification | Surveillance | Recertification |
| 1 to 8 | 1 | 1,5 | 1 | 2,5 | 1,5 | 3 |
| 9 to 15 | 1 | 2,5 | 2 | 4 | 2,5 | 5 |
| 16 to 25 | 2 | 3,5 | 2,5 | 5 | 3 | 6 |
| 26 to 65 | 2,5 | 5 | 3 | 6 | 3,5 | 7 |
| 66 to 85 | 2,5 | 6 | 3,5 | 6,5 | 3,5 | 8,5 |
| 86 to 175 | 2,5 | 6 | 3,5 | 7 | 3,5 | 8,5 |
| 176 to 275 | 3 | 6 | 4 | 8 | 4 | 9,5 |
| 276 to 425 | 3,5 | 7 | 4 | 8,5 | 5 | 11 |
| ≥ 426 | The certification body provides the audit time for a number of EnMS effective personnel exceeding 425. The certification body shall retain documented information on decisions made to calculate the audit time. | | | | | |



## Example

- Calculate the Audit time and surveillance time for the following example:
- Electronics assembly site using 100 GWh of energy with four energy sources and 10 significant energy users and the certification body has calculated that there are 75 EnMS effective personnel

## 9.1.5. Multi-site Sampling

- Need confidence in conformity of the EnMS across all locations but audit needs to be practical and feasible
- Needs central office control of all elements of the system with authority to enforce corrective actions (next slide)
- Need for common approach to all elements of the management system across all locations

- Cannot exclude one problematic site from certification process if one location has major non conformance



Process Requirements

Multi site sampling process

## 9.1.5. Multi-site Sampling

- Need confidence in conformity of the EnMS across all locations but audit needs to be practical and feasible
- Needs central office control of all elements of the system with authority to enforce corrective actions (next slide)
- Need for common approach to all elements of the management system across all locations

- Cannot exclude one problematic site from certification process if one location has major non conformance



## 9.1.5. Multi-site Sampling: Annex B

- The central function is responsible for ensuring that data from all sites is collected and analysed.
- Responsible for

**Table B.1 — Management system data**

| Management system |
|---|
| System documentation and system changes |
| Management review |
| Evaluation of corrective actions |
| Internal audit planning and evaluation of the results |
| Demonstrate ability to collect information on legal requirements and other requirements and initiate changes as needed |

**Table B.2 — Energy performance data**

| Energy performance |
|---|
| Consistent planning process |
| Consistent criteria for determining, adjusting or revising EnB(s), relevant variables and EnPIs |
| Consistent criteria for establishing objectives, energy targets and action plans |
| Centralized process for evaluating applicability and effectiveness of action plans and EnPIs |
| Consistent criteria for evaluating energy performance improvement |

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## Sampling Methodology: Annex B

- 25% selected at random
- Remainder selected to ensure differences are as large as possible



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## Sampling Methodology: Annex B

- Site Selection taking to account the following criteria
- Consider:
  - Results from internal audits and management reviews
  - variations in the size of sites
  - variation in shift patterns
  - complexity and maturity of management systems
  - complexity of energy types energy consumption and SEU, differences in language and legal requirements
  - Energy performance etc.
- Temporary sites has also criteria

## Size of the sample: B4.5

Certification audit sample size is the square root of the number of remote sites rounded up to the next whole number

- Initial certification audit: $Y = \sqrt{x}$ (rounded to the upper whole number)
- Surveillance audit: $Y= 0,6 \sqrt{x}$ (rounded to the upper whole number)
- Recertification audit: $Y = \sqrt{x}$ (rounded to the upper whole number)
- (when EnMS is effective over three years: $Y=0,8 \sqrt{x}$ )
- X=number of sites



## Risk mitigation: B4.6

The central function must be auditted every initial and recertification audit and at least anually as part of surveillance.

