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Energy Audit Course Handbook
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Energy Audit

Course Handbook

par

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Foreword

1) Context

Energy auditing has become an essential tool for energy management and consumption reduction across various sectors (industrial, tertiary, and building). In a context marked by rising energy costs, resource scarcity, and environmental commitments, conducting energy audits has become an indispensable requirement for companies and institutions. In Algeria, legislation now mandates the implementation of regular energy audits, along with the adoption of energy management practices, in order to promote energy efficiency and optimize the use of resources.

It is within this framework that this handbook has been designed. It is primarily intended for first-year Master's students in mechanical and energy engineering, but it can also serve as a practical guide for engineers and technicians wishing to strengthen their skills in energy diagnosis and management.

2) Handbook Overview: Objectives & Structure

This handbook functions as a core guide for first-year Master's students and a practical reference for practicing engineers in the field of energy auditing.

Primary Objectives:

- To deliver the essential theory and practical methodology for performing comprehensive energy audits.
- To develop the skills needed to analyze energy use and identify efficiency opportunities across industrial, tertiary, and building sectors.
- To enable the proposal of viable technical, economic, and environmental solutions.
- To introduce key energy management standards and regulations, such as ISO 50001.
- To instill a systematic, integrated approach to energy efficiency, from initial diagnosis to final reporting.

Structure and Content Flow:

The handbook is organized to logically guide the reader through the entire audit process:

- Foundational Knowledge (Chapters I-III): Covers energy fundamentals, audit principles, and key terminology.
- Audit Execution (Chapters IV-V): Details the preparation and on-site procedures for conducting an audit.

- Analysis & Reporting (Chapters VI-VII): Focuses on data evaluation, identifying inefficiencies, and communicating findings with actionable recommendations.
- Implementation & Feasibility (Chapters VIII-IX): Assesses the technical, economic, and financial viability of proposed energy-saving measures.

The handbook concludes with Multiple-Choice Questionnaires (MCQs) and answer keys to test comprehension, followed by a General Conclusion that synthesizes the key takeaways.

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Symbols and notations

Category	Symbol / Abbreviation	Meaning / Description
General Units and Metrics	kW	Kilowatt — unit of power
	kWh	Kilowatt-hour — unit of energy
	MWh	Megawatt-hour — unit of energy
	€	Euro — currency
	€ HT	Euros excluding tax (*hors taxes*)
	TOE	Tonne of Oil Equivalent — standard energy comparison unit
	m^3	Cubic meter — unit of volume (e.g., gas or compressed air)
	h/an	Hours per year
	%	Percentage
Mathematical Notations	$E = E_0 + c \cdot \alpha$	Empirical formula for energy consumption
	E	Total energy consumption
	E_0	Fixed base load energy consumption
	c	Variable consumption coefficient
	α	Production or driving variable
	$CT = CE + CGN + CPP$	Formula for total energy consumption in TOE
	CT	Total consumption
	CE	Electricity consumption
	CGN	Natural gas consumption
	CPP	Petroleum product consumption
Systems and Concepts	HVAC	Heating, Ventilation, and Air Conditioning
	VSD	Variable Speed Drive
	EPC	Energy Performance Contract
	ESCO	Energy Service Company
	ESPC	Energy Service Providing Company
	ROI	Return on Investment
	KPI	Key Performance Indicator
	SEC	Specific Energy Consumption
	EEI	Energy Efficiency Index
	CUSUM	Cumulative Sum — control chart for performance tracking
	DMD	*Débit Mis à Disposition* — Contracted Demand
	DMA	*Débit Maximum Absorbé* — Maximum Absorbed Demand
	APRUE	National Agency for the Promotion and Rationalization of Energy Use (Algeria)
	EnMS	Energy Management System

Chapter I. General Overview of Energy

Chapter I. General Overview of Energy

I.1) Types and Sources of Energy

There are many forms of energy, but not all of them are always exploitable.

a) Mechanical Energy

Mechanical energy, associated with objects, is the sum of two other types of energy: kinetic energy and potential energy:

- *Kinetic energy* is the energy of moving objects; the faster an object moves, the greater its kinetic energy. The energy of rivers (hydraulic energy) and that of wind (wind energy) are forms of kinetic energy. They can be transformed into mechanical energy (watermill, windmill, wind-driven pump) or into electricity when they drive a generator.

- *Potential energy* is the energy stored in immobile objects. It depends on their position. As its name suggests, it exists potentially, meaning that it only manifests when converted into kinetic energy. For example, a ball acquires gravitational potential energy when lifted, which becomes apparent only when it is released and falls.

b) Thermal Energy

This is simply heat. It is caused by the agitation of molecules and atoms within matter. Thermal energy therefore represents the kinetic energy of a system at rest. In a steam engine, it is transformed into mechanical energy; in a thermal power plant, it is converted into electricity. The subsoil contains thermal energy (geothermal energy), which can be used either for heating or for electricity generation.

c) Chemical Energy

Chemical energy is the energy associated with the bonds between the atoms that make up molecules. Certain chemical reactions can break these bonds, releasing their energy (such reactions are called exothermic). During combustion, which is one such reaction, oil, gas, coal, or biomass convert their chemical energy into heat and often into light. In batteries, electrochemical reactions produce electricity.

d) Radiant Energy

This is the energy carried by radiation. Light energy is one example, as is infrared radiation. Both are emitted, for instance, by the Sun or by the filaments of electric bulbs.

Solar radiation can be captured and converted into electricity (photovoltaic energy) or into heat (solar thermal energy).

e) Nuclear Energy

Nuclear energy is the energy stored at the core of atoms, more precisely in the bonds between the particles (protons and neutrons) that make up their nucleus. When atomic nuclei are transformed, nuclear reactions are accompanied by heat release. In nuclear power plants, fission reactions of uranium nuclei are carried out, and part of the released heat is converted into electricity. In stars such as the Sun, atomic energy is released through fusion reactions of hydrogen nuclei.

f) Electrical Energy

Electrical energy represents energy transferred from one system to another (or stored in the case of electrostatic energy) by means of electricity, i.e., through the movement of electric charges. It is therefore not an energy form in itself, but rather an energy carrier. However, the term is commonly used for convenience. Systems that provide these electrical transfers include alternators or batteries, while systems that receive them include resistors, lamps, or electric motors.

g) Energy Source

An energy source is a physical or chemical phenomenon from which energy can be harnessed for industrial or biophysical purposes. An energy source is called *primary* if it originates from a natural phenomenon and has not been transformed; it is called *secondary* if it results from intentional transformation. It can also be considered *renewable* if its reserves are not significantly depleted over the timescale of its use. Some sources are also referred to as *clean energy* in the ecological context.

- Most forms of energy appear as flows. They are permanently available on a human timescale: these are renewable energies (green in the chart).
- Non-renewable energies are energy stocks (red in the chart) that have been built up over long periods (hundreds of millions of years): fossil fuels (oil, coal, and gas).

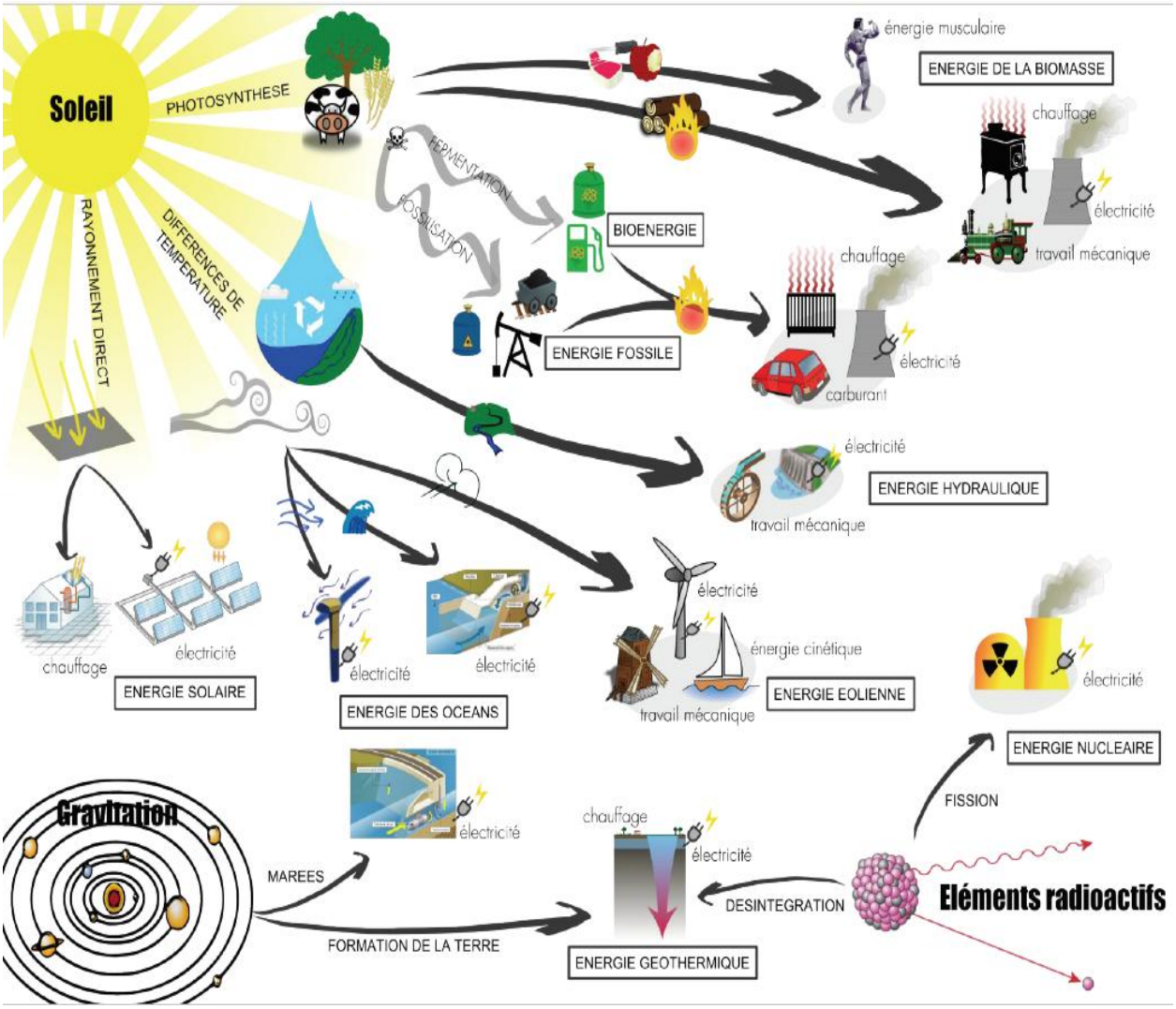


Fig.I. 1.Different forms of energy [6]

I.2) Energy Transport

I.2.1) Transport of Electrical Energy

In the illustration below, we can see the organization of electrical energy transport from the power generation plant (nuclear plant, conventional thermal power plant, hydroelectric plant, etc.) to major users (large consumption centers), cities, railway networks, and industries through the transmission network, and then to the final users (cities, supermarkets, households, small industries) via the distribution network.

I.2.3) Transport of Hydrocarbons

The Pipeline Transport Network ensures the delivery of all hydrocarbon production from Entry Points to Exit Points for the benefit of Users. It also supplies the national market, LNG complexes with natural gas, separation complexes with LPG, and refineries with crude oil and condensate. The surplus gas is intended for export via the GEM, GPDF, and MedGaz pipelines, while surplus crude oil, condensate, and LPG are exported through the ports of Arzew, Skikda, and Béjaïa. The Transport Network constitutes a flexible link in the Hydrocarbon chain, offering the capability to handle potential disruptions either upstream or downstream. To fulfill this mission under optimal safety and environmental protection conditions, and at the lowest possible cost, the Concessionaire relies on established norms and standards based on best international practices for the development and operation of the Transport Network .

On a **global scale**, hydrocarbon transport relies on three main modes: pipelines, maritime shipping, and rail/road transport. Pipelines are the most cost-effective and secure solution for long-term, large-scale transport of crude oil and natural gas. Maritime transport, mainly through oil tankers and LNG carriers, represents the backbone of international hydrocarbon trade, ensuring connections between producing countries in the Middle East, Africa, and South America, and major consumption centers in Europe, North America, and Asia. Road and rail transport are typically reserved for shorter distances and distribution within domestic markets.

In the **Algerian context**, pipelines play a strategic role in securing energy exports to Europe. Algeria is one of the leading gas exporters to the European Union, thanks to three main gas pipelines:

- **TransMed (Enrico Mattei pipeline)**: connecting Algeria to Italy via Tunisia and the Mediterranean Sea.
- **MedGaz pipeline**: a direct offshore connection between Beni Saf (Algeria) and Almería (Spain).
- **GME (Maghreb–Europe pipeline)**: linking Algeria to Spain and Portugal through Morocco (though flows have been suspended since 2021).

These infrastructures, combined with LNG terminals at Arzew and Skikda, provide Algeria with diversified export routes and reinforce its strategic position as a reliable energy supplier to international markets .

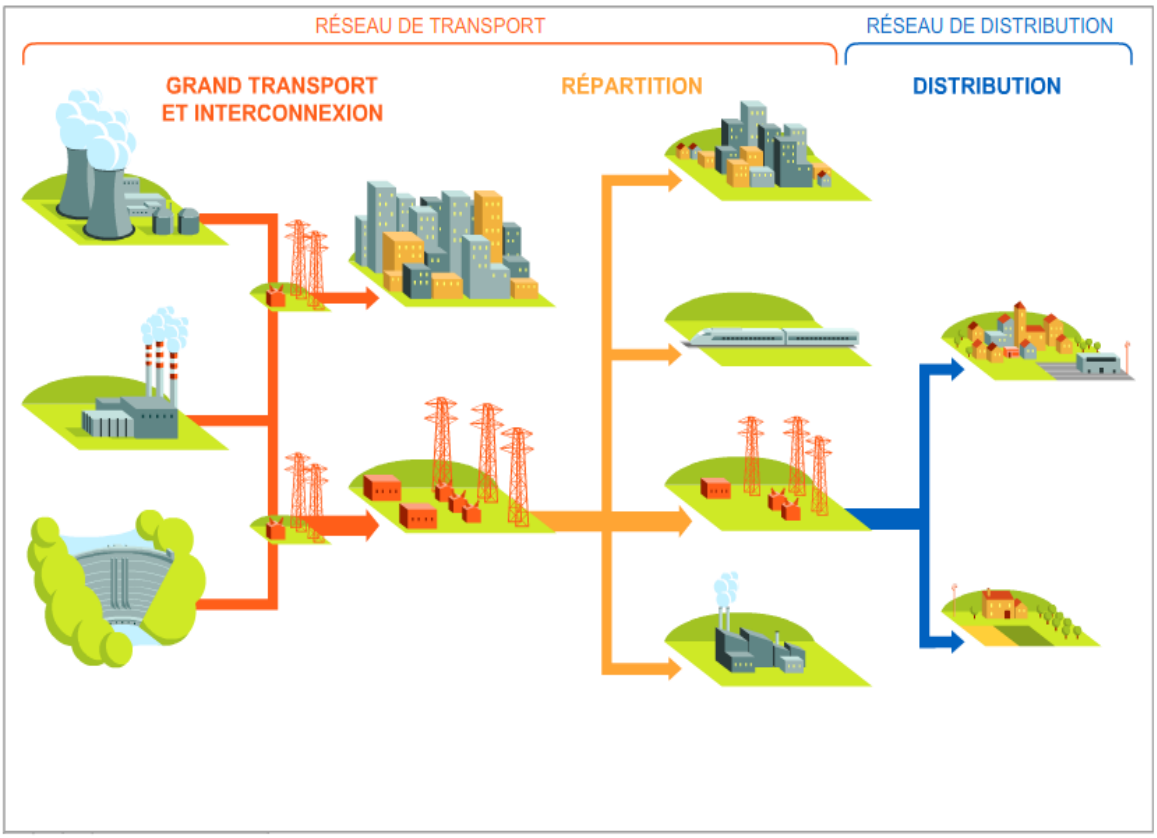


Fig.I. 2. Energy Transport [6]

I.2.4) Algerian Energy Pricing System (Electric and Thermal Energy)

Electricity is a consumer good that has become indispensable to the well-being of the population and to the economic development of Algerian society [7].

