SCOoPE Saving Cooperative Energy

State of the art on Industrial Energy Assessment (EN 16247:2012)

Webinar nº 1

circe
RESEARCH CENTRE FOR ENERGY RESOURCES AND CONSUMPTION

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 695985

SCOoPE Saving Cooperative Energy

CONTENTS

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

Saving Cooperative Energy

1. What is an energy audit?

Concept (European Standard EN 16247-1:2012)

Energy Audit:

Systematic inspection and analysis of energy use y consumption in a location, building, system or organization, in order to:

- Identify and inform about the energy flows
- Identify potential for improvement of energy efficiency

Energy Auditor:

Person, team or organization who develops an energy audit. (requirements: capability, confidentiality, impartiality, transparency)

Competence of energy auditors in EN 16247-5

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

1. What is an energy audit?

General objectives

Reasons to develop an energy audit:

- Reduce energy consumption
- Reduce energy costs
- Reduce environmental impact: raw materials, CO_2, etc.

- Obtain deeper knowledge about your processes and facilities
- Optimize operation and extend working life of equipment

- Comply with legislation or voluntary obligations

Specific objectives and scope must be stated by the auditor and the company being audited in each case.

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

1. What is an energy audit?

Specific Objectives

1. **Describe processes and facilities in energy aspects**.
   - Set up an **inventory** with main features of energy equipment.

2. **Analyse energy use and consumption:**

   What energy sources?, How much?, How? and Where?

   - Analyse energy supply.
   - Analyse and define operating conditions of equipment.
   - Identify inefficiencies.

3. **Develop the Energy Balance by processes or equipment.**
   - Additionally: develop Baseline and Energy Performance Indicators.

4. **Proposal of Energy Efficiency Measures** (EEM), including energetic and economic assessment in each.

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

SCOoPE Saving Cooperative Energy

1. What is an energy audit?

European Directive 2012/27/UE

Objective: 20% increase of EE in UE until 2020 → challenging...

- Non-SME companies → must perform energy audit, except those with existing Energy/Environmental Management Systems:
  - Before 05/12/2015 → Spain already out of time! **Until 13/11/2016**
  - Must be renewed every 4 years
- Certification for energy services suppliers and energy auditors.
- Promotion of EE in heating and cooling: Strengthening of district heating and cogeneration systems.
- Metering of energy consumption in thermal facilities.

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

1. What is an energy audit?

European Directive 2012/27/UE
(transposition in Spain: RD 56/2016, 13/02/2016)

Minimum requirements for energy audits:

- Based in operational data that are measured, updated and verifiable:
  - Energy consumption
  - Load profile of electrical consumption (if possible)
- Detailed consumption analysis of buildings and facilities, including internal transport.
- Consider Life Cycle Costs, if possible.
- Representative enough in order to develop a reliable analysis of the current situation an the energy efficiency opportunities.
- Allow detailed calculations for EE measures.

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

1. What is an energy audit?

European Standards EN
(higher than European Directive requirements)

- UNE-EN 16247-1 (2012). Energy audits. Part 1: General requirements
- UNE-EN 16247-2 (2014). Energy audits. Part 2: Buildings
- UNE-EN 16247-3 (2014). Energy audits. Part 3: Processes
- UNE-EN 16247-4 (2014). Energy audits. Part 4: Transport
- UNE-EN 16247-5 (2015). Energy audits. Part 5: Competence of energy auditor.

1. What is an energy audit?

EN Standard 16247-1

Contents

Quality of the auditor an the audit

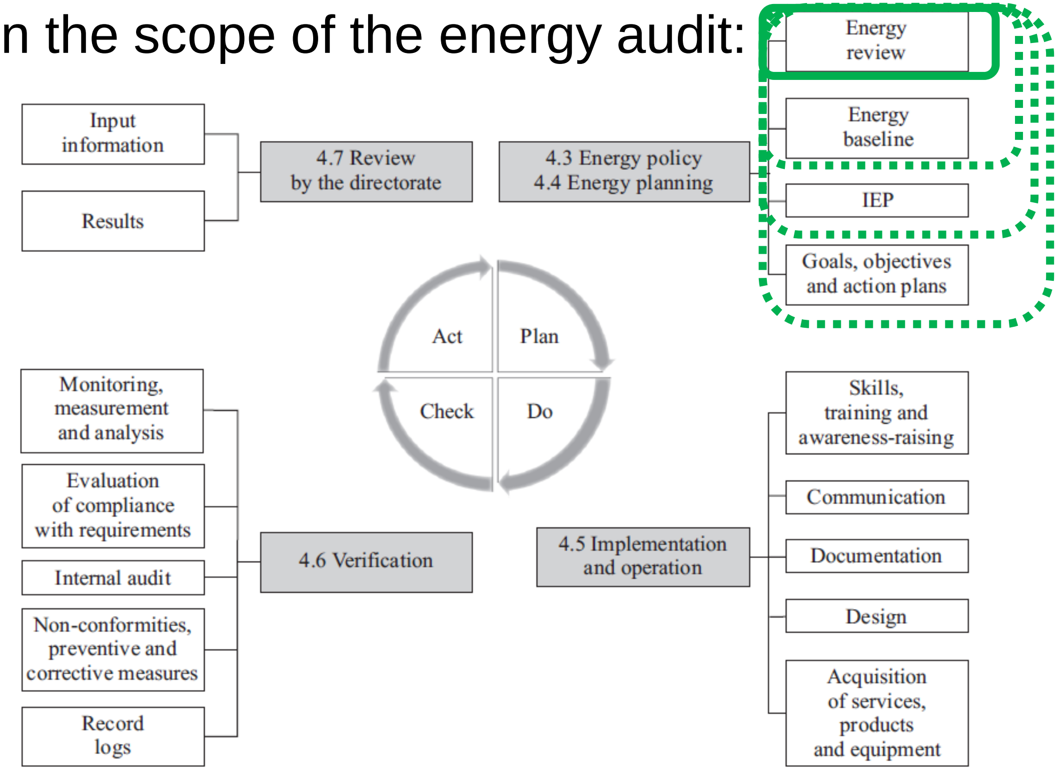
Steps in the energy audit process

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

1. What is an energy audit?

Connection with ISO 50.001: Energy management systems

Depending on the scope of the energy audit:



Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

1. What is an energy audit?

Positive issues in energy audits

- **Energy efficiency is transversal** to all production sectors: knowledge and know-how in energy is transferred to companies.
- **Win-win**:
  - The audit team: work consolidation and specialization.
  - The company being audited: energy and economic savings, higher knowledge and communication.
  - Manufacturing and installer companies: potential collaboration due to energy audits.
  - Environment and society: reduction of energy consumption and CO_2 emissions → help to prevent climate change

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

1. What is an energy audit?

Hot spots in energy audits

- **Scope definition** of the energy audit between companies: it must be very clear so there will be no “surprises”
- **Staff members** of the company **designated** to the audit: they must be committed and have some time reserved.
- **Auditors**: must be capable of doing what is agreed in the scope.
- Documentation of **occupational risks between companies**: must be managed before the audit starts.

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

2. Before an energy audit

The customer…

- Defines type of energy audit: buildings, industry, transport, etc.
- May be private or public sector (existing data, external factors (elections, working pressure), impact of measures, etc.).
- Will decide future investments on energy efficiency measures proposed by the auditors.
- Must appoint a person/s responsible for guiding auditors though the facilities, collect and deliver requested data, coordinate involved areas.
- The appointed should have some technical knowledge and expertise, as well as commitment and time reserved for the audit.

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

2. Before an energy audit

The customer…

- **Variety of industrial sectors** :
  - In Spain: CNAE classification
  - i.e.: agroindustry, iron, chemical, etc.
- **Information** sources:
  - BREF documents (European Comission): Reference document on BATs (Best Available Techniques)
  - Technological guides

BREF Documents

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

SCOoPE Saving Cooperative Energy

2. Before an energy audit

<u>The auditor team</u>:

- Must have a high technical level, and multidisciplinary work team (thermal and electrical facilities, processes, renewable en., etc.).
- Requires the confidence in all levels of the audited company.
- Should have also commercial skills.
- **Obligations of the auditor team:**
  - Inform about the audit plan.
  - Minimise interferences in the day-to-day operations.
  - Follow specific issues about occupational risks in the company.
  - Develop the audit with the agreed scope in the agreed period.

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

This pubblication reflects only the author's view.
The EASME is not responsible for any use that may be made of the information it contains.

2. Before an energy audit

Necessary equipment for auditors

- Depending on the audit scope and objectives, as well as previous information.
- Examples: grid analyser, flue gas analyser, luxmeter, flowmeter, termohygrometer, thermographic camera, etc.
- **It is NOT absolutely necessary for performing the energy audit.**

Previous necessary Documentation

- Confidentiality agreement.
- Exchange and registration of Occupational Risks documentation between de auditing and the audited companies.

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

2. Before an energy audit

Define the scope of the energy audit

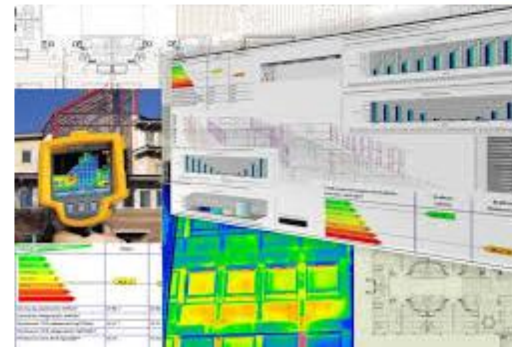
- Scope definition depending on :
  - Needs of the company and previous information available.
  - Competences and equipment of energy auditors.

Specifically:

- Depending on systems included and detail level:
  - Global audit: absolutely everything
  - Audit of specific production processes
  - Audit of auxiliary processes: HVAC equipment, lighting, compressed air, etc.
- Depending on the BUDGET
  - Budget for energy audit with the agreed scope
  - Budget for energy audit and deployment of measures (by ESCOs)
  - Subsidies
  - It may be called an energy “assessment”, “analysis”, “audit”, etc.

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

2. Before an energy audit



Initial Checklist

Does the company have info about…?

- General info?

- Diagrams of electric and thermal facilities?
- Equipment inventory?
- Operating parameters?

- General consumption metering? Indicators?
- Metering or monitoring systems by processes?

- Previous energy audits or assessments.
- Energy Efficiency measures already developed or planned

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

This pubblication reflects only the author's
The EASME is not responsible for any use t
ns.

