Energy Management

Unit 5: Industrial Audit, Analysis and Economic Impact

SAPIENZA
UNIVERSITÀ DI ROMA

DIEGO
Development of qualIty system through EnerGy Efficency cOurses

Co-funded by the Erasmus+ Programme of the European Union

Energy Management in Industry

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- n. 9 steps of the Energy diagnosis
- Energy efficiency measures
  - Lighting
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Introduction to Energy Management
Definition

The efficient and effective use of energy to maximize profits (minimize costs) and enhance competitive positions.

[Source: Guide to Energy Management]

Definition includes many operations: Services, Product, Equipment design, Product shipment, Waste minimization and disposal, Energy opportunities

Buildings

Manufacturing

Industry

Introduction to Energy Management

Definition

The primary objective of energy management is to maximize profits or minimize costs.

Sub-objectives of energy management programs include:

1. Improving energy efficiency and reducing energy use (or rational use of energy), thereby reducing costs;
2. Reduce greenhouse gas emissions and improve air quality;
3. Cultivating good communications on energy matters;
4. Developing and maintaining effective monitoring, reporting, and management strategies for wise energy usage;
5. Finding new and better ways to increase returns from energy investments through research and development;
6. Developing interest in and dedication to the energy management program from all employees;
7. Reducing the impacts of curtailments, brownouts, or any interruption in energy supplies.

Introduction to Energy Management
Definition

Energy efficiency is applied to systems that use energy, in particular,

1. processes (e.g. mechanical processes)
2. passive systems (e.g. buildings).

It represents the degree of “goodness” in the energy utilization.

Rational Use of Energy can be defined as:

A set of technological operations with which it is intended to achieve the same objectives of manufacturing of products or services (in quantity and quality) with a lower consumption of primary energy and possibly with a greater commitment of another type (capital resources, labor, materials, etc.).

In the industrial field, can not, in general, determine which is the minimum energy required for a specific processing, it is more correct to speak of Δ (energy requirements) between a previous situation and an optimized.

Introduction to Energy Management
Definition

In the previous sentence, primary importance is covered by the phrase "same products or services"

- If this condition is not respected, it possible to talk only of lower energy consumption, but not energy rationalization;
- With regard to the "lower consumption of primary energy" it should be noted that we are referring to so-called commercial sources, as a system can be considered energy-efficient even when it consumes a greater amount of energy, if this comes from a less expensive source (also at the level environmental impact) or ensures lower losses in the conversion process;

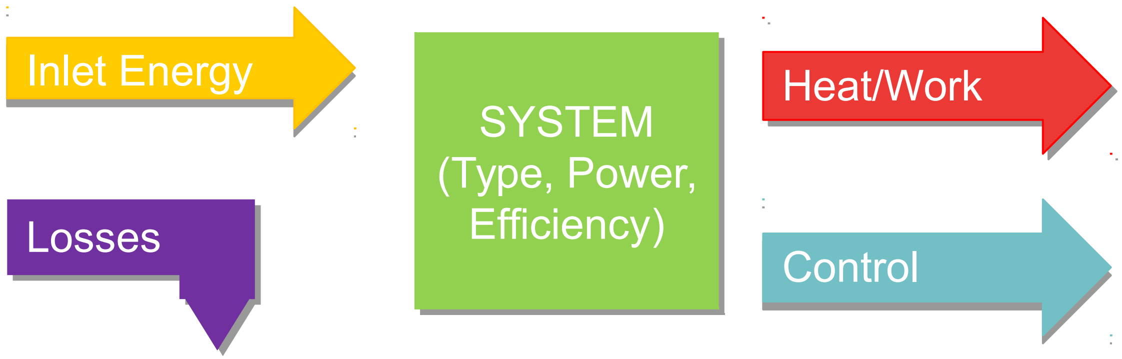
Example: we consider to replace a generator powered by fossil fuel with a solar photovoltaic system.

The second has a lower efficiency and therefore consumes more primary energy, but the life cycle has a cheaper operating cost and a lower environmental impact.

Introduction to Energy Management

Sectors of application

❑Each structure (housing, plant etc.) can be represented as a system in which energy enters under a certain type of energy (for example, heat, work, fuel) and exits energy suitable for end uses for which it is intended. The system is subject to adjustment and, necessarily, a loss of a share of power.



❑Energy efficiency aims to improve the process and to limit losses.

Energy Management in Industry

European and National Regulation

The Directive 2012/27/EC shows that the Energy Efficiency represents the fastest and most efficient mode, cost / benefit, to increase security of supply and reducing greenhouse gases.

Those principles were endorsed by the Legislative Decree no. 102 of July 4, 2014, which:

Art. 8 "Energy Diagnosis & Energy Management Systems" declares that the "big Enterprises" must perform an Energy "Diagnosis" by 12/05/2015 and then <u>every four years</u>.

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Energy Management in Industry

ENERGY AUDIT

Energy Management
1. Energy Audit

The First Step the energy manager should take is to conduct an Energy Audit.

"Energy audit examines the ways energy is currently used in that facility/building/industry and identifies some alternatives for reducing energy costs, preserving the same performance (or improving them)."

The Goals of the audit are:

- to clearly identify the types and costs of energy use,
- to understand how that energy is being used and possibly wasted,
- to identify and analyze alternatives such as improved operational techniques and/or new equipment that could substantially reduce energy costs,
- to perform an economic analysis on those alternatives and determine which ones are cost-effective for the business or industry or building involved.

Energy Management

1. Energy Audit

The three phases of an energy audit:

1. Preparing for the audit visit
    1. Knowledge of the specific needs, problems in energy of examined facility/industry/building
    2. Acquisition of the historical and descriptive energy data (technical survey, interview, analysis of bills, outcomes of existing monitoring systems, etc.)
2. Performing the facility survey
    1. Develop an energy balance for the energy use in the facility/industry/building
    2. Quantification of the energy use (simulation through certificated software)
    3. Analysis of technological/methodological/contractual alternatives
    4. Audit report with some recommendations for changes in equipment, processes or operations to produce energy cost savings
3. Implementing the audit recommendations
    1. Agree on specific interventions of energy savings
    2. Initiate some or all of the actions recommended to achieve those goals
    3. Setting up a monitoring system to allow the assessment of the degree to which the chosen goals have been accomplished and to know which measures have been successful and which have failed.