The new pricing system applied in Algeria pursues the following main objectives:

- To minimize the costs of electrical energy.
- To ensure efficiency both at the collective (national) level and for the end user.

To maintain consistency between national efficiency and user efficiency, the structure of the new pricing system must align with the structure of electricity supply costs. Therefore, it is essential to balance the available capacities of production, transmission, and

distribution (in the medium and long term) with the expected future demand for electricity, in order to optimize expenditure.

Electricity supply costs are considered at a national level. Consequently, the new pricing structure no longer includes regional differentiation, which aligns with Algeria's policy of balanced development across the country.

The analysis of supply costs has been carried out according to the delivery level of electricity to subscribers, leading to three tariff categories based on voltage levels:

- High Voltage (HV): 400, 220, 90, and 60 kV
- Medium Voltage (MV): 30, 22, 10, and 5.5 kV
- Low Voltage (LV): 0.38 and 0.22 kV

I.2.5) The Tariff Formula

The pricing structure is based on a polynomial formula that includes:

- a fixed charge (base fee),
- a term related to energy consumption, and
- a term related to the contracted or maximum demand (flow/debit).

This structure is used to calculate the pre-tax amount of the gas or electricity bill.

The tariff formula can be summarized as follows:

Total Bill (Excl. Taxes)=Fixed Charge+Energy Charge+Demand Charge

Where:

- Fixed Charge (Redevance fixe): A flat fee applied to all subscribers, independent of consumption.
- Energy Charge (Terme qui facture l'énergie): A variable cost based on the actual amount of energy consumed (kWh or therms).
- Demand Charge (Terme qui facture le débit): A cost based on the contracted or maximum absorbed demand:
    - *DMD (Débit Mis à Disposition / Contracted Demand)* – the capacity reserved for the subscriber.
    - *DMA (Débit Maximum Absorbé / Maximum Absorbed Demand)* – the peak power actually used.

This pricing method encourages users not only to manage their overall consumption but also to optimize their peak demand, thereby ensuring better use of national energy infrastructure.



Fig.I .3. The Tariff Formula [6]

The Fixed Charge (Constant Term): Represents the technical and commercial management fees, including:

- Maintenance and verification of the metering system.
- Meter reading and billing services.

Billed Gas Energy: The monthly consumption of natural gas, expressed in thermies.

Contracted Demand (DMD – Débit Mis à Disposition): The DMD corresponds to the hourly flow rate reserved by the Electricity and Gas Distribution Company (Central Region) under a contractual agreement. The client may use this capacity according to their needs.

It is chosen by the customer—generally with the advice of the Commercial and Marketing Department—among standardized flow rates and is contracted for a period of 10 years.

Maximum Demand (DMA – Débit Maximum Atteint): The DMA refers to the maximum flow rate absorbed by the client during the billing period. It must not exceed the contracted demand (DMD).

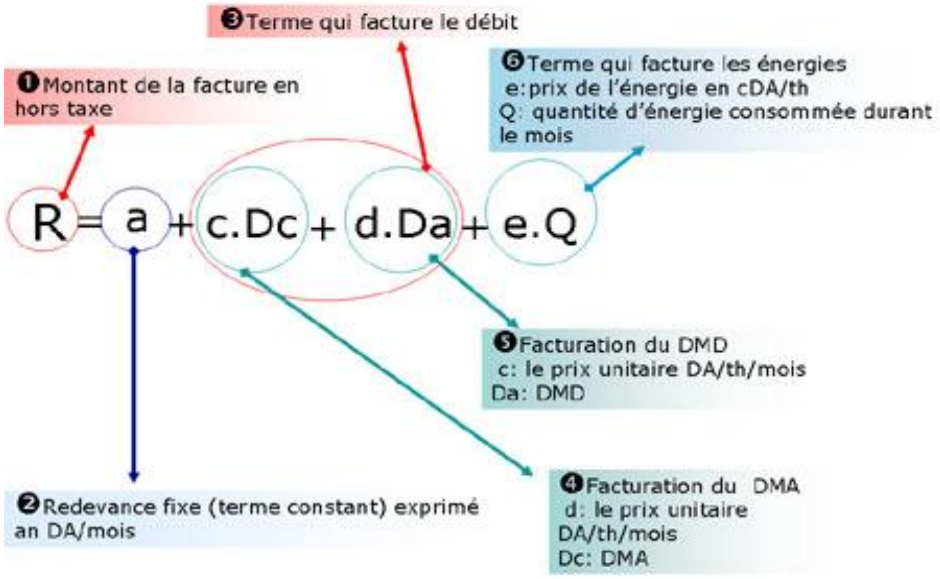


Fig.I .4. The gaz tariff polynomial [6]

I.3) Algerian Legislation and Energy Audit Requirements

a) The energy audit

The energy audit previously called an energy diagnosis is, in fact, the essential initial step to ensure a proper definition of energy management actions. A thorough study of various energy-consuming items allows us to identify potential energy savings and determine the actions and investments that can be made to exploit them, at the best cost for the company [7].

The analysis focuses on the energy consumption of production equipment and utilities (lighting, heating, air conditioning, ventilation, transportation). Successfully carrying out this approach, however, requires taking into account a number of prerequisites regarding the scope of the study, the internal organization to be implemented, the choice of the service provider to be retained, and the process to be implemented.

I.4) Executive Decree on Energy Audits

1. Executive Decree No. 05-495 of 24 Dhou El Kaada 1426, corresponding to December 26, 2005, on energy audits [7].

2. Interministerial Order of September 29, 2010, on the accreditation of audit firms and experts.

• Lists of accredited audit firms and experts:

Industry, Tertiary (Higher Education, Services and Administrations), and Transportation

The database is populated by a survey conducted by the APRUE (French Agency for Energy and Energy Policy) on the energy consumption of high-energy consuming establishments, based on quantitative questionnaires sent to various establishments in the industrial, tertiary, and transportation sectors. This survey aims to assess the energy efficiency of establishments and define their energy consumption patterns.

The National Agency for the Promotion and Rationalization of Energy Use (APRUE) is a public industrial and commercial institution created by presidential decree in 1985 and placed under the supervision of the Ministry of Energy and Mines. The agency's missions are:

• Coordination and leadership of the national energy management policy;

• Implementation and monitoring of the National Energy Management Program (PNME);

• Raising awareness and disseminating information on energy management to various target groups (general public, professionals, schools, etc.);

• Development of sectoral programs and projects in partnership with relevant sectors (industry, construction, transportation, etc.). - Establishments subject to energy audits:

The thresholds for establishments subject to mandatory energy audits are: 2,000 TOE for industry, 1,000 TOE for transportation, and 500 TOE for the tertiary sector.

CT = CE + CGN + CPP

Total energy consumption in TOE = electricity consumption in TOE + natural gas consumption in TOE + petroleum product consumption in TOE.

Chapter II. Energy Management and Audits

Chapter II: Energy Management and Audits

II.1: Energy Management

The Energy management is the primary instrument for achieving energy efficiency in the industrial and tertiary sectors. It is defined as the wise and efficient use of energy to maximize profits and enhance competitiveness. Its goal is to reduce energy input for transformation and processing systems while maintaining or reducing the total cost of the finished product [1].

Ensure that all users of energy systems within the organization are supplied with energy, when needed, in the appropriate form, at the most competitive cost possible, and that the energy provided is used in the most efficient way possible.

II.2) Definition of Energy Audit According to the Standard

According to EN 16247-1, adopted in September 2012, an energy audit is defined as a "methodical examination and analysis of the energy use and consumption of a site, building, system, or organization, aimed at identifying energy flows and opportunities for improving energy efficiency, by defining the actions required to achieve these savings and reporting on them[2].

It is worth noting that this official definition replaces the term "diagnosis" with "energy audit." Previously, the BP X30-120 good practice reference framework had defined the methodology for energy audits in industry since 2006.

II.3) The Role of an Energy Audit

Role of Energy Audit

- Provide decision-makers with information to support energy-related decisions.
- Evaluate energy consumption and costs for the main consumption areas, as well as the primary sources of losses and inefficiencies [3].
- Identify and assess the potential and actions for Energy Efficiency (EE).
    - **No-cost or very low-cost actions:** maintenance, procedures, setpoints, etc.
    - **Actions with acceptable payback time:** feasible for the company in the short term.

  - **Actions with longer payback time:** not immediately feasible but to be considered in future decisions.
- Whenever possible, the audit should organize recommendations into an **Action Plan**, including an **Energy Management System (EnMS)** for long-term planning.

Energy audits are recognized as useful in any country committed to energy efficiency:

- Often promoted and supported (subsidized) by authorities.
- Can be conducted in **group audits by sector**, allowing:
  - Economies of scale
  - Access to sector specialists
  - Information sharing
- Serve as a first step in defining **Negotiated Voluntary Agreements**.
- Energy audits are usefully complemented by a few days of consultant/auditor follow-up.
- The question arises whether audits should be **mandatory or voluntary**.
- Two normative documents can help implement or monitor an energy audit:
  - **ISO 50002:** defines audits in the context of **ISO 50001: Energy Management Systems**[4].
  - **EN 16247:** for mandatory audits of large consumers (Energy Efficiency Directive)[5].

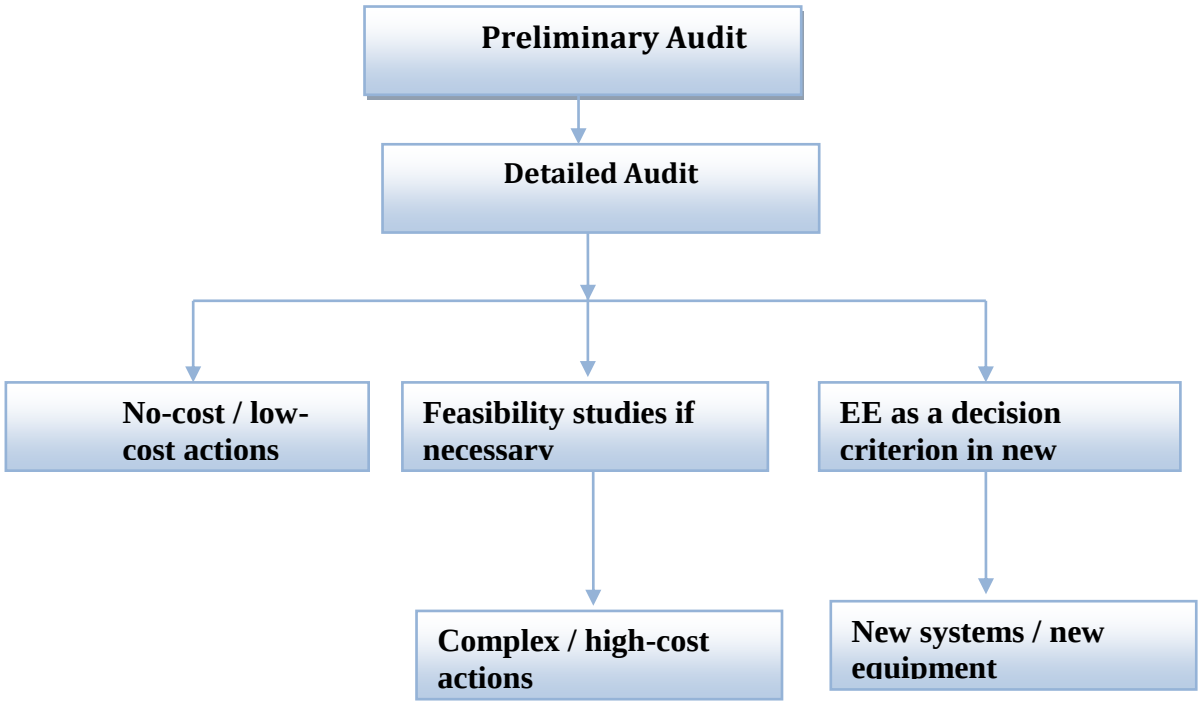


Fig.II. 1: Audit organization chart [8]

II.4) Industrial Sector

II.4.1) The Three Stages of the Audit

a) Preliminary Audit

The scope and level of detail of an energy audit should be tailored to the organization's needs, priorities, and economic considerations. A preliminary audit (also referred to as a first-level audit or pre-diagnosis) can be conducted without an extensive measurement campaign, relying primarily on available information.

The preliminary audit typically includes:

- Establishing an initial assessment of energy consumption.
- Performing a first analysis of the main consumption areas.
- Identifying priority equipment, systems, or workshops.
- Defining the scope and content of the next stage, the detailed audit.

Thus, the preliminary audit serves to focus the detailed audit on key priorities, ensuring that the energy efficiency efforts are economically optimized

b) Detailed Analysis: In-depth investigation of identified energy-saving potentials, analysis of the energy needs of processes and utilities.

***c) Actions and Solutions*:** Definition of actions, evaluation of costs and return on investment periods.

II.4.2) Keys to Success

- **Company Involvement:** Prioritize energy management, mobilize management, and appoint an **Energy Manager**.
- **Choice of Service Provider:** Must be **competent, neutral** (without linked commercial offers), and **discreet**.
- **Precise Terms of Reference:** Must define the scope, detail the necessary information, plan the interventions, and require **recommendations classified by priority** (immediate, priority, useful actions).

II.4.3) Results and Benefits

- **Reduction of production costs** and improvement of productivity.
- **Improvement of product quality** through better control of production conditions.
- **Citizen image** and contribution to sustainable development (reduction of greenhouse gas emissions).
- Basis for implementing an **Energy Management System (EMS)**.

II.5) Tertiary/Building Sector

II.5.1) Legal Obligations

- Establishments are required to carry out an audit if their **total energy consumption** exceeds a threshold (500 TOE for the tertiary sector).
- Consumption is calculated in **Tonne of Oil Equivalent (TOE)**.

II.5.2) The Three Phases of the Audit

a) Preliminary Visit: Evaluation and mission planning.

b) Preliminary Audit: Collection of consumption data, initial measurements, and proposal of an initial action plan.

c) Detailed Audit: Detailed measurements, performance analysis, and establishment of a complete energy balance with an optimized action plan.

II.5.3) Areas of Investigation and Recommendations

The expert examines all consumption areas:

- **Technical Systems:** Heating, air conditioning, ventilation, lighting, domestic hot water.
- **Recommendations:** Improvement of management, maintenance, energy recovery, substitution of sources, use of renewable energies.