3. Developing an energy audit

Steps of the energy audit (i)

KICK-OFF MEETING

- Auditor: request general info and inform about the energy audit.
- Final agreement about objectives, scope, periods, practical aspects.
- Company: appointment of the person in charge of the audit.
- Plan visits and corresponding requirements.

DATA GATHERING (DOCS)

- Data about energy consumption (bills): electricity, fuel, gas…
- Documentation about facilities, processes, equipment.
- Electric, thermal and process diagrams, etc.
- Data about previous measurements, maintenance operations, etc.
- Previous energy audits or assessments.

DATA GATHERING (FIELDWORK)

- Inspection of processes and facilities.
- Equipment identification and operation assessment.
- Performing of measurements when required.
- Initial ideas of energy efficiency measures.

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

SCOoPE Saving Cooperative Energy

3. Developing an energy audit

Steps of the energy audit (ii)

ANALYSIS, BALANCES AND EEMs

- Data analysis: docs, measurements, etc.
- Description of current situation: operating conditions, energy inventory and balances, energy indicators, etc.
- Description of inefficiencies and incidences.
- Proposal of Energy Efficiency Measures.

REPORT

- Meeting the objectives and terms
- Document the whole work: data collected, measurements done, analysis, assumptions made, calculation methodology, assessment of the proposed EEMs.

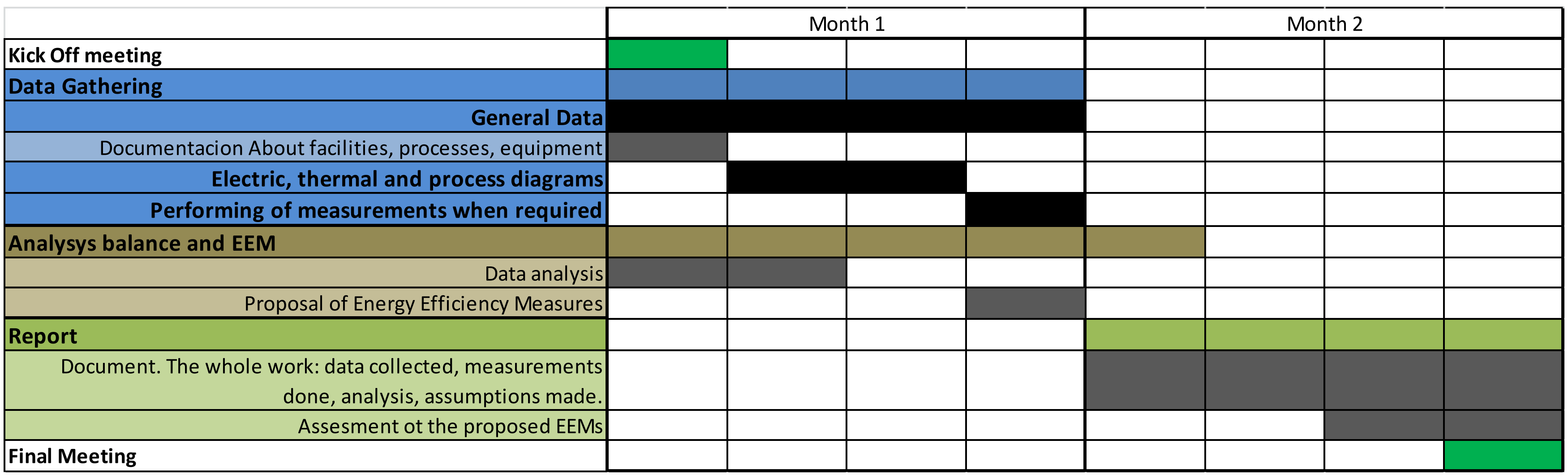
FINAL MEETING

- Report delivery
- Presentation of results and explanation
- Discussion, conclusions and future options.

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

Gantt diagram. Example



Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

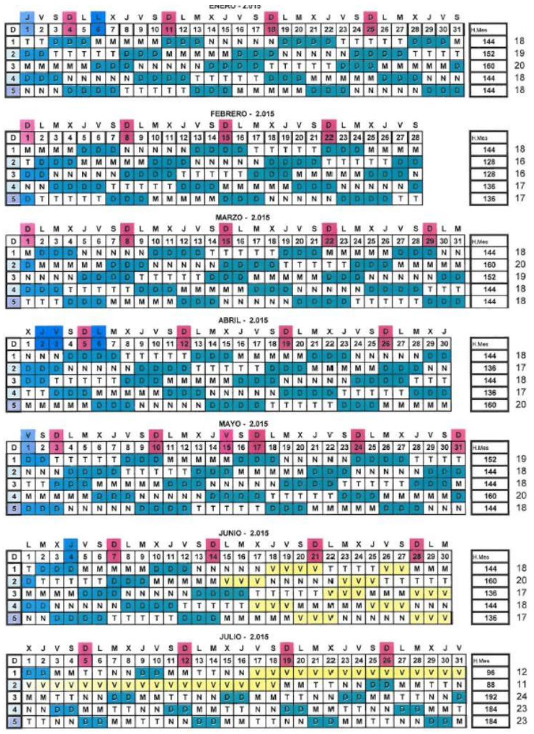
This pubblication reflects only the author's view.
The EASME is not responsible for any use that may be made of the information it contains.

3. Developing an energy audit

Data gathering

General information of the company

- Sector
- Number of employees
- Calendar and timetable
- Processes and facilities involved
- Annual/monthly production
- Global energy supplies and bills
- Other…



Saving Cooperative Energy

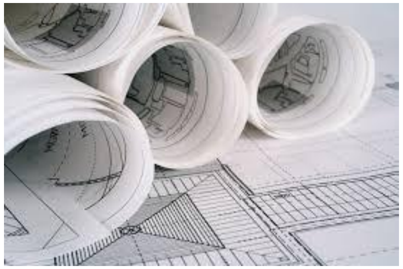
3. Developing an energy audit

Data gathering

Technical data: schemes and diagrams of facilities

(depending on scope and objectives)

- Plant and processes layout drawings
- Electric wiring diagrams, including equipment and meters
- Gas distribution diagrams, including equipment and meters
- Water distribution diagrams (piping, pumps, cooling towers)
- Compressed air diagrams
- HVAC diagrams



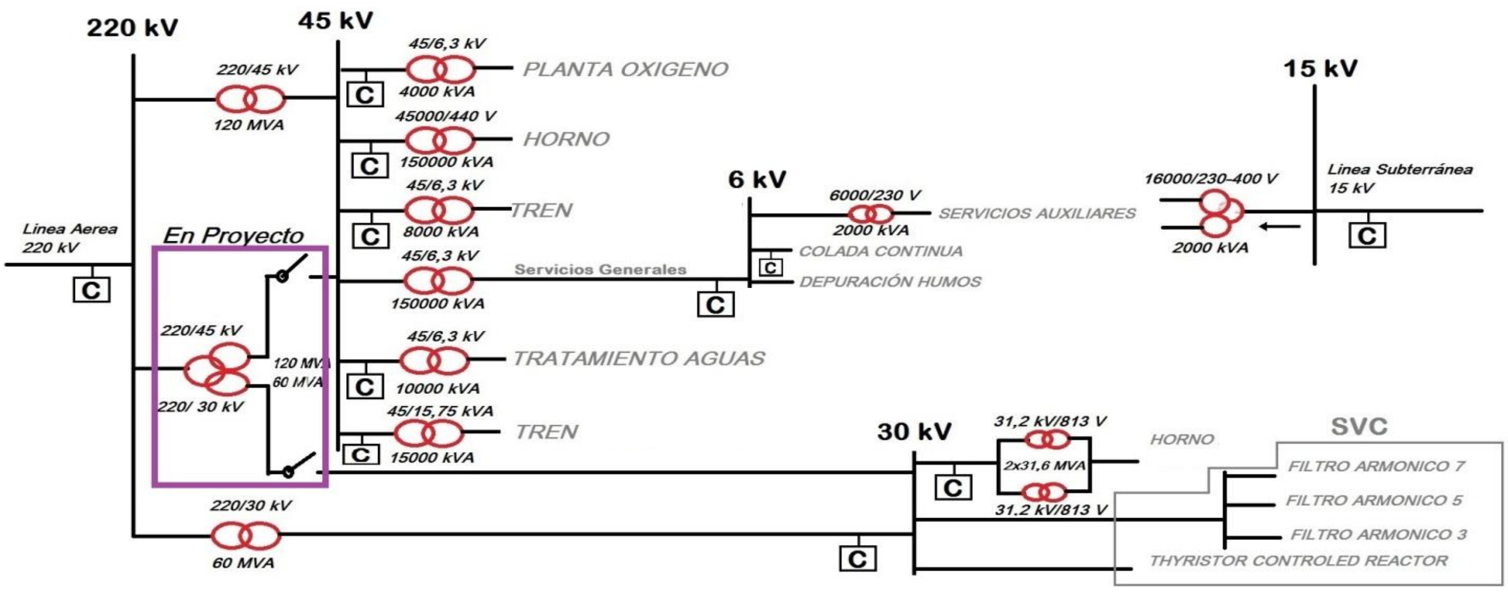
Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

Data gathering

Technical data: schemes and diagrams of facilities

Example. Simplified electrical diagram with equipment and meters



Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

Data gathering

Technical data: equipment inventory

(depending on scope and objectives)

- Construction elements of building: envelope, materials, etc.
- HVAC: number, type, model, power, working hours, age, COP, use and maintenance.
- Lighting: number, type, model, power, working hours, age, location, accessories.
- Boilers: number, type, model, power, working hours, age, efficiency (nominal and operating), applications, yearly consumption.
- Engines: number, type, model, power, working hours, age, IE class, constant/variable torque, Variable Speed Drive.
- Specific data of process equipment

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

Data gathering

Consumption data (energy)

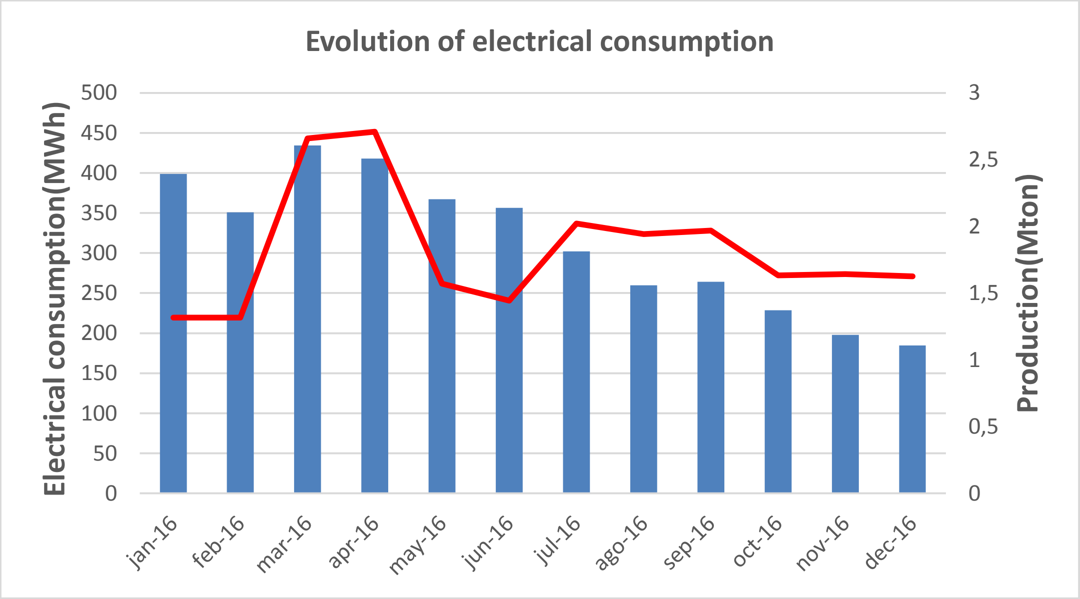
- Data from bills and/or meters by type of energy and by process/systems: electricity, gas, etc.
- Global energy consumption(monthly data) during a complete cycle, at least 1year before energy audit.
- Specific process/equipment energy consumption by means of internal meters.