Energy Management – Energy Audit

1. Preparing for the audit visit

1.1 Gathering Preliminary Data on the Facility

- Analysis of Bills for at least the past 12 months (better 2 yrs for building, 3 yrs for industry),
- Geographic Location/Degree Days/Weather Data
- Facility Layout
- Operating Hours
- Equipment List (that significantly affects the energy consumption)

1.2 Tools for the Audit

To obtain the best information for a successful energy cost control program, the auditor must make some measurements during the audit visit. The amount of equipment needed depends on the type of energy consuming equipment used at the facility, and on the range of potential EMOs (Energy Management Opportunity) that might be considered.

Tape measures, Lightmeter, Thermometers, Voltmeter, Wattmeter/Power Factor Meter, Combustion Analyzer, Ultrasonic Leak Detector, Airflow Measurement Devices, Blower Door Attachment, Smoke Generator, Safety Equipment.

1.3 Safety Considerations

Energy Management – Energy Audit

1. Preparing for the audit visit

1.1 Gathering Preliminary Data on the Facility

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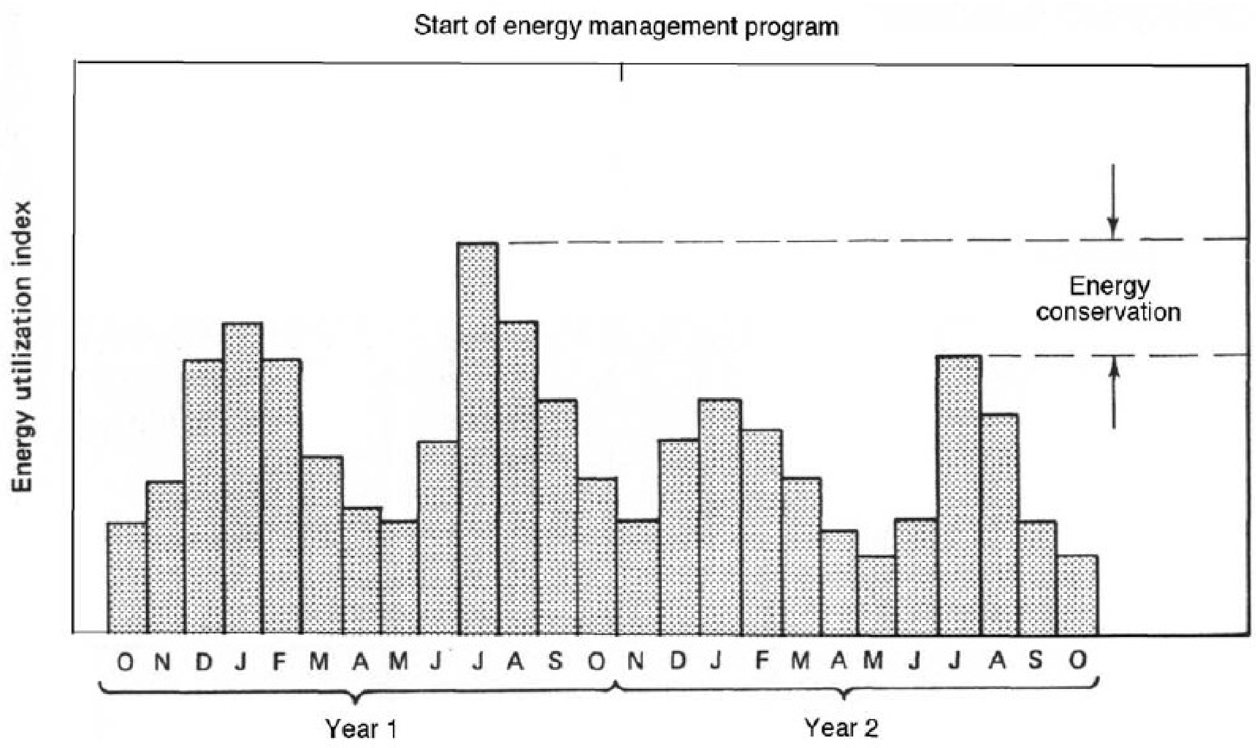
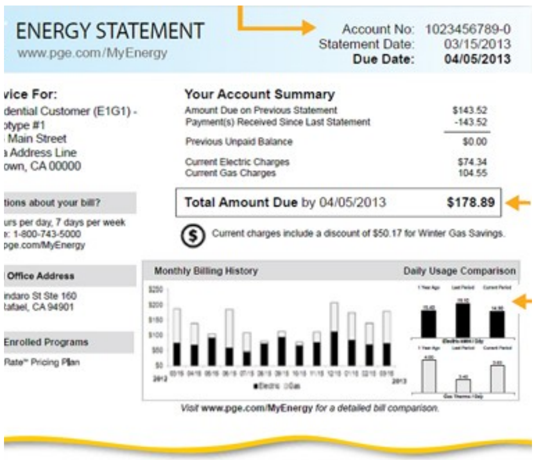




Energy Management – Energy Audit

1. Preparing for the audit visit

1.1 Gathering Preliminary Data on the Facility

- Geographic Location/Degree Days/Weather Data

The geographic location of the facility should be noted, together with the weather data for that location. This
degree-day data is very useful in analyzing the energy needed for heating or cooling the facility.

Heating degree days (HDD) and cooling degree days (CDD) are given separately, and are the conventional parameter specific to a particular geographic location (= local climatic conditions), used to estimate the energy requirements necessary to maintain the indoor environment at a predetermined temperature, specific to a particular geographic location.

The degree day concept assumes that the average building has a desired indoor temperature of 70°F, and that 5°F of this is supplied by internal heat sources such as lights, appliances, equipment, and people. Thus, the base for computing HDD is 65°F.

$$HDD = \sum_{d=1}^{n} (T_0 - T_i)$$

- T_0 = Conventional indoor temperature (18,3°C = 65 F in USA, 20°C in Italy)
- T_i = daily average temperatures

Energy Management – Energy Audit

1. Preparing for the audit visit

- Geographic Location and Degree Days

Climate Zone	From HDD	To HDD	Starting Date	End date	Number of towns
A	0	600	December 1st	March 15th	2
B	601	900	December 1st	March 31st	157
C	901	1400	November 15th	March 31st	989
D	1401	2100	November 1st	April 15th	1611
E	2101	3000	October 15th	April 15th	4271
F	3001	more	All year, without limitation		1071