II.6) Audit of Rolling Stock (where applicable)

The audit for a vehicle fleet must analyze:

- The composition and age of the fleet.
- The optimization of routes and loading.
- Vehicle maintenance and fuel management.
- The energy balance per activity.

Chapter III: Definitions and Operational Strategies

III.1) Definitions

The energy audit is a **key component of a systematic approach to decision-making** in energy management. It can be considered through three different approaches:

III.2) Quick Fixes

Simple, uncoordinated activities that lead to occasional energy consumption reductions (e.g., replacing window insulation, installing timers). They offer benefits but are minimal compared to an integrated approach.

III.3) Energy Projects

A systematic reduction of energy consumption, typically based on an **Energy Audit**. This can be a preliminary ("walk-through") audit, a detailed/general audit, or an investment-grade audit.

III.4) Comprehensive Energy Management Program

The most complete approach, involving the establishment of a true management system for continuous monitoring, control, and reduction of energy consumption, often leading to certification.

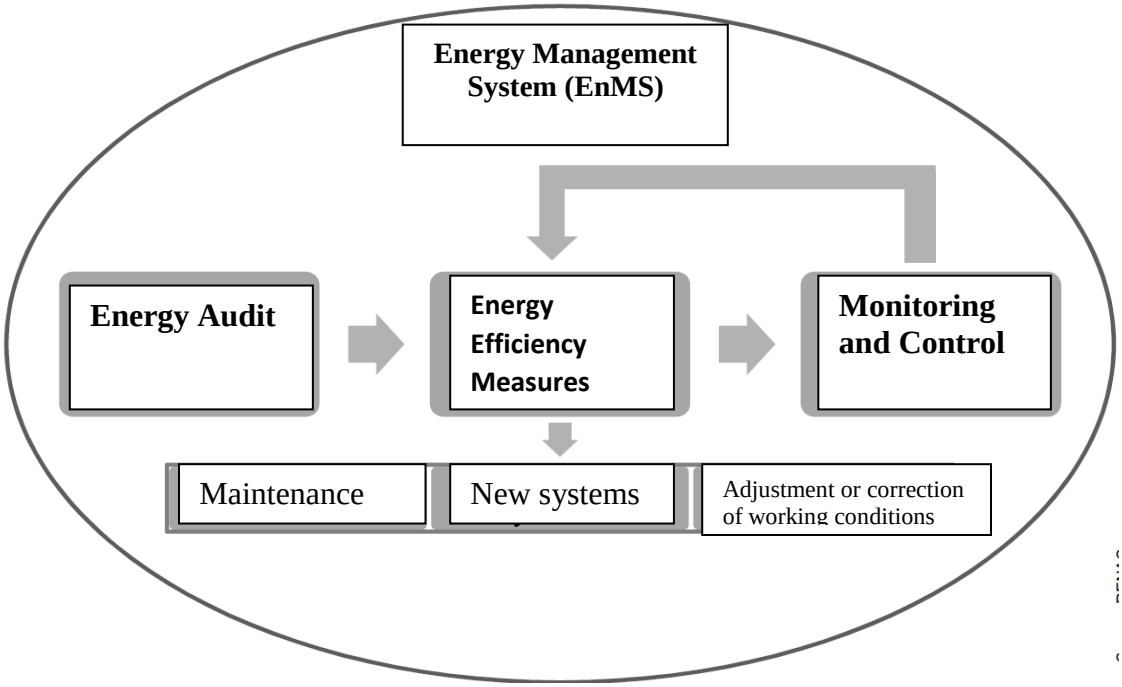


Fig.III. 1:Energy Management Program [8]

III.5) Quick Fixes

"Quick fixes" are activities that result in occasional reductions in energy consumption. These are generally uncoordinated energy efficiency measures, costing little or even nothing, and do not require detailed analysis or an action plan.

Examples include replacing window insulation, installing timers for lighting and air-conditioning systems, and using highly energy-efficient components. While significant economic benefits can be achieved—especially in older buildings or installations—these gains are limited compared to what can be realized through integrated energy management actions.

III.6) Energy Projects

Energy projects involve a systematic approach to reducing energy consumption. Compared to quick fixes, this method can achieve much greater results. A phase of analysis should be carried out to identify the most significant reduction opportunities.

This approach is generally based on a more or less detailed review or analysis, such as through **Energy Audits**.

An **Energy Audit** is an inspection, survey, and analysis of energy flows in a building, process, or system, aimed at reducing the energy input without negatively affecting the product(s). Typical audit types include:

- **Preliminary audit ("walk-through audit")**
- **Detailed/general energy audit**
- **Investment-level audit**

III.7) Comprehensive Energy Management Program

A **comprehensive energy management program** represents the most complete approach to establishing energy efficiency within an organization. It is a true management system.

- This approach fundamentally requires the introduction of monitoring, control, and continuous reduction of energy consumption.
- The trend is to implement **Energy Management System (EnMS) models**, which provide guidance for the organization and can also lead to certification, enhancing the organization's brand image and reputation.

III.8) Defining the Scope of the Energy Audit

1. **Energy Sources:** fossil fuels, electricity, etc.
2. **Audited Object:**
    - Entire site and all energy sources
    - Focus on a specific form of energy
    - Focus on a workshop or particular equipment
    - Utilities vs. production processes
3. **Who can perform an audit?** Depending on the scope:
    - A wide range of skills may be required
    - Knowledge of the process is critical
4. **Recent market trend:** specialization by utilities (e.g., refrigeration, compressed air, etc.)

Chapter IV: Preparing for the Audit

Chapter IV: Preparing for the Audit

IV.1) Energy Analysis – Objectives and Process

The energy analysis constitutes a fundamental stage in any structured approach to energy management. Its main objectives are twofold: first, to analyze and assess the structure of energy demand within the organization, and second, to identify practical and cost-effective measures that can reduce both energy consumption and overall energy costs. Beyond these goals, the analysis also provides valuable insights into consumption patterns, potential inefficiencies, and priority areas where interventions would generate the highest return.

The process of energy analysis generally follows a systematic sequence:

1. Preparation – gathering preliminary data, defining the scope, and identifying critical energy users.
2. On-site audit – direct observation of systems, facilities, and operational practices to verify data and detect improvement opportunities.
3. Analysis and evaluation – assessing collected data, comparing performance against benchmarks, and estimating potential savings.
4. Report – compiling findings, outlining recommendations, and proposing an action plan tailored to the organization's economic and technical context.

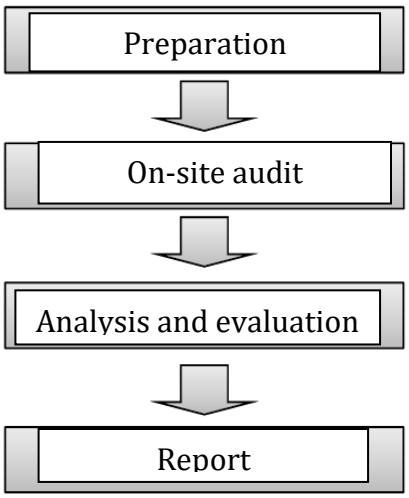


Fig.IV. 1:The process of energy

IV.2) Preparation

The preparation phase relies on the use of **questionnaires and checklists**.

Information to be collected includes:

- Energy supply data based on the average of the past two years (kWh, kW, €/kWh, €).
- Data from existing measuring devices, sub-meters, and measurement reports.
- Existing energy statistics and energy reports.
- Previous audit or assessment reports.
- Plant layout and infrastructure.
- Equipment list.
- Description of the production process.
- Production data.
- Climatic data.

These data are essential for **normalization, calculation of indicators, and benchmarking.**

IV.3) Energy Audit – Objectives and Process

The main objectives of the energy audit are to:

- Assess the **intensity of energy consumption**.
- Analyze the **structure of energy consumption**.
- Review **maintenance systems and office equipment**.
- Define the **scope of the system under study**.

IV.4) Energy Audit: Objectives and Process

The objectives of an energy audit are to:

- Assess the intensity of energy consumption.
- Analyze the structure of energy consumption.
- Review maintenance systems and office equipment.
- Define the scope of the system to be audited.

IV.5) Preparation: Example

Based on the analysis presented in the figure, this example of an energy audit conducted for a warehouse provides a detailed and quantified overview of its electricity consumption distribution. The most significant load is the building's refrigeration system, which alone accounts for 36% of the total consumption, making it the primary target for any optimization efforts. This is followed by the "Other" category (31%), and the ventilation systems (AHUs at 7% and MV fans at 9%), which together form the second largest consumption load. Specific equipment such as the air compressor and the printing shop chiller each account for 6%, while lighting represents 4%. This audit, which also relies on the analysis of historical utility bill data (electricity, gas) and monitoring data, enables the establishment of a precise diagnosis and the prioritization of corrective actions, such as improving the efficiency of the cooling and ventilation systems, to achieve the most substantial consumption reductions and cost savings.

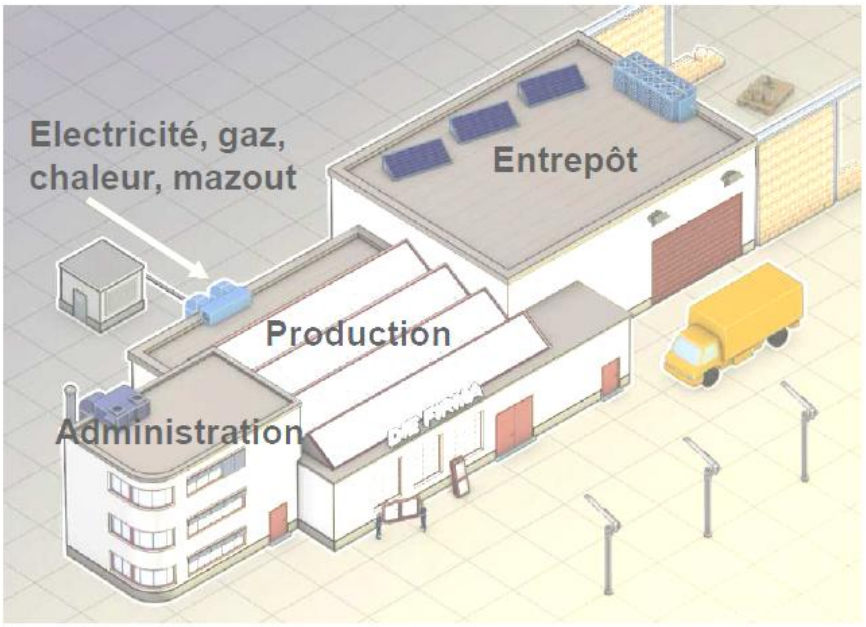


Fig.IV. 2: Efficiency Toolkit for Small and Medium Enterprises [8]

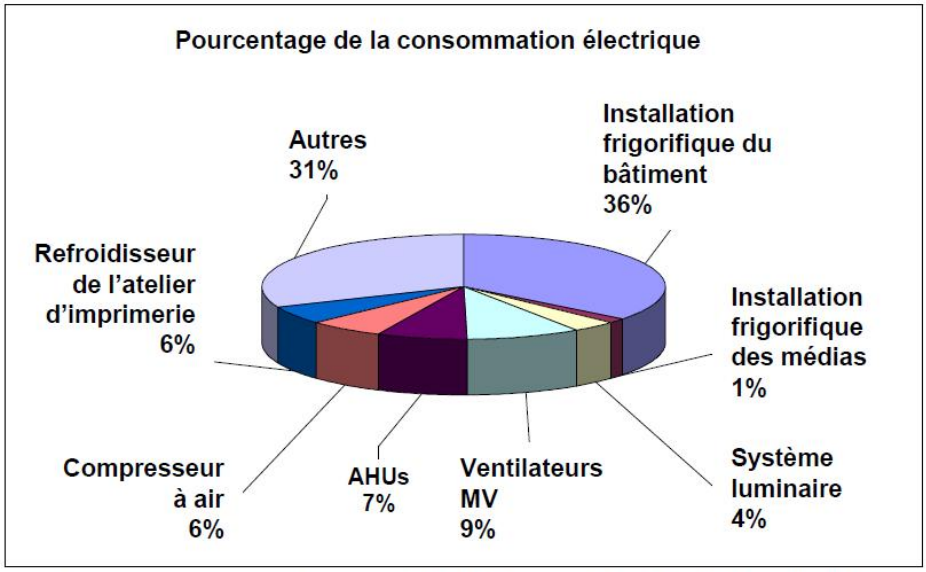


Fig.IV. 3:Percentage of electricity consumption [8]

Électricité		2011	2012
Consommation totale	MWh/a		
Production d'électricité (si applicable)	MWh/a		
Prime de puissance majorée	€/kW		
Coût total	€/a		
Prix mixte	€/MWh		
Gaz naturel			
Consommation totale	MWh Hs /a		
Pouvoir calorifique supérieure	kWh Hs / Nm³		
Prix de consommation	€/kW		
Coût total	€/a		
Prix mixte	€/MWh Hs		

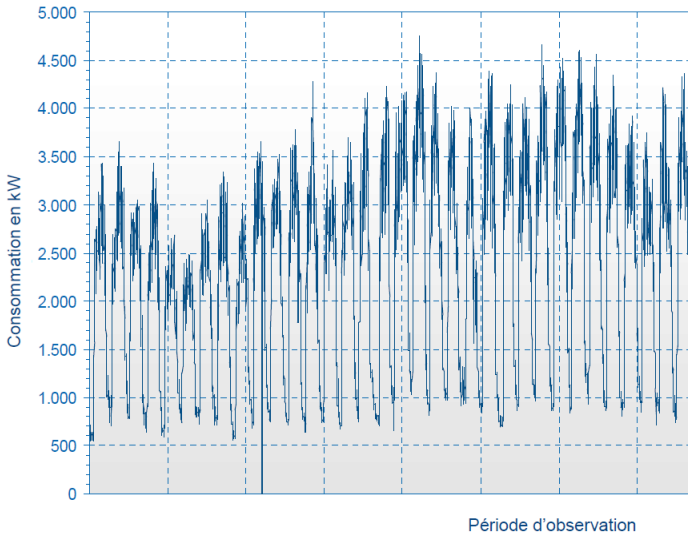


Fig.IV. 4:Data from invoices and Monitoring network data: electricity [8]

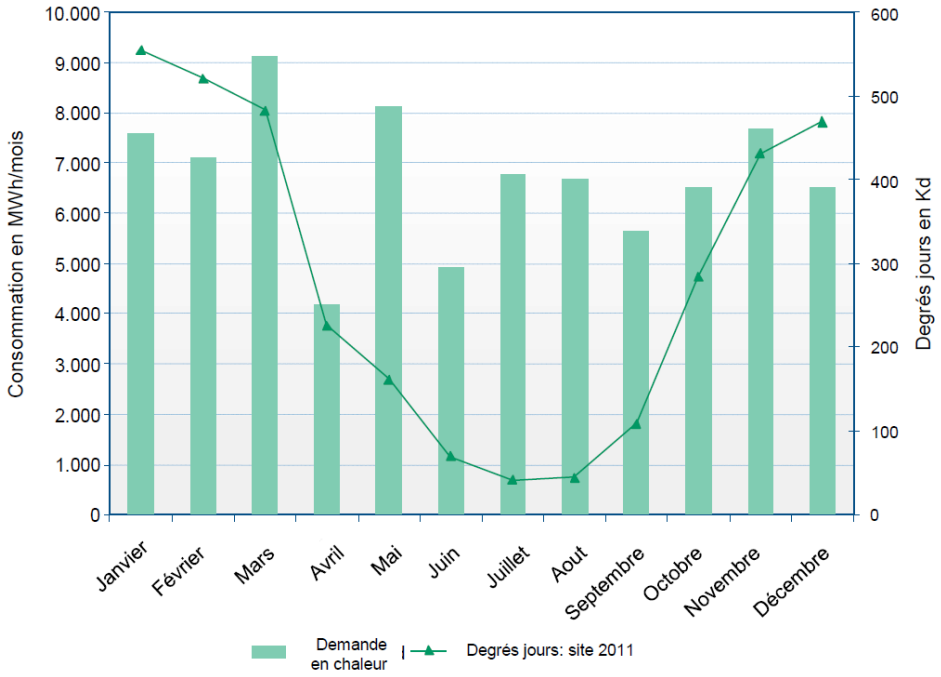


Fig.IV. 5 :Climate-related data [8]

Another example of an energy audit, applied to the industrial penicillin-G fermentation process, demonstrates the importance of a systemic analysis to identify potential savings. The audit is based on a process flow diagram that visualizes not only the sequence of operations (from germinator to extraction), but also the energy (steam, cooling water, air) and material flows, highlighting energy losses and waste. Obvious inefficiencies, such as steam leakage and condensate discharge, are directly highlighted. The analysis identifies modular operations such as the germinator, prefermentor, fermentor, and extraction as the areas with the greatest potential for savings. The prioritization of these areas of intervention is determined by several criteria, including raw material consumption, the energy intensity of each step, its impact on the overall process, and the volume of waste generated. This approach makes it possible to target corrective actions at the most critical points in the production chain for optimal reduction of energy consumption and associated costs.