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

Data gathering

Consumption data (energy)



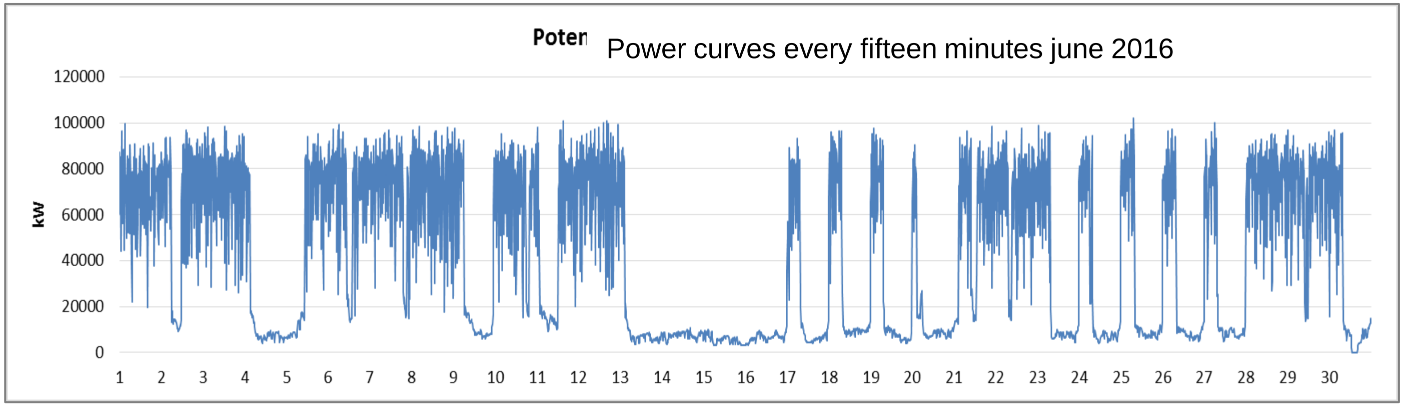
Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

Data gathering

Load curves (power)

- Data from **monitoring systems** in different processes/equipment: electricity, gas, fuel, etc.
- **Analysis** of processes/systems real operation and inefficiency detection.



Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

SCOoPE Saving Cooperative Energy

3. Developing an energy audit

Data gathering. Measurements

Why measure? Depending on the scope and objectives.

- It is not always necessary
- It is necessary if there is no information enough to:
    - Develop energy balance in a reliable way
    - Analyse real operating conditions of equipment
- It is necessary to detect inefficiencies and incidences:
    - In electric facilities
    - In thermal facilities
    - Other parameters

How measure?

- In adequate conditions, depending on the objective: normal operating conditions, under specific load, specific climate, etc.

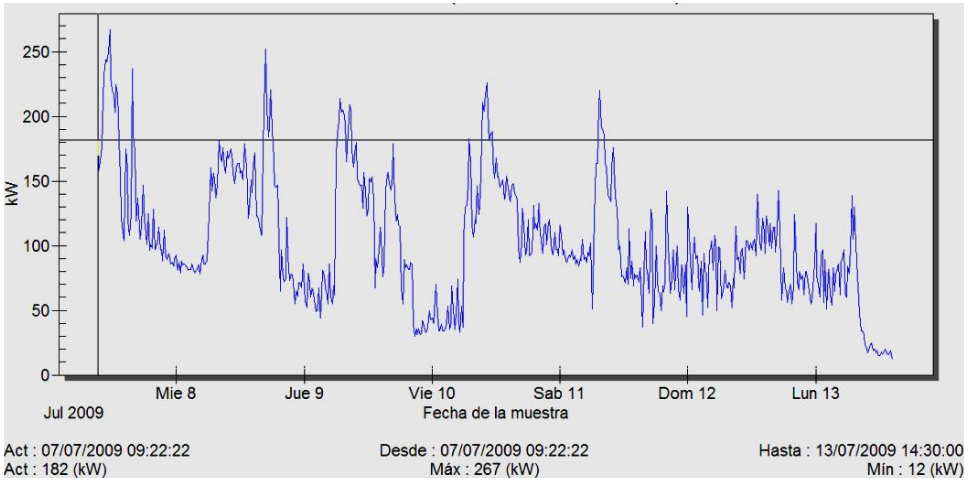
Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

Data gathering. Measurements

Grid analyser, example in a variable torque engine

- Curve load analysis, real operation in power and time, load factor.
- Power factor (reactive energy), balancing of power lines, grid quality, harmonics, stand-by consumption, etc.



Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

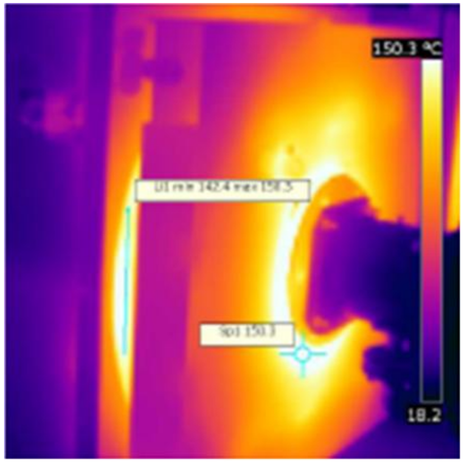
3. Developing an energy audit

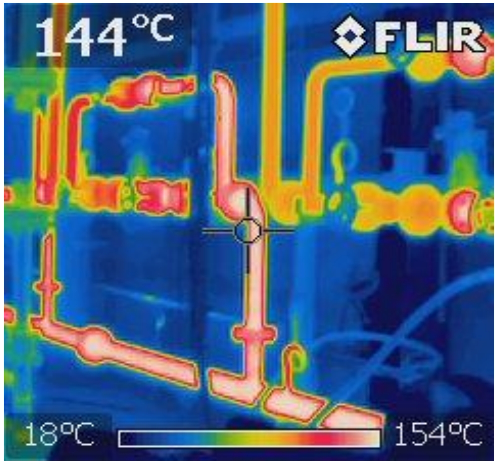
Data gathering. Measurements

Thermographic camera…

In thermal facilities: Boilers, cooling equipment, building envelope, piping:

- Insulation inspection, thermal bridges.
- Heat losses assessment





Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

SCOoPE Saving Cooperative Energy

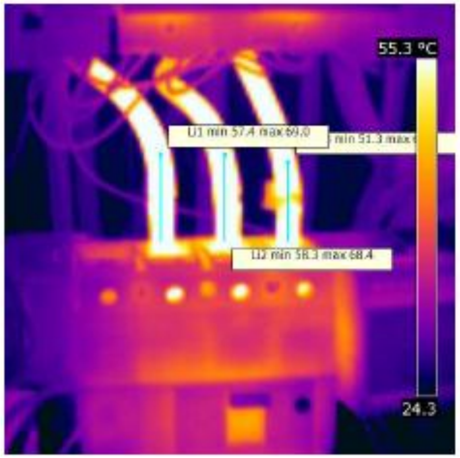
3. Developing an energy audit

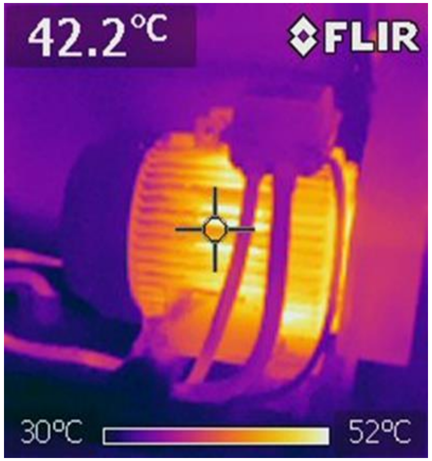
Data gathering. Measurements

Thermographic camera…

In electrical systems:

- Facilities inspection, inadequate maintenance
- Inadequate project design





Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

Data gathering. Measurements

Flue gas analyser

- Combustion assessment and emission analysis
- Efficiency of boilers/furnaces

06.07.10 14:29h

Comb: GasNatural

77.3 °C Temp.Humos
7.5 % ContenidoCO2
4.3 % Per.porhumos
1.59 Exceso aire
7.8 % O2 -cont.
46 ppm CO -cont.
73 ppm CO correg.
-0.019hPa TiroHumos
27.4 °C Temp.Amb.
95.6 % rendimiento
46 ppm CO -cont.

CONFORME USUARIO

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

SCOoPE Saving Cooperative Energy

3. Developing an energy audit

Data gathering. Measurements

CO_2 meter

- measures CO_2 concentration in air, for air quality assessment

CO meter

- measures CO concentration in air closed to combustion processes, for safety reasons.

