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Common audit methodology for determining potential energy saving measures in SMEs of the MMA sector applicable at EU level

Final version

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Abstract	The aim of this document is to provide a common methodology for carrying out energy audits based on the European standard EN 16247, at EU level, but adapted to the partner countries and to the specificities of SMEs of the MMA subsectors, NACE Rev. 2 codes C24, C25 and C28. This deliverable comes from D2.2 which has been updated including improvements that have been observed when carrying out the energy audits.

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COMMON AUDIT METHODOLOGY FOR DETERMINING POTENTIAL ENERGY SAVING MEASURES IN SMEs OF THE MMA SECTOR APPLICABLE AT EU LEVEL. FINAL VERSION

(NACEs 24, 25 and 28)

1 INTRODUCTION

The aim of this document is to provide a common methodology for carrying out energy audits based on the European standard EN 16247, at EU level, but adapted to the partner countries and to the specificities of SMEs of the MMA subsectors, NACE Rev. 2 codes C24, C25 and C28 corresponding to.

C24: MANUFACTURE OF BASIC METAL

C25: MANUFACTURE OF FABRICATED METAL PRODUCTS, EXCEPT MACHINERY AND EQUIPMENT

C28: MANUFACTURE OF MACHINERY AND EQUIPMENT N.E.C.

And annual energy consumption: < 38GWh for the C24 subsector,

> 0.5 GWh for the C25 subsector,

> 0.5 GWh for the C28 subsector.

2 ENERGY AUDIT: DEFINITION, AIMS AND FIELDS OF APPLICATION

2.1 INDUSTRIAL ENERGY AUDIT, DEFINITION

Energy Audit is defined as inspection and systematic analysis of energy use and consumption in a location, building or organization, in order to identify and report on the energy flows and the potential for energy efficiency improvement.

The Audit is the tool which allows companies to be aware of the situation with regard to the use of energy and the energy consumption improvement potential.

2.2 OBJECTIVES OF THE ENERGY AUDIT

The main objective of an energy audit is to reduce energy consumption and costs associated with it, analysing the causes and factors affecting such consumption, without affecting the production or the quality of the service.

Therefore, with the energy audit we will achieve the following objectives:

- To obtain reliable knowledge of the energy consumption of the company and the cost, identifying the factors that influence the energy consumption and introducing energy performance indices;
- To detect and evaluate the different opportunities for energy saving.

2.3 SCOPE OF THE ENERGY AUDIT

To define the scope of the energy audit is one of the most important initial tasks, because it will indicate the objects to be audited and the degree of detail that can be achieved.

In our case, the Energy Audit will comprise the production processes of the company, processes meaning all necessary steps to manufacture a product or provide a service. The audit will also include at least 85% of total energy consumption.

Therefore, the Audit will have to include the following analysis:

- Analysis of the energy supply system (electrical substation, fuel supply systems, renewable energy systems)
- Energy analysis of the equipment and/or operations of the productive process.

- Energy analysis of the auxiliary systems (production of heat and cold, compressed air systems, lighting systems, air extraction systems, combined heat and power generation).
- Analysis of energy cost (type of energy and billing)

3 DEFINITIONS

To understand better this document, we present a review of the most common energy terms.

Energy Audit: Inspection and systematic analysis of energy use and consumption in a location, building, system or organization with the aim of identifying and informing about the energy flow and the potential for improvement of energy efficiency.

Energy Auditor*:* Person or group of people and organization that carries out energy audits.

Adjustment factor*:* Quantifiable parameter which affects the energy consumption.

Audited object*:* Building, equipment, system, process, motor or service to be audited.

Organization*:* Person and institution that has, uses or manages the audited object or objects.

Energy consumption*:* Quantity of energy applied.

Energy efficiency*:* ratio or other quantitative relationship between an output of performance, service, goods or energy, and an input of energy.

Energy performance**:** measurable results related to energy efficiency, energy use and energy consumption.

Energy performance indicator*:* Quantitative value or measure of energy performance, as defined by the organization.

Measure of energy efficiency improvement*:* Amount energy saved determined by measurement and/or consumption estimated before and after implementation of one or more measures to improve energy efficiency, at the same time the standardization of the factors that affect energy consumption is guaranteed.

Energy use*:* Manner or kind of energy application.

Production process: All steps necessary to manufacture a product or provide a service.

Energy carrier*:* Vector energy needed for the process and auxiliary service.

Process to provide energy carrier: Set formed by the related equipment to the energy carrier and the distribution of said carrier.

Boundaries of the energy audit*:* Processes within the limit of the organization.

Building*:* Construction in full, including its enclosure and all technical building systems, in which energy can be used to condition the indoor climate, to provide hot water and lighting and other services related to building use and activities performed within the building.

Energy*:* Electricity, fuels, steam, heat, compressed air and other similar media.

4 PROCESS OF ENERGY AUDIT

To carry out an energy audit is considered important to proceed with the following six stages:

1. Preliminary contact and initial meeting with the company.
2. Data collection
3. Preliminary analysis
4. Field work
5. Energy analysis
6. Report and final meeting

4.1 PRELIMINARY CONTACT AND INITIAL MEETING WITH THE COMPANY

Once the company has decided to proceed with the energy audit, the first step is to arrange a meeting between the auditor and the company and establish the scope of the audit.

The Auditor will explain what an audit consists of and will ask for preliminary information to set the basis for preparing and organizing the work to be done later on.

Moreover, the company will appoint a person responsible for the audit who will be in contact with the auditor to supply him with the information required during the process.

At this meeting agreement will be reached on the period of time and the planning of visits for the audit, as well as special requirements and safety where necessary to install measuring equipment.

At this first meeting the company shall provide a description of the company and its production process and the auditor will request preliminary information necessary for planning later works.

If possible, agreed will be reached with the company on energy performance indicators.

4.2 DATA COLLECTION PRELIMINARY

A questionnaire for the collection of preliminary data has been prepared as set out in Annex I

This questionnaire includes:

- General data of the company
- General data about raw materials, production and mode of operation. (Monthly production over the last two years).

- Description of the productive process and block diagram
- General energy data (monthly consumption, power supply contracts and invoices over the last 24 months of every energy supply: electricity, fuels and other energy sources)
- Inventory of the process equipment that consume energy (description, installed power capacity, operating conditions, energy consumption, existence of specific energy counters, established maintenance plan, revision…..)

If possible, the company will be requested to present single-wire schemes of the installation and drawings with the different locations of existing counters, electric and non-electric, general and specific.

A factory plan with location of different manufacturing divisions and auxiliary services would be useful for the audit process.

4.3 PRELIMINARY ANALYSIS

The data collected in the previous phase will be evaluated in the preliminary analysis. To this end, the following actions will be contemplated:

- Starting with the total energy consumption, shown in the bills or energy invoices, an energy distribution will be carried out, identifying systems and equipment of higher energy consumption. Tables and charts of energy distribution will be made, including absolute and percentage data and graphs of consumption throughout the period being considered.
- Indicator(s) of energy performance and adjustment factor(s) will be established.

  An indicator of energy performance (IEP) is a crucial indicator for performance in relation to use, consumption and energy efficiency. An IEP is a quantitative value which measures and gives information about the energy performance inside the organization.

  The adjustment factor is a quantifiable parameter that affects energy consumption. Adjustment factors are, for example: production, weather conditions, light level, working hours of a machine and its temporary uses.

  The most common indicator of energy performance in the industrial sector is:

  Total energy consumption / equivalent unit of production

  Depending on the numerator and denominator many different variations can be obtained:

  Total electrical consumption / equivalent unit of production

  Total thermal consumption / equivalent unit of production

  Energy consumption of a single production line or equipment or installation / equivalent unit of production of the same production line or equipment or installation

Other indicators can be:

Total electrical consumption per unit of surface

Total electrical consumption per employee

Electrical consumption in lighting per unit of surface

Electrical consumption in lighting per unit of surface and per hours of working

Electrical consumption in lighting per employee

Thermal consumption for heating per unit of surface

Thermal consumption for heating per unit volume.

Thermal consumption for heating per day-degrees

The indicator that best suits the specificities of the audited company will be chosen.

- If possible, an energy baseline will be established. There will be a baseline for each indicator of energy performance adopted.

  An energy baseline represents the current energy behaviour of a company, reflects a specified period and can act as a reference at the time of implementing improvement opportunities, quantifying the savings obtained.

  Saving = consumption according to baseline – real consumption

  To calculate the baseline, the statistical method called Linear regression analysis will be used. This method consists of developing the dispersion of energy consumption chart VS the independent variable that is considered of greater influence in the process.

  Then, by means of linear regression, you get the straight line equation which indicates the influence of the independent variable on energy consumption.

  The form of the equation is of the type:

  $y = a + bx$

  "a" is the fixed consumption of the system and "x" the independent variable with a multiplying factor "b".

  If the independent variable “x” is known, it is possible to calculate the consumption of energy “y” (independent variable) for a known period.

  This way you can establish the difference between the expected and actual consumption.

To determine that the relation between “x” and “y” is significant and the baselines are correct it is necessary to take into account the R value which marks the degree of association between the dependent variable and the independent. A value greater than 0,85 is taken as valid.

As said previously, an energy baseline represents the energy behaviour in a determined period of time, therefore, to set the energy baseline and for these to be representative, the monthly energy data consumption and the independent variable from the last two years (24 months) will be used.

- Data collection and subsequent measurements will be planned

  In the event that the previously obtained data were not coherent or had to be completed in order to identify and evaluate the opportunities of energy saving, the method to be used will be determined.

  The different methods for obtaining these data are:

  - ✓ Measurements: Carrying out in situ measurements with portable equipment
  - ✓ Calculations: by means of the power of the equipment and the equivalent time of use.
  - ✓ Estimates: made from historical data, experience, studies,…

4.4 FIELD WORK

Once the preliminary analysis is done and in the event that more data are needed to carry out the energy analysis, in situ measurements will be made. To do this, it may be necessary to use measuring equipment such as:

Combustion analyser

Thermometers

Air flow measurement devices

Flow meter

Portable power analyser

Light meter

Infrared camera

In Annex II there is a description of the equipment.

