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STUDY ON ENERGY EFFICIENCY IN INDUSTRIAL SECTORS IN GEORGIA AND AZERBAIJAN

Component 1 Report:

EU Policy Framework and Measures for EE in Industry

June 2017

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List of abbreviations

ANRE	Romanian Energy Regulatory
BAT	Best Available Techniques
BPT	Best Practice Technology
CDM	Clean Development Mechanism
CHP	Combined Heat and Power
DC	Direct Current
DH	District Heating
DTI	Danish Technology Institute
EC	European Commission
EE	Energy Efficiency
EED	Energy Efficiency Directive
EEFF	Romanian Fund for Energy Efficiency
EnB	Energy Baseline
EnC	Energy Community
EnCT	Energy Community Treaty
EnM	Energy Management
EnMS	Energy Management System
EnPI	Energy Performance Indicator
EPA	Energy Purchase Agreement
EPC	Energy Performance Contracting
EPEEF	Environment Protection and Energy Efficiency Fund
ESC	Energy Supply Contracting
ESCO	Energy Service Company
ESOS	Energy Savings Opportunity Scheme
ETS	Emissions Trading System
EU	European Union
EUE	Efficient Use of Energy
EuPC	European Plastics Converters
GHG	Greenhouse Gas
IEA	International Energy Agency
IED	Industrial Emissions Directive
IEEN	Industrial Energy Efficiency Network
IPMVP	International Performance Measurement and Verification Protocol
LCTU	Low Carbon Transition Unit
LEEN	Learning Energy Efficiency Network
LIEN	Irish Large Industry Energy Network
M&T	Monitoring & Targeting
M&V	Measurement and Verification
MRE	Ministry of Mining and Energy
MS	Member States
NEEAP	National Energy Efficiency Action Plan
PPP	Public-Private Partnership
RES	Renewable Energy Sources
SEC	Specific Energy Consumption
SGCIE	Intensive Energy Consumption Management System
SME	Small-medium enterprise
toe	ton of oil equivalent
ToR	Terms of Reference
VSD	Variable Speed Drive

Preface

This report presents industrial energy efficiency (EE) policies, rules, regulations and tools applicable mostly in the EU and the Energy Community (EnC) Contracting Parties; it also deals also with the methodology, procedures for the conduction of energy audits as well as with the responsibilities of Member States (and Energy Community Contracting Parties) towards the certification of energy auditors. The report is part of the study "Energy efficiency in industrial sectors in Georgia and Azerbaijan". The study has been implemented in the framework of the project 'Short term high quality studies to support activities under the Eastern Partnership – HiQSTEP, EuropeAid/132574/C/SER/Multi', carried out by an international consortium under the leadership of Kantor Management Consultants.

The study has been implemented between March 2017 and January 2018 by a team under the leadership of George GEORGOCOSTAS (Study Team Leader) and composed of the International Energy Efficiency Experts Konstantinos GEORGAKOPOULOS, Kyriakos ARGYROUDIS, the International Legal Expert Nick PITSAS and the following national experts: Manana DADIANI (Georgia) and Azer ABDULLAYEV (Azerbaijan).

Overall supervision has been carried out by Przemysław MUSIAŁKOWSKI, Team Leader of the HiQSTEP Project.

The views presented in this report are those of the report authors only and do not represent the official position of the European Commission.

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Executive summary

1.1 Introduction

This report "**Component 1: EU policy framework and measures for EE in industry**" is part of the deliverables of the study **"Energy efficiency in industrial sectors in Georgia and Azerbaijan",** implemented under the project "High quality studies to support activities under the Eastern Partnership" (EuropeAid/132574/C/SER/Multi)".

The overall **aim of the study** is to:

> present EU policies, rules, regulations, and tools on energy efficiency (EE) and energy savings, emphasizing on selected industries after consultation with the EC
> review the overall methodology for conducting energy audits in the countries under consideration,
> map and assess existing policies, rules, regulations, and tools towards the implementation of EE measures in specific industrial sectors in Azerbaijan and Georgia, and
> develop pre-feasibility studies for the implementation of EE measures in typical industries following the completion of short energy audits.

The study also aims to prepare a preliminary list of energy savings possibilities and an evaluation of such possibilities based on energy, environmental, technical, operational, and economic criteria. The study will conclude with elaboration of recommendations on how to further enhance industrial EE in Azerbaijan and Georgia.

The study is comprised of three Components:

> The **present Component 1** covers mostly the review of the industrial EE policies, rules, regulations, and tools applicable mostly in the EU and the EnC Contracting Parties. Component 1 deals also with the methodology, procedures for the conduction of energy audits as well as with the responsibilities of Member States (and EnC Contracting Parties) towards the certification of energy auditors.
> **Component 2** will include a review and assessment of the Azerbaijani and Georgian relevant EE framework targeting the industry sector with focus on identifying gaps and elaborating proposals for sustainable EE improvement in industry
> **Component 3** will include the development of four pre-feasibility studies for the implementation of EE measures in typical industries following the completion of short energy audits. Component 3 will conclude with elaboration of recommendations and proposals for energy saving possibilities in the two beneficiary countries.

In more detail, the **aim of the present report, which relates only to Component 1 of the study** is to provide information, analyse the effects and present:

> The main legislative framework in relation to EE with focus in the industrial sector. It includes an overview of existing policies, rules, regulations, and instruments followed in the EU and the Energy Community (EnC) as well as the history of the EE policy and legislative development in Europe in the past decades
> The international standards that are applicable to EE, energy management and energy auditing
> The Best Available Techniques as regards EE for the most energy - intensive sectors

> Successful policy instruments and measures in the EU and EnC Contracting Parties towards the realization of EE potential
> The responsibilities of Member States towards the certification of energy auditors including their qualification criteria, the available certification / accreditation schemes and relevant support programmes for performing energy audits in industrial SMEs
> The overall methodology and procedures for conducting energy audits in the industrial sector.

1.2 Policies on EE and energy savings in the industrial sector in EU and EnC Contracting Parties

During the early years (70's – 90's), following the first oil crisis, EU and individual Member States focused on supporting the EE market opening and development, rather than on legislative and regulatory measures. The focus was on starting-up and creating a critical mass of the EE market. During this period, numerous programmes were launched, and significant financial resources were allocated for their implementation aiming mainly at **capacity building and awareness raising, research and Development (R&D)** for EE equipment, new materials and technologies, development of **technical standards, calculation methodologies** etc, **grant/subsidy schemes** for EE investments combined or not with **technical assistance** (e.g. free energy audits). In parallel **innovative EE financing mechanisms** (e.g. ESCO market development) and other schemes (e.g. voluntary agreements) were developed, tested, and promoted.

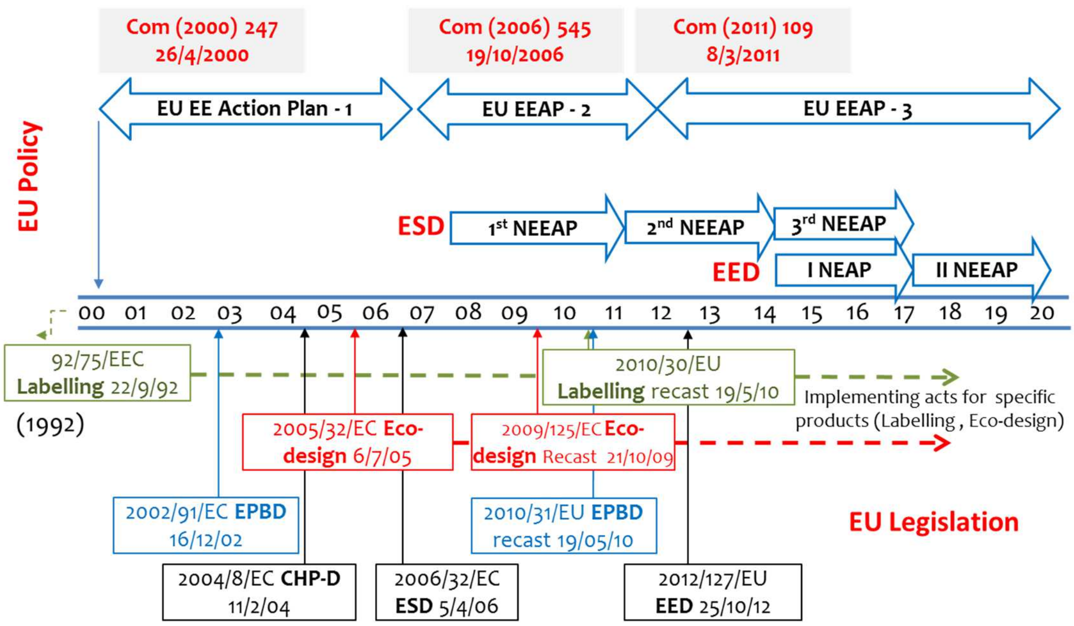
After 2000, with the EE market better prepared in terms of awareness, know-how, availability of EE equipment, materials and techniques, the EU started gradually to impose legislative – regulatory measures for EE. Enforcement of regulatory measures proved to be a difficult task for many EU Member States but, even their initial partial enforcement, helped the EE market to mature further. **Well-informed citizens and energy users** started asking for more EE solutions. Manufacturers, construction-engineering companies, and energy service providers responded to the market demand by offering such solutions at more affordable prices. This way, several mandatory / regulatory provisions of the EU Directives and Regulations gradually became "standard engineering practices" that are "enforced" by the market itself.