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

Data gathering. Measurements

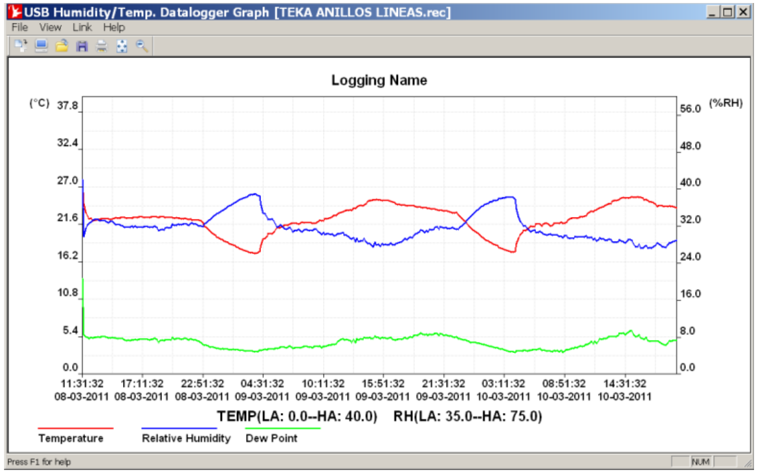
Measurement of thermal parameters in buildings

(temperature, humidity, air velocity, etc.)

- HVAC consumption analysis
- Control air infiltrations

termohygrometer

anemometer



Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

Data gathering. Measurements

Measurement of thermal transmittance of building envelope

- HVAC consumption analysis
- Envelope analysis

Transmittance meter

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

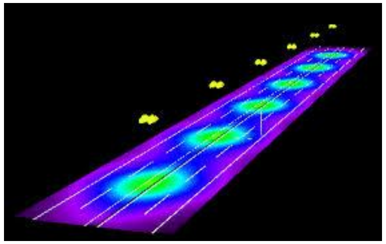
3. Developing an energy audit

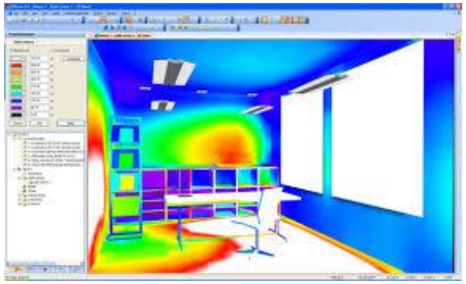
Data gathering. Measurements

Luxmeter: measure of **lighting level**, indoors and outdoors.

- Checking required lighting levels
- Assessing EEMs of lighting substitution

Dialux Simulation





luxmeter

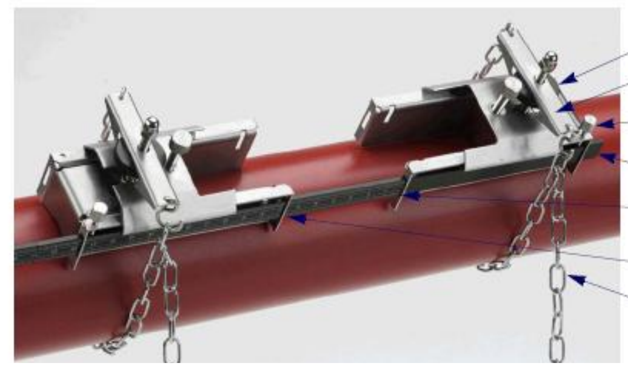
Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

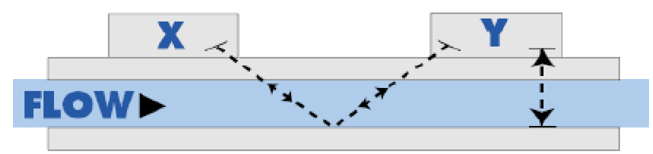
Data gathering. Measurements

Flow metering in thermal facilities (non-intrusive).

- Analysis of operating conditions in piping
- Incidences detection



Ultrasound flowmeter



Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

SCOoPE Saving Cooperative Energy

3. Developing an energy audit

Analysis

On the basis of collected info…

- delivered by the company
- gathered on-site
- from measurements on-site

… Following issues will be analysed:

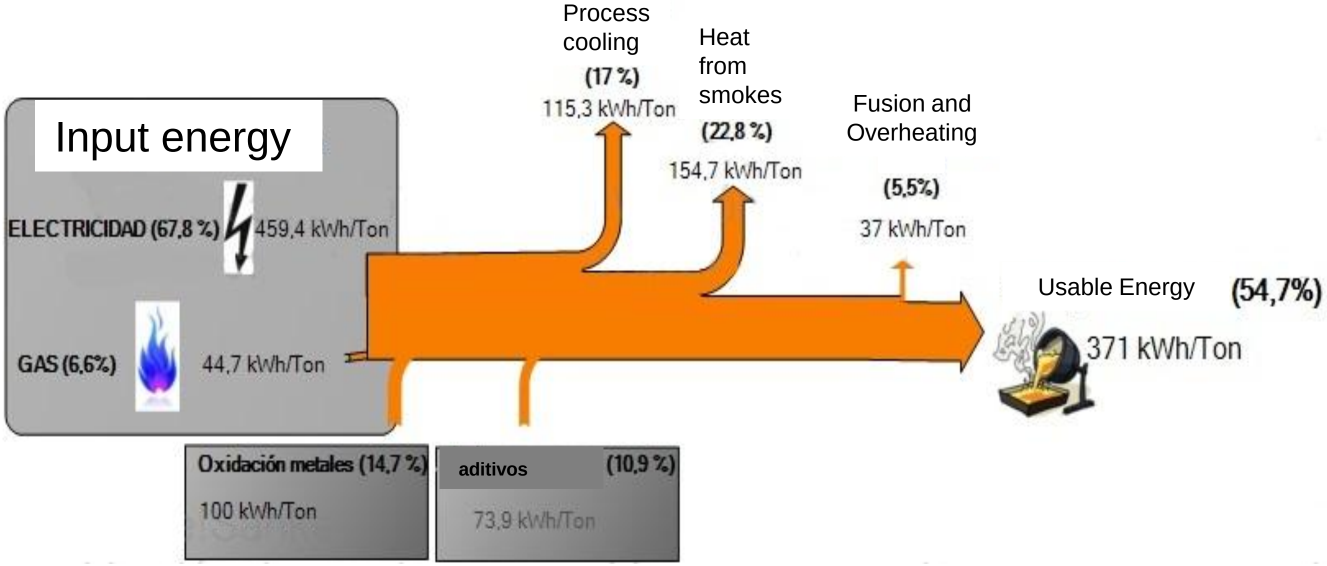
- Energy supplies
- Real operating conditions and load curves of the main equipment
- Energy balances of the main equipment
- Registration of inefficiencies and incidences in equipment
- Energy inventory by source, process, equipment, significant uses
- Energy Performance Indicators (IEP)
- Base Line

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

Analysis. Examples

- Consumption analysis depending on variables
- Energy balance of main processes. Sankey diagram



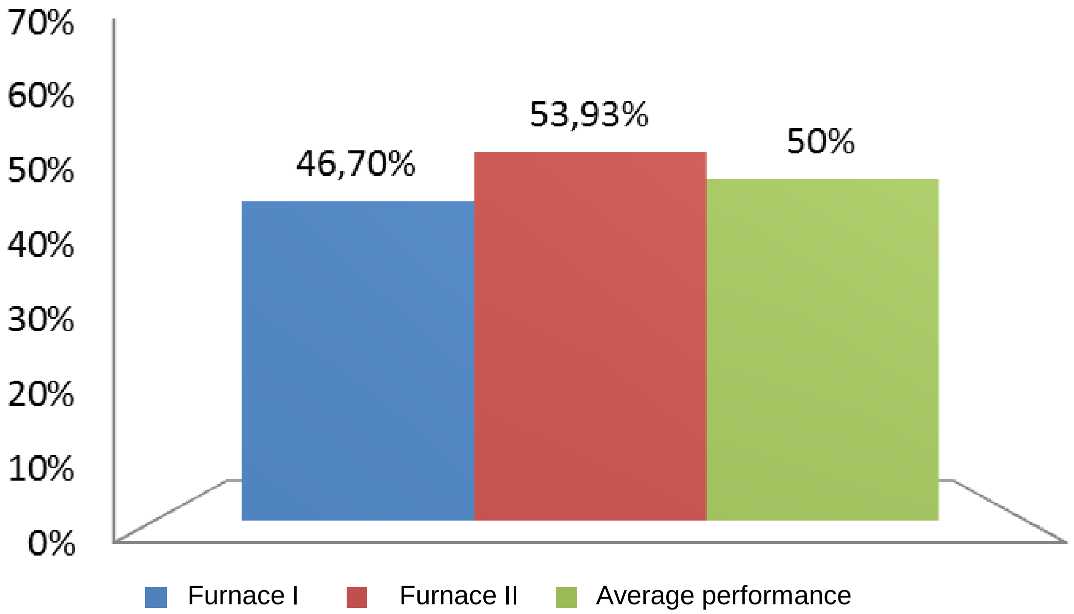
Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

SCOoPE Saving Cooperative Energy

3. Developing an energy audit

Analysis. Examples

- Efficiency of main process and comparison with benchmarks
- Example: melting glass furnaces

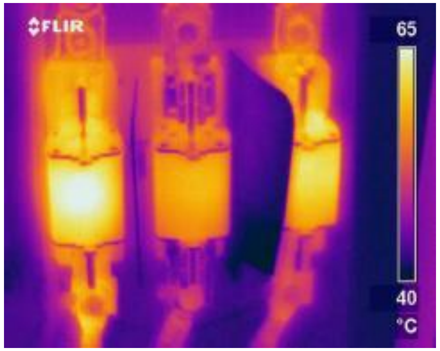


Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

Analysis. Examples

- Inefficiency and incidence detection and reporting
  - Related to safety
  - Related to energy efficiency, without EEM.
  - Related to energy efficiency, with corresponding EEM.