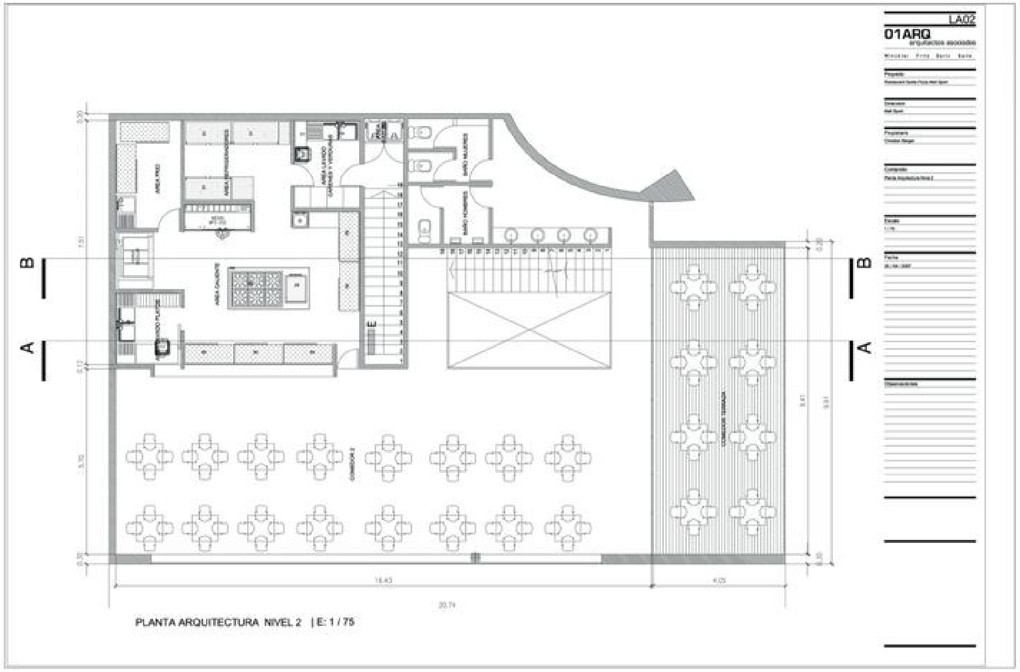
Energy Management – Energy Audit

1. Preparing for the audit visit

1.1 Gathering Preliminary Data on the Facility

- Facility Layout

To determine the facility size, floor plan, and construction features such as wall and roof material and insulation levels, as well as door and window sizes and construction.



Energy Management – Energy Audit

1. Preparing for the audit visit

1.1 Gathering Preliminary Data on the Facility

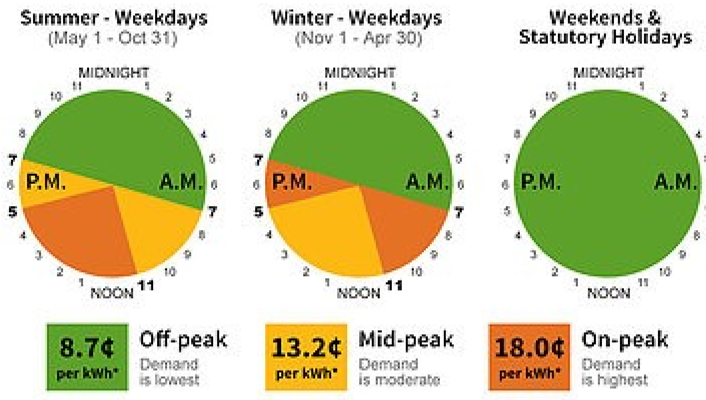
- Operating Hours

Knowing the operating hours in advance allows some determination as to whether any loads could be shifted to off-peak times.

Adding a second shift can often reduce energy bills because the energy costs during second and third shifts are usually substantially cheaper.

On-peak: a period in which electrical power is expected to be provided for a sustained period at a significantly higher than average supply level.

Off-peak refers to lower, discounted electricity prices during specific times. It are generally when residential homes and businesses use less electricity. Off-peak times will vary depending on your location and meter type, but typically are at night or weekends.



Energy Management – Energy Audit

1. Preparing for the audit visit

1.1 Gathering Preliminary Data on the Facility

- Equipment List (that significantly affects the energy consumption)

All large pieces of energy-consuming equipment such as heaters, boilers, air conditioners, chillers, water heaters, and specific process-related equipment have to be identified.

The equipment depends greatly on the type of facility/industry/building involved:

RESIDENTIAL	COMMERCIAL	INDUSTRIAL
• lighting, • heating, • air conditioning • refrigeration • laptop	• lighting, • heating, • air conditioning • refrigeration • laptop • special business equipment	• lighting, • heating, • air conditioning • refrigeration • laptop • office business equipment • highly specialized equipment

Energy Management in Industry

THE N. 9 STEPS OF THE ENERGY DIAGNOSIS

Energy Diagnosis

The n. 9 steps

1. Preliminary Contact
2. Meeting finalized to the start of works
3. Data collection
4. Activities in the Area
5. Analysis and modeling
6. Energy Performance Indicators
7. Opportunities to improve energy efficiency
8. Energy audit report
9. Final Meeting

Energy Diagnosis

1. Preliminary Contact

The auditor must identify the various stakeholders.

Auditor and internal team have to agree on:

1. the "field of interest" (sectors subjected to the energy analysis).

The exclusion of some sectors can provide misleading results.

2. the main goals of the Audit, that can be:

a) the reduction of consumption and energy costs;

b) reduce the environmental impact;

c) compliance with legislation or voluntary targets.

Energy Diagnosis
2. Meeting finalized to the start of works

During the kick-off meeting the auditor agrees with the Enterprise on:

a) visiting hours;

b) level of commitment of the occupants;

c) areas of limited access to potential health risks.

The auditor asks the Enterprise the following information:

a) sep-point and operational limits;

b) the employment patterns for different sectors;

c) Comments on the performance of the building;

d) any energy certificates or other similar documents;

e) any activities for the improvement of the awareness in the use of energy.

Energy Diagnosis

3. Data collection

- Energy vectors;
- Energy data (units purchased, sold, consumed and produced, the curve of the energy demand, etc.);
- Factors that influence energy consumption (climate data, employment factors, etc.);

- Information on important changes (change of the shape, components of the building, technological components, the operating model);
- Geometrical data such as: surface, volume, etc. of the building.
- Documents relating to management and maintenance;
- Building information model
- List of energy-using equipment and other internal loads.

Energy Diagnosis

4. Activities in the Area

The auditor performs approximately the following activities:

1. inspect the site with the received data;
2. evaluating for each significant building service the current and future level of service (for example, temperature, humidity, lighting, etc.);
3. verify that the technical systems are adequate for their intended purposes, ie able to provide the required level of service;
4. evaluate the performance of technical systems, taking into account the generation, storage, distribution and system and emission control;
5. understand the drivers for changes in technical systems, such as seasonal requirements;
6. look for opportunities to energy efficiency and constraints and restrictions.