The following Directives can be considered Milestones in this process:

> the 2002 Energy Performance of Buildings Directive (recast in 2010) that for first time imposes, *inter alia,* minimum energy performance requirements for buildings and their main energy systems
> the 2005 Eco-design Directive that set the grounds for banning from the EU market energy inefficient products
> the 2006 Energy Services Directive that, *inter alia*, introduced the obligation for availability of energy services / energy audits and for adoption and implementation of 3-year NEEAPs with concrete energy savings targets, and
> the 2012 EE Directive that repealed Energy Services Directive and introduced more stringent obligations such as the EE obligations scheme, mandatory energy audits for the large industrial facilities, etc.

The basic **EU policy legislative framework for EE** is presented in **Figure 1-1.**

Figure 1-1: Basic EU policies and legislation in EE (2000 – 2020)



Despite the very significant progress achieved in many EU Member States, there is still a large unexploited EE potential across EU. New policies and measures are being developed to achieve increasingly ambitious energy and environmental targets by 2030.

EnC Contracting Parties started the effort to improve EE about 10-15 years ago with the implementation of several technical assistance projects financed by EU and other donors. The systematic effort to adopt the European EE acquis started with the Decision of the Ministerial Council of 18/12/2009 for the implementation of certain Directives (Energy Services Directive, Energy Labelling, Energy Performance of Buildings). Since then, the transposition work progressed quite satisfactory in many EnC Contracting Parties, but implementation and enforcement of the legislation lags behind.

EE in industry is explicitly addressed only in few articles of the EU/EnC legislation, as most of the provisions refer to cross-sectoral EE measures (addressing also industry) or to specific EE products, as well as to energy performance of buildings. For example, the **Energy Services Directive** – ESD (**2006/32/EC**), repealed by the **EE Directive** – EED (**2012/27/EU**), provides, *inter alia*, for the availability of energy services, as well as for adoption and implementation of 3-year National EE Action Plans (NEEAP) that include horizontal measures, as well as dedicated EE measures for each energy sector, including industry.

Apart from the EE legislation, the **Renewable Energy Directive** – RED (**2009/28/EC),** provides for a favourable environment for energy produced from RES and for the introduction of biofuels in the transport sector. This opens new industrial business opportunities (e.g. biofuels production) as well as optimization of energy resources (e.g. waste to energy) for the industrial sector as well.

In addition, significant environmental Directives promoted EE to reduce greenhouse gas emissions, including the **IPPC Directive, the Industrial Emissions Directive, and the Emissions Trading Directives**.

Transposition and implementation of all the prevailing EU legislation regarding EE and RES (except for the eco-design framework) is among the obligations of the Contracting Parties to the

Energy Community Treaty (EnCT). **Georgia, that recently joined the Energy Community, undertook all these commitments**.

The following paragraphs present in brief key points of the main Directives relevant to EE in industry.

Energy Efficiency Directive

Although the direct references of the **Energy Efficiency Directive** – EED (**2012/27/EU**) to industry are limited, many of its provisions have an impact on industrial EE. Specifically, the EED provides, inter alia, for 3 specific quantitative targets:

- **indicative national EE target** (Art. 3) to be achieved through the implementation of the NEEAPs (Art 24.2) and other measures; as mentioned above EE in industry is one of the energy consuming sectors targeted by the NEEAPs
- **EE obligation schemes** (Art. 7), that impose obligation to energy distributors and/or retail energy sales companies to implement measures that would achieve on an annual basis, new energy savings corresponding to 1.5% of the total annual energy sales of energy to final customers; industry is an ideal target for this scheme, as EE measures applied in selected industrial facilities may lead to considerable energy savings in terms of volume, thus facilitating achievement of the target. Alternatively, each EU Member State or EnC Contracting Party may choose to implement other EE measures that can achieve the same energy saving result.
- **energy rehabilitation of buildings** owned and occupied by the Central Government at a rate 3% of floor area per year (Art. 5), as well as establishment a long-term strategy for mobilizing investment in the renovation of the national building stock. It is expected that these provisions will promote the financing services market (e.g. ESCOs), the building materials/energy equipment production industrial sub-sectors, as well as the construction industry.

Regarding industry, the most important Article of the EED is Art.8 "Energy audits and energy management systems". According to this Article:

- Large enterprises (that are not SMEs) are subject to an energy audit carried out in an independent and cost-effective manner by qualified and/or accredited experts at least every 4 years from the date of the previous energy audit. Enterprises that are implementing an energy or environmental management system - certified by an independent body (that includes energy audit) are exempted from the requirement to conduct a stand-alone energy audit
- Also, the State must develop programmes to encourage SMEs to undergo energy audits and the subsequent implementation of the recommendations from these audits.

In conclusion, the EED streamlines the whole framework on EE including energy auditing, energy management, alternative financing mechanisms, etc., thus **creating a quite favourable environment for promotion of EE in industry** and other economic sectors.

Energy Labelling Directive

The Energy Labelling Directive was first adopted in 1992 and repealed by **Directive 2010/30/EU recast.** It is a framework directive that mandates the EC to introduce, by means of delegated acts, details relating to information to be provided on the label and in the fiche for each type of energy related product. The energy labelling scheme aimed at informing the energy users and did not impose any mandatory minimum requirements for EE performance of products. Mandatory minimum requirements could harm the manufacturing industry during the early years, when new EE technologies were still under development. On the contrary, it gave the time to manufacturers to get prepared for the regulatory measures that followed, such as the eco-design framework.

Eco-Design Directive

The **Eco-design Directive for energy-related products (Directive 2009/125/EC)** is a framework directive; it is implemented for each specific energy related product group through Commission Regulations. The Eco-design Directive aims to reduce the environmental impact and improve EE, by providing EU-wide rules for the design of energy related products. Eco-design applies to several products, **including products widely used in industry** (e.g. high efficiency motors). It has also an impact on manufacturers of energy related products who **cannot sell anymore low efficiency products in the European market.**

Renewable Energy Directive

The Renewable Energy Directive-RED (**Directive 2009/28/EC**) establishes an overall policy for the production and use of energy from RES. Although the RED does not directly refer to industry, many industrial facilities across EU, especially the ones that produce biomass by-products and organic wastes, have exploited the incentives provided by the RED provisions (e.g. priority or guaranteed access to the grid for electricity produced from RES) and Member States support schemes (e.g. favourable feed-in tariffs) to reduce their energy cost and/or to have an extra income from RES electricity/heat sales.

IPPC Directive

The IPPC Directive (**Directive 96/61/EC**) requires that all installations are operated in such a way that energy is used efficiently, and one of the factors to be considered in determining the **Best Available Techniques** (BAT) for a process, is its EE. The IPPC Directive provides for a **permitting system for specified industrial installations**, requiring both operators and regulators to take an integrated, overall view of the potential of an installation to consume and pollute.

As regards **BAT and EE**, there are several key EE opportunities identified in various industrial sectors. These opportunities are either related to horizontal technologies such as the use of high efficient motors or energy efficient boilers, the introduction of Energy Management Systems (EnMS), the use of waste as fuel or the introduction of advanced control system or to EE process technologies for different types of industry.

Energy savings and reduction of CO_2 emissions from adoption of commercial best practice technologies in manufacturing industries are presented in Table 1-1.

Table 1-1: Energy savings and CO_2 emissions

	Low – High Estimates of Energy Saving Potentials			Total energy savings potential (%)
	EJ/yr	Mtoe/yr	Mt CO_2/yr	
Sectoral improvement				
Chemicals / Petrochemicals	5.0 – 6.5	120 – 155	370 - 420	13 - 16
Iron and Steel	2.3 – 4.4	55 - 108	220 - 360	9 - 18

	Low – High Estimates of Energy Saving Potentials			Total energy savings potential (%)
	EJ/yr	Mtoe/yr	Mt CO_2/yr	
Cement	2.5 – 3.0	60 - 72	480 - 520	28 - 33
Pulp and Paper	1.3 – 1.5	31 - 36	52 - 105	15 - 18
Aluminium	0.3 – 0.4	7 - 10	20 - 30	6 - 8
Other non-metallic metals, minerals and non-ferrous	0.5 – 1.0	12 - 14	40 - 70	13 - 25
System / life cycle improvements				
Motor systems	6 - 8	143 - 191	340 - 750	
Combined Heat Power	2 - 3	48 - 72	110 - 170	
Steam Systems	1.5 – 2.5	36 - 60	110 - 180	
Process Integration	1.0 – 2.5	24 - 60	70 - 180	
Increased recycling	1.5 – 2.5	36 - 60	80 - 120	
Energy recovery	1.5 – 2.3	36 - 55	80 - 190	
Total	25 - 37	600 - 900	1900 - 3200	
Global improvement potential – share of industrial energy use and CO_2 emissions	18 – 26%	18 – 26%	19 – 32%	
Global improvement potential – share of total energy use and CO_2 emissions	5.4 – 8%	5.4 – 8%	7.4 – 12.4%	

Industrial Emissions Directive

The Industrial Emissions Directive (IED – **Directive 2010/75/EU**) aims to achieve a high level of protection of human health and the environment in **reducing harmful industrial emission of air pollutants, discharges of waste water and the generation of waste** across the EU, **contributing also to EE**.

Emissions Trading Directives

Directive 2003/87/EC as amended by the **Directive 2009/29/EC** govern the EU Emissions Trading System (ETS). The system works by setting a cap (limit) on the total emissions from covered installations. The cap is annually reduced to achieve the GHG emissions target.

The EU ETS applies to power and heat generation, aviation operations and virtually all branches of energy intensive industries, including oil refineries, steel works and production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids, and bulk organic chemicals. It covers approximately 11,000 power stations and manufacturing plants in the 28 EU Member States plus Iceland, Liechtenstein, and Norway, as well as aviation activities in these countries. In total, approximately 45% of total EU GHG emissions are regulated by the EU ETS.