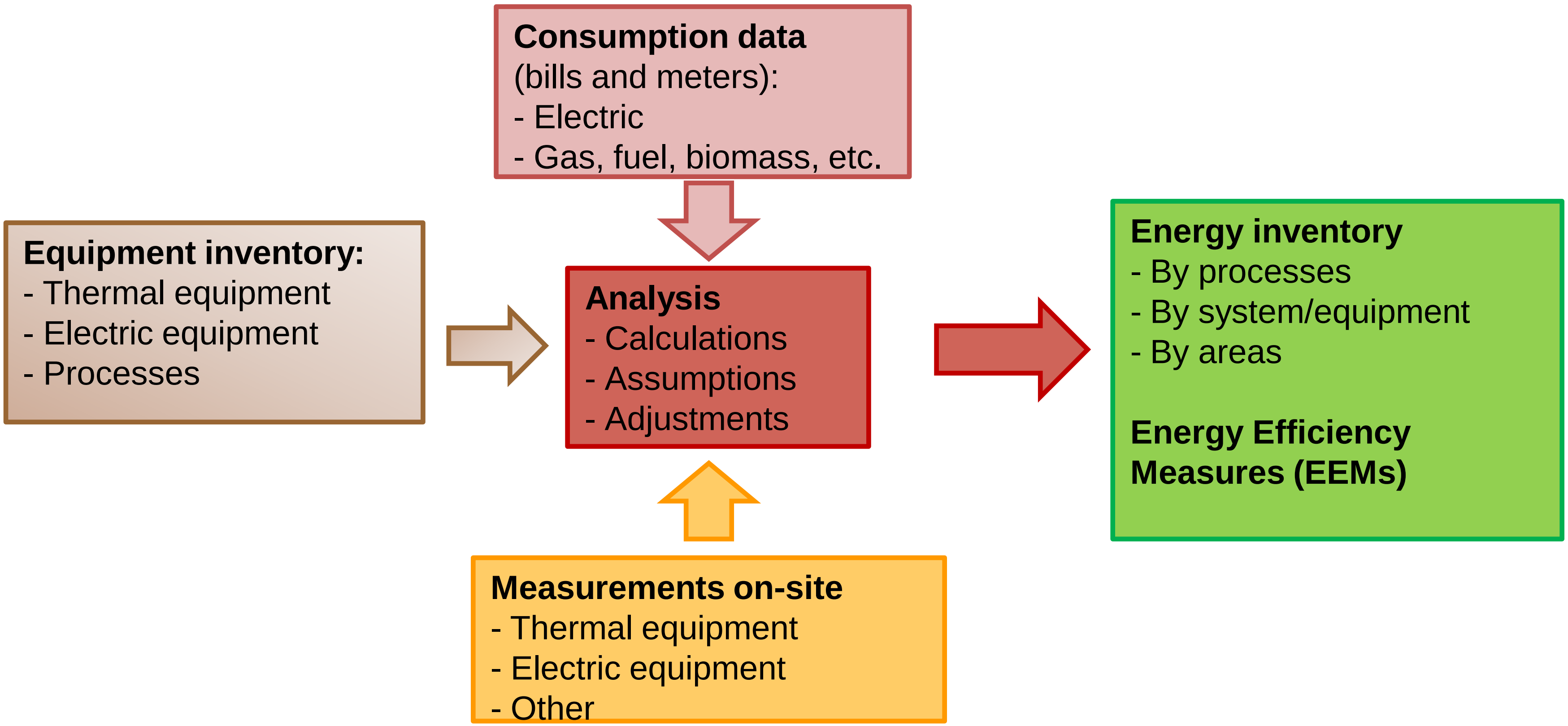
Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

Saving Cooperative Energy

3. Developing an energy audit

Energy inventory

- Breakdown of energy consumption, disaggregated by processes, systems, equipment, areas or other classification.



Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

SCOoPE Saving Cooperative Energy

3. Developing an energy audit

Energy inventory

- The consumption metered should match the consumption calculated with power and operation hours of each equipment

$$E = P \cdot t$$

- What E?
  - Metered E?
  - Assumptions made?

$$E = P_N \cdot f \cdot t$$

- What P?
  - Nominal power?
  - Measured real power?

$$E = P_N \cdot t_{eq}$$

- What t?
  - Suggested by user?
  - Measured in an adequate period?

Calculation process:

- For each source, pre-calculate global consumption as an aggregation of equipment consumption ($E_{global}=P_1 \cdot t_1 + \dots + P_n \cdot t_n$)
- Compare with global energy consumption metered for each source
- Fix consumptions that are absolutely certain (depending on info).
- Adjust consumption of the rest: proportionally, make assumptions, ...

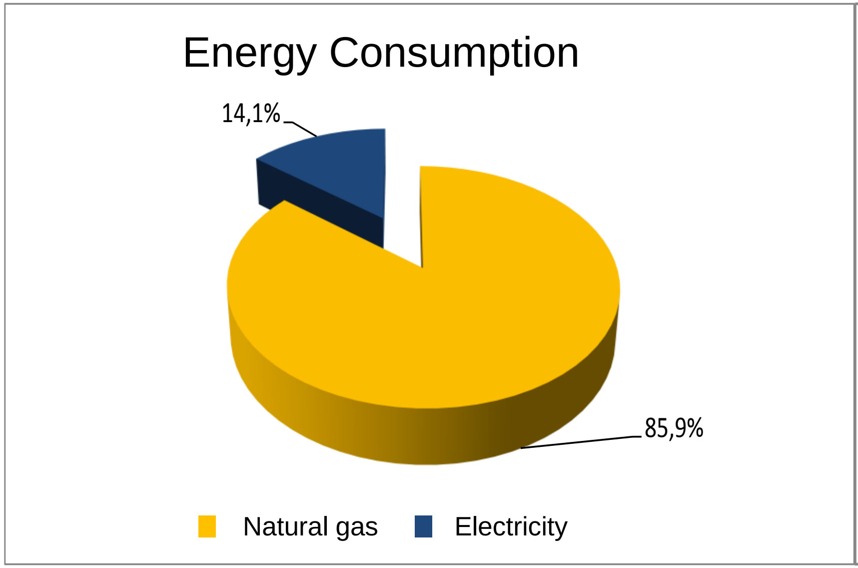
Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

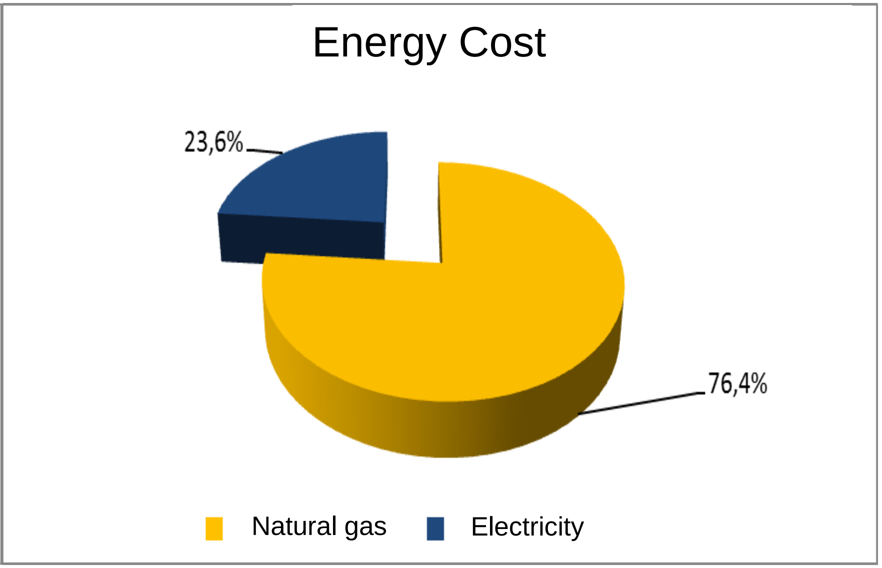
SCOoPE Saving Cooperative Energy

3. Developing an energy audit

Energy inventory

- Breakdown of energy consumption by source and costs



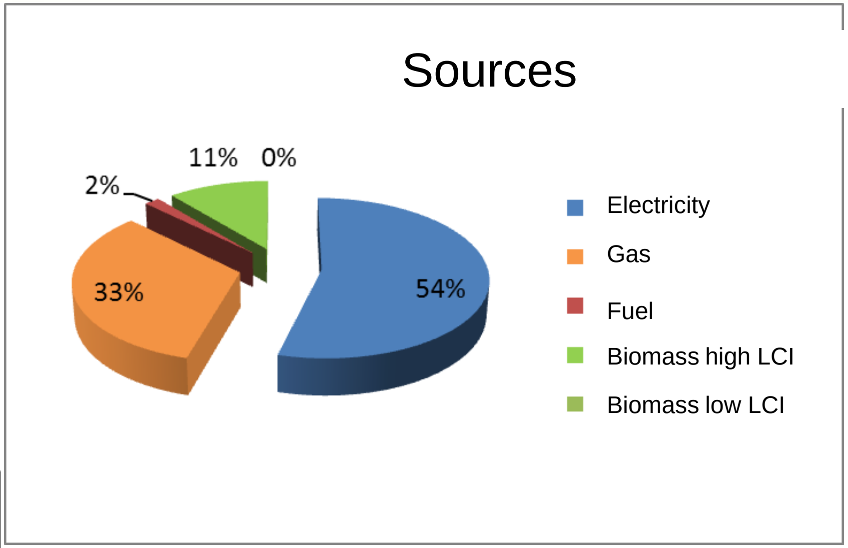


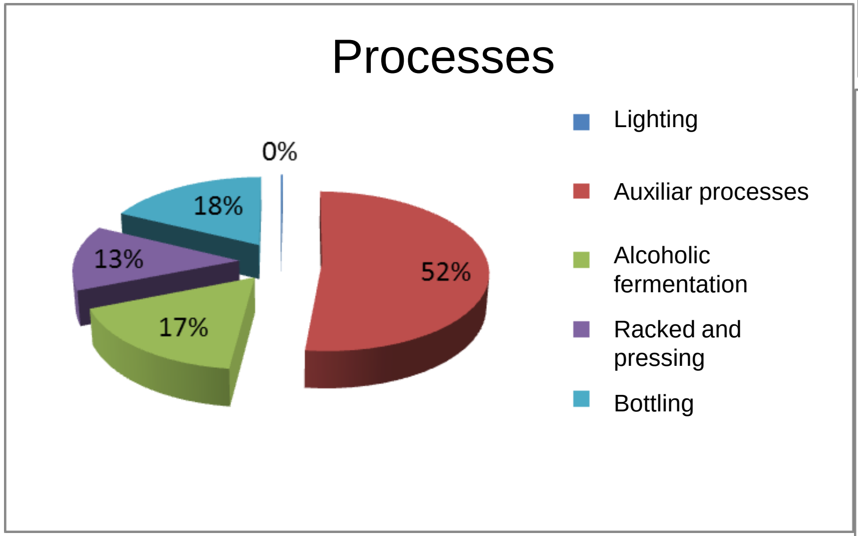
Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