4.5 ENERGY ANALYSIS

The energy analysis will include the following:

- Breakdown of the energy consumption by use and source (both absolute and percentage terms).

Once the data and energy consumption have been collected, this will be distributed between the different equipment and consuming processes. The following distributions will be obtained:

- ✓ Distribution electrical consumption between the different equipment and processes. Both absolute and percentage terms.
- ✓ Distribution consumption of each thermic source (natural gas, diesel oil, fuel,….) among the different equipment and processes. Both absolute and percentage terms.
- ✓ Distribution total energy consumption between the different equipment and processes. Both absolute and percentage terms.

At the end of this process, energy intensive equipment and facilities will be identified.

- Making mass and energy balance.

The mass and energy balance of the equipment or processes which have presented an energy saving potential will be carried out, calculating performance and evaluating energy losses (Sankey diagram).

If possible, the energy consumption when there is no production or activity will be determined.

- Quantification of energy performance indicators.

Once energy performance indicators are set, they will be calculated each month for the following two years. A monthly graph with the trend over time of these indicators will be a precious tool for a clearer observation of their evolution.

- Baseline establishment.

As said previously, a baseline for each energy performance indicator specified will be established.

- Identification and evaluation of energy efficiency improvement opportunities.

The analyses carried out in the previous points are preparatory for the main objective of each energy audit:

To identify and propose energy saving actions

All recommended measures and opportunities for improvement can be organized into the following categories:

- Decreasing energy losses.
- Recovery of energy losses. Use of waste energy.
- Replacement of out-dated equipment by other more efficient.
- Modifying the operating conditions to improve the efficiency of equipment
- Maintenance improvement.
- Changes in staff behaviour.
- Improvements in energy measuring and monitoring plan.

To propose different energy saving measures, what is indicated in Annex III Energy Saving Measures will be taken into account.

Once the energy saving measures and efficiency improvement have been identified, it is necessary to work out an economic evaluation of each one, so as to guarantee the economic return. The saving and improvement measures will be ordered following this profitability criterion, from a lower rate of return on investment to higher. The procedure described in Annex IV will be followed in order to evaluate and order them.

- Analysis and evaluation of a change in energy sources.

  A study will be carried out into the possibility of changing energy source, both wholly and in processes or equipment whose energy can be supplied from other energy sources or by harnessing waste energy and/or renewable energy.

- To study tariff changes to lower the cost of energy.

  A study will be made of energy tariffs that are being applied and the possibility of a change in them that may bring about a reduction in energy costs. To do so, both monthly invoices (last 2 years) and supply contracts must be available.

  The following ratios must be controlled:

  - Average price (€ / kWh) = Total amount of invoice (without VAT)/Consumption
  - Hours of use = consumption (kWh) / Contracted power (kW)

- Distribution of energy consumption per period in %
- Distribution of energy cost per period %.
- Invoicing excess power required or daily flow.
- Invoicing excess reactive energy demanded
- Other items of the invoice.

The trading companies make offers to the clients to hire the energy supply. The price and kind of offer will depend on the characteristics of the energy consumption of the client (consumers of flat load curves, consumers in valley hours, ...), so that the trading company can control their costs and risks.

The offers normally include:

- Contract period and validity of the offer.
- Power to be contracted, annual consumption hired in energy, expected annual consumption and daily volume of flow in natural gas to be hired.
- Treatment of excesses and regulated concepts.
- Price structure: single price, price in 3 or 6 periods, indexed price… in electricity and fixed term, unique variable price, indexed variable price, … in natural gas.
- Price and other terms, for example electricity tax.
- Definition of the profile of consumption and penalizations/bonuses.
- Price review for subsequent years contracted.
- Conditions of payment.
- Quality of supply.
- Measuring and measurement equipment (rental).
- Access to information, i.e. specify if the trading company is required to supply information and what information is available.

The description of energy markets is attached in Annex V as well as different possibilities of hiring.

4.6 REPORT

The report will include the following aspects:

Introduction and applicable regulations

Objectives, limits and phases of the energy audit

General data of the company: production and activities

Description of productive process: Block diagram.

Energy consumption and costs.

Energy facilities (receiving facility, auxiliary and process facilities).

Energy distribution.

Energy analysis.

Good practice.

Summary of savings and investments.

Attached in Annex VI is an index and a brief description of each of the aspects to be reflected in the final summary of the Energy Audit.

5 INFORMATION SOURCES

For the preparation of this document, the following sources of information have been taken into account, mainly:

- European Standard EN 16247. Part 1 and Part 3
- A3E organization. www.asociacion3e.org
- IDAE. www.idae.es

ANNEX I

DATA COLLECTION

It is necessary to collect preliminary data to carry out the audit. The template prepared for this is shown below.

GENERAL DATA OF COMPANY		
Company name		
NIF (tax number)		
Address		
City		
Region		
Postcode		
Country		
Contact person		
Phone number		
e-mail		
web		
Nace code (2009)		
Activity sector		
Main activity of the company. Description		
Age of the company		age
Number of employees		people
Plant surface		m^2
Annual energy consumption 2014		kWh/year
Annual energy cost 2014		€/year
Percentage energy cost over total cost (2014)		%
Production value 2014		€
Annual energy consumption 2015		kWh/year
Annual energy cost 2015		€/year
Percentage energy cost over total cost (2015)		%
Production value 2015		€

OPERATION MODE		
Working hours		
Hours / day		h/d
Days / week		d/w
Days / year		d/y
Hours / year		h/y

PRODUCTION DATA

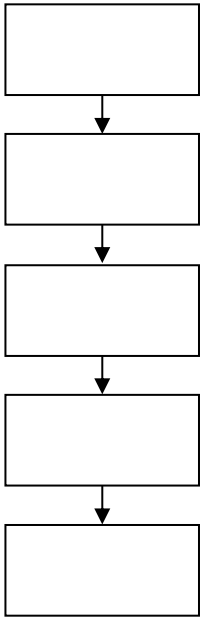
		2014												
Type of raw materials	**Type of unit**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Annual consumption 2014**

		2014												
Type of finished product	**Type of unit**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Annual production 2014**

		2015												
Type of raw materials	**Type of unit**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Annual consumption 2015**

		2015												
Type of finished product	**Type of unit**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Annual production 2015**

DESCRIPTION OF PROCESS
Description of manufacturing process:
Process diagram: Block diagram with the most important operating phases of the manufacturing process



ENERGY SOURCES

IMPORTANT NOTE:
It is essential that the company provide the contract and energy bills over the last 24 months. One of the points of energy analysis will be energy billing. A possible change in the energy tariff will be studied to obtain a lower cost of energy.

NATURAL GAS

Energy distribution company:
Energy supplier company:
Main uses:
Type of tariff
Supply pressure
Consumption range

	2014												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2014**
kWh													
EUROS													
c€/kWh													

	2015												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2015**
kWh													
EUROS													
c€/kWh													

DIESEL

Energy supplier company:

Main uses:

	2014												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2014**
kWh													
EUROS													
c€/kWh													

	2015												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2015**
kWh													
EUROS													
c€/kWh													

OTHER

Energy supplier company:

Main uses:

	2014												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2014**
kWh													
EUROS													
c€/kWh													

	2015												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2015**
kWh													
EUROS													
c€/kWh													

ELECTRICAL ENERGY

Energy distribution company:
Energy supplier company:
Main uses:
Type of tariff
Voltage
Contracted power

	2014												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2014**
kWh													
EUROS													
Power max.													
c€/kWh													

	2015												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2015**
kWh													
EUROS													
Power max.													
c€/kWh													

BIOMASS

Energy supplier company:
Type of biomass:
Main uses:
Net Calorific Value (NVC) kWh/Kg

	2014												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2014**
kWh													
EUROS													
c€/kWh													

	2015												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2015**
kWh													
EUROS													
c€/kWh													

BIOFUELS

Energy supplier company:
Type of biofuel:
Main uses:
Net Calorific Value (NVC) kWh/l

	2014												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2014**
kWh													
EUROS													
c€/kWh													

	2015												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2015**
kWh													
EUROS													
c€/kWh													

THERMAL SOLAR ENERGY

Main use:

Total surface area of solar gain (m2)

Thermal maximum power (kW)

Total accumulation volume (m3)

	2014												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2014**
Thermal energy demand (kWh)													
Energy covered by solar thermal collectors (kWh)													
Average solar fraction													
	2015												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2015**
Thermal energy demand (kWh)													
Energy covered by solar thermal collectors (kWh)													
Average solar fraction													

PHOTOVOLTAIC SOLAR ENERGY

Type of installation (alone or grid-connected)
Main use:
Rated power photovoltaic plant (kW)
Pick power photovoltaic plant (kWp)
Rated voltage (AC) (V)
Grid connection (single-phase or 3-phase)
Type of photovoltaic modules
Number of photovoltaic modules
Number of inverter

	2014												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2014**
Expected electricity production (kWh)													
Actual electricity production (kWh)													
Performance Ratio													

	2015												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2015**
Expected electricity production (kWh)													
Actual electricity production (kWh)													
Performance Ratio													

GEOTHERMAL ENERGY

Type of installation (low, medium or high temperature):

Main use:

	2014												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2014**
Thermal energy production (kWh)													
Electricity consumption (kWh)													

	2015												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2015**
Thermal energy production (kWh)													
Electricity consumption (kWh)													

TOTAL ENERGY CONSUMPTION

	2014												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2014**
kWh													
EUROS													
c€/kWh													

	2015												
Type of unit	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total 2015**
kWh													
EUROS													
c€/kWh													

ENERGY PERFORMANCE INDICATORS (EPIs)			
INDICATORS			
Nº	Energy use identified	Indicator	Units

PROCESS EQUIPMENT

Equipment	Type of energy	Power (kW)	Operation mode (hours/year)	Energy consumption (kWh/year)	Energy cost (€/year)	Are there energy meter? (Yes/no)	Energy consumption relative to energy source total (%) (Natural Gas)	Energy consumption relative to energy source total (%) (Diesel)	Energy consumption relative to energy source total (%) (Electricity)