Each company has its own individual target. Within these limits, companies can buy and sell emission allowances as needed. Emission allowances are the “currency” of the EU ETS. Each allowance gives the holder the right to emit 1 ton of CO_2, or the equivalent amount of other pollutants. This “cap-and-trade” approach is a market-based mechanism that gives companies the flexibility they need to reduce their emissions in the most cost-effective way. Obviously, **improving EE is a means to reduce GHG emissions** and save allowances that can be sold.

1.3 Standards applicable to energy efficiency, energy management and energy auditing

The **ISO 50000 series** was created to provide a comprehensive suite of international standards offering **good practice in energy management**. The standards can be used together, or independently and are suitable for any size of organisation.

ISO 50001 – Energy Management Systems – Requirements with guidance for use is a normative Management Systems International Standard. ISO 50001 is a proven framework for **industrial facilities**, commercial facilities, or entire organizations for implementing an EnMS. ISO 50001, which is **subject to certification**, focuses on processes, introduces concepts, but lacks specificity to EnM techniques. The relevant ISO committee recognised this and is drawing up **supporting standards** (that are not subject of certification). The supporting standards released so far are:

- ISO 50002 – Energy audits - Requirements with guidance for use (based on EN 16247-1)
- ISO 50003 – Requirements for bodies providing audit and certification of EnMSs
- ISO 50004 – Guidance for the implementation, maintenance, and improvement of an EnMS
- ISO 50006 – Energy Baselines (EnB) and Energy Performance Indicators (EnPIs)
- ISO 50015 – Measurement and verification of energy performance of organizations - General principles and guidance.

Apart from ISO standards, CEN and CENELEC have published a series of European Standards (the **EN 16247**) that set out requirements and provide guidance on how to carry out **energy audits**. The EN 16247 series of standards came to support companies throughout Europe to comply with the requirements of the EED.

The ISO and EN standards set standard rules and methodologies, streamlining the EnMS and energy auditing procedures. Certification of EnMS according to ISO 50001 is growing among the EU industry. It introduces a new approach in EE. Instead of taking EE measures and implementing individual EE investments, companies establish a management mechanism (EnMS) that ensures continuous EE improvement through setting targets, planning and “generating” EE measures and investments, monitoring and measurement of their effects and regular repetition of the EnMS cycle, each time with revised, more ambitious, targets and plans.

1.4 Instruments in selected EU Member States and EnC Contracting Parties towards the realization of EE measures

Despite the accumulated experience on EE in EU, barriers still exist, and new policies and instruments are being developed to overcome them. These instruments can be categorised as cooperative measures (voluntary agreements), financial measures, informative / educational measures, legislative measures, or market-based instruments. In addition, in certain countries policy instruments / measures address different target groups, e.g. SMEs or energy-intensive industries or both. The number of instruments however and their level of adoption differs across the EU Member States and EnC Contracting Parties. The cases of Germany, Denmark, Croatia, Romania, Serbia and FYR of Macedonia were selected for review considering the following criteria:

- **Similarities in the level of development** of the legislative/regulatory framework (new EU Member States, e.g. Croatia, Romania or Contracting Parties of the Energy Community, e.g. Serbia, FYR of Macedonia);
- **Advanced cases** so as to show the medium to long term development path for EE improvement (e.g. Germany, Denmark).

Table 1-2 presents the key instruments in each country.

Table 1-2: Key instruments in selected countries for promoting EE in industry

Key policy / instrument	Policy type	Main points
Germany		
Energy Efficiency Fund	Financial (grants, subsidies)	> Two programmes are included in the Fund that refer to the promotion of energy efficient horizontal and process technologies > Provision of investment grants up to 30% of the investment costs if the energy savings achieved are at least 25% compared to the old system
Promotion of EnMSs	Financial (grants, subsidies) & Legislative	> Support of the initial certification of either an EnMS (fulfilling EN ISO 50001) or an energy monitoring system > The funding is in form of grants providing up to 20,000 EUR per industrial company
Obligation of energy audit for large companies	Legislative	> The scheme obliges **large enterprises** to undertake energy audits until 5th of December 2015 and after that, at least every 4 years, in accordance with the energy audit standard EN 16247-1 > Companies already implementing, in accordance with the ISO 50001, an EnMS or an Environmental Management System are excluded from the obligation
Energy audit funding scheme	Financial (grants)	> The program, operated by KfW, supports initial and detailed energy audits in industry > The funding is in form of grants providing 60-80% depending on the type of the energy audit
Energy tax	Financial (subsidies)	This tax can be avoided by energy intensive industries in case they follow a voluntary agreement and/or introduce a certified EnMS.
Energy Efficiency Networks Initiative	Voluntary agreement / Networking	> The initiative is a concept targeting EE in companies from different sectors with common horizontal technologies > The procedure is to establish a network of companies, identify profitable EE measures (through data collection and energy review), make an agreement on the energy and CO_2 targets to be achieved, perform network meetings with the other participants and exchange experience (which is a central success factor)
Denmark		
Voluntary Agreement Scheme for EE	Voluntary agreement & Financial (tax relief)	> Applicable to energy intensive industries > The immediate benefit is an energy tax relief to the participating industries

Key policy / instrument	Policy type	Main points
		> Obligations are to implement a certified EnMS according to ISO 50001, carry out special investigations and projects focusing on their primary production processes and implement all EE projects with a simple payback period of up to 4 years
Energy Efficiency obligation scheme for utility companies	Market based	> Utility companies should support energy savings efforts in all sectors and recover the costs of the savings through the tariffs imposed on the energy bills of the consumers > Launched in 2006 (long time before the adoption of the EED) with an annual target to implement energy savings of 12.2 PJ per year from 2015 until 2020
Energy audit and management system	Legislative	The scheme obliges large enterprises to undertake energy audits every 4 years.
Renewable energy for production processes	Financial (grants, subsidies)	Set up of a subsidy scheme to industries to convert to RES or DH by replacing fossil fuels and investing in EE measures.
Centre for energy savings in industry	Informative / educational	Set up of a centre to identify and exploit the EE potential already existing within primarily SMEs.
International cooperation on EE in industry	Voluntary agreement & Informative / educational	Cooperation agreement with China and set up of a Low Carbon Transition Unit (allocating a total of DKK 20 million to the Unit) to assist the Chinese industrial sector in achieving lower emissions.
Romania		
Grant-supported credit lines (EE Financing Facilities)	Financial (access to financing, grants)	> 3 credit lines operated in the country (with a grant component) > Provision of support to industrial companies to implement EE investments in the form of free technical consultancy, loans, and grants
Romanian Energy Efficiency Fund	Financial (access to financing, loans)	> The Fund, which is a financing institution, assist industrial companies and other energy consumers to adopt modern EE technologies > The assistance is provided in the form of loans
Energy audit and energy management	Financial (grants) & Legislative	> Obligation to economic operators whose annual consumption exceeds 1,000 toe to appoint an energy manager, carry out an energy audit every year and develop EE programs including measures on short, medium and long term > Financing of EE projects is performed through the Romanian Energy Efficiency Fund
RO 05 “Energy Efficiency” Program	Financial (grants, subsidies)	> Financed by the Financial Mechanism of the European Economic Area (EEA, 2009-2014) > The program financed EE investments in industrial SMEs > The total value of the subsidy/grant amounts to 8 million EUR plus a share of 15% co-financed from national funds
Croatia		
Industrial Energy Efficiency Network (IEEN)	Voluntary agreement	> Active in Croatia since 1997 > Link of energy consumers, experts, state institutions and other interested parties > The basic objective is to increase the awareness and knowledge of the management and employees of the industries towards EE

Key policy / instrument	Policy type	Main points
		> Activities include: recording consumption, development of tools, demonstration projects, establishment of energy management, etc.
Environment Protection and Energy Efficiency Fund (EPEEF)	Financial (grants, subsidies)	> Established in 2003 as a non-budgetary institution > EPEEF finances the preparation, development and implementation of programmes, projects in the fields of environmental protection, waste management, EE and use of RES. For industry, co-financing is provided for performing energy audits, as well as introduction and certification of EN ISO 50001 > Financing is secured through environmental charges and is allocated to legal and natural persons through loans, subsidies, financial aid, and grants
High-efficiency cogeneration	Financial (grants, subsidies) & Legislative	In addition to the system of incentives for the production of electricity from high-efficiency cogeneration, this measure also includes the adoption of appropriate regulations for stimulating the production of heat from cogeneration.
Introduction of efficient electric motor drives	Financial (grants, subsidies) & Legislative	> This measure can achieve electricity savings exceeding 16% and financial savings exceeding 10% > The source of financing is expected to be included in the detailed work programme of the IEEN
Energy audits for SMEs	Financial (grants, subsidies) & Informative / educational	Provision of financial support to SMEs to introduce and implement EE measures, and primarily for conducting energy audits and introducing EnMSs.
Serbia		
EnMS for large energy consumers in the industry sector	Financial (grants, subsidies) & Legislative	> Requirement to organisations to conduct energy audits at least every 5 years > Funds for the implementation of the EE measures are provided by: > a designated organisation from its own funds > favourable credits disbursed by IFIs, > the Budget Fund for EE, and > loans extended by commercial banks or other sources.
Incentive rates for the use of highly efficient CHP generation in the industrial facilities	Financial (incentives)	Industries are entitled as privileged electricity producers and have an incentive purchase price for electricity delivered.
Mandatory regular control of the combustion process of boilers and other combustion chambers with the capacity over 20 kW, and air conditioning systems with the capacity over 12 kW	Legislative	> The Law stipulates the obligation of the owners to perform regular control of the combustion process of boilers / air conditioning systems > The Mining and Energy (MRE) will establish the procedure of authorisation of persons eligible to perform these activities
FYR of Macedonia		
Project INDEF: Energy Management	Informative / educational & Voluntary agreement	> The aim is to develop a structure which liaise large groups of energy consumers from industrial, public, and commercial service sectors and connects them with expert and national organizations for the realization of EE measures

Key policy / instrument	Policy type	Main points
		> It provides support to industries through implementation of an energy audit scheme.
Introduction of efficient electric motors	Financial (access to financing, subsidies)	Support is provided through the provision of access to soft loans for the purchase of EE equipment of this type.
Waste heat utilization/ CDM	Financial (grants, subsidies) & Legislative	> The aim is to support the waste heat utilization in industrial SMEs > Supporting actions are: > launch of a programme for small scale projects (not qualifying for CDM) and creation of a mechanism for control of projects' implementation > provision of financial incentives
Project COGENPRO: Cogeneration	Financial (access to financing, subsidies) & Legislative	The objective is to provide the necessary preconditions to obtain soft loans for the distributed production of heat and electricity for small and micro energy consumers in the industrial sector.