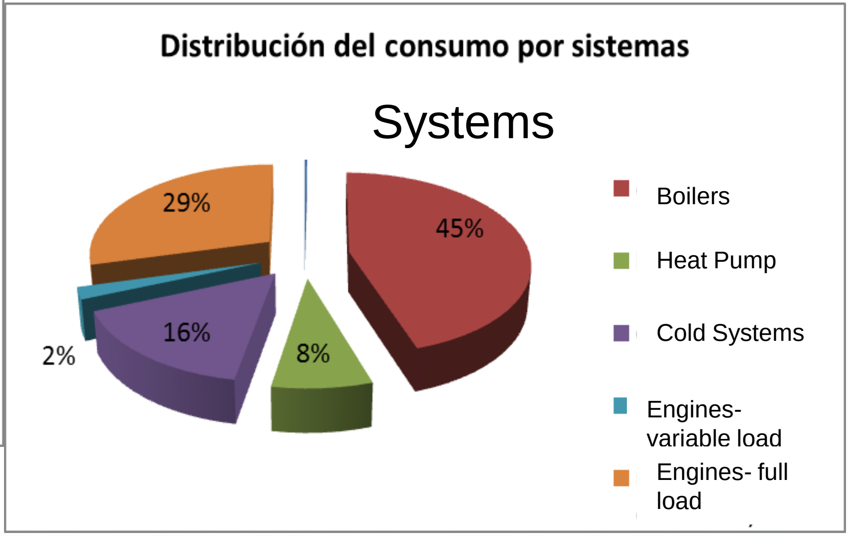
3. Developing an energy audit

Energy inventory

- Breakdown of energy consumption by source, processes and systems/equipment





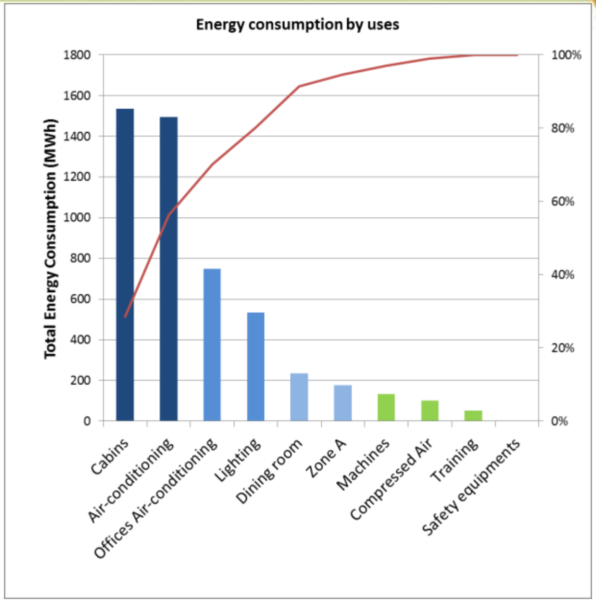


Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

This pubblication reflects only the author's view. The EASME is not responsible for any use that may be made of the information it contains.

Saving Cooperative Energy

3. Developing an energy audit

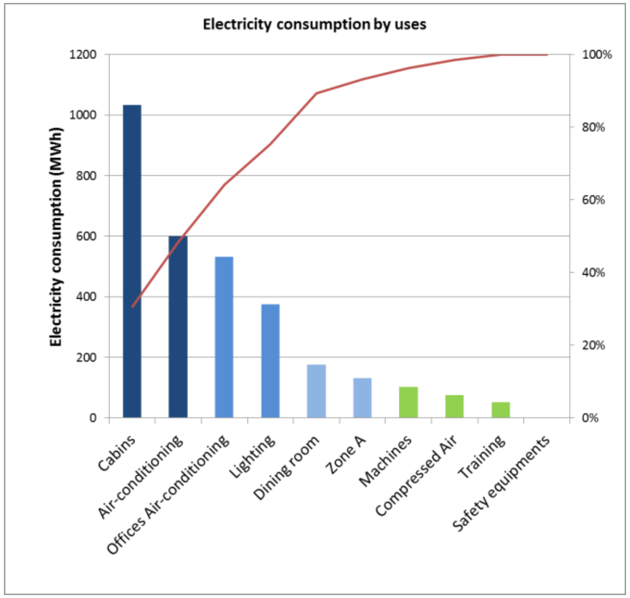


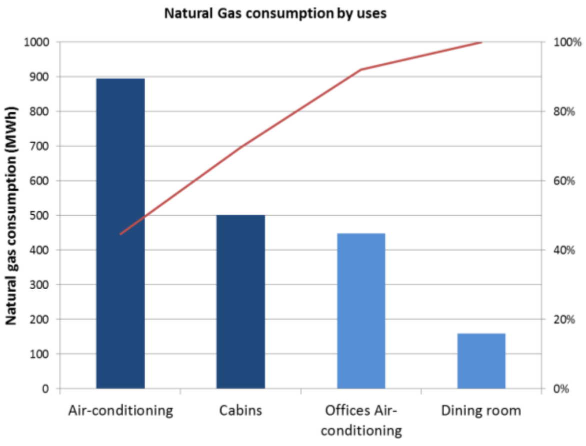
Energy inventory

- Identification of **significant uses** of energy by source

Pareto:

20% of uses → 80% energy



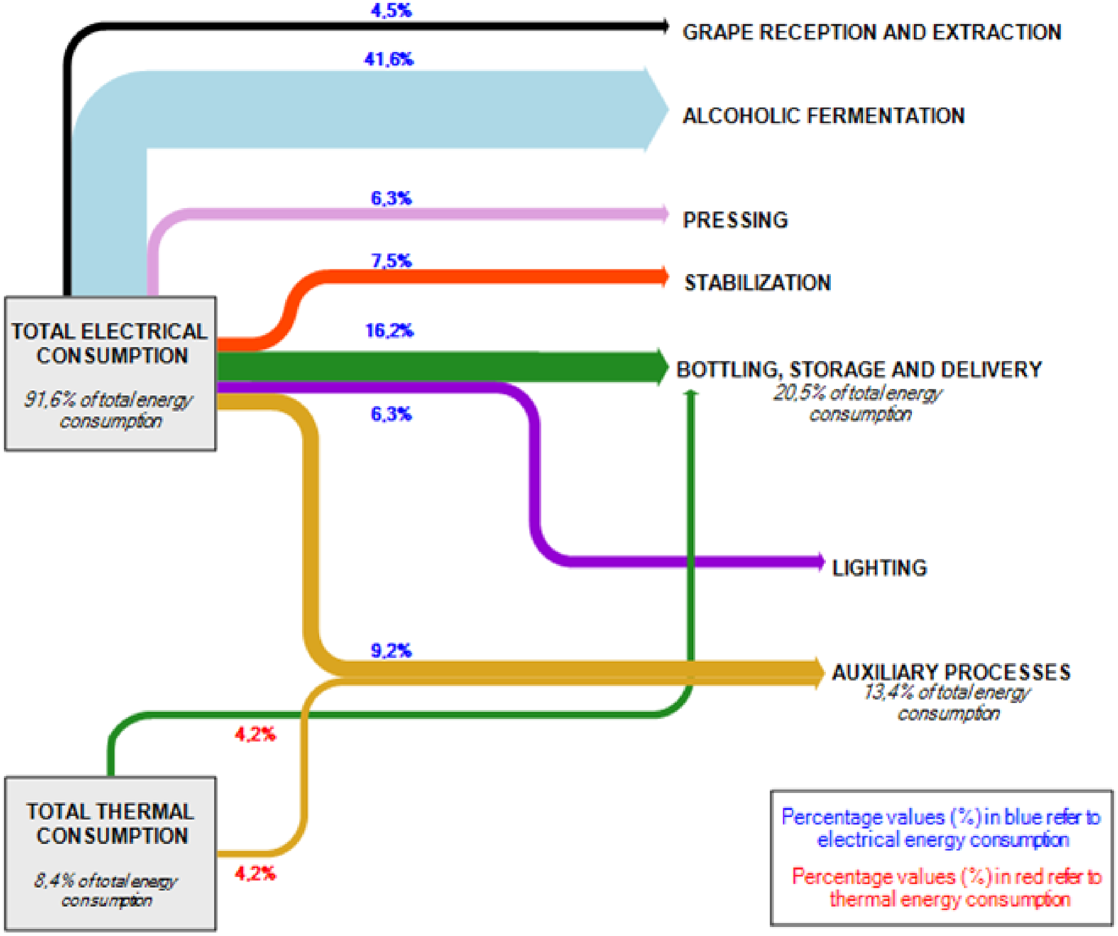


Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

Energy inventory

Sankey diagram by processes



Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

Energy inventory

- Monthly evolution for consumption: global, by processes, systems, ...
- Analyse, inform and search explanations
- Electricity: by billing periods

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

Energy Performance Indicators (IEP)

Specific energy consumption at different levels: global, by process, etc.

Is an objective parameter to **compare energy efficiency** in different moments, within processes, facilities, etc. with other plants in the sector or reference plants (BREF documents).

Example of Energy Performance Indicators :

- **Energy consumption:**

  $kWh/\ ton$

  $kWh_e/\ ton$

  $kWh_t/\ ton$

  $kWh_e/\ user$

  $kWh_t/\ user$

  $kWh/\ unit$

  $kWh/\ (inhab \cdot year)$

  $kWh_e/(year \cdot m^2_{úseful})$

  $kWh_t\ /(year \cdot m^2_{useful})$

  $kWh_t/(año \cdot m^2_{heat})$

  $kWh_t/(año \cdot m^2_{cooling})$

  $kWh_e/(año \cdot m^2_{lighting})$

  $kWh_e/\ m^3_{compressor}$

- **Emissions:**

  $kg\ CO_2/\ kWh$

  $kg\ CO_2/\ kWh_e$

  $kg\ CO_2/\ kWh_t$

  $kg\ CO_2/\ user$

  $kg\ CO_2/\ ton$

- **Costs:**

  €/ kWh

  €/ kWh_e

  €/ $kWh_{t\_ cold}$

  €/ kWh_{t_heat}

  €/ ton

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

SCOoPE Saving Cooperative Energy

3. Developing an energy audit

Energy Performance Indicators (EPin)

Examples:

- Energy performances indicators
  - for main process
  - for the whole plant
- Monthly evolution of indicator

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

Base Line

Equation that describes energy consumption (gas, electricity, etc.) **depending on the main process variables**

How? A linear regression analysis is performed

Why? Objectives:

- Describe energy consumption on the basis of reliable past data
- Predict energy consumption in the future
- Savings verification from EEMs (although conditions would change).