Energy Diagnosis

5. Analysis and modelling

The auditor must analyze the potential energy saving according to the scope and purpose of the control.

The analysis should include:

1. The construction of an actual comparison for services that takes into account the level of the service itself (eg internal environmental policies, etc.).
2. assessing the actual performance of technical systems against an appropriate benchmark;
3. the evaluation of building envelope performance;
4. the evaluation of the energy efficiency of the entire building, taking into account the interaction between technical systems and the building envelope.

Energy Diagnosis

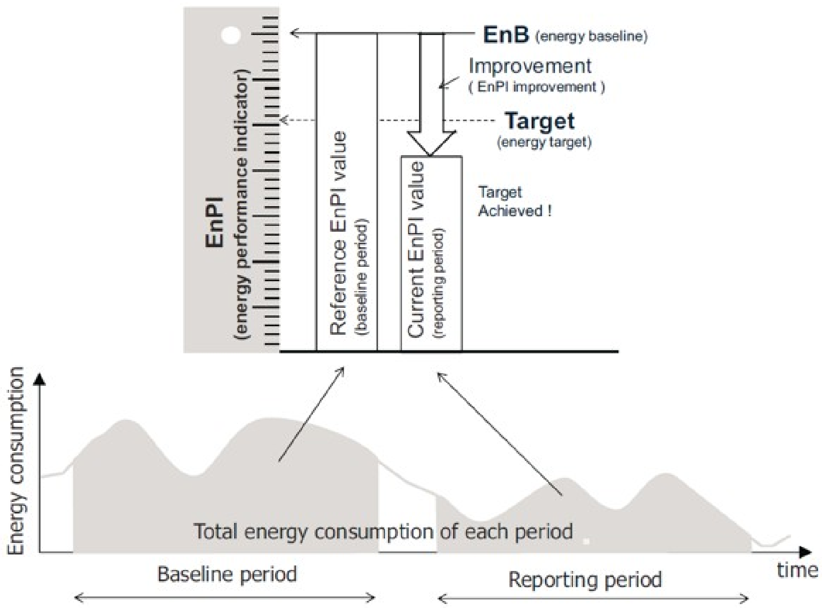
6. Energy Performance Indicators

The energy audit foresees the "*reconstruction*" of the specific consumption expressed in terms of Energy Performance Indicators (EnPI).

The same indicator will be used for the calculation model of the same system.

The two analysis should converge in order to validate the model of the same calculation.

The use of appropriate indicators will allow to evaluate the possible adjustments of the current situation.



Energy Diagnosis

7. Opportunities to improve energy efficiency

The auditor must identify opportunities to improve energy efficiency.

The above opportunities are preliminarily processed by comparison with reference parameters.

In this phase are important the experience and the *sensitivity* of the Auditor in capturing any critical issues with regard to age, maintenance, management or otherwise.

Energy Diagnosis

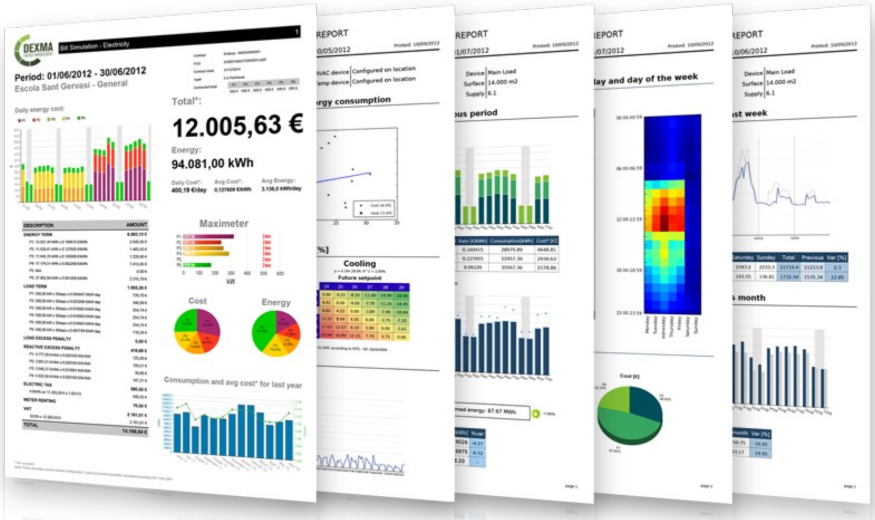
8. Energy audit report

The technical report must take account of technical aspects and feasibility.

The energy saving measures must be listed in the following categories:

- ❑high cost measures (construction and plant operations);
- ❑low-cost measures (adaptation of the mode of operation or other);
- ❑training and raising awareness of end-users;
- ❑any revision of the comfort requirements as regards for example: temperature, humidity, etc.

The report must contain the recommendations relating to the measurement and verification of the results obtained with the energy saving measures proposed.



Energy Management in Industry

ENERGY EFFICIENCY MEASURES

Energy Management
Energy efficiency measures

In the industrial sector the typical interventions depend on the type of industry, the typical interventions are generally in:

- Lighting
- Compressed air production and distribution systems for the process
- Heat and / or steam generation systems
- Cogeneration
- Building
- Electric motor and inverter
- Transport and logistics
- Other operations dependent on the plant characteristics

The monitoring of production processes must be implemented within the diagnosis and allows to better understand the interventions

Energy Management
Lighting

The lighting system provides many opportunities for cost-effective energy savings with little or no inconvenience.

Lighting improvements are excellent investments in most commercial businesses because lighting accounts for a large part of the energy bill—ranging from 30-70% of the total energy cost.

Lighting energy use represents only 5-25% of the total energy in industrial facilities, but it is usually cost-effective to address because lighting improvements are often easier to make than many process upgrades.

The energy consumption is connected to the use of obsolete lamp systems, characterized by low renewal times (normally more than 10 years).

In the industrial sector, the average renewal rate of these plants is around 20 years, with intervals more often in production areas and less in the office areas and services.

Energy Management
Lighting

The technical potential of energy savings to 2020 in terms of electricity consumption for lighting in Italy is so identified

[Source: GREENPEACE data]

Energy Management
Lighting

Substantial energy savings can be achieved through:

- ❑regulation of the use;
- ❑maximizing system efficiency.