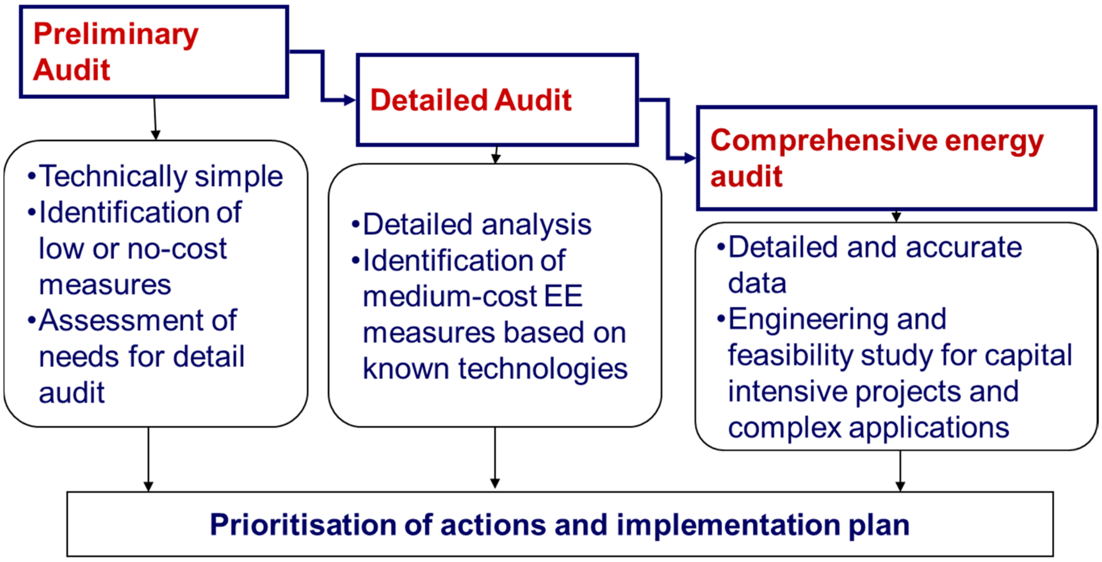
1.5 Energy audits – methodology, types, qualification criteria for energy auditors and accreditation schemes

According to Annex VI of the EED "minimum criteria for energy audits", the energy audits should:

- Be based on up-to-date, measured, traceable operational data on energy consumption and (for electricity) load profiles
- Comprise a detailed review of the energy consumption profile of buildings or groups of buildings, industrial operations, or installations, including transportation
- Build, whenever possible, on life-cycle analysis instead of Simple Payback Periods (SPP) in order to take account of long-term savings, residual values of long-term investments and discount rates
- Be proportionate and sufficiently representative to permit the drawing of a reliable picture of overall energy performance and the reliable identification of the most significant opportunities for improvement.

There are 3 types / levels of energy audits; the preliminary, the detailed and the comprehensive energy audit, as presented in Figure 0-2.

Figure 0-2: Types of energy audits



The energy audit approach includes the following steps:

> Agreement with the factory
> Kick-off meeting (presentation of the objectives and the auditing team)
> On site survey
> Data collection and evaluation
> Identification / discussion of energy saving opportunities
> Description/evaluation of measures
> Audit report presentation
> Follow-up implementation.

As already mentioned, according to article 8 of the EED, an energy audit must be carried out in an independent and cost-effective manner by qualified and/or accredited experts and supervised by independent authorities under national legislation.

As of June 2015, 17 Member States have adopted **qualification criteria for energy auditors**. Qualification criteria for Slovenia are defined only for persons that carry out energy audits for buildings. Portugal and Sweden have no minimum requirements for education. Austria and Ireland require the completion of adequate training. Denmark, Italy, and the UK require a certain professional status instead of an educational degree. All the other Member States require certain academic degrees as educational background. As regards the work experience, in general between 2-6 years of professional relevant experience is required.

Additionally, and according to article 8 of the EED, all Member States should put in place **certification / accreditation schemes** for the providers of energy audits to make sure that a sufficient number of reliable professionals are available. As of August 2015, a significant number of countries have in place accreditation schemes and a register of energy auditors. However, these schemes differ among them and depend on the specificities of each Member State.

As regards **support programmes**, certain Member States developed programmes to encourage SMEs to undergo energy audits and the subsequent implementation of the recommendations from these audits. As of June 2015, only a few Member States had developed specific programmes to support SMEs to undertake energy audits.

1.6 Conclusions

- Europe can demonstrate a substantial progress on EE. However, there is still substantial potential for EE improvement.
- Despite the experience and the available know-how, some EU and most EnC countries face difficulties to properly and effectively **enforce the regulatory measures for EE.** On the other head, awareness among energy users increases and the demand for EE solutions grows.
- There are a number of instruments and measures in the EU Member States and EnC Contracting Parties for promoting EE in the industrial sector. However, certain barriers, such as access to financing, lack of information and knowledge, inadequate skills of industry's personnel, still hinder the application of EE investments.
- **Provision of financial incentives (grants, subsidies) used to be (and still is) the most dominating instrument** in industry. Approximately, half of the policies addressing EE in industry can be attributed to this type of measure. The trend however is **to gradually phase out the grants and subsidies that are not sustainable and entail high social cost and replace them with more market-based instruments and legislative measures**. However, a small grant/subsidy component is usually included in other, market-based instruments.
- **Easier access to EE financing** is a well-established and growing instrument, promoted mainly by IFIs and States through EE Financing facilities, EE Funds and ESCOs.
- **Voluntary agreements are considered a popular policy instrument** for the industrial sector, especially in developed countries since the 1990s; however only a few countries have solid experience with the implementation of national voluntary agreements for more than 10 years.
- The current trend for new policy instruments is to promote:
  - the establishment of **energy management systems**, and certification according to ISO 50001.
  - **voluntary agreements and networking** between industry based on commitments to achieve energy savings and/or to establish coordinated EnMS and share resources and knowledge.
  - **mandatory energy audits**, EE obligations and other legislative/regulatory measures triggered also by the EED, and
  - **"innovative" financing mechanisms** (innovative in the sense that these mechanisms are now widely applied, though they are known since many decades).

EnC Contracting Parties that started the EE effort much later than EU Member States can benefit from the vast EU policy experience and know-how, as well as the wide availability of EE technologies and best practices in the market. However, **enforcement of the EE legislation requires significant institutional strengthening, development of local know-how and awareness raising,** that must be done locally in each country. The significant technical and financial assistance provided so far, helped to a certain extent towards this direction, but the key role in EE improvement is with the local authorities and the local market players.

2 Introduction

This report “**Component 1: EU policy framework and measures for EE in industry**” is drafted as part of the deliverables of the study **“Energy efficiency in industrial sectors in Georgia and Azerbaijan”,** which is implemented under the project “High quality studies to support activities under the Eastern Partnership” (EuropeAid/132574/C/SER/Multi)”.

The overall **aim of the study** is to present EU policies, rules, regulations and tools on energy efficiency (EE) and energy savings, emphasizing on selected industries after consultation with the EC, review the overall methodology for conducting energy audits in the countries under consideration, map and assess existing policies, rules, regulations and tools towards the implementation of EE measures in specific industrial sectors in Azerbaijan and Georgia, and develop pre-feasibility studies for the implementation of EE measures in typical industries following the completion of short energy audits. The study also aims to prepare a preliminary list of energy savings possibilities and an evaluation of such possibilities based on energy, environmental, technical, operational, and economic criteria. The study will conclude with elaboration of recommendations on how to further enhance industrial EE in Azerbaijan and Georgia.

The **aim of the present report** is to provide information, analyse the effects and present:

- The main legislative framework in relation to EE with focus in the industrial sector. It includes an overview of existing policies, rules, regulations, and instruments followed in the EU and the Energy Community (EnC) as well as the history of the EE policy and legislative development in Europe in the past decades
- The international standards that are applicable to EE, energy management and energy auditing
- The Best Available Techniques as regards EE for the most energy - intensive sectors
- Successful policy instruments and measures in the EU and EnC Contracting Parties towards the realization of EE potential
- The responsibilities of Member States towards the certification of energy auditors including their qualification criteria, the available certification / accreditation schemes, and relevant support programmes for performing energy audits in industrial SMEs
- The overall methodology and procedures for conducting energy audits in the industrial sector.