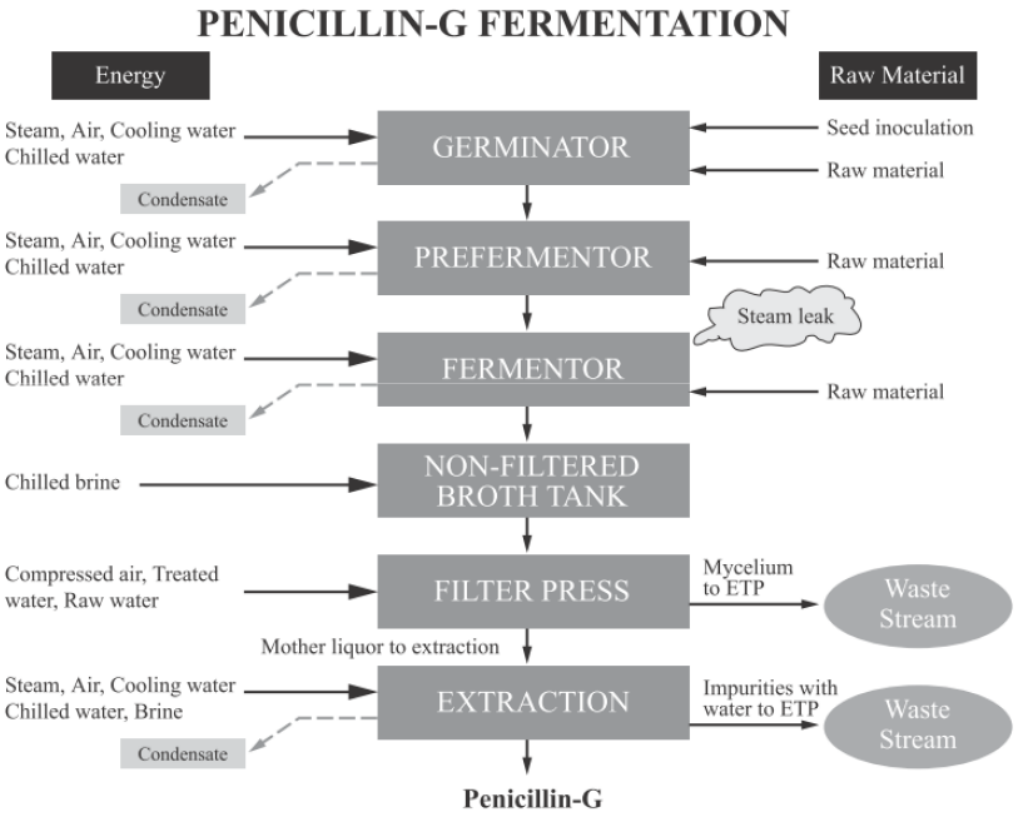


Fig.IV. 6 :Industrial penicillin-G fermentation process [9]

Chapter V: The On-Site Audit

Chapter V: The On-Site Audit

V.1) Objectif et Méthodologie de l'Audit sur Site

The main objective of the on-site audit is to collect additional data in order to identify concrete energy-saving measures. To achieve this, the methodology used is based on a systematic approach including a detailed inspection of the installations (often documented by photographs), interviews with operational and maintenance personnel, and, if necessary, the performance of specific measurements. These one-off or short-term measurements (temperature, electrical power, flow rates, etc.) make it possible to validate preliminary hypotheses and obtain precise data on the actual operation of the equipment. This field phase is essential to move from theoretical analysis to the formulation of practical recommendations adapted to the context of the installation.

V.2) Temporary Measurements

Short-term instrumentation is used to gather missing data and evaluate equipment operation. Examples include:

- Temperature (air, water, surfaces)
- Light levels (lux meter)
- Electrical measurements (clamp meter)
- Thermographic camera for infrared imaging
- Ultrasonic leak detector for compressed air
- Combustion gas analyzer
- Air and liquid flow measurement devices
- Data loggers



Fig.V. 1 :Instrumentation measurements [8]

V.3) Typical examples of temporary measurements

- **Temperature**
  - **Thermographic camera:** Detects radiation in the infrared spectrum of electromagnetic waves to visualize heat losses, poor insulation, or electrical faults.
  - **Thermometer:** Measures surface or fluid temperatures (using contact or infrared methods).
- **Electrical Measurements**
  - **Clamp meter:** Measures electrical current without breaking the circuit.
  - **Power quality analyzer:** Assesses parameters like voltage, current, power factor, and harmonics.
- **Air and Fluid Flow**
  - **Anemometer:** Measures air velocity in ventilation systems.
  - **Ultrasonic flow meter:** Measures the flow rate of liquids in pipes without direct contact.
- **Leak Detection**
  - **Ultrasonic leak detector:** Identifies leaks in compressed air systems by detecting the high-frequency sound they produce.
- **Lighting**
  - **Lux meter:** Measures illuminance levels to assess lighting system efficiency.
- **Data Logging**
  - **Data loggers:** Portable devices that record measurements (e.g., temperature, power) over a defined period to analyze trends and operating profiles.

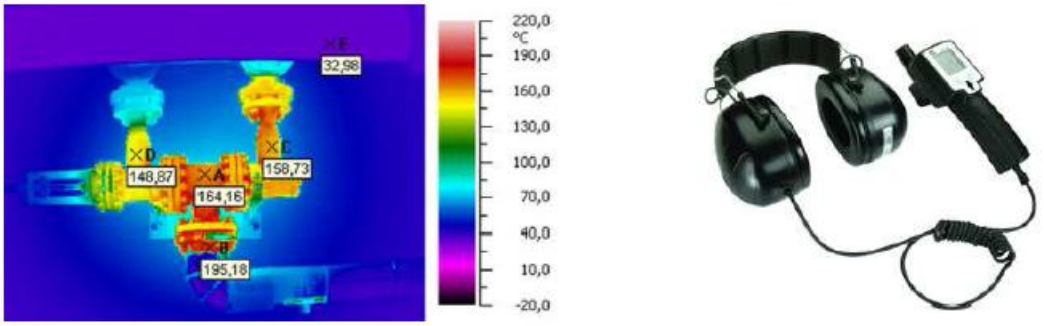


Fig.V. 2:Temporary measurements [8]

Lengths, distances

- **Digital distance measurer:** Electronic distance measurements for rooms, walls, pipes, etc.

Lighting

- **Lux meter:** Portable instrument for measuring indoor light intensity.





Fig.V. 3:Distance measurements and Portable instrument. [8]

Combustion

- **Combustion gas analyzer:** Analyzes flue gas, including its chemical composition, temperature, etc.

Electrical Measurements

- **Voltmeter, wattmeter, power factor meter:** Instruments for assessing the quality of the electricity consumed.

Air Flow Measurement Device

- **Liquid flow measurement device**
- **Data logger**
- **Airtightness test**
- **Smoke generator**



Fig.V. 4:Combustion, Electrical Measurements and Air Flow Measurement Device [8]

Chapter VI: Analysis and Evaluation

Chapter VI: Analysis and Evaluation

VI.1) Objectives

The primary objective of the analysis and evaluation phase is to transform the collected data into a comprehensive and actionable synthesis. Its initial aim is to establish an energy flow diagram, providing a clear visualization of energy consumption and losses across the site. Building on this foundation, the auditor identifies additional savings opportunities. The following crucial step is the quantification of these savings, both in terms of energy (MWh, kWh) and costs (€). This quantification enables a rigorous economic analysis for each proposed measure and project, comparing potential savings against the required investments. The ultimate goal is to produce a prioritized strategic roadmap, empowering the company to make informed decisions that enhance its energy performance and profitability.

VI.2) Qualitative Energy Assessment

To establish a quantitative energy balance from the provided figure, it is essential to reduce the information gap by performing measurements, extrapolations, or estimations. The table illustrates the energy sources (electricity, natural gas, heating oil), their conversion via equipment such as transformers, chillers, air compressors, and the boiler, as well as the energy transfer in the form of compressed air or hot water to end consumers (lighting, offices, ventilation, air conditioning, production line, etc.). In order to quantify the energy flows and assess the system's efficiency, it is necessary to measure consumption at various points, extrapolate from partial data, or estimate missing values, for example for conversion losses or the distribution of energy among the various consumers. This approach makes it possible to fill the gaps in the data and obtain a precise and comprehensive view of the energy performance, thus facilitating the identification of opportunities for savings and optimization.

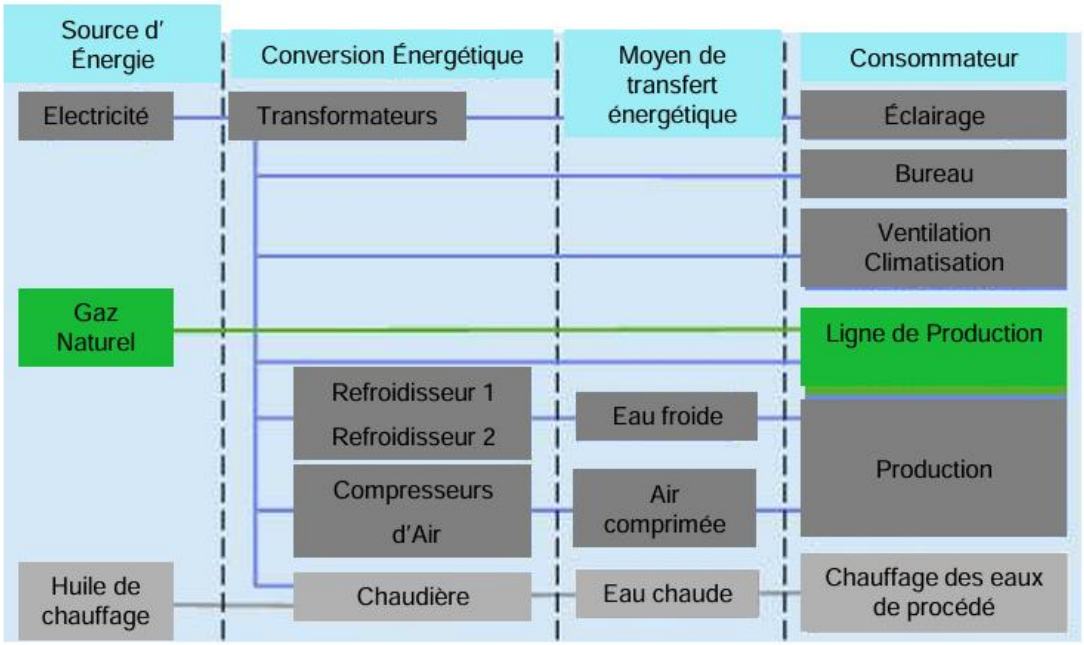


Fig.VI. 1: Qualitative Energy Assessment [8]

VI.3) Sankey Diagram

Based on the figures provided, a Sankey diagram proves to be a valuable tool for visualizing and quantifying energy flows within an industrial system. For instance, for the factory as a whole (Ex1), the diagram could illustrate the main input electrical energy flow (1,322 kW) and visually distribute it among the various consumers: the production line (injection moulding machine, hydraulic circuit), utilities (ventilation, compressed air, air conditioning, pumps), and losses. The width of the arrows would be proportional to the power consumed, highlighting the most energy-intensive areas such as the production line (over 600 kW).

Focusing on a specific system like the compressed air system (Ex2), the second diagram details the fate of the input energy. Only 13% of the electrical power supplied to the compressor is transformed into useful compressed air, while a majority share (94%) is dissipated as heat, a large part of which is potentially recoverable. A Sankey diagram would strikingly visualize this low efficiency and these significant thermal losses, drawing a

narrow flow for the compressed air and wide arrows for the various waste or recoverable heat streams. This visualization greatly facilitates the identification of inefficiencies and opportunities for savings, such as implementing a heat recovery system

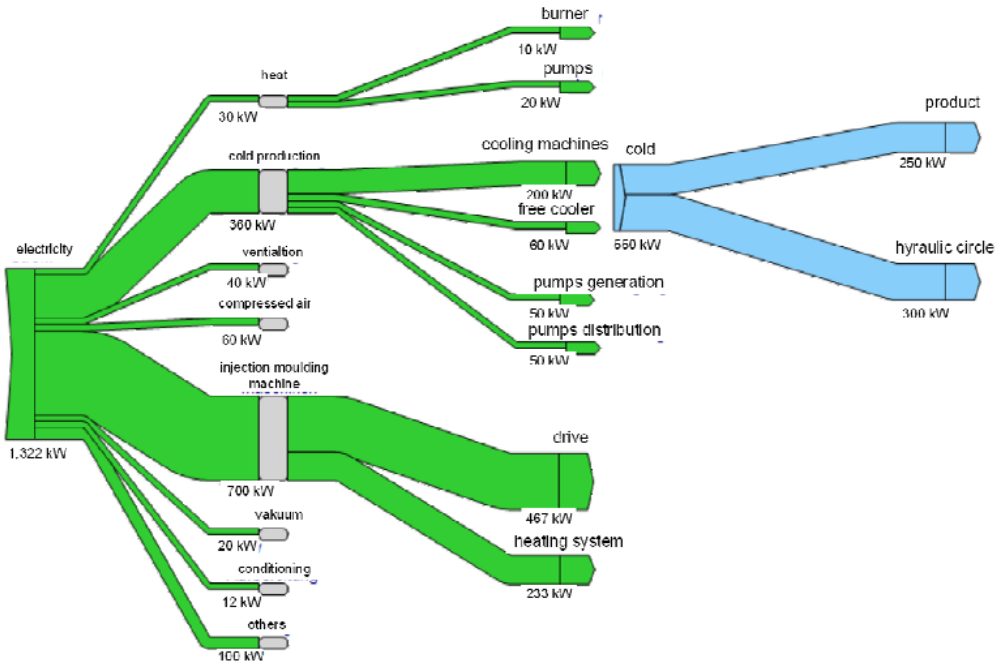


Fig.VI. 2:A Sankey diagram: factory as a whole[8]