PROCESS EQUIPMENT - AUXILIARY FACILITIES

FURNACE	
Functional description	
Type of energy consumed	
Energy consumption (kWh/year)	
Energy cost (€/year)	
Brand	
Model	
Power	
Type	
Capacity of equipment	
Technical efficiency	
Process time	
Cycle/day	
Working temperature	
Material per cycle	
Regulation type	
Equipment control	
Maintenance	
Maintenance description	
Comments	

PROCESS EQUIPMENT - AUXILIARY FACILITIES

FLUID PRODUCTION (STEAM, HOT WATER)	
Functional description	
Type of generator:	
Type of energy consumed	
Energy consumption (kWh/year)	
Energy cost (€/year)	
Brand:	
Model:	
Capacity of equipment	
Technical efficiency	
Safety pressure:	
Working temperature:	
Regulation type	
Equipment control	
Maintenance	
Maintenance description	
Comments	

STEAM DISTRIBUTION (LAGGING AND LEAKAGE)	
Comments	
CONDENSATE RECOVERY (IF APPLICABLE)	
% Recovery:	
Network condition (lagging and leakage):	
Comments	

PROCESS EQUIPMENT – AUXILIARY FACILITIES

COOLING SYSTEMS		
Functional description		
Cooling systems production		
Cooling capacity (kW):		
Characteristics of the compressor:	Type	
	Brand	
	Model	
	Power (kW)	
Type of energy consumed		
Energy consumption (kWh/year)		
Energy cost (€/year)		
Capacity of system		
Technical efficiency		
Regulation type		
Equipment control		
Condensation system		
Maintenance		
Maintenance description		
Comments		

AUXILIARY SERVICES

COMPRESSED AIR		
Functional description		
Type of compressors (piston engine, screw engine, etc.)		
Characteristics of compressors:	Brand	
	Model	
	Power (kW)	
	Working pressure (bar)	
	Functioning conditions (loaded, empty)	
Type of energy consumed		
Energy consumption (kWh/year)		
Energy cost (€/year)		
Capacity of equipment		
Technical efficiency		
Network pressure (bar)		
Regulation type		
Compressors control		
Maintenance		
Maintenance description		
Comments		

AUXILIARY SERVICES	
AIR CONDITIONING	
Functional description	
Heating system	
The heating system (Fan heaters, Radiant tube heaters, etc.)	
Power and characteristics of the heating equipment.	
Type of energy consumed	
Energy consumption (kWh/year)	
Energy cost (€/year)	
Capacity of equipment	
Technical efficiency	
Regulation type and Equipment control.	
Working temperature.	
Maintenance	
Maintenance description	
Comments	

Cooling system	
Cooling system (Air conditioning, heat pump equipment, etc.)	
Power and characteristics of the cooling equipment.	
Type of energy consumed	
Energy consumption (kWh/year)	
Energy cost (€/year)	
Regulation type and Equipment control.	
Working temperature.	
Maintenance	
Maintenance description	
Comments	

AUXILIARY SERVICES	
DOMESTIC HOT WATER	
Functional description	
Domestic Hot Water system (Natural Gas Boiler, Electricity Accumulators, etc.)	
Power and characteristics of the Domestic Hot Water equipment.	
Type of energy consumed	
Energy consumption (kWh/year)	
Energy cost (€)	
Capacity of equipment	
Technical efficiency	
Regulation type and Equipment control.	
Working temperature.	
Maintenance	
Maintenance description	
Comments	

AUXILIARY SERVICES										
LIGHTING										
Functional description										
Dependency	**Dimensions L x W x h (meters)**	**Type luminaire**	**Power (kW)**	**Energy consumption (kWh)**	**Energy cost (€)**	**Number of luminaires**	**Operation mode (hours/year)**	**Regulation type**	**Equipment control**	**Maintenance**
Industrial plant										
Comments										

AUXILIARY SERVICES												
MAIN ELECTRIC MOTORS												
Description	**Power (kW)**	**Operation mode (hours/year)**	**Energy consumption (kWh/y)**	**Energy cost (€/y)**	**Age or Efficiency Level**	**Variable speed drive (Yes/No)**	**Average percentage of speed variation**	**Constant load**	**Medium load (%)**	**Maintenance and Operation**		**Maintenance**
										The motor has been repaired? Yes/No	**How many times has the motor been repaired?**	
Comments												

OTHER FACILITY

NAME:	
Functional description	
Type of energy consumed	
Energy consumption (kWh/year)	
Energy cost (€)	
Installed power (kW):	
Technical efficiency	
Other features	
Maintenance	
Maintenance description	
Comments	

BUILDINGS

General information				
Name				
Functional description				
Construction/technology of structure				
Year built				
Weekly operating hours				
Number of storeys				
Net building area [m2]				
Heated volume [m3]				
Characteristic of building partitions				
External walls	Description		Thermal transmittance [W/m2K]	
Roof/flat roof	Description		Thermal transmittance [W/m2K]	
Ceiling structure	Description		Thermal transmittance [W/m2K]	
Floor	Description		Thermal transmittance [W/m2K]	
Windows	Description		Thermal transmittance [W/m2K]	
Doors	Description		Thermal transmittance [W/m2K]	
Characteristic of ventilation system				
Type of ventilation system				
Method of supplying and removing air				
Type of energy consumed				
Energy consumption [kWh/year]				
Energy cost [EUR/year]				
Characteristic of heating system				
Type of heating system				
Percent of space heated				
Type of energy consumed				

Energy consumption [kWh/year]	
Energy cost [EUR/year]	
Characteristic of cooling system	
Type of cooling system	
Percent of space cooled	
Type of energy consumed	
Energy consumption [kWh/year]	
Energy cost [EUR]	
Characteristic of domestic hot water system	
Type of domestic hot water system	
Heat generation for hot water	
Type of energy consumed	
Energy consumption [kWh/year]	
Energy cost [EUR/year]	
Characteristic of other system	
Type of system	
Type of energy consumed	
Energy consumption [kWh/year]	
Energy cost [EUR/year]	
Comments	

ANEXO II

MEASURING EQUIPMENT FOR FIELD WORK

To carry out the consumption measurements on site, the following measurement equipment can be used:

- **Combustion analyser.**

Combustion analysers are portable devices which estimate the combustion efficiency of furnaces, boilers and other fossil fuel burning machines. Their application is based on taking a sample of the gases that flow through the chimney or flue pipe, by suction through a hole and obtaining the concentration of their components by electronic analysers with electrochemical sensors which are fitted to these analysers. Moreover, these devices are supplied with a thermocouple probe for taking gas temperature and software which, depending on the analysis of gases, temperature and room temperature, provide the combustion efficiency.

- **Thermometers.**

Thermometers are needed to measure temperatures in offices and other working areas, and to measure the temperature of operating equipment. Knowing the process temperatures allows the auditor to determine process equipment efficiencies, and also to identify waste heat sources for potential heat recovery programs. Some common types include an immersion probe, a surface temperature probe and a radiation-shielded probe for measuring true air temperature. Other types of infra-red thermometers and thermographic equipment can measure line or equipment temperatures that are not accessible without a ladder.

- **Air flow measuring devices.**

Measurements of energy efficiency of air flow heating, air conditioning or ventilating ducts, compressed air systems or other sources of air flow is one of the energy auditor's tasks. Airflow measuring devices can be used to identify problems with air flows. Typical airflow measuring devices include pressure transmitters, flow meters, anemometers or air flow hoods, an ultrasonic device for finding losses in compressed air distribution network.

- **Flow meter.**

The flow meters are instruments designed to measure the flow of fluid circulating through a pipe, usually water and air.

In an energy audit, the type of flow meter to be used is normally a portable ultrasonic flow meter, not intrusive, for measuring the volume flow without contact with the liquid. Basically ultrasonic flow meters can be used in all places where the liquid flowing through the pipes allow the propagation of sound.

- **Portable power analyser.**

Electrical network analysers are measuring instruments that measure directly or calculate different electrical parameters of a network, usually at low voltage: voltage, current, power and active and reactive power, power factor, etc. All this type of equipment also have the possibility of registering these parameters through various programming functions. Usually, the results of the measurements are presented in the form of computer files in a specific format that can only be handled by the software manufacturer, or in standard ASCII format that can be handled with any conventional software applications (EXCEL, ACCESS , etc.).

- **Light meter.**

The light meter is an instrument that measures the illumination or lighting level (lux) on a given surface. Normally it is a very simple and light piece of equipment, consisting of the analyser and the photosensitive probe.

- **Infrared camera.**

The infrared camera is a device, similar to a common camera, that detects infrared energy (heat) and converts it into an electronic signal, which is then processed to produce a thermal image and perform temperature calculations. Heat detected by an infrared camera can be quantified, allowing you to identify and evaluate heat-related problems (heat leaks, poor insulation, overheating in electrical systems, etc.).

- **Other measuring equipment.**

Depending on the scope of the Energy Audit it may be interesting (or even essential) to use other portable measuring equipment. Thus, for the comprehensive study of the environmental conditions and the functioning of the facilities, it may be necessary to have room temperature and fluid (air and water) probes in ducts, anemometers and flow probes, static and dynamic pressure (pitot), pyrometers optical, infrared cameras etc.

- **Tools.**

Apart from more or less specialized equipment, and other materials commonly used tools, such as screwdrivers, pliers, scissors, tape measure, flashlight, extension cords, adapters, electrical cables, terminals, tape, etc., may be necessary in an energy audit.

- **Safety Material.**

Professional work requires the adoption of safety measures to protect oneself and others, especially when carrying out measurements.

During the development of an energy audit, the main physical hazards are often of an electrical origin, but there are others such as falls or burns.
The minimum personal protective equipment recommended is listed below (used to be homologated.)

- Helmet

- Safety footwear
- Dielectric gloves Class "0" up to 1,000V.
- Safety glasses
- Dielectric Mat

ANEXO III

ENERGY SAVING MEASURES

Below are some suggested energy saving measures for industrial equipment/systems that consume energy, both thermal and electricity.

THERMAL ENERGY CONSUMERS

Steam, thermal fluid and superheated water boilers.