3 Policies on EE and energy savings in the industrial sector in EU and Energy Community Contracting Parties

3.1 Overview of the legislative framework in the EU and the Energy Community (EnC) Contracting Parties

3.1.1 Introduction

Before presenting the main legislative framework regarding EE with a focus on the industrial sector, the Study Team considers it important to present briefly the history of the EE policy and legislative development in Europe in the past decades.

After the 1973 oil crisis the western world realised that security of energy supply is not guaranteed, and imported energy can become too expensive, thus undermining economic development. Europe had to develop EE policies and act appropriately. The main driving forces were the:

> **security of energy supply** (defined as the uninterrupted availability of energy sources at an affordable price)
> reduction of **dependency from energy imports**
> reduction of **effects to the economy** from sharp energy price changes
> **improved competitiveness** of the economy and businesses through more efficient utilisation of energy resources

while from mid-90's onwards,

> the **increasing awareness and concern about the climate change**, linked also with the energy production and use.

During the early years (70's – 90's) EU and individual Member States focused on supporting the EE market opening and development, rather than on legislative and regulatory measures. Premature obligatory regulations regarding EE could harm businesses (manufactures, construction companies, etc.), as well as burden the end-users with excessive costs, as, at that time, EE solutions were quite expensive to implement. To start-up and create a critical mass of the EE market, numerous programmes were launched, and significant financial resources were allocated for their implementation, including mainly:

> **Capacity building and awareness raising** (training of energy auditors, engineers, and professionals; EE guides; information campaigns for the citizens, etc.)
> Support **Research and Development (R&D)** for EE equipment, new materials, and technologies (including voluntary agreements with manufacturers to invest on improving energy performance of their products, such as a voluntary agreement with motors manufacturers; financing to research centres; demonstration projects, etc.)
> Development of **technical standards, calculation methodologies**, etc.
> Development of **EE financing mechanisms combined or not with technical assistance** (provisions of grants, soft loans, support ESCO market development, energy audits and technical assistance to energy users)
> Limited **regulatory measures** (e.g. regulations for buildings' thermal insulation, etc.).

After 2000, the EU started gradually to impose legislative – regulatory measures for EE. Enforcement of regulatory measures proved to be a difficult task for many Member States but, even their initial partial enforcement, helped to:

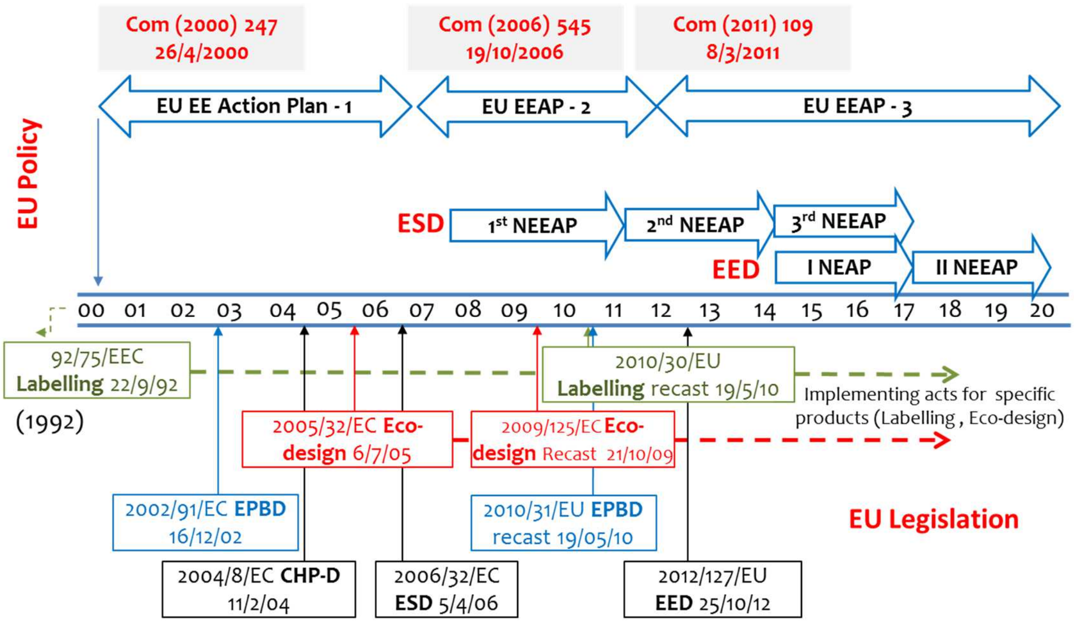
> develop further the capacities among professionals, state officials, etc.
> developed new businesses in EE (ESCO's, EE consultants, constructors/ installers, etc.)
> enlarged the market of EE products allowing further R&D by manufacturers and reduction of costs of EE products and techniques
> increased awareness among the energy consumers.

This helped the EE market to mature. Well-informed citizens and energy users started asking for more EE solutions. Manufacturers, construction-engineering companies, and energy service providers responded to the market demand by offering such solutions at more affordable prices. This way, several mandatory / regulatory provisions of the EU Directives and Regulations gradually became "standard engineering practices" that are "enforced" by the market itself.

The basic **EU policy legislative framework for EE** is depicted in

Figure 3-1.

Figure 3-1: Basic EU policies and legislation in EE (2000 – 2020)



In its Resolution on EE of 7th December 1998, the Council invited the Commission to come forward as soon as possible with a proposal for a prioritised Community action plan for EE (**COM(2000) 247**). The 1st EE Action Plan proposed a number of measures, sought indications of the contribution of other Community policies towards EE, and stated that the plan should show Community and Member State responsibilities, particularly regarding financing and timetables. One of the primary objectives of the 1st Action Plan for EE was to present for endorsement, common and co-ordinated policies, and actions to be undertaken in the light of the Kyoto Agreement to contribute to the reduction of greenhouse gas (GHG) emissions by 8% by the period 2008-2012.

The 2nd Action Plan for EE: Realising the Potential (**COM(2006) 545**) aimed at achieving a 20% reduction in energy consumption by 2020. The Action Plan run for a 6-year period from 1 January 2007 to 31 December 2012. In more specific, the primary objective of the Action Plan was to control and reduce energy demand and to take targeted action on consumption and supply in order to **save 20% of annual consumption of primary energy by 2020 (compared to the**

energy consumption forecasts for 2020). This objective corresponded to achieving approximately a 1.5% new energy saving per year up to 2020.

The 3rd EE Action Plan (**COM(2011) 109**) - Energy Efficiency Plan 2011, published on 8 March 2011, restated the 20% target.

The 3rd EE Action Plan was in line with the "Energy 2020: A strategy for competitive, sustainable and secure energy" (**COM(2010) 639 final**) setting the well-known **20-20-20 targets to be achieved by 2020** regarding the 20% of reduction of EU GHG emissions, 20% of energy consumption to come from RES and the 20% reduction in primary energy use by improving EE. More ambitious targets are indicated in the "Policy framework for climate and energy in the period from 2020 to 2030" (**COM(2014) 15 final**).

During the same period, several important Directives and regulations were adopted, as shown in

Figure 3-1. **EE in industry is explicitly addressed only in few articles of the EU legislation**, as most of the provisions refer to cross-sectoral EE measures (addressing also industry) or to specific EE products, as well as to energy performance of buildings. For example, the **Energy Services Directive** – ESD (**2006/32/EC**) repealed by the **EE Directive** – EED (**2012/27/EU**), provides, i.e., for the availability of energy services, as well as for adoption and implementation of 3-year National EE Action Plans (NEEAP) that include horizontal measures, as well as dedicated EE measures for each energy sector, including industry.

Apart from the EE legislation, the **Renewable Energy Directive** – RED (**2009/28/EC),** provides for a favourable environment for energy produced from RES and for the introduction of biofuels. This opens new industrial business opportunities (e.g. biofuels production) as well as optimization of energy resources (e.g. waste to energy) for the industrial sector as well.

Currently transposition and implementation of **all the prevailing EU legislation regarding EE and RES (with the exception of the eco-design framework) is among the obligations of the Contacting Parties to the Energy Community Treaty** (EnCT). Georgia, that recently joined the Energy Community (EnC), undertook all these commitments.

In the following paragraphs, the most important EU EE legislation, and policies, relevant to the industrial sector, are presented.

3.1.2 Energy Efficiency Directive[1]

The **Energy Efficiency Directive** – EED (**2012/27/EU**) had a general implementation deadline of 5th June 2014 for EU Member States, while the deadline of Contracting Parties to the EnCT is 15th October 2017.

The EED complements and repeals Directives 2004/8/EC on high efficiency CHP and 2006/32/EC on energy services (ESD). Unlikely the previous EE related directives that focused

[1] Directive 2012/27/EU of the EUROPEAN PARLIAMENT and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC

on the demand side, the EED addresses for first time EE in the whole energy chain, from production, transformation, transmission, distribution, up the end-use of energy. The EED is also harmonised with and promotes implementation of the **Energy Performance of Buildings Directive** – EPBD (**2010/31/EU**). In this respect, the EED links together all previous EE legislation and is the basis for a robust EE Law for each country, in the view of promoting achievement of the overall EU and EnC EE target by 20% in 2020.

On 30 November 2016, the Commission proposed an update to the EED, including a new 30% EE target for 2030, and measures to update the Directive to make sure the new target is met.