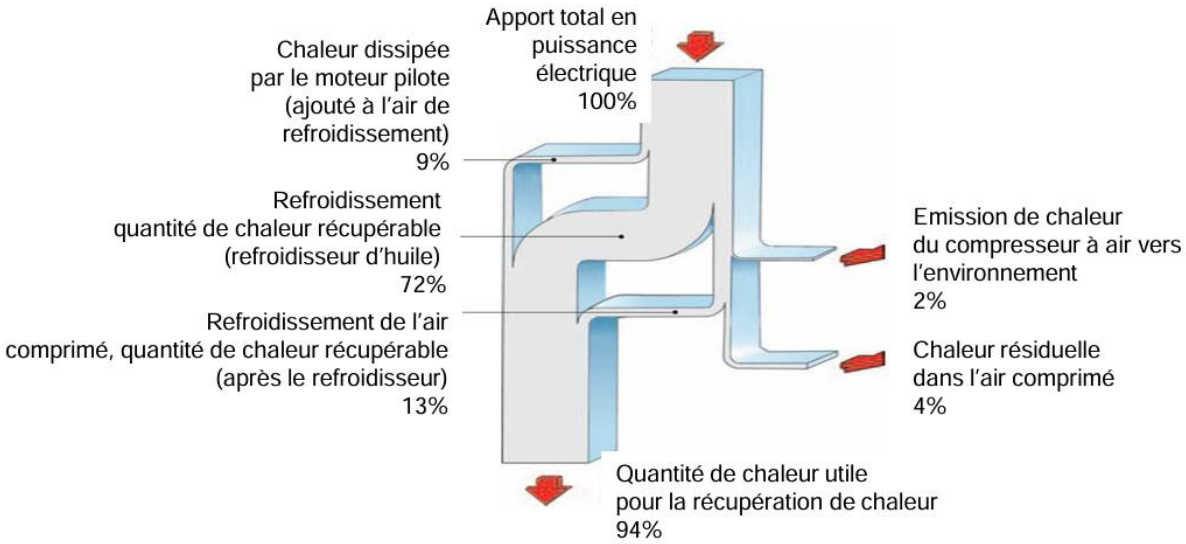


Fig.VI. 3: A Sankey diagram: A single machine (compressed air system) [8]

VI.4) Estimating Energy Consumers

Determining the installed power is a key step. However, information on the energy consumption of individual systems is often missing due to a lack of sub-meters and/or recorded data.

Consumption can be estimated in the following way: by determining a plant's Full Load Hours (FLH).

- **Example:** Driving a ventilation system, 20 kW, with FLH: 24 h/day · 5 days/week · 50 weeks/year.
  - **Consumption:** 20 kW · 6,000 h/year = 120,000 kWh/year.
  - The ventilator's instantaneous power can be measured spot-on for greater accuracy, without the need for long-term recording.

Often, the number of full load hours is difficult to determine, for example:

- With air compressors when only an operating hour counter is installed.
- With pumps with variable power.

Alternatively, estimates can be made by:

1. Determining the power demand under load and in standby mode, or an average power.
2. Determining the number of hours in standby and/or in operation.

- **Example:** Driving an air compressor, power demand: 50 kW (under load), standby power: 17 kW.
  - Operating hours: 2,000 h/year, of which hours in standby mode: 600 h/year.
  - **Consumption:** (50 kW · 1,400 h/year) + (17 kW · 600 h/year) = 80,200 kWh/year.

VI.5) Example of electrical balance sheet

Electrical balance in a meat processing plant obtained without a measurement campaign. Table (VI.1) presents a preliminary electrical energy balance for a meat processing plant, notably constructed without a dedicated measurement campaign. It

breaks down the total annual electricity consumption of 2,245,200 kWh by major end-use categories.

The methodology relies on two key pieces of data for each system:

1. Installed Power (P installée): The nominal power rating of the equipment.
2. Equivalent Full-Load Operating Hours (Temps de Fonctionnement équ. 100%): An estimated number of hours per year the system is considered to be running at full capacity.

The annual consumption for each category is then calculated as: Installed Power (kW) × Operating Hours (h/an) = Annual Consumption (kWh/an).

Key Observations and Discussion:

1. Dominant Energy Consumer: Industrial cooling, fans, and pumps are the most significant energy users, accounting for 55% of the total consumption (1,225,000 kWh/year). This is typical for a meat processing plant, which requires extensive refrigeration for storage and processing, supported by fluid transfer and circulation systems.

2. Major Process Consumers: The second tier of significant consumers includes electric furnaces/resistors (11%) and steam generators (11%). These are likely used in cooking, pasteurization, or cleaning processes, representing the core thermal energy needs of the facility, which are met here by electricity.

3. Baseline Loads: Systems like lighting (4%) and compressed air (4%) represent a smaller but consistent share of the load. Their consumption is determined by their installed power and scheduled operating hours.

4. Critical Analysis of the Methodology:

   - Strength: This approach provides a rapid, cost-effective initial overview of energy flows, identifying major areas of consumption without the need for sub-metering.

   - Limitation: The primary source of potential inaccuracy lies in the estimation of equivalent full-load hours. Systems like pumps, fans, and compressors often

operate at partial load, meaning this method can overestimate their actual consumption. For example, a compressor with a 44 kW rating may not draw that full power continuously throughout its 2,000 hours of operation.

This electrical balance successfully identifies the plant's energy-intensive areas, with industrial cooling being the primary target for any energy efficiency initiative. However, for a more precise and actionable analysis, a detailed measurement campaign using sub-meters on major systems like refrigeration and compressed air is recommended to validate these estimates and uncover partial load inefficiencies.

Table VI. 1.Electrical Balance in a Meat Processing Plant (Obtained without a Measurement Campaign) [8]

Part of the Electrical Balance	Installed Power	Operating Time (equiv. 100%)	Annual Consumption	Share of Total
	kW	h/year	kWh/year	%
Industrial cooling, fans, pumps	350	3,500	1,225,000	55%
Air Conditioning	50	1,500	75,000	3%
Lighting	23	4,000	92,000	4%
Compressed Air	44	2,000	88,000	4%
Hot Water	120	1,000	120,000	5%
Electric Furnaces/Resistors	252	1,000	252,000	11%
Steam Generators	304	800	243,200	11%
Other Process Equipment	150	1,000	150,000	7%
Total	**1,293**		**2,245,200**	**100%**

VI.6) Load curve

The provided figure is a load curve or load profile, which visually represents the variation in a facility's power consumption (in kilowatts, kW) over time (in hours).

The graph illustrates three key concepts:

Base Consumption (Consommation de base): This is the minimum, constant level of power required outside of active operational hours, likely representing essential systems that run continuously.

Consumption during Working Hours (Consommation lors des heures de travail): This shows the significant increase in power demand during periods of active operation, reflecting the energy used by machinery, lighting, and other processes.

Peak Consumption (Pic de consommation): This is the highest point on the curve, representing a short-term, maximum power draw.

The central insight is that the maximum power demand (la demande de puissance max) directly influences energy costs! Utility companies often charge higher rates based on the highest peak consumption recorded during a billing period, as it determines the required capacity of the infrastructure needed to supply the facility.

The load curve is crucial because it determines where this peak consumption occurs. By analyzing this profile, a company can identify the causes of these peaks and implement strategies to reduce them (a process called "peak shaving"), leading to significant cost savings.

Finally, the note specifies that upon request, energy suppliers provide these load curves to their customers, enabling them to conduct this type of analysis.

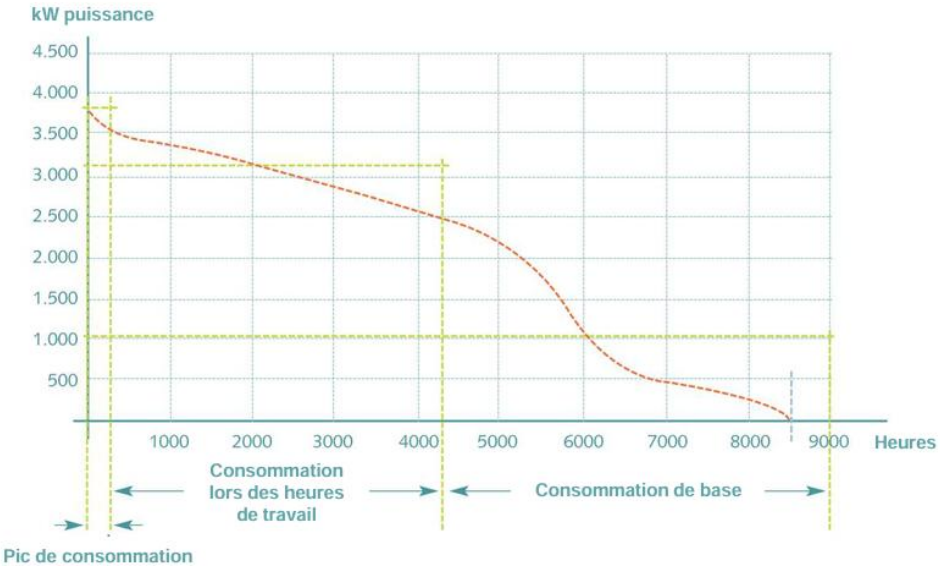


Fig.VI 4.Load curve [8]

VI.7) Key Features and Data

Table (VI.3) represent the Key Performance Indicators, which introduces a fundamental tool for energy management: a set of specific metrics used to quantify and evaluate energy performance.

These KPIs transform raw operational data into meaningful insights, allowing for:

- **Objective Performance Tracking:** Moving beyond absolute consumption figures to measure efficiency.
- **Benchmarking:** Comparing performance against past data, other facilities, or industry standards.
- **Informed Decision-Making:** Identifying inefficiencies and prioritizing improvement actions.

The table categorizes these indicators, providing their formulas and units, which can be broken down as follows:

a) Absolute Consumption vs. Relative Efficiency:

- **Total Energy Consumption (Consommation totale d'énergie):** This is a basic, absolute metric (kWh per unit of time). It tracks overall usage but lacks context, making it difficult to assess efficiency on its own.
- **Specific Energy Consumption (Consommation spécifique d'énergie):** This is a crucial normalized indicator. By dividing energy use by a relevant output (e.g., pieces, kg, m^2), it directly measures the **energy efficiency of production**. A decrease in this value indicates improved efficiency, even if total production (and total consumption) increases.

b)Process-Level Analysis:

- **Energy Intensity (Intensité énergétique):** This indicator identifies the "energy footprint" of a specific process within the total consumption. It answers the question: "What percentage of our total energy bill is consumed by this particular system (e.g., compressed air, cooling)?" This is vital for targeting the most energy-intensive processes for optimization.

c) System-Specific Efficiency:

- **Heat Recovery Efficiency (Efficacité de récupération de la chaleur):** This measures the effectiveness of a heat recovery system (e.g., in ventilation). It quantifies how much of the available waste heat is successfully captured and reused, directly evaluating the return on investment for such systems.
- **Compressed Air Generation Efficiency (Efficacité de génération d'air comprimé):** Compressed air is often a very inefficient utility. This KPI (m^3/kWh) measures how much compressed air is produced per unit of electrical energy consumed. Monitoring this helps detect issues like leaks, pressure drops, or inefficient compressor operation.

This set of KPIs provides a comprehensive framework for moving from simple energy monitoring to active energy management. By implementing these indicators, a company can shift its focus from "How much energy did we use?" to "How efficiently did we use our energy to create value?", which is the cornerstone of strategic energy and cost reduction.

Table VI. 2:Key Performance Indicators [8]

Characteristic	Formula	Unit
Total Energy Consumption	Absolute	kWh/unit of time
Specific Energy Consumption	Energy Consumption in kWh _____ Quantity Produced in pieces/m²/kg	kWh / unit of production
Energy Intensity	Energy Consumption of a Process in kWh _____ Total Energy Consumption in kWh	%
Heat Recovery Efficiency (Ventilation System)	Recovered Heat in kWh _____ Available Heat in kWh	%
Compressed Air Generation Efficiency	Quantity of Compressed Air Generated in m³ _____ Compressor Electricity Consumption in kWh	m³/kWh

A comprehensive energy analysis employs a multi-faceted methodology to diagnose performance, identify inefficiencies, and drive continuous improvement. This evaluation is structured around four key dimensions: analytical, empirical, control, and comparative studies.

VI.8) Analytical Method

The analytical method involves a detailed, bottom-up examination of a process. The system is broken down into its constituent elements, and for each one, a precise mass and energy balance is established. This approach is exemplified in Fig. VI.5, which details a Yarn

Dyeing process with a batch size of 200 kg. The table meticulously tracks each step (e.g., Scouring, Hot Wash, Cold Wash), its duration, and the inputs of chemicals, water, and steam. By quantifying all mass inflows and outflows, as well as energy carriers like steam, this method provides a fundamental understanding of where and how energy is consumed, forming a rigorous baseline for identifying losses and optimization potential at the process level.