Example: glass production

- Main variables in gas.
  - Tons/month produced
  - HDD
- Main variables in electricity.
  - Tons/month produced
  - Kind of Products
  - Ambient temperature

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

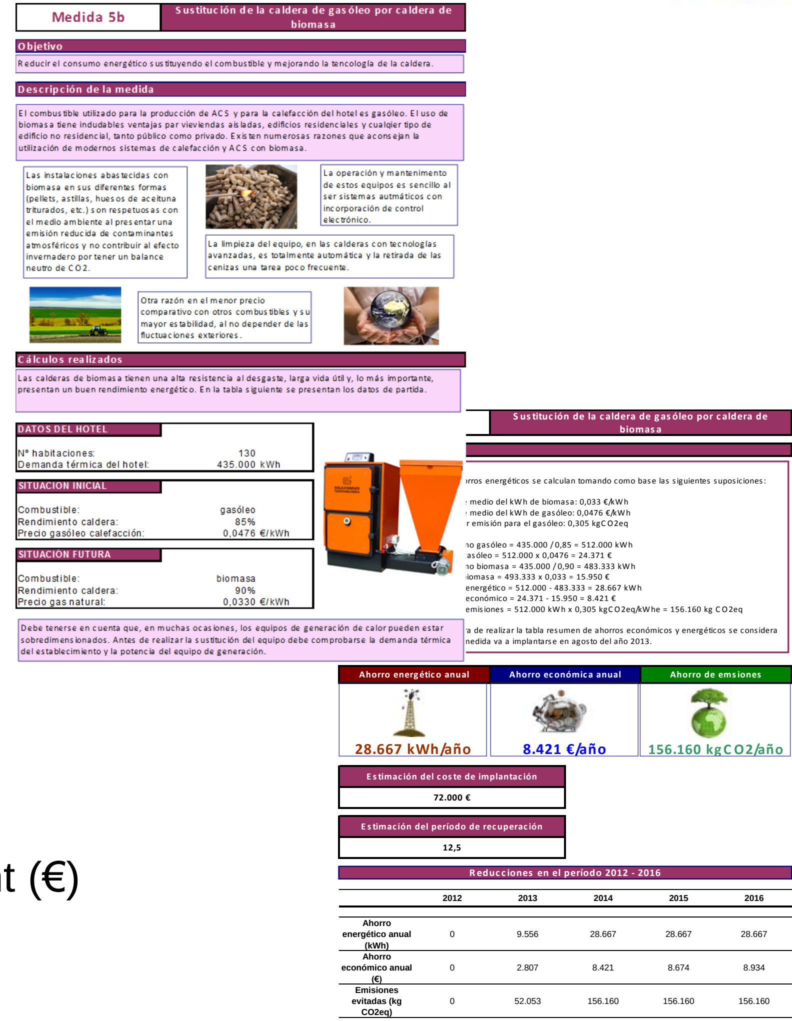
Energy Efficiency Measures

For each EEM:

- **Description and scope**
  - Technical calculations
  - Deployment issues

- **Savings to be achieved with EEM**
  - Energy savings (kWh/year)
  - Economic savings (€/year)
  - CO_2 emission savings ($kgCO_2$/year)

- **Economic analysis - option1: simple**
  - Estimated investment for EEM deployment (€)
  - Payback (years)



Medida 5b — Sustitución de la caldera de gasóleo por caldera de biomasa

Objetivo

Reducir el consumo energético sustituyendo el combustible y mejorando la tencología de la caldera.

Descripción de la medida

El combustible utilizado para la producción de ACS y para la calefacción del hotel es gasóleo. El uso de biomasa tiene indudables ventajas par vieviendas aisladas, edificios residenciales y cualqier tipo de edificio no residencial, tanto público como privado. Existen numerosas razones que aconsejan la utilización de modernos sistemas de calefacción y ACS con biomasa.

Las instalaciones abastecidas con biomasa en sus diferentes formas (pellets, astillas, huesos de aceituna triturados, etc.) son respetuosas con el medio ambiente al presentar una emisión reducida de contaminantes atmosféricos y no contribuir al efecto invernadero por tener un balance neutro de CO2.

La operación y mantenimiento de estos equipos es sencillo al ser sistemas autmáticos con incorporación de control electrónico.

La limpieza del equipo, en las calderas con tecnologías avanzadas, es totalmente automática y la retirada de las cenizas una tarea poco frecuente.

Otra razón en el menor precio comparativo con otros combustibles y su mayor estabilidad, al no depender de las fluctuaciones exteriores.

Cálculos realizados

Las calderas de biomasa tienen una alta resistencia al desgaste, larga vida útil y, lo más importante, presentan un buen rendimiento energético. En la tabla siguiente se presentan los datos de partida.

DATOS DEL HOTEL

Nº habitaciones:	130
Demanda térmica del hotel:	435.000 kWh

SITUACION INICIAL

Combustible:	gasóleo
Rendimiento caldera:	85%
Precio gasóleo calefacción:	0,0476 €/kWh

SITUACION FUTURA

Combustible:	biomasa
Rendimiento caldera:	90%
Precio gas natural:	0,0330 €/kWh

Debe tenerse en cuenta que, en muchas ocasiones, los equipos de generación de calor pueden estar sobredimensionados. Antes de realizar la sustitución del equipo debe comprobarse la demanda térmica del establecimiento y la potencia del equipo de generación.

Sustitución de la caldera de gasóleo por caldera de biomasa

orros energéticos se calculan tomando como base las siguientes suposiciones:

medio del kWh de biomasa: 0,033 €/kWh
medio del kWh de gasóleo: 0,0476 €/kWh
r emisión para el gasóleo: 0,305 kgCO2eq

no gasóleo = 435.000 / 0,85 = 512.000 kWh
asóleo = 512.000 x 0,0476 = 24.371 €
no biomasa = 435.000 / 0,90 = 483.333 kWh
iomasa = 493.333 x 0,033 = 15.950 €
energético = 512.000 - 483.333 = 28.667 kWh
económico = 24.371 - 15.950 = 8.421 €
emisiones = 512.000 kWh x 0,305 kgCO2eq/kWhe = 156.160 kg CO2eq

a de realizar la tabla resumen de ahorros económicos y energéticos se considera nedida va a implantarse en agosto del año 2013.

Ahorro energético anual	Ahorro económica anual	Ahorro de emsiones
28.667 kWh/año	8.421 €/año	156.160 kgCO2/año

Estimación del coste de implantación

72.000 €

Estimación del período de recuperación

12,5

Reducciones en el período 2012 - 2016

	2012	2013	2014	2015	2016
Ahorro energético anual (kWh)	0	9.556	28.667	28.667	28.667
Ahorro económico anual (€)	0	2.807	8.421	8.674	8.934
Emisiones evitadas (kg CO2eq)	0	52.053	156.160	156.160	156.160

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 695985

3. Developing an energy audit

Energy Efficiency Measures

- **Economic analysis – option 2: in detail** (depending on scope)
  - **Detailed investment for the EEM deployment**:
    - Quotation from suppliers of the equipment to be installed
    - Quotation from installation companies
    - Quotation for legalising facilities
  - **Variables involved in economic analysis**:
    - Replacement costs of equipment
    - Maintenance costs
    - Inflation rate of energy prices, discount rate of money
    - Funding methods and interest rate
  - **Economic parameters' calculation during life time**:
    - Net Present Value: NPV – VAN (esp)
    - Internal rate of return: IRR – TIR (esp)

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

General EEM. Examples

- Building envelope retrofitting
- Windows substitution

- Optimization of energy supply bills (no investment required): adjusting de contracted power, supply conditions, etc.

- Actions based on people:
  - Appoint an energy manager in the company
  - Encourage, optimize and coordinate energy efficiency actions
  - Improve user habits in energy consumption
  - Implement and certify an Energy Management System

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit
EEM in thermal systems. Examples

- Fuel substitution by natural gas or biomass
- Replacement of current boiler with low temperature or condensing boilers
- Thermal insulation in boilers, furnaces, piping, …
- Heat recovery systems from flue gas, in order to pre-heat combustion air or raw materials.
- Replacement of current HVAC/cooling equipment with high efficiency models.
- Combustion adjustment
- Control optimization installations
- Consumption metering

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

SCOoPE Saving Cooperative Energy

3. Developing an energy audit

EEMs.
Examples in thermal systems

				Energy Saving		Economic Saving	
Thermal equipments in EEM	Size	Investment	Ratio	%	kWh/año	€/year	Payback
Building envelope retrofitting	500 m2	50.000 €	100 €/m2	65	26134	1808	27,6
Replacement of current HVAC	100 kWe	30.000 €	300 €/kWe	29	34800	5226	5,7
Installation of thermal solar	80 m2	55.200 €	690 €/m2	100	72800	5038	11
Installation of biomass boiler	500 kWt	196.000 €	392 €/kWt	100	750000	26550	7,4

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

EEM in electric systems. Examples

- Replacement of current lighting devices with other more efficient (a fluorescent, LED, induction, natural lighting)
- Installing presence detection systems
- Replacement of electric engine with premium efficiency engine (IE3)
- Installation of variable speed drives (VSD)
- Measures in compressed air systems
- Consumption timing and reducing stand-by consumption
- Harmonic filtering
- Replacement of power transformers with high efficiency models
- Installation of capacitor bank for reducing reactive energy

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

SCOoPE Saving Cooperative Energy

3. Developing an energy audit

EEMs.