Energy Management
Lighting

Use as much natural lighting as possible;

Turn off unnecessary lamps;

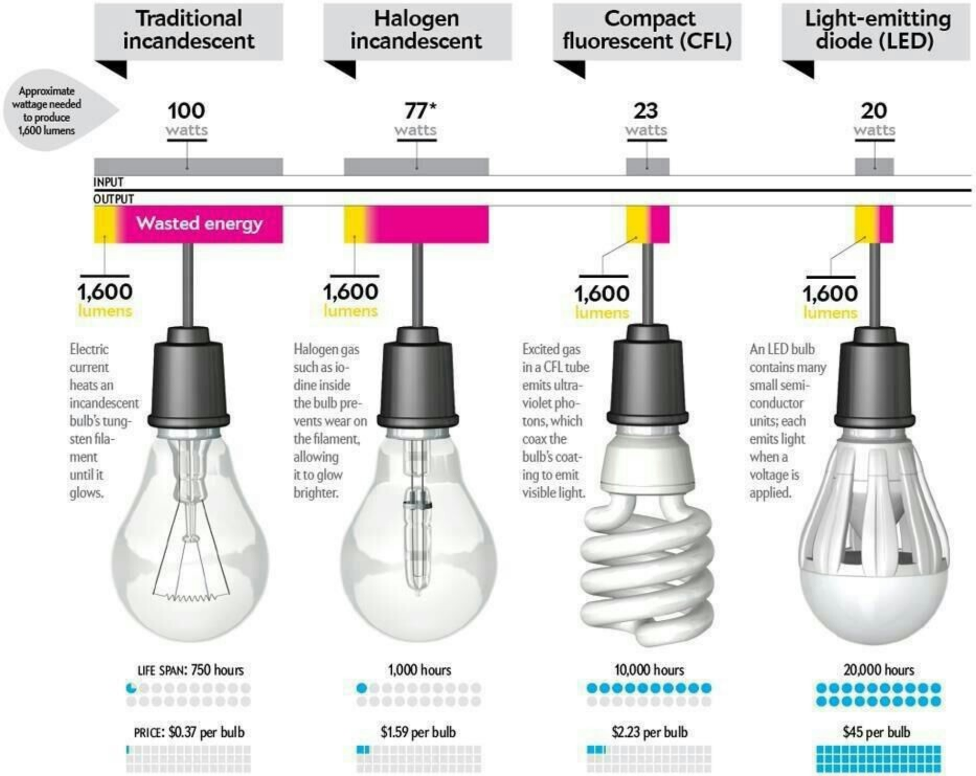
Design according to energy saving criteria:

- use of presence sensors and lighting;
- take care of the layout of lighting fixtures;
- optimize armor and light fixtures;
- put adequate attention to the chromatic tone.

Energy Management

Lighting

A lighting system consists of light sources (lamps), luminaires (or fixtures), and ballasts. Each component will affect the performance, energy use and annual operating cost of the lighting system.



Energy Management
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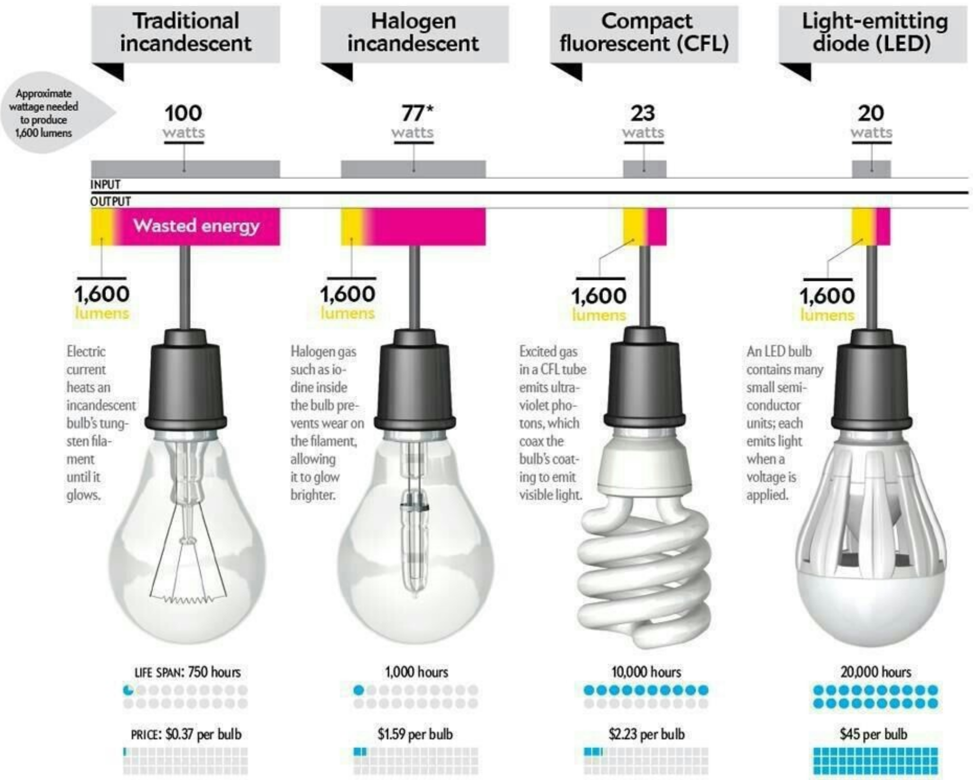


Energy Management

Lighting

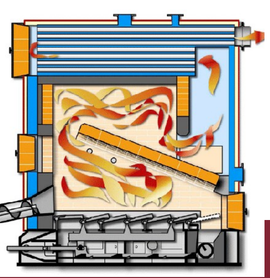
The margins of energy saving in the consumption of fluorescent lighting systems (T8)	
Improvement of the management	5%
Correction of the power factor	2%
Replacement of traditional reactors with electronic ballasts	8%
Replacement of existing pipes with new high frequency T5 and / or new generation of compact fluorescent	15%
Use of ceiling lights at high luminous efficiency with an optical system optimized for the actual usage;	20%
Use of automatic control systems of lighting (shutdown and/or partial use)	30%
Use of the stabilization apparatus and reduction of the supply voltage	30%

Energy Management

Flue Gas Heat Recovery

The preheating of the combustion air and/or thermo-vector fluids, using the heat contained in the fumes, is the most traditional system to increase the energy efficiency of an industrial process.

ENEA – Energy Efficiency Centre of Research (source: RAEE 2012) registers an average energy savings approximately equal to 1.000 toe/year for installation, in Italy.



Energy Management

Flue Gas Heat Recovery

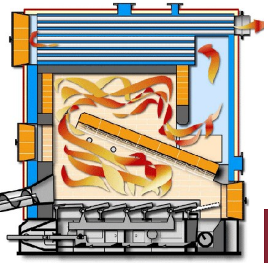
Case Studies

Case Studies: Ceramic Industry

Objective: of the process is the heat recovery from the flue gas by a post-combustion plant used for the abatement of pollutants coming from an furnace.