Sample can be increased or decreased based on

-

a) size of the sites and number of EnMS effective personnel;
b) differences in working practices (e.g. shifts);
c) differences in activities undertaken;
d) differences in the energy consumption or SEUs;
e) evidence of corrective action retained as documented information;
f) applicable legal requirements or other requirements;
g) results of internal audits and management review;
h) the ability to demonstrate energy performance improvement and improvement of the EnMS.

## Calculation of Audit days Multi site

Hospitality organization

- A central site with call centre
- Three permanent sites related to catering, he activities of the three sites are the same but the size of the sites varies
- Four permanent sites related to hotel activities, the activities and size of the four sites are the same at each location

Can a sampling plan be developed for this organization?

- What do you need?



## Calculation of Audit days Multi site

Treated as three subset

| Subset | Site description | Energy consumption Tj | Types of energy | SEUs | EnMS effective personnel |
|---|---|---|---|---|---|
| Subset 1 | Call centre and data centre (central function performed here) | 1,5 | 2 | 3 | 3 |
| Subset 2 | North American site | 0,4 | 3 | 2 | 10 |
| | European site | 1,1 | 2 | 3 | 20 |
| | Australian site | 0,2 | 2 | 1 | 5 |
| Subset 3 | Hotel activities- 4 identical sites | 5 | 3 | 2 | 7 |

## Calculation of Audit days Multi site

Subset 2

Sample size is 3
Number of sites to be visited [redacted]

Wide range of in consumption and SEU, sample size can be increased of decreased.

Random selection: site Australia
Specific selection: site European





## Calculation of Audit days Multi site

Subset 3

Sample size is 4 (A,B,C and D)
Number of sites to be visited [redacted]

Sites are the same in respect to energy consumption and SEU

Random selection: site A
Specific selection: site B

## Calculation of Audit days Multi site

Subset 1

C=(1*25%)+(1*25%)+(1*50%)=1 ➔ EnMS complexity is low

EnMS effective personell = 3

Number of audit days is [redacted]



## Calculation of Audit days Multi site

Subset 2: EU site

C=(1*25%)+(1*25%)+(1*50%)=1 ➔ EnMS complexity is low

EnMS effective personell = 20

Number of audit days is [redacted]

Adjustment by

- 10% for repetitive process
- 20% for not to be audited for the EnMS items (central function)

Number of audit days is 3,5

# Calculation of Audit days Multi site

Subset 2: Australian site

C=(1*25%)+(1*25%)+(1*50%)=1 ➔ EnMS complexity is low

EnMS effective personell = 5

Number of audit days is [redacted]

Adjustment by

- 0% for repetitive process (small)
- 20% for not to be audited for the EnMS items (central function)

Number of audit days is [redacted]



# Calculation of Audit days Multi site

Subset 3:

C=(1*25%)+(1,2*25%)+(1*50%)=1 ➔ EnMS complexity is low

EnMS effective personell = 7

Number of audit days is [redacted]

Adjustment by

- 10% for repetitive process (small)
- 20% for not to be audited for the EnMS items (central function)

Number of audit days is [redacted]

# Calculation of Audit days Multi site

The total audit days:

| Subset | | Number of sites | Audit time per site (audit days) | Audit time for subset (audit days) |
|---|---|---|---|---|
| Subset 1 | | 1 | | |
| Subset 2 | European site | 1 | | |
| | Australian site | 1 | | |
| Subset 3 | | 2 | | |
| Total | | 5 | | |



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# See you after Lunch

Process Requirements
Conducting the audit



## 9.4 Conducting the Audit

- When conducting the audit, the auditor shall collect and verify audit evidence related to energy performance which include at minimum:
- Energy planning
- Operational control
- Monitoring, measurement and analysis

How would you recognise this during a witnessed assessment?

## 9.4.8 Audit Report

The Audit report shall In addition to ISO17021 requirements include:

- The scope and boundaries of the EnMS being audited
- Statement of achievement of continual improvement of the EnMS and energy performance improvement with audit evidence to support the statements.