Examples in electric systems

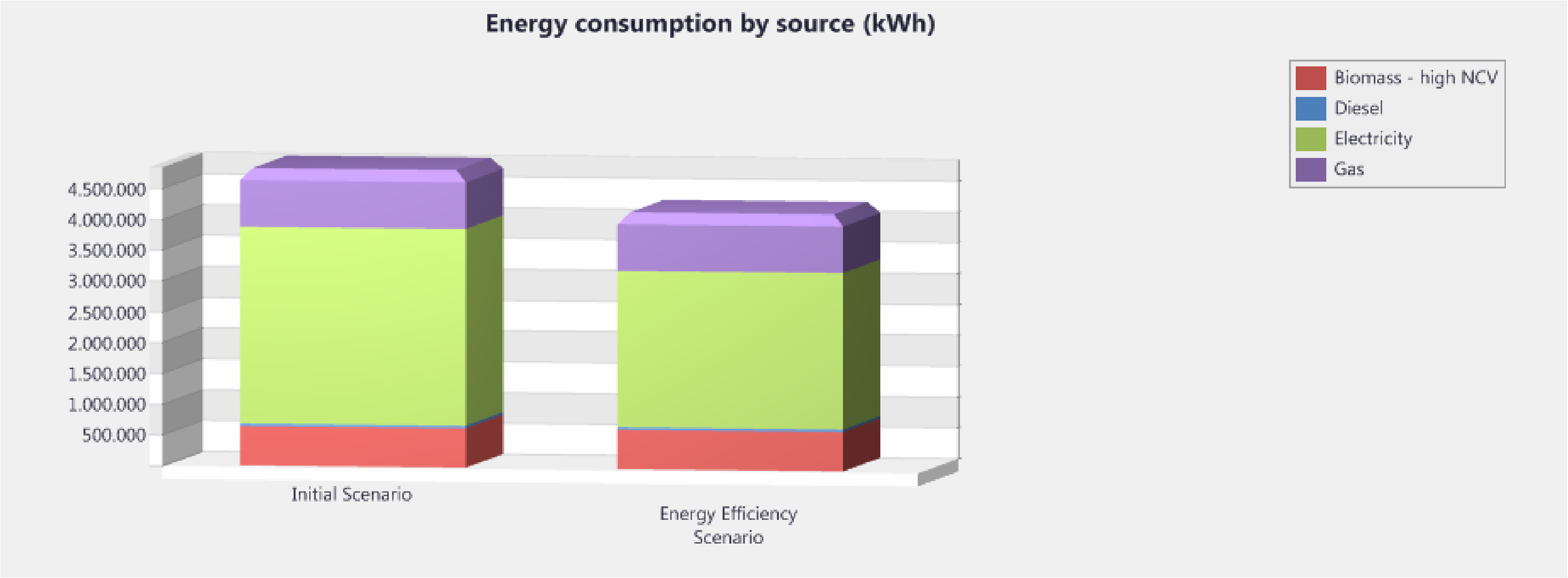
				Energy Saving		Economic Saving	
Electrical equipments in EEM	Size	Investment	Ratio	%	kWh/año	€/year	Payback
Replacement of current lighting by LEDS	10 kWe	15.000 €	1500 €/kWe	60	24.000	3.604	4,2
Replacement of electric engine	100 kWe	50.000 €	500 €/kWe	20	80.000	12.013	4,2
Installation of photovoltaic	100 kWe	180.000 €	1800 €/kWe	100	156.000	23.425	7,7
Replacement of street lighting	22 kWe	44.000 €	2000 €/kWe	60	55.440	8.325	5,3

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

EEMs.
Examples including life cycle costs

- Initial investment
- Replacement and maintenance costs
- Inflation and energy price evolution during life time of equipment



Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

EEM in energy production systems. Examples

- Installation of solar thermal systems
- Installation of photovoltaic systems
- Installation of mini-wind energy systems
- Installation of energetic use of biomass
- Installation of co-generation systems
- Installation of geo-thermal systems
- Energetic use of waste products
- Energetic use of waste heat

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

Energy Efficiency Measures

Action Plan

- Collect and classify EEMs proposed
- Plan EMMs' deployment depending on:
    - Safety and current regulations
    - Size of investment: high, medium, low, null
    - Size of economic savings: high, medium, low
    - Payback
    - Easy deployment
    - Specific interests of the customer
    - Other: production calendar, process restrictions, etc.

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

The report of the energy audit shall contain:

a) Executive summary:

1) ranking of energy efficiency improvement opportunities;

2) suggested implementation programme.

b) Background:

1) general information of audited organisation, energy auditor and energy audit methodology;

2) context of the energy audit;

3) description of audited object(s);

4) relevant standards and regulations.

c) Energy audit:

1) energy audit description, scope, aim and thoroughness, timeframe and boundaries;

2) information on data collection;

i) metering setup (current situation);

ii) statement about which data was used (and which is measured and which is estimated);

iii) copy of key data used and calibration certificates where appropriate;

3) analysis of energy consumption;

4) criteria for ranking energy efficiency improvement measures.

d) Energy efficiency improvement opportunities:

1) proposed actions, recommendations, plan and implementation schedule;

2) assumptions used in calculating savings and the resulting accuracy of the recommendations;

3) information about applicable grants and subsidies;

4) appropriate economic analysis;

5) potential interactions with other proposed recommendations;

6) measurement and verification methods to be used for post-implementation assessment of the recommended opportunities.

e) Conclusions.

Audit report (EN 16247-1)

Summary:
main EMMs proposed

Background: general info, methodology, regulation, …

Energy audit: Description, data used, measurements, analysis, energy inventory, assumptions and criteria, etc.

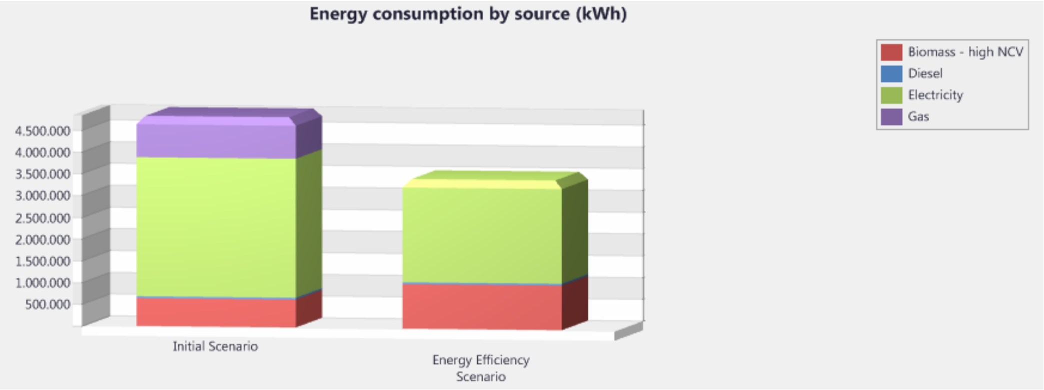
Proposal of EEMs:
Description,
savings calculation,
investment estimation, etc.

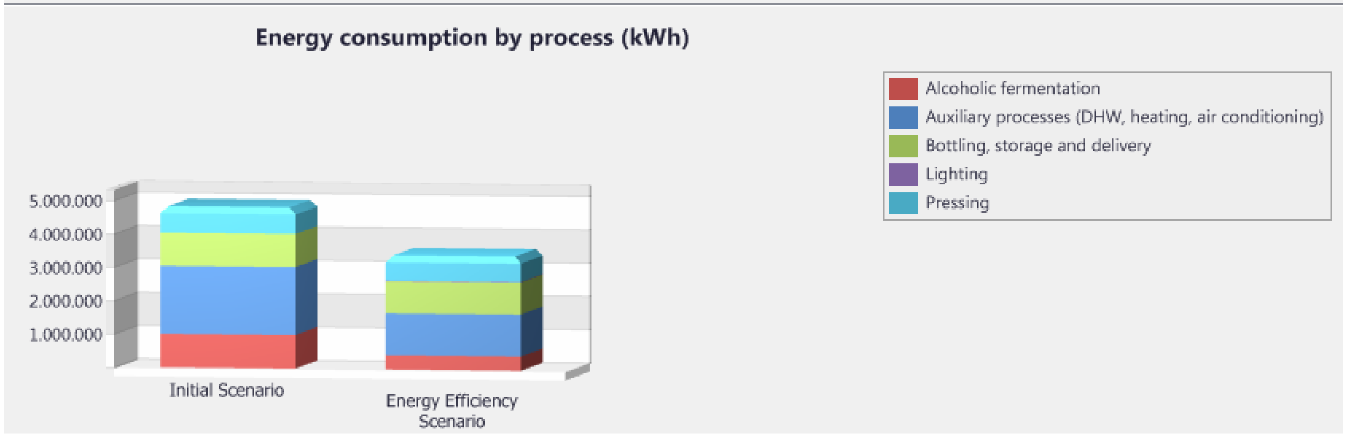
Conclusions

3. Developing an energy audit

Report. Conclusions.
(depending on scope)

- Potential energy savings, annually, global and disaggregated.



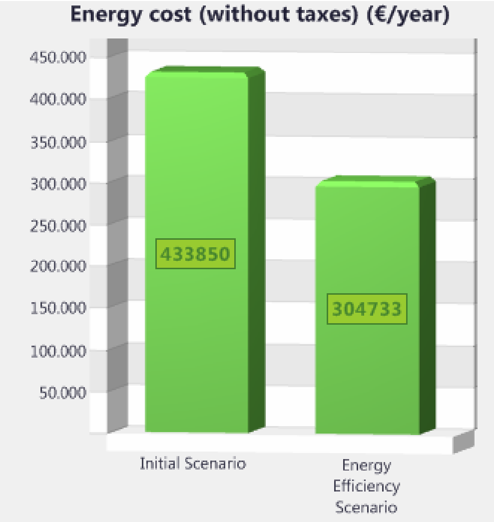


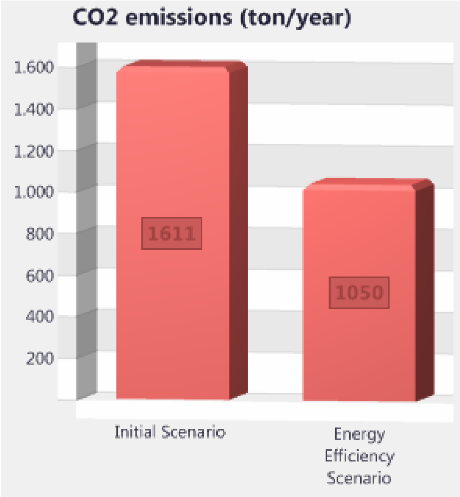
Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

3. Developing an energy audit

Report. Conclusions. (depending on scope)

- Potential cost savings and CO_2 emissions savings per year





Current Scenario **VS** Energy Efficiency Scenario (after EEMs deployment)

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

SCOoPE Saving Cooperative Energy

4. After an energy audit

Deployment of EEMs

- **By installation companies:**
  - There should be fluent communication amongst auditors, installers and suppliers in order to make a successful assessment of EEMs
  - The installing company must review EEMs and confirm budget

- **By Energy Services Companies (ESCOs)**
  - The company is able to include all energy services: audit, engineering, installation, maintenance, but also **project funding end energy management**.
  - Its income is depending directly on energy savings obtained →

    Maximum guarantee of the proposed EEMs

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

4. After an energy audit

Measurement & Verification of savings

- Energy savings obtained with EEMs can be verified by means of **IPMWP protocol** (International Performance Measurement and Verification)

- Specially important within an Energy Management System

- **Certifications for M&V:**

  - CMVP certification (*Certified Measurement & Verification Professional*) by EVO (Efficiency Valuation Organization)

  - CEM certification (*Certified Energy Manager*) by AEE (Asociation of Energy Engineers)

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

Saving Cooperative Energy

Thank you for your attention!

Inmaculada Fraj
Gema Millán

ifraj@fcirce.es
gmillan@fcirce.es

RESEARCH CENTRE FOR ENERGY RESOURCES AND CONSUMPTION

Co-funded by the Horizon 2020 programme of the European Union. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 695985

This pubblication reflects only the author's view. The EASME is not responsible for any use that may be made of the information it contains.