- Reduction of heat loss in boilers and hot circuits due to defects in the insulation.
- Reduction of heat loss due to leaks in the flanges, valve presses, etc.
- Heat recovery from combustion gases:

  Depending on the temperature of the combustion gases, we can have the following heat recovery applications:

  500 – 1000ºC

  - Preheating of the feed in furnaces
  - Generation of high pressure steam
  - Reheating of steam

  300 - 500ºC

  - Preheating of the combustion air
  - Production of medium pressure steam

  150 – 300ºC

  - Preheating of the feed water in boilers
  - Preheating of the combustion air
  - Generation of low pressure steam

  <150ºC

  - Absorption cooling
  - Application of a heat pump

  The equipment most commonly used is:

  - Boiler economisers
  - Heat recovery boilers
  - Combustion air heaters

Furnaces.

- Reduction of heat loss due to defects in the insulation.

- Heat recovery from combustion gases through the following systems:

  Combustion air heaters:

  - Heat regenerators. In a regenerator, the transfer of heat between two currents is transported by the alternating passing of hot and cold fluids through a bed of solids, which has an appreciable heat storage capacity.
  - Heat recovery units. In a recovery unit, the two fluids are separated by an internal partition which enables the heat to be directly transferred.
    - Convection recovery units. This generally consists of one or more bundles of tubes through which the air to be heated flows whilst the gases bathe the outside of the tubes.

      Hot gas temperature < 1,000ºC, gases that do not contain corrosive compounds or a large amount of solid particles.

      Applications: Forging furnaces, Iron and steel industry, Calcining furnaces, Waste recovery, Cooling of gases or air.

    - Radiation recovery units. This type of recovery unit is especially suitable for cases where the temperature of the gases is very high and constant. Radiation recovery units cannot be used with batch-type furnaces, where the temperature of the gases is very low during the furnace heating periods. Jacketed radiation recovery units offer reduced fuel consumption of 40% or more thanks to preheating the combustion air and a compact design which facilitates their installation into the chimney flue.

      Hot gas temperature: > 1,000ºC, gases that contain aggressive compounds or a large amount of particles

      Applications: Forging furnaces, Frit smelting, Glass manufacturing, Aluminium smelting

    - Mixed convection-radiation recovery unit

  Product pre-heaters: The heat from the gases is applied directly to preheat the product, so the consumption of fuel needed to reach the product's heating temperature is reduced.

- Recovery of the product's waste heat through:

  Preheating the product entering the furnace. The energy exchange between hot and cold products can be carried out in the furnace itself or in a separate heat exchange chamber.

Heating of combustion air. This method allows the use of the product's heat when leaving the furnace or the hot parts of the furnace to heat the air that will be used as a combustion agent in the combustion.

Driers.

- Reduction of heat loss due to defects in the insulation.
- Heat recovery from the output vapours, preheating the drying gases.
- Recovery of the product's waste heat: These driers are also known as regenerative, as they try to recover the product's heat whilst also drying it.

Other energy saving measures.

- Minimise purges in steam boilers.
- Recovery of condensates and hot waters: The waste heat from circuits of condensates and hot water coming from the steam used in processes can be recovered in two forms:

  Direct form: introducing the condensates and hot water into the feed tank and mixing them with the feedwater to the boiler, provided that they are not contaminated.

  Indirect form: transferring the residual heat to another fluid through exchangers.
- Heat recovery from the cooling circuits of refrigeration machines, for example through a heat pump.
- Replace pieces of equipment with others that are more efficient.

Energy saving measures in combustion.

- Suitable control of combustion.
- Change of energy source, i.e., the combustible used.

ELECTRICITY CONSUMERS

Industrial cooling.

Industrial cooling can be achieved through the following systems:

- Compression: cooling machine
- Absorption: absorption machine
- Evaporation: evaporative cooling

The energy saving measures that can be considered in the different systems are:

Cooling machines:

- Replace the compressors with others with a better performance.
- Centralise equipment, compared to having independent and split equipment
- Install multi-stage compressors to meet cooling demands at different temperatures.
- Recovery of cooling heat from the compressors, for heating or hot water.
- Adjust the evaporation temperature to the highest possible.
- Defrost using hot fluid, not electricity.
- Adjust the condensation temperature to be as low as possible.
- Use the condensation heat for other uses.

Absorption machines:

- Use of thermal waste heat as recovery of heat from boilers, recovery of condensates, solar thermal panels, etc. to generate cooling and avoid the use of electricity in systems with compression.

Evaporative cooling (cooling towers):

- Replace constant flow water pumps with variable flow pumps.
- Stop ventilators or adjust their speed.

Compressed air.

As energy saving measures, we can:

- Reduce the air pressure to the minimum permitted level.
- Section the distribution lines: by pressure, production line, equipment, etc.
- Reduce leaks in the compressed air networks.
- Take the suction air from the compressor at the lowest possible temperature.

- Prevent the compressors from working on empty.
- Recover the cooling heat from the compressors.
- Replace the pieces of equipment with others offering a better performance.

Lighting.

- Adjust the lighting levels to the needs of the area.
- Replace lights with a poor light performance with others that are more effective.
- Replace lights with louvres that are badly deteriorated, or those that do not fit the characteristics of the premises.
- Take advantage of natural light.
- Install regulation and control systems.
- Implement a suitable management and maintenance system.

Electric motors.

- Adjust the motors to the power needed. (The motor size must be suitable for the work to be performed)
- Use high efficiency motors
- Regulate the motor's speed.

Pumps and ventilators.

- Adjust the operating points of the pumps.
- Prevent the motor from overheating. Place in a ventilated location.
- Correctly place the motor to prevent its premature wear.
- Regulate the flow.
- Perform the proper maintenance and cleaning of the hydraulic circuits, valves and accessories.

Transformers.

- Adjust the power factor.
- Adjust the transformer's load factor.
- Reduce the effect of harmonics.
- Reduce the temperature in the transformer's enclosure.
- Replace old transformers with new ones.

ANNEX IV

PROCEDURE FOR ASSESSMENT OF ENERGY SAVING MEASURES

As mentioned previously, the economic cost of the different energy saving measures will be carried out as described in this procedure.

We take as a basis the following input data:

1) input data:

- ✓ Investment, **I** (€). Economic valuation at market prices, the purchase of equipment and work to be done to carry out the energy saving measure.
- ✓ Annual reduction of energy costs, **ARE** (€).). Evaluation of the saving in energy costs as a result of implementing the energy saving measure.
- ✓ Annual increase in maintenance/operation costs, **AIMO** (€). Evaluation of the annual increase in maintenance and operation costs related to energy improvement.
- ✓ Annual economic saving, **AES** (€). Evaluation of the resultant annual economic saving.

  AES = ARE - AIMO
- ✓ Lifetime of equipment, **Lt** (years)
- ✓ Present value, **PV**. Present Value describes the process of determining what a cash flow, to be received in the future, is worth in today's Euros . It is calculated using the formula below:

  $PV = FV / (1+r)^n$

  Where:

  FV = future value

  r = interest or discount rate

  n = number of years

And as indices of economic evaluation:

2) Profitability Ratios:

- ✓ Gross amortization period (return time of the investment), **GP** (years):

  GP = I / AES
- ✓ Gross return of the investment, **GRI** (%). It expresses the percentage of profit obtained on investment throughout the life of the installation resulting from the improvement:

$$GRI = (AESn-I) / I \times 100$$

- ✓ Annual Gross return of the investment, **AGR** (annual %). The annual benefit is calculated with this indicator. It is usually more operative than the GRI:

$$AGR = GRI / Lt$$

- ✓ Annual depreciation of equipment, D (€, linear):

$$D = I / Lt$$

- ✓ Net present value, **NPV**. It is the difference between the present value of cash inflows and the present value of cash outflows.

$$NPV = I_1 / (1+r) + I_2 / (1+r)^2 + \ldots + I_n / (1+r)^n - C_0 - C_1 / (1+r) - C_2 / (1+r)^2 - \ldots - C_n / (1+r)^n$$

In our case:

$$NPV = AES/(1+r) + AES/(1+r)^2 + \ldots + AES/(1+r)^{Lt} - (I/Lt + AIMO) - (I/ Lt + AIMO)/(1+r) - (I/ Lt + AIMO)/(1+r)^2 - \ldots - (I/ Lt + AIMO)/(1+r)^{Lt}$$

Where:

AES = Annual economic saving

Lt = Lifetime of equipment

I = Investment

AIMO = Annual increase in maintenance/operation costs

r = interest or discount rate

Example:

I = 200 €

Lt = 5 years

AES = 75 €

AIMO = 5 €

r = 10%

Time period (Lt)	Cash inflow (AES)	PV where r=10%	Cash outflow (I/Lt+AIMO)	PV where r=10%
0	0	0	45	45
1	75	68	45	41
2	75	62	45	37
3	75	56	45	34
4	75	51	45	31
5	75	47	45	28
TOTAL		284		216
NPV	**68**			

The savings measures identified and evaluated will be sorted in descending order, from higher NPV to lower.

ANNEX V

ENERGY MARKETS. SUPPLY CONTRACT

ITALY

1 ELECTRICITY MARKET IN ITALY.

1.1 INTRODUCTION.

The liberalization of the electricity market started in 1999 with the Legislative Decree n. 79 of 16th March 1999, which limited access to the free market of electricity at first to large consumers (annual consumption over 30 GWh), with a progressive decrease in this threshold (20 GWh from 1st January 2000 and 9 GWh from 1st January 2002). Large consumer means a single company or also a consortium.

With Law n° 239 of 23th August 2004, from 1st July 2004 every customer has become eligible for the free electricity market, excluding the residential customers, who were admitted from 1st July 2007.

Liberalization is aimed at greater efficiency in investments and operation of the electrical systems. The aim is to decrease costs, and therefore the price, that final customers pay for electricity, and to increase the quality and reliability of supply.

The restructuring of the electrical sector means a change in the organization where electricity generation, transport, distribution and marketing now operate independently.

The generation and marketing of electricity are carried out in competition in the new electricity market, although transport and distribution continue to be regulated by the Government and AEEGSI (Italian Regulatory Authority for Electricity, Gas and Water).