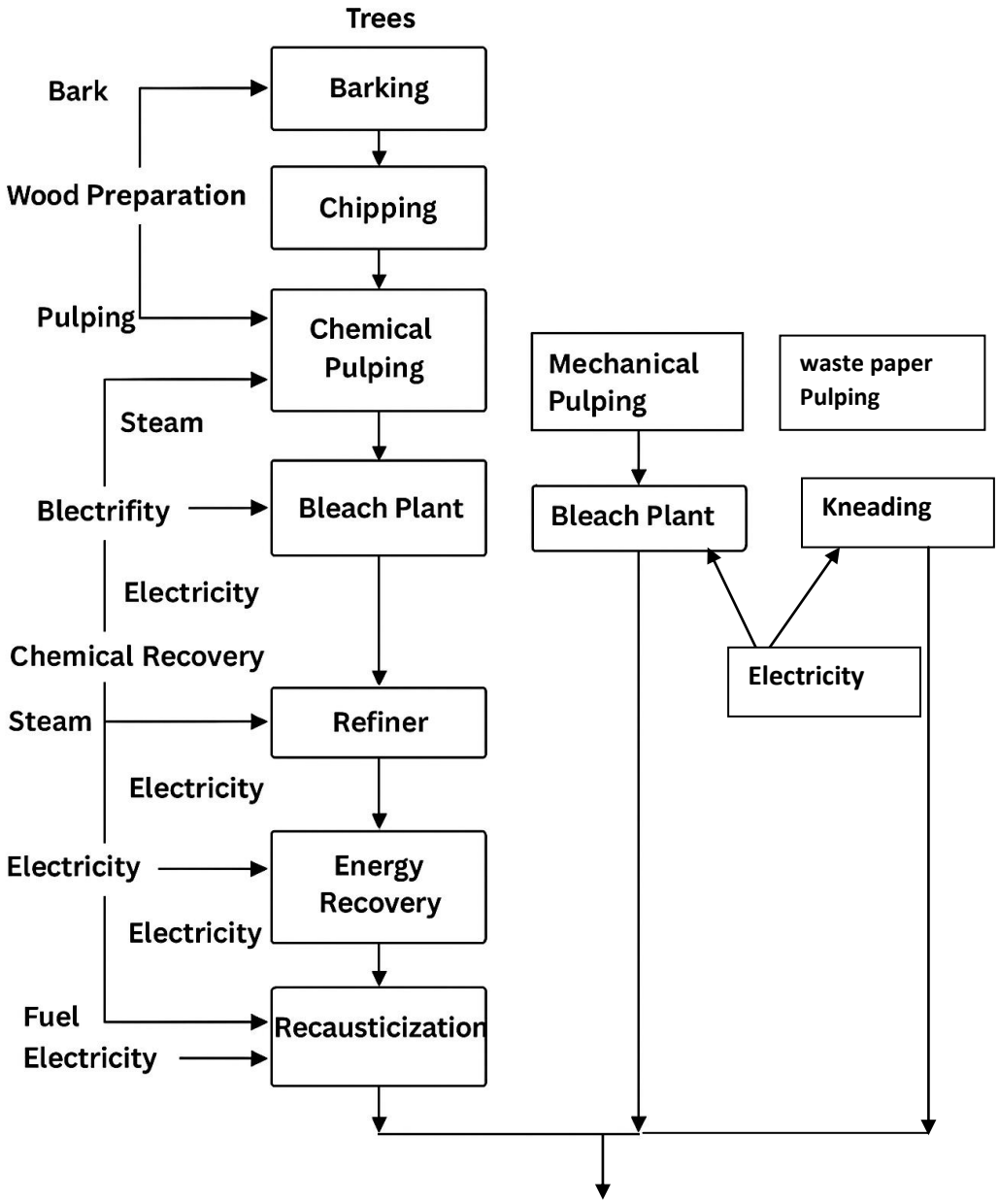


Fig.VI 5. Yarn Dyeing process **[8]**

Table VI. 3:1 Yarn Dyeing Material and Energy Balance (Batch size – 200 kg) **[8]**

Step	Process (Cycle time, minutes)	Operation	Time In Min	Measured Cold Water (litre)	Measured Hot Water (litre)	T (°C)	Actual Steam (kg)	Theoretical Steam (kg)	Measured Wastewater (litre)
1	Scouring (120')	Filling water Chemical addition Raise to 100°C Circulation Drain	10 30 15 60 5	-	2000	100	295	260	1865
2	Hot Wash (45')	Filling water Raise to 85°C Circulation Drain	10 15 15 5	-	2000	85	288	200	1902
3	Cold Wash (30')	Filling water Circulation Drain	10 15 5	2000	-	-	-	-	1987
4	Neutralising (30')	Filling water Circulation Drain	10 15 5	2000	-	-	-	-	1991
5	Cold Wash (30')	Filling water Circulation Drain	10 15 5	2000	-	-	-	-	1990

VI.9) Empirical Method

Where detailed process data is unavailable, the empirical method offers a powerful alternative. This top-down approach uses statistical analysis to identify correlations between total energy consumption and other influential variables, known as energy drivers. These drivers can include production data (e.g., tonnes per day), weather conditions, or operational factors like the number of shifts. As shown in the scatter plot of Fig. VI.6, a clear linear correlation between daily production and energy consumption can be established. This relationship can be expressed by a formula such as $E=E_0+c\cdot\alpha$, where E_0 represents the fixed base load and $c\cdot\alpha$ represents the variable consumption linked to production. This model is crucial for forecasting and anomaly detection.

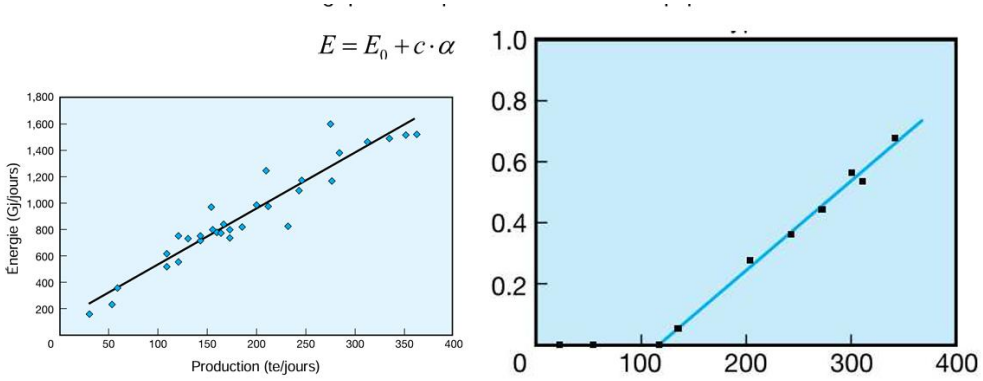


Fig.VI 6. Linear correlation between daily production and energy consumption **[8]**

VI.10) Control

Building on the empirical model, control techniques are used to monitor ongoing performance. The predictive equation derived from the empirical analysis is used to forecast expected energy consumption. Deviations from this forecast are tracked using control charts**.** Fig. VI.7 illustrates a CUSUM (Cumulative Sum) chart, which plots the cumulative difference between actual and predicted consumption over time. This tool is highly effective for visually identifying persistent shifts in performance—whether positive (indicating savings) or negative (indicating emerging problems or inefficiencies)—that might be obscured in simple monthly data.

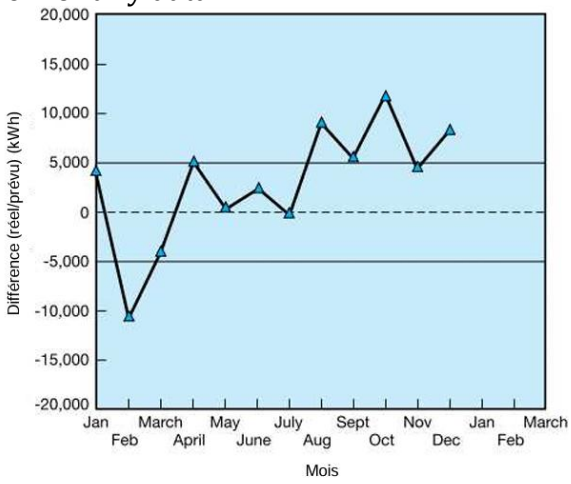


Fig.VI 7. Cumulative Sum **[8]**

VI.11) Comparative Studies (Benchmarking)

Benchmarking is the process of comparing an organization's energy performance against references to gauge its relative standing and identify improvement opportunities.

As underscored by standards like ISO 50001, which requires the establishment of an Energy Baseline (EnB), benchmarking is a cornerstone of systematic energy management. Two primary types of benchmarks are commonly used:

- **Specific Energy Consumption (SEC):** A ratio of energy consumption to a unit of output (e.g., kWh/tonne, kWh/product).
- **Energy Efficiency Index (EEI):** The ratio of actual consumption to the consumption achievable by applying best practices.

Furthermore, benchmarking can be categorized as **internal** (comparing performance over time or between similar units within the organization) or **external** (comparing with industry standards or best-in-class performers). It can also be **quantitative** (comparing numerical data) or **qualitative** (comparing management practices and activities). This multi-faceted approach, as summarized in Fig. VI.8, enables organizations to set realistic targets, measure progress, and foster a culture of continuous energy efficiency improvement.

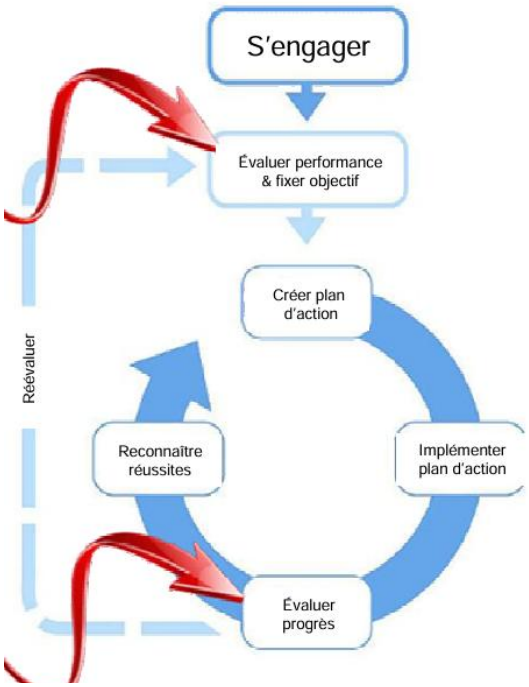


Fig.VI 8. Types of benchmarks **[8]**

Chapter VII: Reporting and Recommended Measures

Chapter VII: Reporting and Recommended Measures

The final report must present clear and actionable recommendations, structured around several key areas for energy optimization. These measures aim to reduce consumption, improve efficiency, and control costs.

VII.1) Optimization of Equipment Use

This involves adapting equipment operation to actual needs. This includes turning off unused machinery, adjusting temperature and pressure levels (heating, cooling, compressed air), and modifying operational parameters. For example, in the textile industry, successive trials enabled the reduction of dye bath temperatures from 70 °C to 55 °C in some cases, without compromising quality. Controlling air flow rates and lighting, as well as optimizing process sequences, are also part of the actionable levers.

VII.2) Optimization of Energy Distribution

This section focuses on reducing losses between production and end-use. Priority actions include: detecting and eliminating leaks (especially compressed air), insulating hot and cold water distribution networks, correcting power factor, and optimizing pump hydraulics. The choice between a centralized and a decentralized solution can also have a significant impact on losses.



Fig.VII .1: Optimization of Equipment Use **[8]**

VII.3) Introduction of New Efficient Equipment

Using higher-performing technologies allows for significant gains. This includes heat recovery (from exhaust air or process waste streams), proper sizing of electric motors, the use of variable speed drives, and replacing standard motors with high-efficiency models. Tools such as energy balances and Pinch analysis help identify recovery potentials.

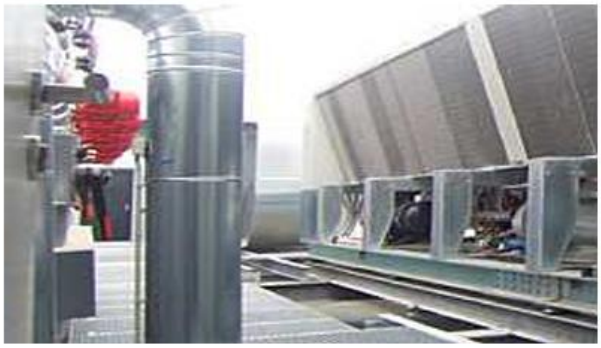


Fig.VII 2 : New Efficient Equipment **[8]**

VII.4) Improvement of Energy Production and Transformation

For steam boilers, it is necessary to minimize losses (e.g., economizer) and reduce standby consumption. In cooling stations, the use of free cooling, optimization of control systems, and using chillers in heat pump mode are recommended. Compressed air systems, renewables, and cogeneration complete the range of feasible solutions.

VII.5) Energy Procurement Policy

A detailed analysis of supply contracts and utility bills allows for adjusting subscribed power capacity, negotiating better terms, and comparing offers. Active management of consumption peaks – through load curve analysis and organizational or technical actions – helps reduce costs.



Fig.VII 3.Energy Procurement Policy [8]

VII.6) Industrial Maintenance

A rigorous maintenance program is essential for maintaining energy performance: regular inspections, replacement of seals and fluids, cleaning of heat exchangers and ducts. These actions prevent performance degradation and ensure optimal operation.

VII.7) Consideration of Total Costs

Finally, it is crucial to integrate maintenance costs into investment decisions. Equipment with a higher purchase price but reduced maintenance fees and a longer lifespan may prove more economical in the long term.

This structured approach allows for prioritizing actions and ensuring continuous improvement of the plant's energy performance.

Chapter VIII: Technical and Economic Feasibility

Chapter VIII: Technical and Economic Feasibility

The evaluation of proposed energy efficiency measures requires a systematic assessment across two critical dimensions: technical feasibility and economic viability.

VIII .1) Technical Feasibility

This assessment addresses fundamental implementation constraints. Key considerations include: technology availability and maturity, space requirements, access to skilled labor, system reliability, service support, and safety implications. Furthermore, the potential impact of the measure on product quality, production rates, and process stability must be evaluated. Finally, ongoing maintenance requirements and the availability of spare parts are crucial determinants of long-term success.

VIII .2) Economic Feasibility

Often the decisive factor for management approval, economic feasibility analysis can be conducted using various methods. For minor investments or short-duration measures with attractive economics, the simple **Payback Period** method is often sufficient. The provided worksheet outlines the core financial elements for this calculation:

- **Investment:** Includes costs for equipment, civil works, and instrumentation.
- **Annual Operating Costs:** Encompasses maintenance, labor, energy for auxiliaries, water treatment, and capital costs (e.g., depreciation).
- **Annual Savings:** Primarily derived from reduced consumption of thermal and electrical energy, and sometimes raw materials.

The Net Annual Savings is calculated as:

Net Savings/Year = (Annual Savings - Annual Operating Costs)

The Payback Period (in months) is then determined by:

Payback Period (months) = (Investment / Net Savings) / 12

Economic Feasibility Worksheet

Table VIII. 1:Economic Feasibility Worksheet [8]		
1. Investment	2. Annual Operating Costs	3. Annual Savings
Equipment	Cost of Capital	Thermal Energy
Civil Works	Maintenance	Electrical Energy
Instrumentation	Labor	Raw Materials
Auxiliary	Energy	Water Treatment Costs
	Depreciation	

VIII .3) Project Prioritization Guidelines

To systematically rank projects, the following matrix combines economic and technical feasibility with risk assessment:

Table VIII. 2:Economic and technical feasibility [8].			
Priority	Economic Feasibility	Technical Feasibility	Risk / Feasibility
A: High	Well-defined and attractive	Adequate existing technology	No risk / Perfectly feasible
B: Medium	Well-defined but only marginally acceptable	Existing technology may need updating; unconfirmed	Minimal operational risk / Could be feasible
C: Wait	Poorly defined and marginally unacceptable	Existing technology is inadequate	Doubtful
D: None	Clearly unacceptable	Requires a major breakthrough	Not feasible

This structured approach allows organizations to prioritize resource allocation effectively, focusing first on "Priority A" projects that are technically sound, economically attractive, and low-risk, thereby ensuring the highest probability of successful implementation and return on investment.

VIII.4) Example of presentation of audit results

The table (VIII.2) presents a comprehensive set of recommendations from an energy audit focused on optimizing the compressed air system. This analysis breaks down the proposed measures, highlighting the strategic approach to improving efficiency, reducing costs, and prioritizing investments.

Table VIII. 3:Example of presentation of audit results **[8].**

N	Recommended Actions for the "Compressed Air" System	Cost	Identified Savings		Simple Payback Period
		€	MWh/year	€ excl. tax/year	years
1	Compressed Air: Leak Reduction	Internal	150	12,750	Immediate
2	Compressed Air: Pressure Reduction	Internal	85	7,225	Immediate
3	Compressed Air: Solenoid Valves on Machines	3,000	125	10,625	0.3
4	Compressed Air: Pressure Regulators	8,000	170	14,450	0.6
5	Compressed Air: Small Compressor for Nights & Weekends	25,000	150	12,750	2.0
6	Compressed Air: Compressor Management Automation	65,000	150	12,750	5.1
7	Compressed Air: New Variable Speed Drive Compressor	180,000	200	17,000	10.6
8	Compressed Air: New VSD Compressor vs. New Fixed-Speed Compressor	30,000	120	10,200	2.9
	Total with New VSD Compressor	**281,000**	**790**	**67,150**	**4.2**

Note"€ excl. tax/year" est l'abréviation de **"Euros excluding tax per year"**.