Although the direct references of the EED to industry are limited, many of its provisions have an impact on industrial EE. Specifically, the EED provides, i.e.., for 3 specific quantitative targets:

- **indicative national EE target** (Art. 3) to be achieved through the implementation of the NEEAPs (Art 24.2) and other measures; EE in industry is one of the energy consuming sectors targeted by the NEEAPs
- **EE obligation schemes** (Art. 7), that impose obligation to energy distributors and/or retail energy sales companies to implement measures that would achieve on an annual basis, new energy savings corresponding to 1.5% of the total annual energy sales of energy to final customers; industry is an ideal target for this scheme as EE measures applied in selected industrial facilities may lead to considerable energy savings in terms of volume, thus facilitating achievement of the target. Alternatively, each EU Member State or EnC Contracting Party may choose to implement other EE measures that can achieve the same energy saving result. Depending on the mix of these measures, industry can be encouraged through incentives (e.g. through voluntary agreements, financing schemes and instruments, fiscal incentives, etc.) or disincentives (e.g. through energy or CO2 taxes) to implement EE measures
- **energy rehabilitation of buildings** owned and occupied by the Central Government at a rate 3% of floor area per year (Art. 5), as well as establishment a long-term strategy for mobilizing investment in the renovation of the national building stock. It is expected that these provisions will promote the financing services market (e.g. ESCOs), the industry producing building materials and equipment, as well as the construction industry.

Regarding industry, the most important Article of the EED is Art.8 "Energy audits and energy management systems". According to this Article:

- Large enterprises (that are not SMEs) are obligatory subject to an energy audit carried out in an independent and cost-effective manner by qualified and/or accredited experts at least every 4 years from the date of the previous energy audit. Enterprises that are implementing an energy or environmental management system - certified by an independent body (that includes energy audit) are exempted from the requirement to conduct a stand-alone energy audit
- Also, the State must develop programmes to encourage SMEs to undergo energy audits and the subsequent implementation of the recommendations from these audits.

Energy audits, as a legal obligation or as a prerequisite to receive State support, must be carried out under a national scheme based on:

- appointment of independent authorities under national legislation who shall implement and supervise this scheme including quality control mechanisms
- a body of qualified and/or accredited experts (auditors) according to qualification criteria.

Article 8 and Annex VI of the EED provides the framework for the setting up such schemes including the minimum criteria for energy audits.

Both Articles 8 and 16 of the EED provide for "availability of qualification, accreditation and certification schemes" such as energy management schemes, etc. The Directive refers to "European and International Standards" without explicit reference to the relevant EN and ISO standards that are presented in the following section.

In conclusion, the EED streamlines the whole framework on EE including energy auditing, energy management, alternative financing mechanisms, etc., creating a quite favourable environment for promotion of EE in industry and other economic sectors. These issues will be further discussed and analysed in the following chapters.

3.1.3 Energy Labelling Directive[2]

The first **Energy Labelling Directive** was adopted back in 1992 and its recast (**Directive 2010/30/EU)** in May 2010. The Energy Labelling Directive is a framework directive that mandates the EC to propose, by means of delegated acts, details relating to information to be provided on the label and in the fiche for each type of product. Products are ranked, according to their energy performance, in general, on an A to G scale, clearly marked with colours from dark green to red. Initially energy labelling covered household appliances but gradually it included other energy related products used in the commercial and industrial sectors.

Energy labelling **is an informative scheme** aiming at providing information and increasing awareness among energy consumers about the benefits of purchasing energy efficient products. This scheme encouraged also manufacturers to invest on research and development in order to offer more efficient products to the market at affordable prices. The energy labelling scheme did not impose any mandatory minimum requirements for EE performance of products that could affect manufacturing industry. On the contrary, it gave the time to manufacturers to get prepared for the regulatory measures that followed, such as the eco-design framework.

3.1.4 Eco-Design Directive[3]

The **Eco-design Directive for energy-related products (Directive 2009/125/EC)** is a Framework Directive adopted on 21 October 2009, recasting the relevant Directive of 2005. It is implemented for each specific energy related product group by Commission Regulations. The Eco-design Directive aims to reduce the environmental impact of products, by providing EU-wide rules for the design of energy related products.

As mentioned, Eco-design moves a step ahead from the energy labelling scheme through imposing minimum energy performance and other requirements, thus banning for the European markets products of low efficiency (the ones that are ranked low in the scale of the energy labelling scheme).

Eco-design applies to several products, **including products widely used in industry** (e.g. high efficiency motors). It has also an impact on manufacturers of energy related products who cannot sell anymore low efficiency products in the European market. However, as a result of the technological developments and the increased awareness of energy users, the minimum efficiency requirements for several product groups are equal or very close to specifications of the

[2] http://www.eceee.org/ecodesign/Energy-labelling-directive/

[3] http://ec.europa.eu/growth/industry/sustainability/ecodesign_el & http://www.eceee.org/ecodesign/

products widely sold nowadays in the markets; therefore, more stringent regulations are needed to have a more significant energy saving impact.

The Implementing Regulations in force for product groups which are most relevant for the industrial sector are presented in Table 3-1.

Table 3-1: Related industrial products covered by the Eco-Design Directive

ECODESIGN Product	Regulation
Small, medium, and large power transformers	Regulation (EU) No 548/2014
Ventilation units	Regulation (EU) No 1253/2014
Professional refrigerating and freezing equipment	Regulation (EU) No 2015/1095 and 2015/1094
Glandless standalone circulators and glandless circulators integrated in products	Regulation (EU) No 622/2012 amending Regulation (EU) No 641/2009
Glandless standalone circulators and glandless circulators integrated in products	Regulation (EU) No 622/2012 amending Regulation (EU) No 641/2009
Water pumps	Regulation (EU) No 547/2012
Air conditioners and comfort fans	Regulation (EU) No 206/2012
Fans driven by motors with an electric input power between 125 W and 500 kW	Regulation (EU) No 327/2011
Electric motors	Regulation (EU) No 640/2009 amended by Regulation (EU) No 4/2014
Space heaters and combination heaters	Regulation (EU) No 813/2013
Fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps	Regulation (EU) No 245/2009 amended by Regulation (EU) No 347/2010

3.1.5 Renewable Energy Directive

The Renewable Energy Directive-RED (**Directive 2009/28/EC**) establishes an overall policy for the production and use of energy from RES. On 30 November 2016, the Commission published a proposal for a revised Renewable Energy Directive to make the EU a global leader in renewable energy and ensure that the target of at least 27% renewables in the final energy consumption in the EU by 2030 is met.

The RED, i.e., provides for:

> Mandatory national overall targets and measures for the use of energy from RES to achieve the overall 20% RES target in EU by 2020
> Mandatory target for RES (mainly biofuels) contribution by at least 10% in transport consumption by 2020
> Development and implementation of National Renewable Action Plans, etc.

On the other hand, the RED incentivises RES by:

> by granting priority or guaranteed access to the grid for electricity production from RES
> by allowing Member States, individually or collectively, to establish support schemes for RES.

Although the RED does not directly refer to industry, many industrial facilities across EU, especially the ones that produce biomass by-products and organic wastes, have exploited the incentives provided by the RED provisions and Member States support schemes to reduce their energy cost and/or to have an extra income from RES electricity sales.

As mentioned above, also production of biofuels is a growing industrial activity.

3.1.6 IPPC Directive

The IPPC Directive (**Directive 96/61/EC**) requires that all installations are operated in such a way that energy is used efficiently, and one of the factors to be considered in determining the **Best Available Techniques** (BAT) for a process, is its EE.

The purpose of the IPPC Directive is to achieve integrated prevention and control of pollution, leading to a high level of protection of the environment as a whole, including the EE and the wise use of natural resources.

The IPPC Directive provides for a **permitting system for specified industrial installations**, requiring both operators and regulators to take an integrated, overall view of the potential of an installation to consume and pollute.

The overall aim of such an integrated approach is to improve the design and construction, management, and control of industrial processes so as to ensure a high level of protection for the environment as a whole. Central to this approach is the general principle given in Article 3 of the Directive that operators should take all appropriate preventative measures against pollution, in particular through the application of "Best Available Techniques", enabling them to improve their environmental performance, **linked also to EE.**

3.1.7 Industrial Emissions Directive

The Industrial Emissions Directive (IED – **Directive 2010/75/EU**) aims to achieve a high level of protection of human health and the environment in **reducing harmful industrial emission of air pollutants, discharges of waste water and the generation of waste** across the EU, **contributing also to EE**. Indeed, one of the pillars[4] of the IED is the integrated approach, meaning that the permits granted under the IED must take into account the whole environmental performance of the plant, covering e.g. emissions to air, water and land, generation of waste, use of raw materials, **EE**, noise, prevention of accidents, and restoration of the site upon closure.

The IED provides that the BAT conclusions shall be the reference for setting the permit conditions of the approximately 50,000 industrial installations it covers[5].

3.1.8 Emissions Trading Directives

The EU Emissions Trading System (ETS), launched in 2005, is a key component of the EU's policy to combat climate change and it is a key tool for reducing GHG emissions in a cost-effective way. EU ETS is the world's first and biggest carbon market.

[4] The other major pillars of Directive 2010/75/EC are: (a) use of best available techniques for pollution reduction, (b) the provision of flexibility to the Member States to set less strict emission limit value in specific cases, (c) the imposition of mandatory environmental inspections through the establishment of inspections systems and plans; and (d) the setting-up of public participation scheme to allow the public to take part in the decision-making process

[5] Commission Staff Working Document, Good practice in energy efficiency, Brussels, 30.11.2016 SWD(2016) 404 final, Part 2/4 (COM(2016) 761 final)

The EU ETS market evolves in 4 phases (2005-2007, 2008-2012, 2013-2020, 2021-2028) from "learning by doing" to a more strict and better functioning system that covers more sectors gradually.

Directive 2003/87/EC as amended by the **Directive 2009/29/EC** govern the EU ETS. The system works by setting a cap (limit) on the total emissions from covered installations. The cap is annually reduced to achieve the GHG emissions target.