In this new stage all consumers can freely choose the power supplier (negotiating their contract with a retailing company or a trader). In any case, as well as the cost of consumed energy, a toll or fee for access to the transport and distribution networks is mandatory and it is regulated by the Government and AEEGSI.

Usually SMEs of sector C24, C25 and C28 buy electricity on the open market through a retailing company.

These consumers, who are engaged in the open electricity market, sign a contract with the chosen marketing company. The agreement concerns only economic conditions about the energy cost. Other items (almost 20) which are indicated in the bill are not negotiable and refer to taxes and network charges regulated by Governmental (for example IVA, the equivalent of VAT) and Authority dispositions (distribution and dispatch costs, measurement charges, etc.).

All charges are related to level of voltage, available power and hourly discrimination. The specific charges are regularly updated (normally every three months) and are available in the so-called TIT document (text with dispositions of AEEGSI about transmission and distribution services for electricity).

Currently, energy supply cost represents about the 30% of total amount of energy cost.

1.2 TYPE OF CONTRACTS

The more common types of contract are:

Fixed price offer and fixed price offer with hourly discrimination

Both parties reach an agreement about the price of kWh and volumes.

All charges and taxes, with no exception, are directly transferred from the seller to the buyer, as mentioned above.

Many customers choose this option because it is simple. Differences about the annual estimated consumption or deviations in different periods of time are normally included in the fixed price.

Penalty for consumption deviations are normally not applied.

In the case of hourly discrimination, three different time slots (F1, F2, F3) are defined by AEEGSI Decision n° 181/2006:

- F1 is the peak time slot: from 8 AM to 7 PM on weekdays;
- F2 is the medium load time slot: from 7 AM to 8 AM and from 7 PM to 11 PM on weekdays; from 7 AM to 11 PM on Saturday;
- F3 is the off-peak time slot: from 11 PM to 7 AM on weekdays and Saturday, 24 hours a day on Sunday and Public Holidays.

For the duration of the contract, fixed price offers (even with hourly discrimination) can have different prices according to the different periods they refer to.

In this type of contract all risks are assumed by the seller (trading company).

Offer price-indexed "pool" (EQUIVALENTE AL PUN)

In these contracts, the price is variable and depends on the purchase price of energy in the wholesale market (the single national price, or PUN). In this way, the risk, instead of being assumed by the trading company, is totally transferred to the client.

Normally penalties due to variations in daily forecast demand are price-included in the contract.

2 NATURAL GAS MARKET IN ITALY.

2.1 INTRODUCTION.

The liberalization process of the natural gas sector is parallel to the process in the electricity sector following the principles set out in European Directive 98/30 / EC for the creation of the European internal market in natural gas.

The natural gas system includes facilities in the transport network, distribution networks, regasification plants, underground storage and other complementary facilities.

As in the case of the electricity sector, some activities are regulated by governmental and Authority dispositions. These activities refer to regasification, basic storage, transportation and distribution. Other activities, such as procurement and marketing of energy, are developed in a free competition system.

In a free retail market, the trading companies sell natural gas to their customers (residential, commercial and industrial and power plants using natural gas) under terms freely agreed by the parties.

Consumers of natural gas with more than 200,000 Sm3 / year Annual consumption should be supplied by a trading company at free pricing.

Consumers whose annual consumption is less than 200,000 Sm3 / year have voluntarily the possibility of hiring in the free market instead of the last resort tariff (established by Government).

The cost components included in trading company offer are the following:

- Cost of gas purchases in the wholesale market, managed by the trading companies in the wholesale acquisition (buying gas directly from producers, other traders, etc.)
- Cost of access tolls (specifically referred to the daily capacity defined between customer and supplier) for use of gas transport and distribution networks, regulated by law.
- Other costs and charges (rental of measuring equipment, VAT, etc.) included in the bill are defined and regularly updated by Governmental and Authority stipulation.

Each consumer pays the corresponding access tolls, depending on their pressure connection to the network and their annual consumption.

2.2 TYPE OF CONTRACTS

The most common types of contract for the natural gas for SMEs are similar to the electricity contracts:

Fixed price contracts

It is usually for customers with small and medium consumption.

Indexed contracts

Natural gas price can be indexed to variable indices of energy markets. Indices are chosen in relation to the forecast trend.

The choice of fixed or indexed price contract is up to the customer.

For SMEs **Indexed contracts with maximum price limit** (price cap) and **Indexed contracts with maximum price and minimum price** are not available at the moment.

The Italian Regulatory Authority for Electricity Gas and Water

SOURCES:

- **AEEGSI (Italian Regulatory Authority for Electricity Gas and Water) - "Annual Report on the state of services and on the regulatory activities", Book n°1 – March 2017**

(https://www.autorita.energia.it/it/relaz_ann/17/17.htm)

- **AEEGSI**

https://www.autorita.energia.it/it/index.htm

- **GME (Manager of the Energy Markets)**

http://www.mercatoelettrico.org/It/default.aspx

- **TERNA (the majority owner of the Italian high voltage and very high voltage electricity National Transmission Grid)**

http://www.terna.it/it-it/sistemaelettrico.aspx

- **SNAM (construction and integrated management of natural gas infrastructure)**

http://www.snam.it/

POLAND

3 ELECTRICITY MARKET IN POLAND

3.1 INTRODUCTION

The model of the electricity market in Poland is comparable to the one used throughout the European Union. Creation of the Energy Law in April 1997 is considered the symbolic beginning of the development of the market in Poland (Act of 10 April 1997 on Energy Law (Journal of Laws of 2012, item 1059, as amended). The law sanctioned the road map for the liberalisation of the Polish energy market, which was to move from a natural monopoly to a competitive segment.

Although important upgrades have been made to modernise the Polish energy infrastructure, considerable investments are still required to ensure a sustainable energy supply, trim the share of carbon-intensive plants and boost the exploitation of renewable energy sources. Despite major emission reductions realised over the last two decades, Poland is hesitant to support the ambitious EU climate policy targets beyond 2020. This seems to be due to its concerns about energy security and its heavy dependence on coal, of which it has the biggest reserves in the EU and which is instrumental for electricity production.

In the territory of the Republic of Poland there is one transmission system operator for electricity – PSE S.A., whose 100% of shares belong to the State Treasury. PSE S.A. provides services of electricity transmission in the territory of the Republic of Poland using mostly its own transmission network.

Wholesale market

Since 2010 a dynamic development of the commodity exchange market has been observed in the wholesale electricity market. The change of the electricity trading structure from bilateral transactions to transactions concluded on the transparent and liquid electricity exchange market proves that the electricity market is becoming more and more mature.

The wholesale market embraces power producers, energy traders, power exchanges and the balancing market operated by the Transmission System Operator (TSO). The retail market comprises the Distribution System Operators (DSOs) selling energy to tariff, third party access (TPA) customers, energy traders and TPA customers with direct access to energy producers.

Sale and purchase of electricity on the Polish market is performed mainly through the power exchange managed by TGE S.A. (Polish Power Exchange/Towarowa Giełda Energii, POLPX) in the form of standard transactions and contracts. Status of the power exchange member can be held by trading companies and energy generators, as well as big end users who can act independently after becoming a power exchange member or through the brokerage houses. Currently the status of power exchange member is held by 67 undertakings, i.e. energy generators, trading companies and brokerage houses.

In 2014 POLPX managed the following electricity sales markets: Intra-Day Market (IDM), Day-Ahead Market (DAM) and Commodity Forward Instruments Market with Physical Delivery (CFIM). Sales of electricity were also conducted in the auction system. The biggest volume of trade was conducted on the CFIM.

The total volume of transactions concluded in 2014 on all the POLPX's electricity markets amounted to 186,7 TWh and was by 5% higher that the volume of 2013, which was 176,6 TWh.

Retail market

Participants of the retail market comprise, along the end-users (both households and businesses), undertakings managing distribution network, including Distribution System Operators (DSOs), and electricity suppliers (trading companies). In 2015 there were 5 big DSOs operating on the electricity market, whose grids are directly connected to the transmission grid (DSOt) and who are obliged to separate distribution activity performed by the system operator from other types of activity not connected with electricity distribution, i.e. generation or trading activities conducted within a vertically integrated company (unbundling). Moreover, in 2015 there were 164 active companies performing the DSO function – acting within vertically integrated companies − that are not subject to the unbundling obligation (DSOn).

The biggest share in the sale of electricity to end-users was still held by the incumbent suppliers who, after the distribution network operators' unbundling, remained a party to the common service agreements, i.e. agreements combining both the provisions of electricity sale agreements and distribution agreements with customers. They perform a function of default suppliers for household consumers who had not decide to switch to a new supplier. In 2015 there were five default suppliers and over 100 alternative trading companies active in the electricity supply to end-users, including suppliers active in the household market segment. On the electricity market there are also suppliers (164 of them) acting within undertakings vertically integrated with the DSOn.

There are approximately 17,05 million of end-users. 90,3% of end-users (over 15,4 million) are the customers in G tariff group, with a great majority of household consumers (over 14,5 million) who purchase electricity for the household consumption. The rest of end-users are customers of A, B and C tariff groups. **Groups A and B** comprise customers supplied from the high and medium voltage grids, the so-called **industrial customers**, whereas **group C** are the customers connected to the low voltage grid, consuming electricity for the purpose of business activity, the so-called **commercial customers**.

The extent to which customers exercise their rights on the electricity retail market can be measured with their willingness to conclude electricity sale agreements with a freely chosen electricity supplier. Since the 1st of July 2007 Poland has had a free energy market, which means that every customer can change their energy supplier.

The customers of A, B and C groups the most actively exercise the right to purchase electricity from a chosen supplier with comparison with others customers groups (i.e. G – household).

Thanks to the information activities maintained by the Energy Regulatory Office and marketing campaigns run by trading companies, the number of energy vendor changes is growing steadily. By the end of June 2016 the number of customers who changed energy supplier was: in tariff groups A, B, C - 170 107 and in tariff group G - 427 214, increasing 7,3% among industrial customers and 9,2% in the group of households (in comparison to 2015).