En français, cela signifie : **"Euros hors taxes par an"** (€ HT/an).

Cela indique que le montant financier des économies (dans ce cas, 12 750 €) est exprimé **avant** l'application de toute taxe, comme la TVA (Taxe sur la Valeur Ajoutée).

a) Detailed Breakdown of Recommended Actions

The measures are listed in a logical sequence, often starting with low-cost, high-impact interventions before moving to major capital investments.

b) Leak Reduction (Internal Cost):

- **Explanation:** This is the most fundamental step. Compressed air leaks are a primary source of energy waste. This action involves an audit to identify and repair leaks in the piping network.
- **Analysis:** With no direct investment cost (handled by internal labor) and immediate payback, this is the highest priority action, offering substantial savings (€12,750/year) for minimal expense.

c) Pressure Reduction (Internal Cost):

- **Explanation:** Lowering the system pressure to the minimum required by the applications can significantly reduce the energy consumed by the compressors, as energy use is directly proportional to pressure.
- **Analysis:** Like leak reduction, this is a no-cost measure with an immediate return. It demonstrates that operational changes can yield significant financial benefits (€7,225/year).

d) Solenoid Valves on Machines (€3,000):

- **Explanation:** Installing solenoid valves ensures that compressed air is supplied to machines only when they are in operation, eliminating constant consumption during idle or standby modes.
- **Analysis:** This low-cost investment has a very short payback period (0.3 years or ~4 months) and provides excellent savings, making it a highly attractive quick win.

e) Pressure Reducing Valves (€8,000):

- **Explanation:** Not to be confused with overall system pressure reduction, this involves installing local pressure regulators for applications that do not require the full system pressure, thereby reducing air consumption and wear.
- **Analysis:** Another measure with a short payback (0.6 years), it further optimizes air usage at the point of consumption after the system-wide parameters have been addressed.

f) Small Compressor for Nights & Weekends (€25,000):

- **Explanation:** During low-demand periods, running a large primary compressor is inefficient. Investing in a small, dedicated compressor to handle the base load during these times can lead to substantial energy savings.
- **Analysis:** This represents a medium-level investment with a still-attractive 2-year payback, targeting a specific operational inefficiency.

g) Compressor Management Automation (€65,000):

- **Explanation:** This system uses a programmable logic controller (PLC) to optimally sequence and control multiple compressors, ensuring the most efficient combination is running to meet demand and avoid wasteful operation.
- **Analysis:** A more significant investment with a 5.1-year payback, this is a strategic upgrade for systems with multiple compressors, improving the overall base efficiency of the compressed air production.

h) New Variable Speed Drive (VSD) Compressor (€180,000):

- **Explanation:** A VSD compressor adjusts its motor speed to match the air demand precisely, unlike fixed-speed compressors that load and unload. This eliminates cycling losses and is highly efficient under partial load conditions.
- **Analysis:** This is a major capital investment with a long payback period (10.6 years). It is typically considered when existing compressors are due for replacement or when the system has highly variable demand.

i) VSD vs. Fixed-Speed Compressor (Incremental Cost €30,000):

- **Explanation:** This line item compares the choice between a new VSD compressor and a new fixed-speed compressor. The €30,000 represents the additional investment required for the VSD technology.
- **Analysis:** The analysis shows that the incremental cost for the VSD option has a favorable payback of 2.9 years, making a strong economic case for choosing a VSD when a new compressor is needed.

k) Strategic Implications and Overall Project Portfolio

The "Total" row presents a compelling package. By bundling all measures, including the new VSD compressor, the total investment of €281,000 leads to annual savings of €67,150. The aggregated payback period for the entire package is a respectable **4.2 years**.

This table effectively demonstrates a classic energy efficiency strategy:

- **Phase 1 (Immediate):** Implement no- and low-cost measures (Actions 1-4) to achieve rapid savings and improve the system's baseline performance.
- **Phase 2 (Medium-term):** Invest in operational optimizations (Actions 5-6) that further reduce waste.
- **Phase 3 (Long-term Capital Planning):** Plan for major equipment replacements (Actions 7-8) that offer the next step in efficiency, justifying the investment based on the cumulative savings and the need for reliable equipment.

This structured presentation allows management to easily compare options, understand the financial implications, and make informed decisions on which energy-saving measures to implement based on available capital and strategic payback targets.

VIII.4) Reporting – Cost-Effectiveness of Measures

Based on the provided data, the cost-effectiveness analysis of the proposed energy efficiency measures can be effectively visualized and reported using a matrix that plots investment against annual savings. This approach, often called a "Cost-Saving Matrix," allows for the clear prioritization of measures.

The analysis reveals distinct clusters of measures:

- Quick Wins (High Savings, Low Investment): Measures such as W1 (Increase turbine operating time), W4 (O_2 regulation optimization), D1 (Leak reduction), and E3 (Replacing mercury bulbs) offer substantial annual savings with minimal investment, resulting in immediate or very short payback periods. These should be implemented as a first priority.
- Medium-Term Projects: Several measures, including W5 (Isolation of fixations), W6 (Steam line insulation), and E2 (Pump optimization), require a moderate investment

but deliver significant savings, placing them in a favorable position for the second phase of implementation.

- Strategic Investments (High Investment, High Savings): Larger projects like K2 (Superheater installation) and K1 (Combining cold water systems) represent significant capital expenditure but also deliver the highest absolute energy savings. These are long-term strategic investments that require careful financial planning.

This structured reporting method enables management to quickly identify the most economically attractive opportunities. The recommended implementation strategy is to begin with the "Quick Wins" to secure early savings, which can then help fund the larger, strategic investments for a comprehensive and cost-effective energy optimization program.

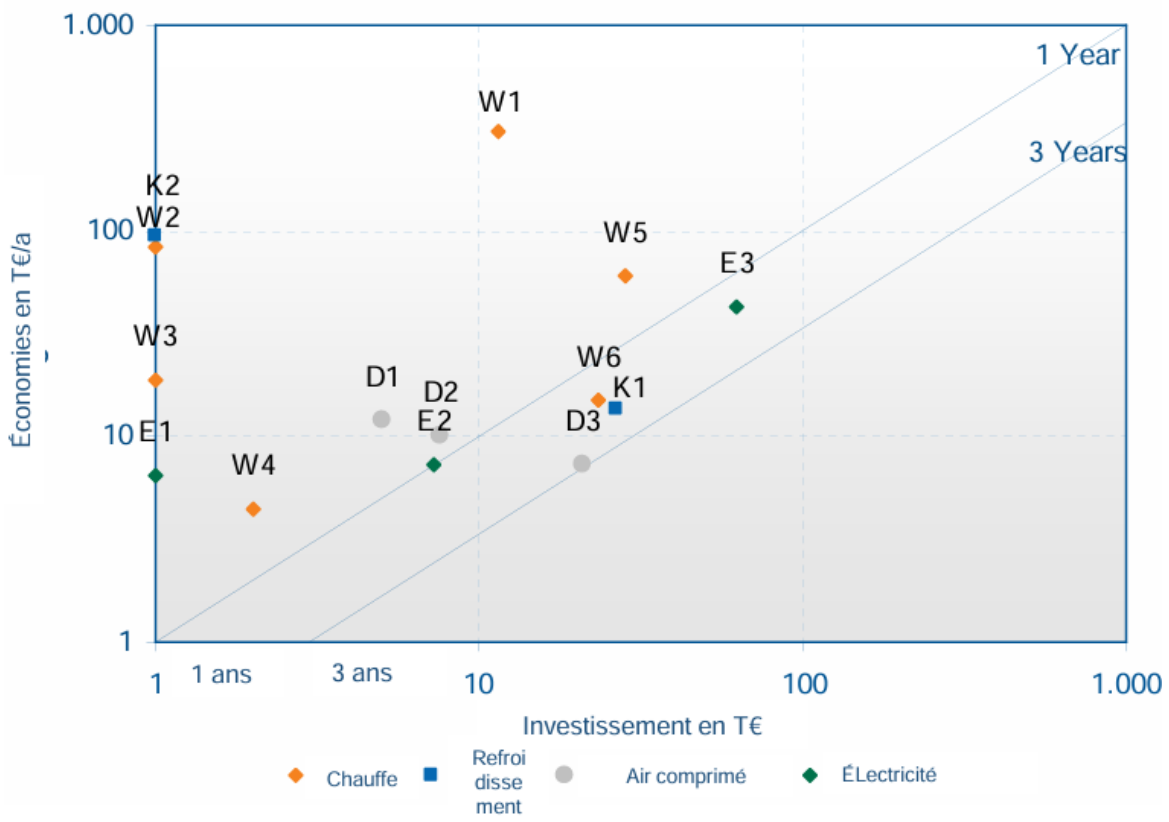


Fig.VIII 1 : Cost-Saving Matrix [8].

Chapter IX: Energy Efficiency - Economic and Financial Considerations

Chapter IX: Energy Efficiency - Economic and Financial Considerations

Economic evaluation is a crucial step for the successful implementation of any energy efficiency project. This chapter presents the main financial tools and models used to prioritize investments and ensure their profitability.

IX .1. Return on Investment (ROI) Analysis

The objective of Return on Investment (ROI) is to quantify the periodic rate of return on capital invested in an economic entity to assess its profitability. This indicator is also essential for comparing different projects within an investment portfolio, with the project showing the highest ROI generally being prioritized. Companies typically require a minimum ROI between 10% and 25% to validate a project.

As illustrated in Table (IX.1), it is possible to classify actions based on their cost and return. For example, repairing pipe leaks, with a low cost and a 30% ROI, is a "quick win" to prioritize.

Table IX. 1:Project profitability (ROI) analysis table **[8].**

Project	Cost (€)	Annual Energy Savings (€)	ROI
Pipe Leaks	100	30	30%
Variable Frequency Drive Mechanism	1000	200	20%
Warehouse HVAC Lighting	1000	100	10%

IX .2. Investment Levels and Action Typology

Energy efficiency projects can be categorized according to their initial investment level, which helps in planning their financing (Table IX. 2):

- **Simple Maintenance:** Actions with no direct financial investment (e.g., turning off lights, organizational changes).
- **Low-Cost Investment:** Measures with a very short payback period (e.g., LED bulbs, variable frequency drives).

- **Medium Cost:** Replacement of major equipment (e.g., boilers, HVAC systems, cogeneration).
- **High/Very High Cost:** Heavy investments in production lines or new facilities.

Table IX. 2:Action classification by investment level. **[8].**

Investment Level	Action/Investment
Simple Maintenance	- Turn off lights and other equipment when not used - Organizational change, e.g., switch to night tariff, if available
Low-Cost Investment	- Replace lights with fluorescent bulbs (CFLs) - Variable frequency drive mechanism
Medium Cost	- Replacement of heating, ventilation, and air conditioning - New refrigerators, new boilers - Replacement of the backup generator - Cogeneration
High Cost	- Replacement of complete production lines - New energy production units, in the case of an isolated site, on-site renewable energy production - On-site energy transmission
Higher Cost	- Process equipment updates and selective equipment replacement
Highest Cost	- New factory, new facilities

IX .3. Outsourcing and Energy Performance Contract (EPC) Models

To overcome the lack of internal capital or expertise, outsourcing to a specialized contractor is a common option. There are two main models (**Fig. XI.3**):

- **Classic Outsourcing (≈85% of the market):** The contractor finances, builds, and operates a plant. The client pays for the delivered energy, plus base fees.

- **Energy Performance Contract - EPC (≈15% of the market):** The contractor (often an ESCO) guarantees energy savings and is remunerated with a share of the achieved savings.

a)Motivations for Outsourcing:

- Insufficient internal budget or financing capacity.
- Lack of technical expertise.
- Pursuit of a more reliable energy supply.
- Transfer of performance risks (in the case of an EPC).

b)Disadvantages to Consider:

- Sharing of savings with the contractor over the contract duration.
- Partial loss of technical control over the system.
- Potentially obsolete assets at the end of the contract (10-12 years).

IX .4. The Role of Energy Service Companies (ESCOs/ESPCs)

a) Energy Service Companies (ESCOs) often offer turnkey projects, including financing and performance guarantees. Their remuneration is directly linked to the generated energy savings.

b) Energy Service Providing Companies (ESPCs) offer a range of services (equipment supply, maintenance, heat supply) usually for fixed fees. Although they may have incentives to reduce consumption, gain sharing is less central to their model than for ESCOs.

In conclusion, a robust financial analysis, coupled with an understanding of the different financing and implementation models, is essential for successfully selecting and deploying the most cost-effective energy efficiency projects for the company.

Fig. 3: Diagram of costs and savings within an Energy Performance Contract framework. (Description based on provided text: The diagram likely shows annual energy costs over time, comparing scenarios with and without contracting, highlighting the point of investment by the contractor, contract duration (5-12 years), and eventual transfer back to the client, emphasizing the shared savings model.)

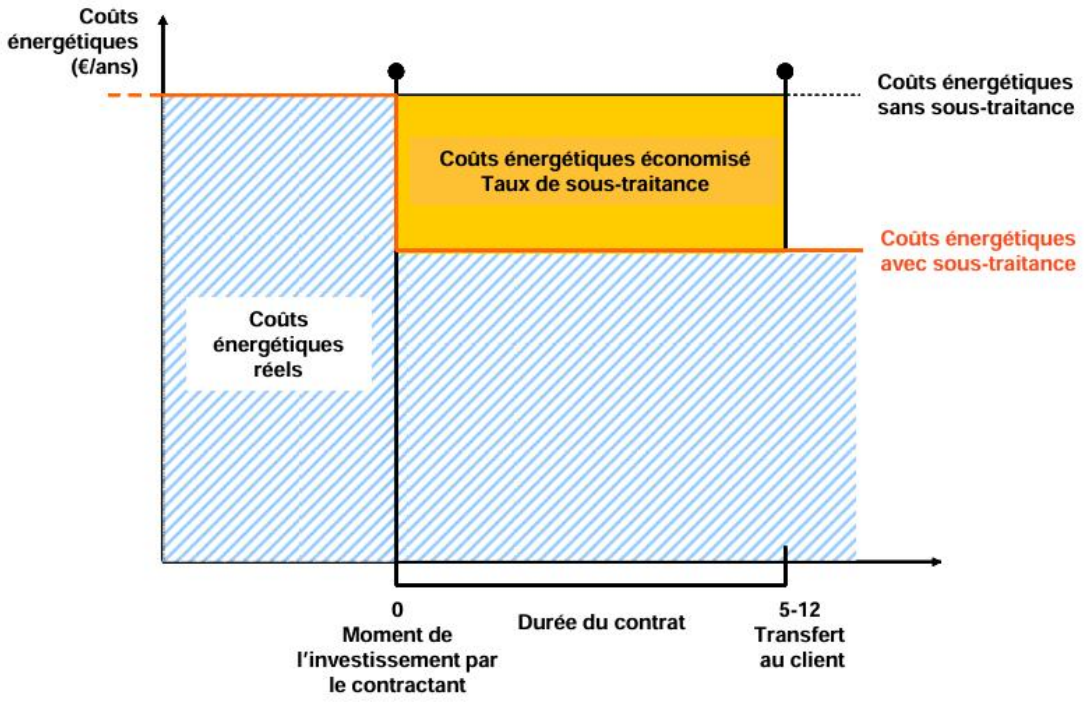


Fig.IX. 1. Diagram of costs and savings within an Energy Performance Contract framework [8].