Within this limit, companies can buy and sell emission allowances as needed. Emission allowances are the "currency" of the EU ETS. Each allowance gives the holder the right to emit 1 ton of CO_2, or the equivalent amount of nitrous oxide (N_2O) and perfluorocarbons (PFCs). Allowances can be used only once. Companies have to submit allowances for every ton of CO_2 (or the equivalent amount of N_2O or PFCs) covered by the EU ETS that they emitted in the previous year.

Companies can receive allowances from governments through auctions (that is the current trend) or for free. At the beginning of the current trading period (2013), **manufacturing industry** received 80% of its allowances for free. This proportion decreases gradually each year to reach 30% in 2020. Power generators since 2013, in principle (with some exemptions) do not receive any free allowances.

Companies must cover the rest of their emissions (that exceed the allowances purchased or given for free), by:

- buying additional allowances
- using any surplus allowances that they have saved from previous years.

Within limits, they can also buy credits from certain types of approved emission-saving projects around the world.

This "cap-and-trade" approach gives companies the flexibility they need to reduce their emissions in the most cost-effective way. Obviously, **improving EE is a means to reduce GHG emissions** and save allowances that can be sold.

The EU ETS applies to power and heat generation, aviation operations and virtually all branches of energy intensive industries, including oil refineries, steel works and production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids, and bulk organic chemicals. It covers approximately 11,000 power stations and manufacturing plants in the 28 EU Member States plus Iceland, Liechtenstein, and Norway, as well as aviation activities in these countries. In total, approximately 45% of total EU GHG emissions are regulated by the EU ETS.

The EC presented in July 2015 a legislative proposal on the revision of the EU ETS for its next phase (2021-2030), in line with the EU's 2030 climate and energy policy framework. **The proposal aims to reduce EU ETS emissions by 43% compared to 2005**.

3.2 International standards applicable to energy efficiency, energy management and energy auditing

3.2.1 ISO 50000 series on Energy Management

The **ISO 50000 series** was created to provide a comprehensive suite of international standards offering **good practice in energy management**. The standards can be used together, or independently and are **suitable for any size of organisation**.

ISO 50001 – Energy Management Systems – Requirements with guidance for use is a normative Management Systems International Standard. **The request to ISO to develop an international energy management standard came from the United Nations Industrial Development Organization (UNIDO)** which had **recognised industry's need** to an effective response to climate change and to the proliferation of national energy management standards[6].

ISO 50001 is a proven framework for **industrial facilities**, commercial facilities, or entire organizations for implementing an Energy Management System (EnMS). An EnMS helps an organization internalise the policies, procedures, and tools to systematically track, analyse and improve EE. It considers maintenance practices, operational controls, and the design and procurement of renovated, modified, and new equipment, systems, processes, and facilities. With ISO 50001, energy management is integrated into normal business processes involving multiple types of employees across the organization.

ISO 50001 is based on the **Plan-Do-Check-Act structure** to continual improvement held in common with the ISO 9001 (quality management), ISO 14001 (environmental management), and other management systems. ISO 50001 is designed to be compatible with these management systems.

ISO 50001, which is subject to certification, focuses on processes, introduces concepts, but lacks specificity to EnM techniques. The relevant ISO committee recognised this and is drawing up **supporting standards** (that are not subject of certification). The supporting standards released so far are:

- **ISO 50002 – Energy audits - Requirements with guidance for use (based on EN 16247-1)**. This standard specifies the process requirements for carrying out an energy audit in relation to energy performance. It is applicable to all types of establishments and organizations, and all forms of energy and energy use. It specifies the principles of carrying out energy audits, requirements for the common processes during energy audits, and deliverables for energy audits.
- **ISO 50003 – Requirements for bodies providing audit and certification of EnMSs**. This Standard specifies requirements for competence, consistency and impartiality in the auditing and certification of EnMS for bodies providing these services.
- **ISO 50004 – Guidance for the implementation, maintenance, and improvement of an EnMS**. This Standard provides practical guidance and examples for establishing, implementing, maintaining, and improving an EnMS in accordance with the systematic approach of ISO 50001.
- **ISO 50006 – Energy Baselines (EnB) and Energy Performance Indicators (EnPIs)**. This Standard provides organizations with practical guidance on how to meet the requirements of ISO 50001 related to the establishment, use and maintenance of EnPIs

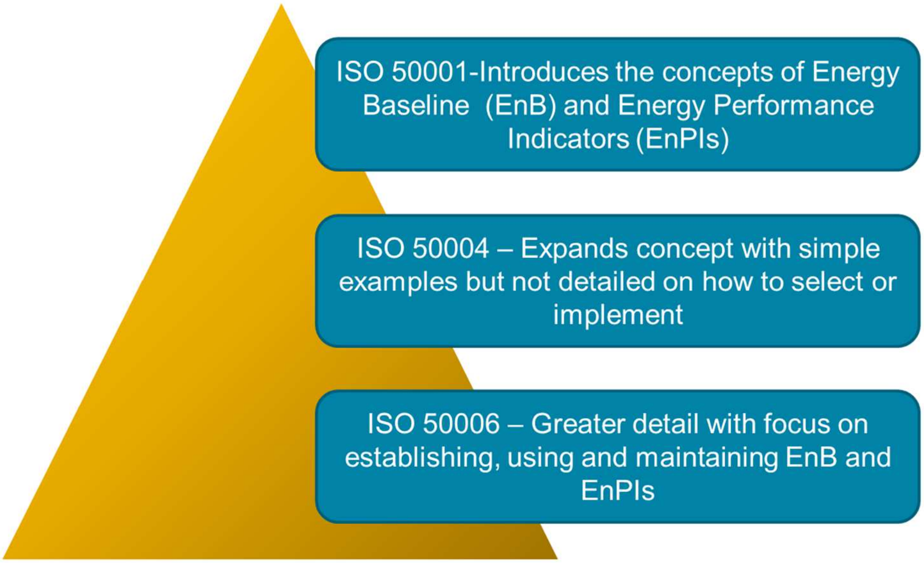
[6] https://www.iso.org/files/live/sites/isoorg/files/archive/pdf/en/iso_50001_energy.pdf

and EnBs in measuring energy performance and energy performance changes. EnPIs and EnBs are two key interrelated elements of ISO 50001 that enable the measurement and therefore management of energy performance in an organization.

> **ISO 50015 – Measurement and verification of energy performance of organizations - General principles and guidance.** This Standard establishes general principles and guidelines for the process of measurement and verification (M&V) of energy performance of an organization or its components. M&V is the process of planning, measuring, collecting data, analysing, verifying, and reporting energy performance or energy performance improvement for defined M&V boundaries.

An example of how EnMS standards are structured is presented in Figure 3-2.

Figure 3-2: Example of how EnMS standards are structured



3.2.2 EN standards on Energy Auditing

Apart from ISO standards, CEN and CENELEC have published a series of European Standards (the **EN 16247**) that set out requirements and provide guidance on how to carry out energy audits. The **EN 16247 series of standards came to support companies throughout Europe to comply with the requirements of the EED**.

The standards developed are the following:

> EN 16247-1: Energy audits – Part 1: General requirements
> EN 16247-2: Energy audits – Part 2: Buildings
> EN 16247-3: Energy audits – Part 3: Processes
> EN 16247-4: Energy audits – Part 4: Transport
> EN 16247-5: Energy audits – Part 5: Competence of energy auditors

EN 16247-1 specifies the general requirements, common methodology and deliverables for energy audits. It applies to commercial, **industrial**, residential, and public-sector organisations, excluding individual private dwellings. The other standards in these series are dedicated to specific energy audit requirements for buildings, industrial processes, and transportation.

It is noted that ISO 50002 for energy audits and EN 16247-1 have similar definitions and apply very similar processes for establishing energy baselines, determining consumption, and identifying opportunities for EE.

3.2.3 Measurement and Verification

An important issue stressed out in the EED is the measurement and verification of energy savings so as a State can prove achievement of targets. Annex V of the EED establishes the "Common methods and principles for calculating the impact of energy efficiency obligations schemes or other policy measures".

These methods are broadly in line with the concepts of "ISO 50006 – Energy Baselines (EnB) and Energy Performance Indicators (EnPIs)" and "ISO 50015 – Measurement and verification of energy performance of organizations - General principles and guidance."

Apart from the above-mentioned standards, EVO, the Efficiency Valuation Organisation, developed the "International Performance Measurement and Verification Protocol (IPMVP)" that is more analytical comparing to ISO 50015. IPMVP is widely used in the USA and certain other countries. Gradually its use is spread to EU countries as well, especially by ESCOs for which M&V of guaranteed savings is essential for their projects.

3.3 Best Available Techniques

3.3.1 Concept of Best Available Techniques

The term BAT is defined in Article 2(12) of the IPPC Directive as "*the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole*".

More analytically:

> **"techniques"** includes both the technology used and the way in which the installation is designed, built, maintained, operated, and decommissioned
> **"available"** techniques are those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced inside the Member State in question, as long as they are reasonably accessible to the operator
> **"best"** means most effective in achieving a high general level of protection of the environment as a whole.

3.3.2 BAT in selected industrial sectors

BAT as regards EE for the most energy - intensive sectors, mentioned also in the ToR of this study, will be presented for the sectors of chemicals and petrochemicals, iron and steel, non-metallic minerals (mainly cement), pulp and paper, and food and beverages.

3.3.2.1 Chemical and petrochemical

Key EE opportunities in the chemical and petrochemical industry are presented in brief in Table 3-2.