3.2 TYPE OF CONTRACTS

The electricity trade assumes three main forms: bilateral contracts covering 80-85% of the total energy production, power exchange transactions accounting for 10-15% and balancing market transactions, assumed to be about 5% of total demand.

Since 2010 all electricity suppliers selling energy to final consumers have been legally obliged to publish on their websites and to make publicly available at their seats information about prices of electricity sales and terms and conditions for their application. For big industrial/commercial consumers, supply companies usually present their offer on individual basis. Prices and other terms are each time negotiated with counterparts and are different, depending on duration of supplies, volumes and firmness of take-off.

Enterprises sign a dealer contract for electricity grid connection and so-called **comprehensive agreement** covering the terms of the energy sales contract and the contract for electricity distribution services.

The sales contract should include the following provisions, among others:

- amount of energy assigned, per contractual periods,
- contractual power and conditions for its adjustment,
- price or tariff group applied,
- financial terms,
- duration of the contract and conditions for its termination.

The most commonly used terms are the **tariff groups** (so-called tariffs). The tariff of electricity is a table of fees and conditions for their application, developed by the Operator (reseller) and implemented for specific groups of customers.

Tariffs for transmission or distribution of electricity are set by licensed energy companies, according to the rules defined in the Energy Law Act and the Regulation of the Minister of Economy on detailed methods of determining and calculating tariffs and financial settlements in electricity trading (“tariff regulation”). The energy companies submit tariffs to the President of ERO (Energy Regulatory Office-URE) for approval on their own initiative or upon the request of the President of ERO.

For each category of enterprises (A,B,C) the following tariffs may be applied: flat-rate, 2-rate and 3-rate.

- **Flat-rate tariff** - tariff in which the price of energy is the same at every hour of the day. It is therefore the tariff appropriate for companies which are not able to determine the time at which the power consumption would exceed the minimum of 20% of the daily electricity consumption.
- **2-rate tariff**, in which the whole day is divided into zones which correspond to two different energy prices:
  - **2-rate tariff (rates: peak, off-peak)** day is divided into two zones: the more expensive (peak) and cheaper (off-peak). These tariffs may be cost-effective for companies which consume (or are able to consume) a large part of energy (estimated at least 25% -40% of the total daily energy consumption) during the cheaper zone.
  - **2-rate tariff (rates: day, night)**, divides the zones into nighttime and daytime. This tariff is most favourable for companies which use a significant amount of electricity at night.
  - **2-rate tariff (weekend for C group)** Companies which consume a significant amount of electricity on Saturdays and Sundays can also benefit from the weekend tariff. Under this tariff company pays a lower price for electricity in the afternoon, night, and on Saturdays and Sundays.
- **3-rate tariff** (rates: morning peak, afternoon peak, the remaining hours of the day) - is beneficial for companies which are able to identify their consumption in the morning peak zones, afternoon peak and the remaining hours of the day. Within this tariff companies pay the most for electricity during the afternoon peak and the least for the consumption in the so-called remaining hours of the day (ie. the early hours of the afternoon and night).
- **4-rate tariff** – available only to large enterprises. Not all providers offer this tariff.

4 NATURAL GAS MARKET IN POLAND

4.1 INTRODUCTION

The principles of operation of the natural gas market are drafted in the Energy Law Act and the executive regulations at national and EU level, in particular those relating to the functioning of the regulated, ie. the infrastructural part of the gas system, and calculating tariffs for gas fuels.

The gas sector in Poland has yet to complete its liberalisation process. Currently, the natural gas market in Poland includes the two main areas: distribution and gas trading. The structure of the gas sector is still highly monopolised. This is due to the market dominance of one group – PGNiG, which is involved in the transmission, distribution, trading, storage and exploration and production activities either directly or through its related entities.

In February 2013, the President of Energy Regulatory Office published the "Roadmap of Natural Gas Prices Liberalisation" making the deregulation of prices for commercial and household consumers a priority. Market conditions have improved.

The current, monopolised structure of the gas sector is not conducive to the functioning of market competition mechanisms. Although formally the customers had acquired the right to change the reseller (commercial users in 2011, household customers in 2014). In practice execution of this right is quite complicated. Despite the administrative regulation of prices of natural gas, the law permits the sales of gas below the price established in the tariff provided that equal treatment of the customers in tariff groups is assured.

Accelerating the liberalization of the domestic gas market may lead to diversification of gas supply. In 2015, the gas terminal was opened (LNG terminal in Swinoujscie), which may become the first step to the gas source diversification. The construction of the LNG terminal in Swinoujscie is the first investment of this type not only in Poland but also in Central and Eastern Europe. It will allow for the reception of LNG from virtually any area in the world, as well as its sales to other countries. Moreover, in Poland it is possible to obtain natural gas unconventionally: methane from coal deposits, as well as methane and shale gas from isolated rock pores.

Wholesale market

Sale and purchase of gaseous fuels in the Polish gas exchange market is, like in case of electricity, performed mainly on the commodity exchange managed by POLPX. The power exchange members include mainly gas trading companies and big end-users, who can act independently after concluding a relevant contract with POLPX and gaining the status of power exchange member, or through the brokerage houses. Trading on the exchange is performed through sales contracts (transactions) concluded between the members of the exchange.

In 2014 POLPX managed the following gas markets: Intra-Day Market (IDM), Day-Ahead Market (DAM) and Commodity Forward Instruments Market with Physical Delivery (CFIM). Sale of gas was also conducted within the auction system. In 2014, as a result of execution of contracts concluded on POLPX, 44 619 144 MWh of gas was delivered at the average price of 102,17 PLN/MWh.

Retail market

As in the case of electricity, gas tariffs for business customers are regulated by the President of the Energy Regulatory Office. The dominant entity which is responsible for the distribution and sales of gas is PGNiG, which supplies gas to entities of all sizes, operating in, among others: agriculture, metallurgy, trade and services, chemical and food industries. The company purchases gas from its own sources and imports fuel mainly from the East. In addition to PGNiG, the Polish gas market includes smaller energy companies, which mainly acquire gas on the domestic and foreign markets.

The end-buyers acquire the fuel gas on the basis of comprehensive agreements which include:

- prices of gas and subscription fees and conditions for their use under the tariff and
- distribution or transmission fees and conditions of use resulting from the tariff of the Operator, to whose network the customer is connected.

4.2 TYPE OF CONTRACTS

Commercial gas customers are qualified to different tariff groups, for example, A, B, S, Z, R, based on, among others:

- annual amount of fuel consumed,
- type of gas fuel consumed
- location of gas consumption,
- fixed contractual power
- financial terms applied.

For companies there are two options offered:

- **"Permanent discount for businesses - guaranteed fixed price" -** this offer is designed for customers, for whom the key need is to plan fixed costs at a certain level. It has three variants:
  - **Matched contract** - Fixed price of gas for 6 months. Short-term contract allows for quick and dynamic offer matching.
  - **Optimum contract** - Fixed price of gas for 12 months. The year is the optimum period to assess the savings.

- **Safe contract** - Fixed price of gas from 18 to 24 months. The longer the term of the contract is a guarantee of fixed costs at a certain level.

- **Offer "Flexible price, tailored to your needs"**
  Offer designed for customers with high demand for gas, for whom the key need is to adjust the consumption to individual needs.
  Contract duration: from 6 to 24 months, with customised contract duration, invoice payment date and the number of invoices, according to the customer needs.

Source:

- National Report, Energy Regulatory Office, 2015
- Taryfa ENERGA-OPERATOR SA 2015
- Energy sector in Poland, PAIZ 2013
- URE, MAPA DROGOWA uwolnienia cen gazu ziemnego, Warszawa, January 2013
- Taryfa PGNiG Obrót Detaliczny sp. z o.o. w zakresie obrotu paliwami gazowymi Nr 4, Warszawa, Warszawa, 16 czerwca 2016 r.
- https://oferta.pgnig.pl
- http://www.rynek-gazu.cire.pl/

FRANCE

5 ELECTRICITY MARKET IN FRANCE.

5.1 INTRODUCTION.

The French electricity market was opened to the competition, according to the European directives of December, 1996 ("energy package "), of 2003 and finally of 2009, by which the European Union organizes the unification of the internal market of the electricity.

In France, since 1946, the electricity was a public service mainly assured by one virtual monopoly: EDF (“Electricité De France”).

The law of February 10th, 2000, transposing an European directive, created in particular the Commission of regulation of the energy (CRE), the independent authority, asked to watch the smooth running of the market of the energy (gas and electricity) and to arbitrate the disputes between the users and the diverse developers.

The opening in the competition of the electricity market in France respected the following phasing :

- June 2000 : eligibility of any site consuming more than 16 GWh (that is a rate of opening of the market of more than 30 %).
- February 2003 : eligibility of any site consuming more than 7 GWh
- July 2004 : eligibility of companies and local authorities
- July 2007 : eligibility of all the consumers (among which the residential customers)

To note that the opening of the market to the first eligible consumers (industry) came along initially with a sharp increase in electricity prices, these consumers having previously been widely subsidized.

5.2 TYPE OF CONTRACTS

Two types of contracts are possible for customers :

- "Contract with regulated price" (with historic suppliers)
- "Contract in offer of market" (with historic or alternative suppliers).

Contracts with regulated price :

The consumers have access, in France, to prices defined by the government, on proposal of the Commission of regulation of the energy. Only the historic suppliers have to propose these prices.

There are several categories of regulated prices :

Kind of site (signed power P)	Prices
Small sites: P ≤ 36 kVA	Blue price
Average Sites: 36 kVA < P ≤ 250 kVA	Yellow price
Big sites: P > 250 kVA	• Green price A (customers connected to the distribution network) • Green price B and C (customers connected to the transport network)

Since January 1st, 2016, the regulated prices intended for the professional consumers whose signed power is superior to 36 kVA (Green and Yellow prices) disappeared under the influence of the NOME (New Organization of the Market of the Electricity) law of December 7th, 2010.

Contracts in offer of market :

Market prices result from the addition of :

- the TURPE (Price of use of the public networks of electricity), fixed by ministerial decision to proposal of the CRE)
- the price of supply which is free and depends on the supplier.