The recovered heat reduces costs:

- ❑of the post-combustion treatment through a heat exchanger flue gas/combustion air;
- ❑of the brick production through a diathermic oil circuit, powered by a second flue gas/oil exchanger, in order to produce high-temperature air to the brick and steam dryer for process uses.



Energy Management
Flue Gas Heat Recovery

Case Studies: Ceramic Industry

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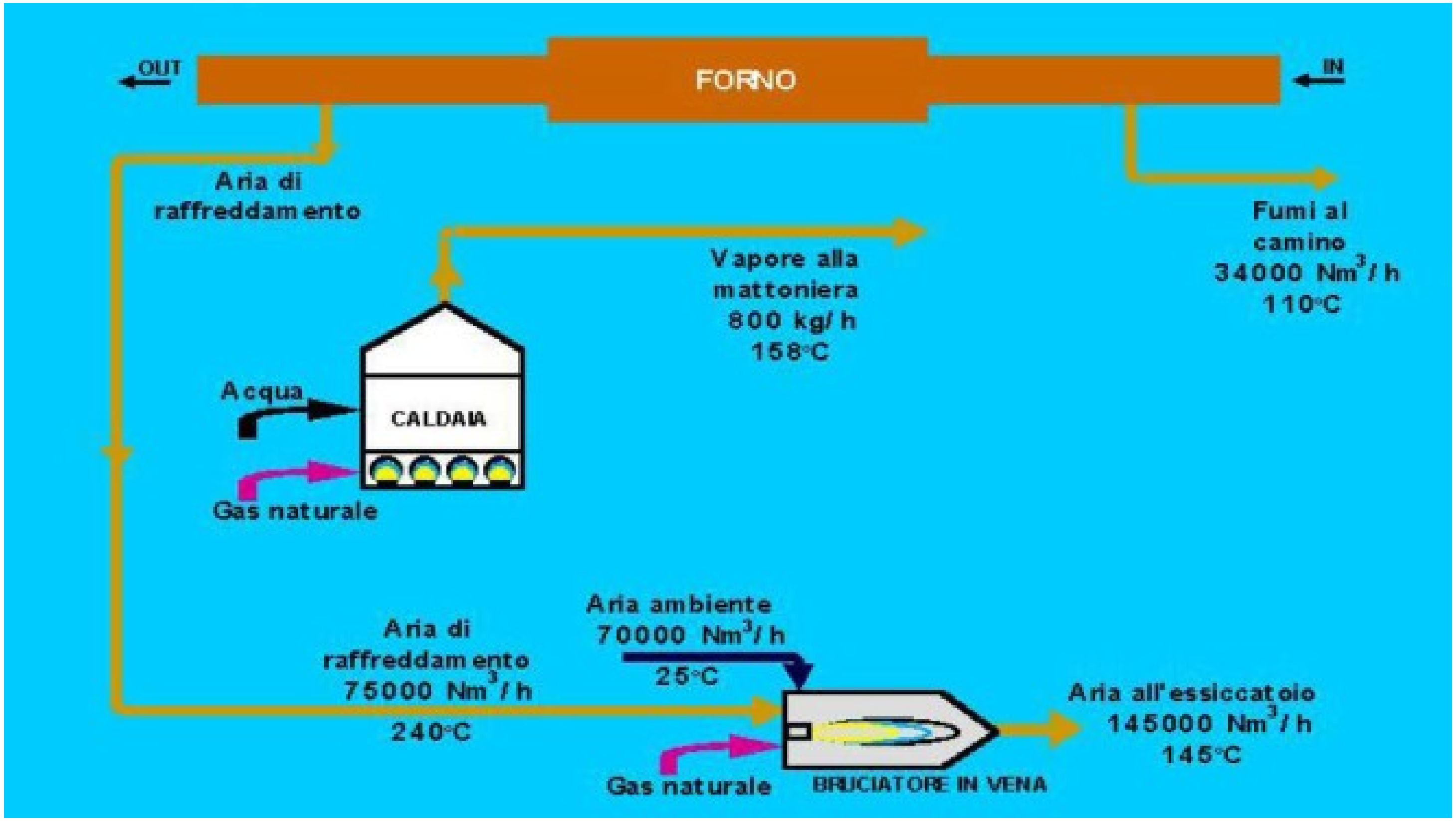
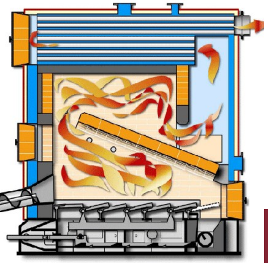
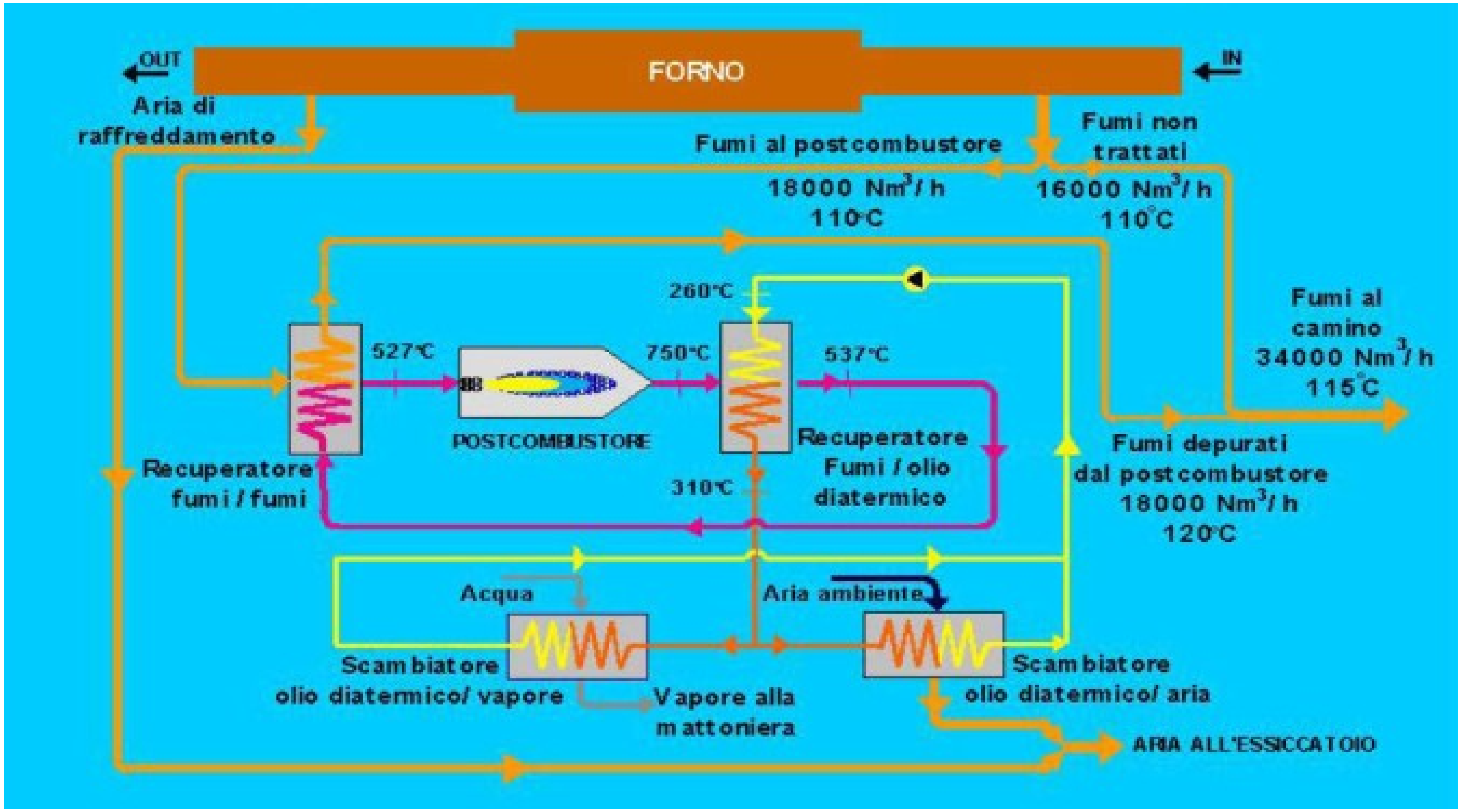