Multiple-choice questionnaires (MCQs)

Our dedicated multiple-choice questionnaires (MCQs) on energy auditing are essential to improve your understanding and preparation for your property diagnostic certification. They cover various aspects of energy audits, including regulations, assessment techniques, and the interpretation of results.

Each question offers several options, of which one or more may be correct. Check the correct answer(s).

1) What is mechanical energy?
- The sum of kinetic and potential energy.
- A form of energy related to heat.
- Energy produced only by water streams.
- Energy related to the motion and position of objects.

2) Potential energy depends on:
- The speed of an object.
- The position of an object.
- The heat stored in an object.
- The ability of an object to be transformed into kinetic energy.

3) Which energy represents the agitation of molecules and atoms?
- Kinetic energy.
- Thermal energy.
- Chemical energy.
- Nuclear energy.

4) Chemical energy is released during:
- Combustion.
- A nuclear reaction.
- Exothermic reactions.
- Conversion into kinetic energy.

5) Which form of energy is carried by radiation?
- Thermal energy.
- Chemical energy.
- Radiant energy.
- Mechanical energy.

6) Which statement is correct regarding nuclear energy?
- It comes from the decay of molecules.
- It is used in power plants through fission reactions.

• It is released by the fusion of nuclei in the Sun.
• It is a renewable energy.

7) What is a characteristic of a renewable energy source?
• It comes from stocks formed over millions of years.
• It is available as a constant flow on a human timescale.
• It includes coal and oil.
• It does not deplete its reserves significantly.

8) The electricity transmission network includes:
• Power plants and the distribution network.
• Export ports.
• Large consumption centers.
• Liquefied natural gas production systems.

9) What is the main role of the Pipeline Transport Network?
• Transport electricity to homes.
• Route hydrocarbons from the entry point to the exit point.
• Ensure the export of gas and oil.
• Directly supply small energy consumers.

10) What is the main objective of Executive Decree No. 05-495 of December 24, 2005?
• Regulate household energy consumption.
• Define the legal framework for the energy audit.
• Grant subsidies to industrial establishments.
• Promote energy efficiency in large establishments.

11) The sectors concerned by the energy audit are:
• Industry.
• The tertiary sector (higher education, services, administrations).
• Transport.
• Agriculture.

12) What is the role of APRUE?
• Directly supply energy to companies.
• Coordinate and lead the national energy efficiency policy.
• Implement and monitor the National Energy Efficiency Program (NEEP).
• Raise awareness among the general public and professionals about energy efficiency.

13) Which consumptions are included in the calculation of Total Consumption (TC) in TOE?
• Electricity consumption (EC).
• Natural gas consumption (NGC).
• Nuclear energy consumption.
• Petroleum product consumption (PPC).

14) What is the main objective of the first stage of an energy audit (pre-diagnosis)?
• Collect specific data on equipment.
• Identify low or no-cost "no-regret" actions.
• Assess the environmental impact of the facilities.
• Perform detailed measurements on industrial processes.

15) During the second stage of the energy audit, the analysis focuses on:
• The actions needed to improve product quality.
• The energy needs of industrial processes and the associated means.
• Developing a training plan for staff.
• Managing contracts with energy suppliers.

16) Among the following, which is essential to guarantee the success of an energy audit?
• Limit management involvement to avoid internal conflicts.
• Select qualified and neutral specialists.
• Entrust the entire process to an external provider without internal involvement.
• Perform only technical analyses without considering costs.

17) Why is it important to establish precise terms of reference for the energy audit?
• To facilitate the signing of a confidentiality agreement.
• To clearly define the expectations, scope, and stages of the audit.
• To reduce the cost of the audit.
• To comply with accounting standards.

18) What are the potential benefits of an energy audit?
• Reduction of production costs.
• Improvement of product quality.
• Promotion of a citizen image.
• All of the above.

19) During an energy audit in the building sector, which installations must be analyzed?
• Heating and air conditioning systems.
• Mechanical ventilation systems.
• Lighting systems.
• All of the above.

20) What is the main objective of the ISO 50001 standard?
• Promote renewable energies.
• Help companies develop a methodical management of energy.
• Reduce the water consumption of industrial facilities.
• Standardize energy audits in the public sector.

21) What is an energy audit?

Indicate the wrong answer.

• Assess the energy consumption of a building (house, apartment, or any other structure)
• Identify sources of waste
• Assess the energy and environmental performance of a dwelling
• Propose solutions to reduce costs and improve energy efficiency.

22) What is the main objective of the energy audit?

• Define the work to be carried out to consume less energy
• Check the performance of the heating system
• Save money, gain comfort, and enhance the property's value
• Find sources of heat loss

23) What types of dwellings can be subject to an energy audit?

• Only single-family homes
• All types of dwellings
• Only entire buildings
• Only apartments

24) What does the energy audit report contain?

• The analysis of the property and technical installations
• Heat losses
• Energy consumptions
• Improvement proposals

25) On which readings is the energy audit primarily based?

• Readings of the building's construction characteristics
• Temperature readings
• Energy consumption readings
• Readings on the quality of construction materials

26) What is the difference between an energy audit and the DPE (Energy Performance Diagnosis)?

• The energy audit is more precise than the DPE
• The energy audit does not propose improvement work
• The energy audit is more expensive than the DPE
• The energy audit only concerns single-family homes

27) Indicate the order in which the events listed below occur in an audit?

A. Analysis and evaluation of internal control.
B. Acceptance of the mission.
C. Tests to obtain corroborating evidence.
D. Mission planning.
E. Drafting of the audit report.
• B, D, C, A, E.

• B, D, A, C, E.
• D, B, C, A, E.
• D, B, C, A, C, E.
• No answer is correct.

28) Among the following operations, which one must the auditor perform during the mission acceptance procedure?
• Establishing the threshold of significance.
• Identifying internal control policies and applied procedures.
• A discussion of important points with the client's audit committee.
• Obtaining the list of suppliers for confirmation.
• Analysis of inherent risk.

29) Who can perform an energy audit?
Note, multiple answers are possible.
• An independent professional (e.g., an architect who has undergone training)
• A qualified design office/engineering firm
• A certified real estate agency
• An architecture firm
• The municipality

30) How is an energy audit conducted?
Note, classify in order.
a) identify sources of energy waste
b) collect data on energy consumption.
c) a detailed inspection of the building,
d) data collection may include meter readings, temperature readings, energy bills.
e) propose solutions to reduce them.
Classify in order

Technical Questions of the Audit

31) For the sale of a house built in 1998; can an asbestos survey be necessary:
Yes, because its building permit may date from before 01/07/1997
No, because asbestos was banned before construction
Yes, it is mandatory because its electrical installation is over 15 years old
No, if its net floor area is less than $50m^2$

32) Asbestos causes:
Only cancers
Cancers and lung diseases
Nausea

33) Before intervening in an occupied room or space, what must be done?:
Create a draft / cross-ventilation

Have it supervised by the client
Signal, isolate, confine
Evacuate the entire building

34) A wall described as having "integrated insulation" is:
A wall associated with an external lining system
A wall associated with a false wall/stud wall
A wall insulated from the outside and the inside
A load-bearing and insulating wall within its thickness

35) To insulate a flat roof, one can insulate:
Above the waterproofing
Below the waterproofing
On the underside of the slab
Using a greening/vegetation system

36) Which heating system offers the best comfort?:
Underfloor heating at low temperature
Heating provided by electric convectors
Infrared radiant heating
Heating produced by an open fireplace

37) Which buildings are subject to the DPE (Energy Performance Diagnosis)?:
Constructions or buildings for mainly agricultural use
Ice rinks
Places of worship
Buildings for residential use where energy is used to regulate the indoor temperature

38) Which is the most insulating material?:
Plastic
Concrete
Brick
Aerated concrete

39) The machine to detect lead in paints:
Is capable of analyzing the K-line of the lead spectrum
Recognizes the presence of lead by thermography
Detects metallic compounds by scanning optical microscopy
Indicates the radiation rate of materials

40) The validity period of the energy performance diagnosis is:
5 years
10 years
It depends on the type of property diagnosed
Depending on the energy rating

The correct answers of MCQs

Section 1: Energy Types and Sources

1. **What is mechanical energy?**
    - The sum of kinetic and potential energy.
    - Energy related to the motion and position of objects.
2. **Potential energy depends on:**
    - The position of an object.
    - The ability of an object to be transformed into kinetic energy.
3. **Which energy represents the agitation of molecules and atoms?**
    - Thermal energy.
4. **Chemical energy is released during:**
    - Combustion.
    - Exothermic reactions.
5. **Which form of energy is carried by radiation?**
    - Radiant energy.
6. **Which statement is correct regarding nuclear energy?**
    - It is used in power plants through fission reactions.
    - It is released by the fusion of nuclei in the Sun.
7. **What is a characteristic of a renewable energy source?**
    - It is available as a constant flow on a human timescale.
    - It does not deplete its reserves significantly.

Section 2: Energy Transport

8. **The electricity transmission network includes:**
    - Power plants and the distribution network.
    - Large consumption centers.
9. **What is the main role of the Pipeline Transport Network?**
    - Route hydrocarbons from the entry point to the exit point**.**

- Ensure the export of gas and oil.

Section 3: Energy Audit Regulations and Framework

10. **What is the main objective of Executive Decree No. 05-495 of December 24, 2005?**
    - Define the legal framework for the energy audit.
    - Promote energy efficiency in large establishments**.**
11. **The sectors concerned by the energy audit are:**
    - Industry.
    - The tertiary sector (higher education, services, administrations).
    - Transport.
12. **What is the role of APRUE?**
    - Coordinate and lead the national energy efficiency policy.
    - Implement and monitor the National Energy Efficiency Program (NEEP).
    - Raise awareness among the general public and professionals about energy efficiency.
13. **Which consumptions are included in the calculation of Total Consumption (TC) in TOE?**
    - Electricity consumption (EC).
    - Natural gas consumption (NGC).
    - Petroleum product consumption (PPC).
      Energy Audit Process and Methodology
14. **What is the main objective of the first stage of an energy audit (pre-diagnosis)?**
    - Identify low or no-cost "no-regret" actions.
15. **During the second stage of the energy audit, the analysis focuses on:**
    - The energy needs of industrial processes and the associated means.
16. **Among the following, which is essential to guarantee the success of an energy audit?**
    - Select qualified and neutral specialists.
17. **Why is it important to establish precise terms of reference for the energy audit?**

- To clearly define the expectations, scope, and stages of the audit.

18. **What are the potential benefits of an energy audit?**
    - All of the above.
19. **During an energy audit in the building sector, which installations must be analyzed?**
    - All of the above.
20. **What is the main objective of the ISO 50001 standard?**
    - Help companies develop a methodical management of energy.

General and Technical Questions

21. **What is an energy audit?** *Indicate the wrong answer.*
    - Assess the energy and environmental performance of a dwelling. (The document defines it as examining energy use and efficiency, not a broader environmental performance assessment).
22. **What is the main objective of the energy audit?**
    - Save money, gain comfort, and enhance the property's value. (This encompasses the core benefits: cost reduction, improved comfort, and asset valorization).
23. **What types of dwellings can be subject to an energy audit?**
    - All types of dwellings.
24. **What does the energy audit report contain?**
    - All of the above are standard components of an audit report.
25. **On which readings is the energy audit primarily based?**
    - Energy consumption readings. (This is the primary data source for establishing a baseline).
26. **What is the difference between an energy audit and the DPE (Energy Performance Diagnosis)?**
    - The energy audit is more precise than the DPE. (An audit is an in-depth analysis, while a DPE is a more standardized, less detailed assessment).
27. **Indicate the order in which the events listed below occur in an audit?**
    - B, D, A, C, E. (Standard audit process: Acceptance -> Planning -> Control Evaluation -> Substantive Testing -> Reporting).

28. **Among the following operations, which one must the auditor perform during the mission acceptance procedure?**
    - A discussion of important points with the client's audit committee. (This is part of understanding the client and the engagement).
29. **Who can perform an energy audit?** *Note, multiple answers are possible.*
    - An independent professional (e.g., an architect who has undergone training)
    - A qualified design office/engineering firm
30. **How is an energy audit conducted?** *Note, classify in order.*
    - b) collect data on energy consumption.
    - d) data collection may include meter readings, temperature readings, energy bills.
    - c) a detailed inspection of the building,
    - a) identify sources of energy waste
    - e) propose solutions to reduce them.
      (This is the logical sequence: data gathering -> inspection -> analysis -> proposing solutions).

Technical Questions of the Audit

31. **For the sale of a house built in 1998; can an asbestos survey be necessary:**
    - No, because asbestos was banned before construction. (Asbestos was banned in France in 1997, so a house built in 1998 should not contain any).
32. **Asbestos causes:**
    - Cancers and lung diseases.
33. **Before intervening in an occupied room or space, what must be done?:**
    - Signal, isolate, confine. (Standard safety procedure to prevent exposure).
34. **A wall described as having "integrated insulation" is:**
    - A load-bearing and insulating wall within its thickness. (e.g., monolithic walls made of insulating blocks).
35. **To insulate a flat roof, one can insulate:**
    - All of the above are valid methods.
36. **Which heating system offers the best comfort?:**

- Underfloor heating at low temperature. (It provides radiant heat, which is considered very comfortable and even).

37. **Which buildings are subject to the DPE (Energy Performance Diagnosis)?:**

- Buildings for residential use where energy is used to regulate the indoor temperature.

38. **Which is the most insulating material?:**

- Aerated concrete. (It has a much lower thermal conductivity than plastic, concrete, or brick).

39. **The machine to detect lead in paints:**

- Is capable of analyzing the K-line of the lead spectrum. (This describes an X-ray fluorescence (XRF) analyzer, the standard tool for this purpose).

40. **The validity period of the energy performance diagnosis is:**

- 10 years.

General Conclusion

This Energy Audit Course Handbook provides a comprehensive and structured framework for understanding and implementing energy audit processes, aligning with both international standards and specific national regulations in Algeria. It systematically guides the reader from fundamental energy concepts through the entire audit lifecycle—from preparation and on-site assessment to detailed analysis, reporting, and economic evaluation.

The handbook emphasizes that energy auditing is not merely a technical exercise but a crucial management tool for enhancing profitability, competitiveness, and environmental stewardship. By adopting the methodologies outlined—such as establishing energy balances, utilizing Sankey diagrams, calculating key performance indicators (KPIs), and applying both analytical and empirical evaluation methods—organizations can transition from simple energy monitoring to active energy management.

Furthermore, the document underscores the importance of economic feasibility and strategic prioritization, providing clear guidelines for assessing project viability based on return on investment (ROI), payback period, and risk. It also introduces modern approaches like outsourcing and Energy Performance Contracts (EPCs), highlighting the evolving role of Energy Service Companies (ESCOs) in the energy efficiency landscape.

In the context of rising energy costs and regulatory pressures, this handbook serves as an essential resource for future engineers and practitioners. It equips them with the necessary skills to identify significant energy-saving opportunities, propose cost-effective measures, and contribute to a sustainable energy future, thereby fostering a lasting culture of energy efficiency within industrial and tertiary sectors.

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