Several taxes are added to the regulated price as to the market price :

- *taxes on the final consumption*
- *contribution to the public service of the electricity (CSPE), which finance in particular the development of the renewable energies*
- *contribution of routing (CTA), fixed by ministerial decree in percentage of the price of routing of the electricity*
- *value-added tax (VAT).*

6 NATURAL GAS MARKET IN FRANCE.

6.1 INTRODUCTION.

The process of liberalization of the natural gas sector is parallel to the process of the electricity sector. In France, the supply of gas was mainly insured since 1946 by GDF (Gaz de France), which was then an industrial and commercial public undertaking in monopoly position. The opening in the competition of the natural gas market followed the same phasing.

6.2 TYPE OF CONTRACTS

Two types of contracts are possible for customers :

- "Contract with regulated price" (with historic suppliers)
- "Contract in offer of market" (with historic or alternative suppliers).

Contracts with regulated price :

The customers whose annual consumption is lower or equal to 30 MWh can sign an offer of market or an offer to the regulated Price at any time and free of charge.

The customers whose annual consumption is superior to 30 MWh are not eligible anymore in regulated price since January 1st, 2016.

Contracts in offer of market :

Fixed-price offer – Variable-price offer

A fixed-price offer is an offer which does not evolve on the duration of the contract (generally 1 or 2 years). Contrary to variable-price offer which the price follows the evolutions of regulated price or other indications in the contract.

Duale offer

It's either the combination of an offer at the regulated price for the first energy and by an offer of market for second, or the combination of two offers of market.

Several taxes are added to the regulated price as to the market price :

- *Internal tax* on the consumption of natural gas (TICGN)

- *contribution of routing (CTA)*
- *value-added tax (VAT).*

Source:

- Ministry of Energy : https://www.ecologique-solidaire.gouv.fr/
- Energy Regulatory Commission : http://www.cre.fr/
- Key figures of energy in France : http://www.statistiques.developpement-durable.gouv.fr/fileadmin/user_upload/Datalab-13-CC-de_l-energie-edition-2016-fevrier2017.pdf
- EDF : https://www.edf.fr/entreprises
- ENGIE : https://entreprises-collectivites.engie.fr/faq/ouverture-marches-de-lenergie/

SPAIN

7 ELECTRICITY MARKET IN SPAIN.

7.1 INTRODUCTION.

With liberalization of the electricity market, starting in 1997 with the 54/1997 electricity sector law, greater efficiency in investments and operation of the electrical systems are being sought. The aim is to reduce costs and, therefore, the price that final users pay for electricity, and increase the quality and reliability of supply.

The restructuration of the electrical sector means a change in the organization where the generation, transport, distribution and marketing now operate independently.

The generation and marketing of electricity are carried out in competition in the new electricity market, although transport and distribution continue to be regulated by the Government

In this new stage, all consumers can freely choose the power supplier (negotiating their contract with a retailing company) or buy straight from the production market. In any case, in addition to paying for the energy consumed it is obligatory to pay a toll or fee for access to the transport and distribution networks, regulated by the Government.

In the case of SMEs in sectors C24, C25 and C28 in most cases the purchase of electricity in the open market it is done through a retailing company.

Consumers who are engaged in the open electricity market sign a contract with the marketing company they choose, which includes the contractual conditions that are agreed and the prices to be paid for the supply. The concepts included in the agreed prices are:

- Price freely agreed with the marketing company for the purchase of electricity in the wholesale market.
- Access tolls. The consumers may hire the access to the networks with the marketing company (including this, therefore, in the invoice) or keep it with the distribution company (having to pay the toll concept, and therefore not included on the invoice). In any case the holder of the contract for access to networks is the consumer.
- Hiring the measuring and meter reading equipment. This concept may be on the invoice in the event it is hired. If the consumer opts to buy it, it will not appear on the invoice.
- Special electricity tax, established by law, is expressed as 4.864% of the total amount (supplements included). The taxable amount is made up of the result of multiplying the invoice amount by the coefficient 1.05113.
- VAT. Applied on the concepts of the invoice.

In the open market the trading company has the freedom to choose the terms included in the contract and, therefore, on the invoice/bill, so it will be very important to be clear about what concepts are included in the offer of the trading company.

Access tolls are regulated by the level of voltage and hourly discrimination. The tariff periods are defined according to the RD 1164/2001, of 26 December and the Order IET/2444/2014 of 19 December.

7.2 TYPE OF CONTRACTS

The more common types of contract are:

Fixed price offer

Both parties reach an agreement about the price of kWh. The contract must state not only the price but the volume of energy consumed. Settlement of energy, tolls, surcharges, etc., are the responsibility of the trading company.

Many clients choose this option because it is simple. However, the trading company offer this price based on estimated annual consumption and energy consumed during different periods, so deviations in the consumption profile can lead to penalisation.

These contracts generally incorporate two clauses. These clauses, common in this type of contract, are called “complement for consumption volume” and “deviations from the load curve”.

- The complement for volume is the result of estimating a volume consumption (estimate of consumption for a fixed time period). The client undertakes to consume at least a percentage of the consumption during the period the contract is valid. In the case of deviations a surcharge or a bonus may be received, depending on the direction of the variation.
- The complement for load curve: the contracted price is the result of the assessment of a consumer profile in hours Period 6 (sometimes also Period 1), which reaches a certain percentage of consumption during the contract period. Alterations in the time profile change the relative weight of consumption in each period, resulting in a percentage different from the one valued and therefore affecting the average price of the energy supplied. It may involve a surcharge or a bonus, depending on the direction of change.

Fixed-price offer with hourly discrimination

The price for each tariff period is fixed. Periods can be the traditional: peak, plain and valley hours, the 6 periods of the access toll, or anything established between the parties. It is also, as in the above type, a fixed-price contract.

The access tolls, including the power, in this case are included in the price. The liquidation of energy, tolls, surcharges, etc... are the responsibility of the trading company.

Additional terms that are indicated in the contract must be taken into account.

Offer of binomial per period

The price per kWh of energy and the price per kW of power is fixed for different periods.

It is targeted at customers with variation both in the consumption profile and the volume of consumption. The average price may be different for each month. This enables the customer to optimize the cost of energy.

Offer price-indexed "pool"

In these contracts, the price is variable and depends on the purchase price of energy in the wholesale market. In this way the risk, instead of being assumed by the trading company, is partially transferred to the client. The customer must report their daily forecasts of electricity demand, and pay the penalties stipulated in the contract for deviations incurred between the electricity requested and what is really consumed.

8 NATURAL GAS MARKET IN SPAIN.

8.1 INTRODUCTION.

The process of liberalization of the natural gas sector is parallel to the process of the electricity sector. The principles set out in European Directive 98/30 / EC for the creation of the European internal market in natural gas were incorporated into Spanish law by Law 34/1998 on the Hydrocarbons Sector, amended by Law 12/2007 to further strengthen a more competitive market.

The natural gas system includes facilities of the transport network, distribution networks, regasification plants, underground storage and other complementary facilities.

As in the case of the electricity sector, some activities are considered natural monopolies. These activities (regasification, basic storage, transportation and distribution) are subject to a system of regulated income by the Spanish government, while activities such as procurement and marketing of energy are developed in a regime of free competition.

In free retail market, trading companies sell natural gas to their customers (domestic, commercial and industrial and power plants using natural gas) under terms freely agreed by both parties.

Consumers of natural gas with more than 50,000 kWh / year annual consumption must be supplied by a trading company at free pricing.

Consumers with annual consumption below 50,000 kWh / year voluntarily have the possibility of contracting in the free market instead of last resort tariff (established by Government).

The cost components that the trading company allocates in their offers to consumers are:

- The cost of gas purchases in the wholesale market, managed by the trading companies in the wholesale acquisition (buying gas directly from producers, other traders, etc.)
- -The cost of access tolls for use of gas transport and distribution networks, regulated by law. The consumer may contract directly the access to the network and pay access tolls for their supply or may authorize the trading company to manage this on their behalf.
- Rental of measuring equipment.
- VAT. Applied to the concepts included in the bill.

In the liberalized market, the trading company is free to choose the terms included in the contract and therefore the invoice/bill, so it will be important to be clear what items are included in the offer of the trading company.

The access tolls for the transport and distribution of natural gas are regulated by RD 949/2001, and economic values are regularly updated by the government.

Each consumer pays the corresponding access tolls, depending on their pressure connection to the network and their annual consumption.

8.2 TYPE OF CONTRACTS

The more common types of contract are:

Fixed price contracts

It is usually format for customers with small and medium consumption. Both parties reach an agreement on a single price per kWh and agree on the billing terms determined by the daily amount contracted.

Indexed contracts

Similar to the case of electricity supply, in these contracts, the costs of hedging the risk of changes in prices of natural gas supply, which are usually indexed to variable indices of energy markets, are distributed.

In this way, the part of the supply price corresponding to the purchase of gas is not a fixed term, but rather the real cost or its variation with respect to the value of one or more of the following benchmarks is transferred to the consumer:

- CMP: Cost of Raw Materials for the tariff market in Spain, Spanish border.
- HH (Henry Hub): gas prices on the spot market NYMEX US
- NBP (National Balancing Point): gas prices on the spot market in the UK
- Brent: Brent crude international quote

Indexed contract with maximum price limit (price cap)

It is a variant of contract indexed to energy market values (oil prices, gas prices in spot markets, etc.) but with a maximum price limit, which gives some assurance to consumers on upward price fluctuations in international oil and gas markets.

Indexed contract with maximum price and minimum price

It is a variant of contract indexed to energy market values (oil prices, gas prices in spot markets, etc.) but with a maximum price limit and a price floor, which gives some assurance to consumers on upward price fluctuations in international oil and gas markets, but it does not allow you to fully benefit from a significant drop in prices.