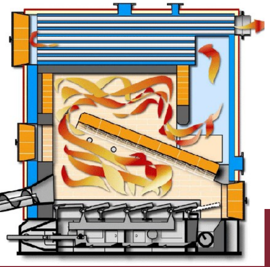


Energy Management
Flue Gas Heat Recovery

Case Studies: Ceramic Industry

POST OPERAM





Energy Management
Flue Gas Heat Recovery

Case Studies: Ceramic Industry

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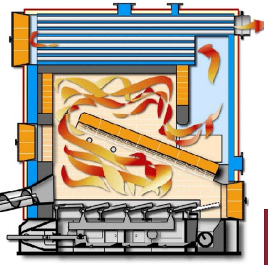
The new layout saves:

- 2,700 kW in favor of post-combustion
- 1,280 kW for the production process,
- for a total of 2,713 toe/year
- payback Period (SPP) = 1.5 years

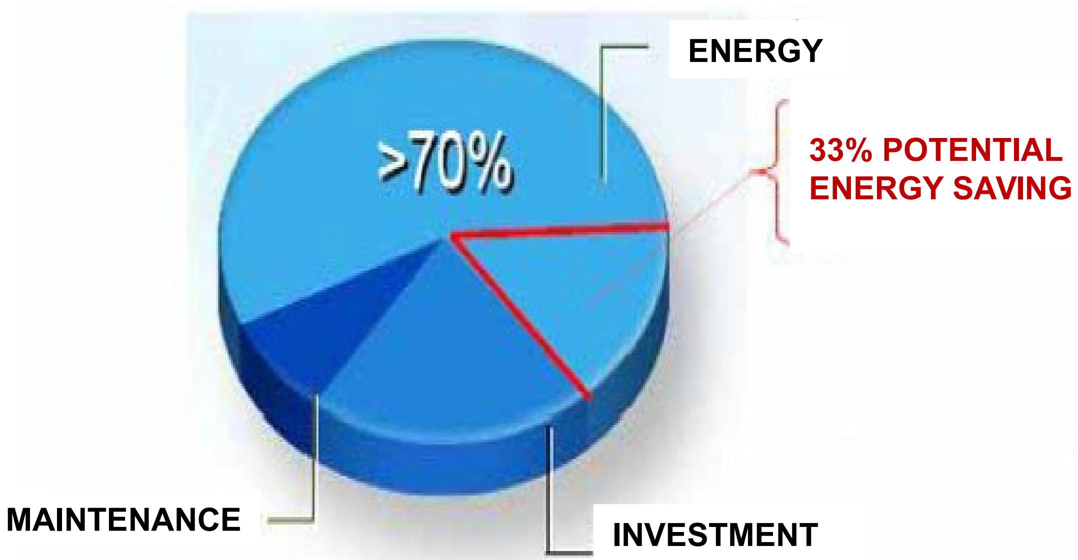


Energy Management
Compressed air systems

In Italy, the compressed air accounts for 11% of all energy used for industrial process (12 TWh/year).

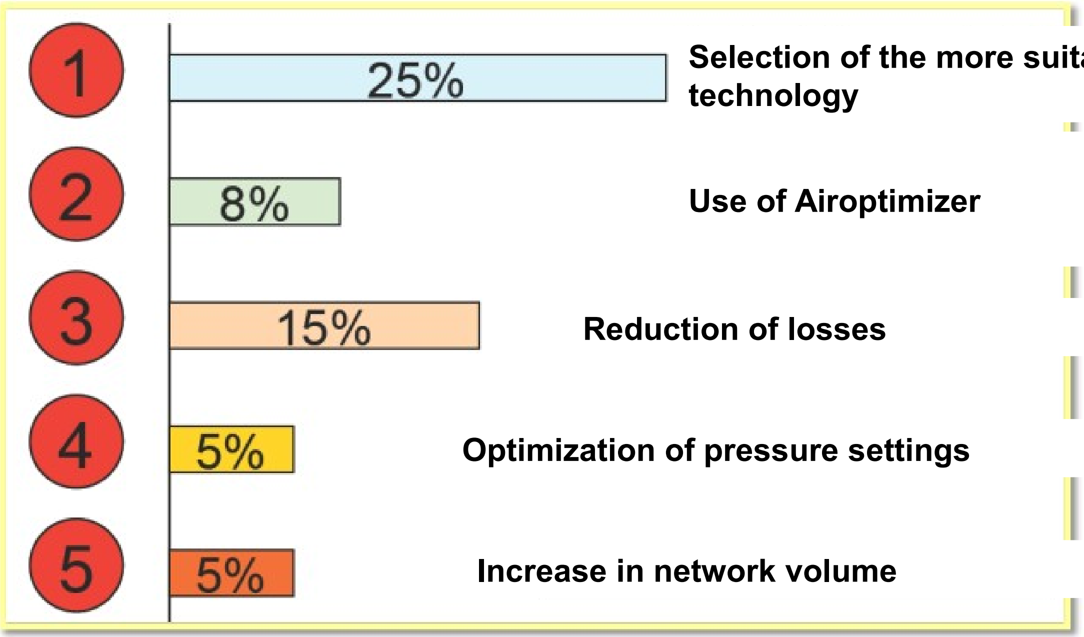
32.9% could be saved with a potential of about 4 TWh/year.