## 9.3.1 Stage 1 Audit

- Review scope and boundaries and confirm the scope boundaries
- Confirm the number of EnMS effective personnel, energy type, SEU's and annual energy consumption to verify audit time
- Review planning process
- Review of used EnPI and EnB to determine energy performance
- Review opportunities, objectives targets and action plans
- In addition to general requirements for Stage 1 as outlined in ISO17021 which ensures all elements of the management system are in place

## 9.3.2 Stage 2 Audit

- Compile evidence to demonstrate that energy performance improvement has occurred prior to making a recommendation and a certification decision

Note: Confirmation of energy performance improvement is required for initial certification

Note : examples of energy performance improvement are in ISO 50001:2018 A.10 and Annex C of ISO 50003



Process Requirements

Maintaining certification

## 9.6.2 Surveillance Audit

- Compile evidence to determine whether or not continual energy performance improvement has been demonstrated
- Evidence of implemented (energy saving) action
- During Surveillance Audit demonstration of energy performance is not required



## 9.6.2 Recertification Audit

- Compile evidence to demonstrate that energy performance improvement has occurred prior to making a recommendation and re-certification decision

Note: Confirmation of energy performance improvement is required for re-certification

Exercise



## Workshop

- Review the case study material and identify if continuous improvement has occurred based on objective evidence
- Prepare the output from the workshop in the same summary as you would for senior management in a closing meeting

Management review



## Effective Management Review

- Is there an understanding of the energy issues at management level?
- Is the system there only in name?
- How would you assess this?
- Are they aware of the issues that are known throughout the site?
- Is the management review only for show?
- Have they been trained on the system?

## Discussion on management support

- Do senior management need to understand all EnPIs
- Do they need to understand the operational control set-points of all SEUs
- What do they need to demonstrate?

- How do you demonstrate improvements in the system?
- How do you demonstrate energy performance improvement?
- Is this apparent in the management systems you have assessed?



## Energy performance determination

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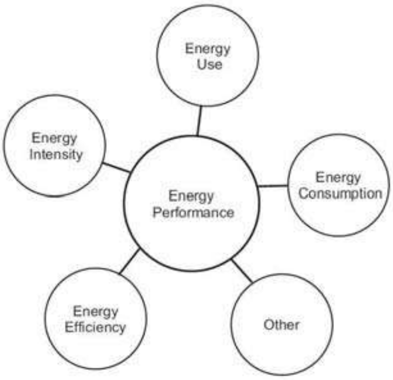
## Continuous Improvement

- How would you recognise it?
- Does it come in many forms?



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## Continuous Improvement Annex C

Consider

- Compare the EnPI value against the corresponding EnB
- Some Enpi can improved and others not but across the scope of the EnMS the organisation will demonstrate energy performance improvement
- For a multi site organisation, not every site will contribute equally to the energy performance improvement of the multi site organisation. However, the data are expected to be available at the central function and confirmed at the sample sites

## Continuous Improvement Annex C

- Organisation can use a number of methods like ratios, regression, complex models , simulation
- Audit should expect for each EnPI has done the following
  - Collected the energy consumption and the potential relevant variable
  - Determined which variables are relevant
  - Establish appropriate EnPI using the relevant variables
- If there is no relevant variable then absolute energy consumption reduction can demonstrate energy performance improvement



## Improvement in performance?

- Facility energy consumption reduces by 5% in one year and production output remains constant.

- Is this improved performance?

## Improvement in performance?

- Facility energy consumption increases by 5% and production output increases by 5%.
- Is this improved performance?



## Improvement in performance?

The total energy consumption increased by 25% but the measure of energy performance defined by the organisation improved.

The manufacturing facility which manufactures glass bottles has had to increase the furnace operating times to a 24*7 operation from a 16*5 to keep up with the market demand. This has increased the energy consumption of the furnace but the output has also increased. The energy performance indicator for the plant has reduced as a result.

Is this performance improvement?

## Thank you

- It' s been a pleasure working with you over the past two days
  - We already knew it would be when we prepared the slides ☺
- On-going assistance is available according to contact details
- Remember: Keep it simple
- The best of luck with your future efforts with EnMS auditing or training to aid improved energy performance country-wide



**DISCLAIMER**