SOURCES:

- Ministerio de Energía, Turismo y Agenda Digital. http://www.minetad.gob.es/energia/es-ES/Paginas/index.aspx
- OMIE. http://www.omie.es/inicio
- IDAE. http://www.idae.es/
- Comisión nacional de los mercados y la competencia. CNMC. https://www.cnmc.es/ambitos-de-actuacion/energia

OTHER EU COUNTRIES

For other countries of the EU, it is possible to check the following website:

http://eur-lex.europa.eu/summary/chapter/energy.html?root_default=SUM_1_CODED=18

ANNEX VI

ENERGY AUDIT REPORT

In drawing up the Energy Audit Report you are recommended to follow the index as outlined below:

1. Introduction and applicable legislation

The EE-METAL project aims to provide enterprises with innovative technical, commercial and financial tools in order to overcome existing barriers that hinder the adoption of energy saving measures.

The EE-METAL project actions are mainly targeted at Metalworking and Metal Articles (MMA) SMEs, given that this sector is the biggest manufacturing sector in Europe and is mostly composed of SMEs.

One of the actions included in the technical tools is to carry out an energy audit.

In this sense, the company XXXXXXX S.L., has been selected to carry out an energy audit at the plant that it has in XXXXXXX XXXX, and whose activity is XXXXXXXX (NACE XX).

The energy audit was made according to the specific methodology developed in the project EE-METAL. This methodology is based on the UNE EN 16247 Part 1 "Energy audits: General Requirements" and Part 3 "Energy audits: Processes"

This audit includes energy analysis of plant facilities, both auxiliary and process, in relation to the use of energy and efficiency, to propose improvement actions, with assessment of profitability based on the generated energy savings.

The development of the energy audit is framed as an initial action, within the scope of the EE-METAL project to reduce energy consumption.

2. Objectives, boundaries and phases of an energy audit

Objectives

The main objective of an energy audit is to reduce energy consumption and costs associated with it, analysing the causes and factors affecting such consumption, without affecting the production or the quality of the service.

Therefore, with this audit we intend to achieve the following objectives:

- To obtain reliable knowledge of the energy consumption of the company and the cost, identifying the factors that influence energy consumption and introducing energy performance indices;
- To detect and evaluate different energy saving opportunities.

Boundaries

Boundaries of the energy audit in each company will be established. At this point, the systems and/or equipment included in the audit will be listed and described, as well as energy analyses performed.

Phases

To carry out this energy audit we performed the following steps:

1. Preliminary contact and initial meeting with the company.
2. Data collection
3. Preliminary analysis
4. Field work
5. Energy analysis
6. Report and final meeting

3. General Company. Production and operation mode.

It will include the following elements:

GENERAL DATA OF COMPANY		
Company name		
NIF (tax identification number)		
Address		
City		
Region		
Postcode		
Country		
Contact person		
Phone number		
e-mail		
web		
Nace code (2009)		
Activity sector		
Main activity of the company. Description		
Age of the company		age
Number of employees		people
Plant surface		m^2
Annual energy consumption 2014		KWh/year
Annual energy cost 2014		€/year
Percentage of energy cost on total cost (2014)		%
Production value 2014		€
Annual energy consumption 2015		KWh/year
Annual energy cost 2015		€/year
Percentage of energy cost on total cost (2015)		%
Production value 2015		€

OPERATION MODE		
Working hours		
Hours / day		h/d
Days / week		d/w
Days / year		d/y
Hours / year		h/y

PRODUCTION DATA														
		2014												
Type of raw materials	Type of unit	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual consumption 2014
		2015												
Type of raw materials	Type of unit	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual consumption 2015

		2014												
Type of finished product	**Type of unit**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Annual production 2014**
		2015												
Type of finished product	**Type of unit**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Annual production 2015**

4. Description of production process. Block diagram.

   A) Description of the production process of the company, including energy consumption equipment, power of equipment, operating mode, temperatures of flue / gases ....

   B) Description of auxiliary facilities, including energy consumption equipment, power of equipment, operating mode, ….

   C) Preparation of block diagram with the sequence of the most important phases. Included in each phase is the type of energy consumed, amount, %, ...

5. Consumption and energy costs

   A) Analysis of the electricity and fuels used in the company and its monthly energy distribution as well as usage points. Monthly data for the years 2014 and 2015 are used.

   B) Study of billing and hiring of different energy sources.

   Obtaining the following consumer graphics

- Graph of monthly consumption of each energy source. Line chart or column chart.
- Graph of annual consumption with percentage distribution of each energy source (%, pie chart)
- Graph of annual energy cost with percentage distribution of each energy source (% pie chart)
- In the case of electricity consumption, if possible, a graph of hourly consumption during a typical week. Line graph.

In addition, the following annual data will be obtained, relating production to consumption and energy costs:

- Specific thermal cost and consumption:

Annual production:	t, piece, ...
Annual thermal consumption:	GWh
Hours of use:	h
Annual thermal cost:	€
Specific thermal consumption:	GWh/t, GWh/piece, …
Specific thermal cost:	€/t, €/piece, …

- Specific electrical cost and consumption:

Annual production:	t, piece, ….

Annual electrical consumption (including self-consumption from renewable sources):	GWh
Hours of use:	h
Annual electrical cost:	€
Specific electrical consumption:	GWh/t, GWh/piece, …
Specific electrical cost:	€/t, €/piece, …

- Specific energy consumption and cost:

Annual production:	t, piece, ….
Total annual energy consumption:	GWh
Total annual energy cost:	€
Specific energy consumption:	GWh/t, GWh/piece, …
Specific energy cost:	€/t, €/piece, …

6. Energy facilities (Reception facilities, auxiliaries and process)

   In this section, a tour of all the facilities where there is energy consumption is carried out, describing the main consumption equipment and their characteristics.

   5.1.- Reception facilities: equipment or systems directly involved in energy supply (example: transformers, electrical substation, fuel supply systems, renewable energy systems, etc.)

   5.2.- Auxiliary facilities (horizontal technologies and services): equipment supporting one or more manufacturing process (example: compressed air system, boilers for steam production, air extraction system, electric motors, etc.) and systems that indirectly affect manufacturing process (example: office, lighting, indoor heating and cooling etc.)

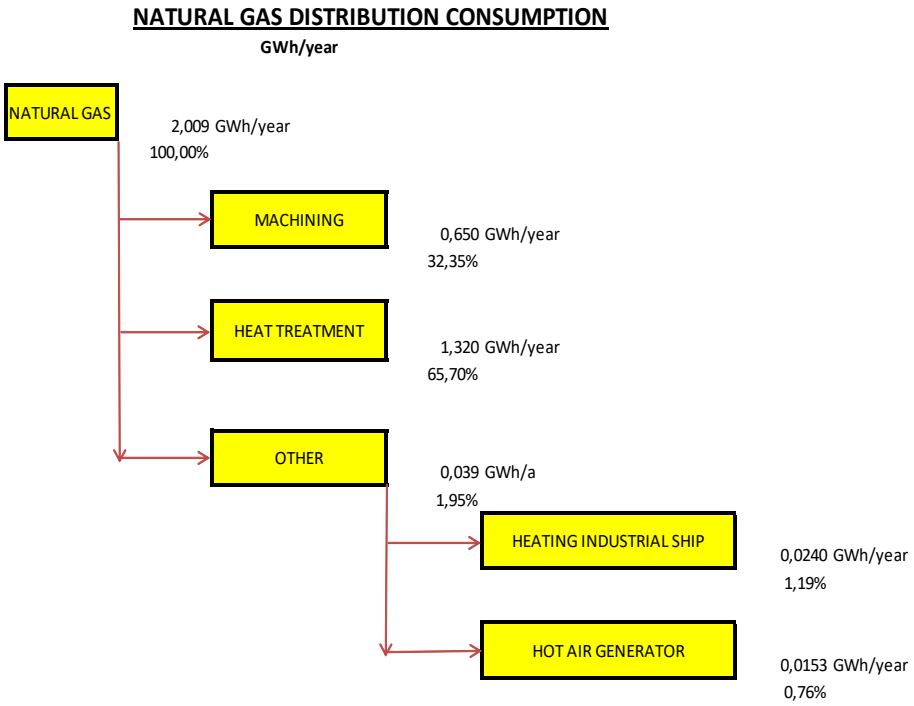
   5.3.- Process facilities: equipment directly involved in a specific manufacturing process (example: transfer machines, press, furnaces, dryers, etc.)

7. Energy distribution

   In this section, the energy distribution of each type of energy among the various consuming equipment is carried out.

   To this end, flow charts of use are performed with absolute and percentage data.

e.g.



A graph of hourly distribution of electricity consumption during a typical week will be carried out. In this graph, day and night consumption on weekdays and on Saturdays and Sundays will be shown.

8. Energy Analysis

In this section, an analysis of the facilities subject to improvement, based on the data provided by the company and the measurements and the study of possible energy improvements is carried out.

e.g.

Energy analysis of furnaces

Machining energy analysis

Heating energy analysis of plant

Energy analysis of heating generator

Study of main electric motors, more efficient, variable speed use

Study of lighting system

Study of automation facilities

Possibility of changing energy source

Energy contracting optimization

…..

9. Good Practices

A series of best practices for energy savings will be established.

10. Summary of savings and investments

A chart-summary, where savings and necessary investments is shown in order to carry out saving measures described above, and the period of return on such investments.

The energy saving measures will be arranged in descending order of NPV

Saving measure	Final energy saving (GWh/year)	Primary energy saving (GWh/year)	Primary energy saving (Tep/year)	Cost savings (€)	Investment (€)	Gross amortization period GP (years)	Net Present Value NPV

Note:

The total annual primary energy saving of the company will be calculated by each partner in their own country.

To obtain total annual primary energy saving (GWh), the following conversion factors will be used:

- Electrical primary energy saving = Electrical final energy saving x specific conversion factor for each country (e.g. Spain factor 2014 =2,403 source: IDAE)

- For fossil fuel, the Net Calorific Value is always used.

Natural Gas (NCV) = 34,493 MJ/Nm^3 (Spain)

Natural Gas (NCV) = 36,385 MJ/m^3 (Spain)

Gas/diesel oil (NCV) = 43,38 GJ/t

For others energy sources, units and conversion factors: see "Energy Statistics. MANUAL. Annex 3. Units and Conversion Equivalents" from INTERNATIONAL ENERGY AGENCY, ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT and EUROSTAT. 2004 edition.

https://www.iea.org/publications/freepublications/publication/statistics_manual.pdf