The cost of a compressor is around 16% of operating costs calculated on a useful life of 10 years. It is clear the importance of energy-efficient machine.



Energy Management
Compressed air systems

In general, the optimization of a compressed air plant is based on five main areas of action (source: Atlas Copco):

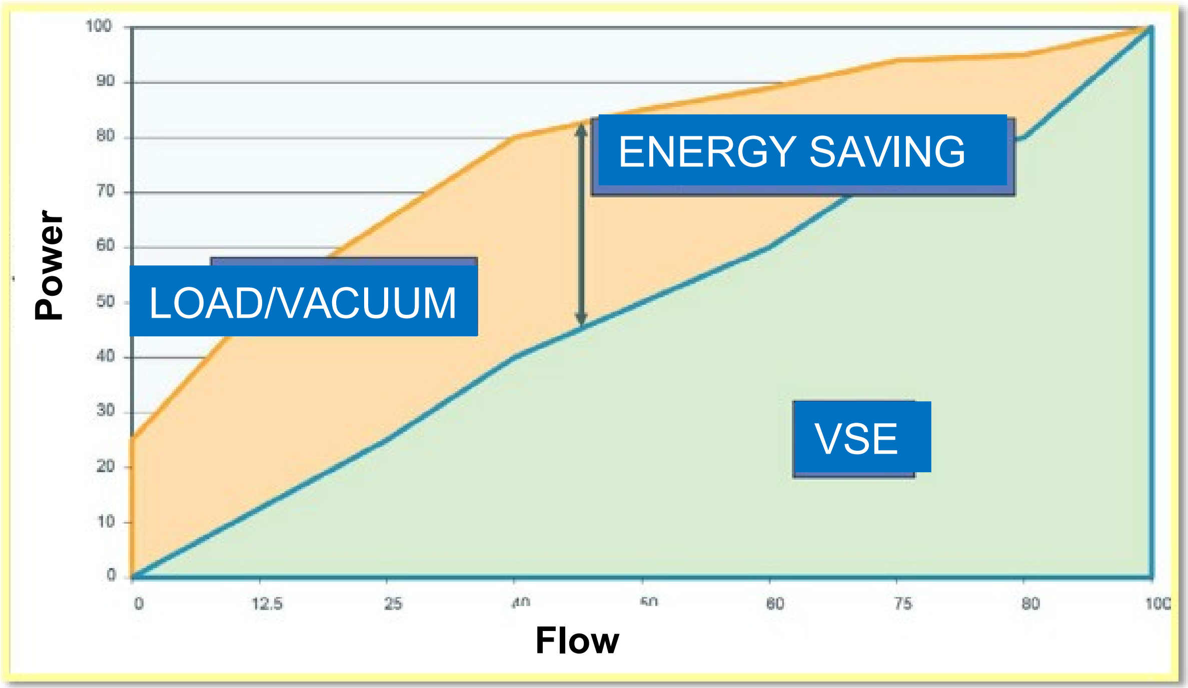


Energy Management

Compressed air systems

The use of variable speed engines allows, for example, to drastically reduce consumption in flow rates below nominal.

[Source: Atlas Copco]



Energy Management

Compressed air systems

A high proportion of energy waste is also associated with poor management:

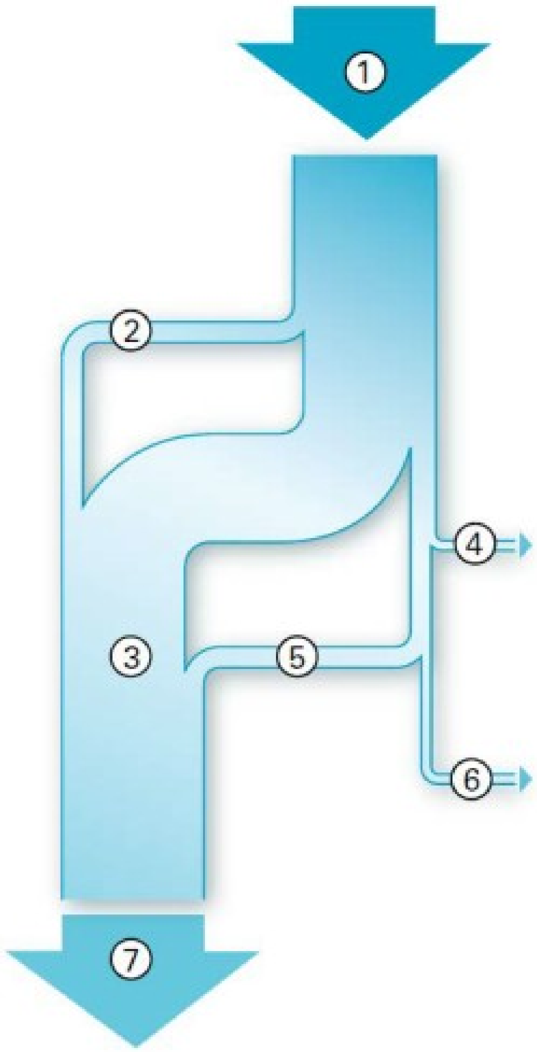
- ❑losses in an AC network can reach up to 30%, though a value of 10% can be considered as "physiological";
- ❑losses can be made at any point of the circuit, but they are most frequently localized on connectors, flanges and flexible couplings;
- ❑losses are expensive (a single hole of 3 mm in a network to 12 bars "edge" over 7,000 € / year) by activating the compressors even when there is the technological air demand;
- ❑abandoned branches of distribution lines are often the cause of losses, as well as defective safety valves;
- ❑It promotes excessive pressure losses and requires a higher power for the same volume of air supplied;
- ❑Manual drains can be imperfectly closed.

Energy Management
Compressed air systems

The heat recovery from an air compressor can be summarized as follows:

1. energy input to the system;
2. heat from the engine (9%);
3. heat from the oil cooler (72%);
4. heat dissipated into the environment (2%);
5. heat recovered from the post-cooling (13%);
6. residual heat in the compressed air (4%);

7. overall energy recoverable (94%).



Thank you for your attention!

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