Table 3-2: Key EE opportunities in the chemical and petrochemical industry[7]

[7] BAT Reference Document on Large Volume Organic Chemical Industry, February 2003

Area	Measure
Measures related to general utilities	
Compressed air	> System improvements and optimisation, including leak detection
Cogeneration	> Use of gas turbine exhaust gas as combustion and for heating furnaces
Motors	> Use of high efficient motors with VSDs and soft start for all pumps, fans and blowers and transport systems
Process control systems	> Use an EnMS > Monitoring and control of processes, using advanced control systems
Process specific measures	
Catalytic Hydro treatment	> Improve catalysts
Distillation	> Optimisation of distillation columns operational > Advanced distillation column designs > Progressive crude distillation
Boilers and Furnaces	> Heat recovery techniques > Flue gas monitoring > Use advanced heating and process control > Use high efficiency burners > Integrated gasification combine cycle
Overall	> Reduction in flaring and venting

3.3.2.2 Iron and steel

Key EE opportunities in the iron and steel industry are presented in brief in Table 3-3.

Table 3-3: Key EE opportunities in the iron and steel industry[8]

Area	Measure
Measures related to general utilities	
Compressed air	> System improvements and optimisation including leak detection
Motors	> Use of high efficient motors with VSDs and soft start for all pumps, fans and blowers and transport systems
Process control systems	> Introduce EnMS > Monitoring and control of processes, using advanced control systems
Process specific measures	
Coke making	> Coke Dry Quenching[9] > Coal moisture control > VSD coke oven gas compressors > Automation and process control system > Emissions Optimised Sintering > SCOPE 21 – next generation coke making technology
Sinter and pellets plant	> Waste heat recovery in sinter plants

[8] BAT Reference Document for Iron and Steel Production, 2013

[9] Coke Dry Quenching (CDQ) is an alternative to the traditional wet quenching of the coke. Coke is cooled using an inert gas in dry cooling plant, instead of cooling by sprayed water which results in high CO2 emissions and thermal energy loss
(source: http://ietd.iipnetwork.org/content/coke-dry-quenching).

Area	Measure
	> Improved charging of materials > Optimised sinter pellet ratio
Iron making	> Use of top gas pressure recovery turbines > Improve hot stoves process control > Improve blast furnace process control > Natural gas injection > Top gas recycling blast furnace > Improve recovery of blast furnace gas > Pulverised coal injection > Heat recovery from hot blast stoves
Steel making	> BOF (Basic Oxygen Furnace) waste heat and gas recovery > Scrap pre-heating > Bottom stirring/gas injection > Direct Current (DC) Arc Furnaces > Twin-shell DC Arc Furnace > Foamy slag practices > Installation of oxy-fuel burner > Improve process control
Rolling and Finishing	> Process control in hot strip mill > Regenerative burners for re-heating furnaces > Improve insulation of re-heating furnaces > EE in the hot strip mill > Hot charging > Reducing losses in annealing line (cold rolling) > Automated M&T system (cold rolling)

3.3.2.3 Cement (non-metallic minerals)

Key EE opportunities in the cement industry are presented in brief in Table 3-4.

Table 3-4: Key EE opportunities in the cement industry[10]

Area	Measure
Measures related to general utilities	
Heat generation	> Use of wastes as fuels
Reduction of electrical energy use	> Installation of power management systems > Use of high efficient motors with VSDs and soft start for all pumps, fans and blowers and transport systems
Cogeneration	> Cogeneration/combined heat and power plants
Process control systems	> Process control optimisation including computer based automatic control systems
Process specific measures	
Raw materials preparation	> Replacement of traditional mills with high efficiency roller mills > Use of high efficiency separators and classifiers > Automation of raw materials mixing control > Closed circuit system for ball mills

[10] BAT Reference Document for the Production of Cement, Lime and Magnesium Oxide, 2013

Area	Measure
	> Improving the grinding media in ball mills
Clinker process	> Change from wet to dry process > Use of dry kilns with multi-stage pre-heaters and pre-calciners > Use of efficient cooler technology > Energy recovery from kilns and coolers/cogeneration > Reducing clinker content in cement products
Process control optimisation in Kilns	> Optimizing combustion efficiency in kilns > Reducing kiln shell heat losses and cold air leakages > Recovering excess heat from kilns

3.3.2.4 Glass (non-metallic minerals)

Key EE opportunities in the glass industry are presented in brief in Table 3-5.

Table 3-5: Key EE opportunities in the glass industry[11]

Area	Measure
Measures related to general utilities	
Heat generation	> Combustion performance improvements for furnaces > Minimising the use of excess air > Proper tuning and positioning of burners in the furnace
Compressed air	> System improvements and optimisation including leak detection
Electricity	> Use of high efficient motors with VSDs and soft start for all pumps, fans and blowers and transport systems
Process control systems	> Process optimisation, through the control of the operating parameters > Regular maintenance of the melting furnace
Process specific measures	
Furnaces/ Melting	> Preheating the cullet/batch materials > Improve furnace design and the selection of the melting technique > Use of increasing levels of cullet, where available and economically and technically viable > Use of regenerative furnaces > Use of oxy-fuel furnaces > Use of more efficient forehearths > Use of a waste heat boiler for energy recovery, where technically and economically viable
Process control	> Forehearths process control > Continuous gob monitoring
Annealing process	> Improve annealing process
Finishing	> Hot end inspection

[11] BAT Reference Document for the Manufacture of Glass, 2013

3.3.2.5 Pulp and paper

Key EE opportunities in the glass industry are presented in brief in Table 3-6.

Table 3-6: Key EE opportunities in the pulp and paper industry[12]

Area	Measure
Measures related to general utilities	
Heat generation	> Use of energy efficient boilers > Boilers sequencing
Cogeneration	> Use of black liquor boilers, combined cycle, and biomass boilers
Compressed air	> System improvements and optimisation including leak detection
Electricity	> Use of high efficient motors with frequent inverters and soft start for all pumps, fans and blowers and transport systems
Process control systems	> Introduction of an EnMS > Monitoring and control of processes, using advanced control systems
Process specific measures	
Raw material preparation	> Automated chip handling & thickness screening > Replace pneumatic conveyors with belt conveyors > Bio-treatment > Use of secondary heat in debarking > Dry debarking
Chemical pulping	> Increase EE of digesters by increasing yield of pulp > Use continuous digesters
Bleaching	> Improved brownstock washing > Heat recovery from bleach effluents > Replace conventional vacuum pressure units with washing presses
Chemical recovery	> Black liquor gasification > Lime kiln modifications > Use quaternary air injection
Mechanical pulping	> Refiner improvements > Heat recovery in thermomechanical pulp > Pressurised groundwood
Paper making	> Use of concave shoe press > Reducing air requirements > Waste heat recovery from paper drying > Use Condebelt drying > Use EE vacuum systems for dewatering > Use of thermo-compressors
Pulping recycling	> Increased use of recycled pulp > Heat recovery from de-inking effluents
Water	> Introduce water management program

[12] BAT Reference Document for the Production of Pulp, Paper and Board, 2015

3.3.2.6 Aluminium and copper (non-ferrous metals)

Key EE opportunities in the aluminium and copper industry are presented in brief in Table 3-7.

Table 3-7: Key EE opportunities in the aluminium and copper industry[13]

Area	Measure
Measures related to general utilities	
Compressed air	> System improvements and optimisation including leak detection
Electricity	> Use of high efficient motors with VSDs and soft start for all pumps, fans and blowers and transport systems
Process control systems	> Introduce an EnMS > Monitoring and control of processes, using advanced control systems
Process specific measures	
Metals processing	> Installation of regenerative or recuperator burners in furnaces to recover heat from flue gases > Use of regenerative afterburner
Metals processing furnaces	> Reduction of furnace shell losses by improving insulation and minimising losses from seals and openings > Optimising furnaces operations through scheduling and control of combustion > Use oxy-fuel firing > Use circulate fluid bed calciners > Oxygen enrichment of combustion air
Metals processing (primary/ secondary production)	> Inert anode technology > Increase the recycling of scraps

3.3.2.7 Food and beverages

Key EE opportunities in the food and beverages industry are presented in brief in Table 3-8.

Table 3-8: Key EE opportunities in the food and beverages industry[14]

Area	Measure
Measures related to general utilities	
Cogeneration	> Adoption of CHP technologies (they can result in significant energy savings in many sub-sectors of the food industry)
Heat generation	> EE technologies can be used in steam generation and distribution systems
Compressed air	> System improvements and optimisation including leak detection
Electricity	> Use of high efficient motors with VSDs and soft start for all pumps, fans and blowers and transport systems
Process control systems	> Use of EnMS > Monitoring and control of processes, using advanced control systems
Process specific measures	

[13] BAT Reference Document for the Non-Ferrous Metals Industries, Final Draft Oct 2014

[14] BAT Reference Document for the Food, Drink and Milk Industries, First Draft Jan 2017 and Aug 2006

Area	Measure
Process Heating/Cooling, Pasteurisation, Evaporation	> Process heat recovery: several options in many processes including pasteurisation section in a milk packaging plant, evaporation plants in the food industry, process heating, process cooling
Refrigeration	> Use of energy efficient chillers > Automation and control in refrigeration equipment
Drying	> Improving insulation > Mechanical dewatering
Air conditioning	Cooling and refrigeration efficiency can be improved by: > Optimising head pressure controls > Controlling air purges > Installing a refrigerant gas heat recovery system > Re-designing the entire refrigeration system

3.3.3 Benchmarking on EE and GHG emissions in selected industrial sectors

In 2005, the industrial sector worldwide used approximately 121 EJ (Exajoule) of final energy accounting for more than 1/3 of the global final energy use (Table 3-9).

Table 3-9: Final energy in industry, 2005 (EJ/yr)[15]

Industry	World	OECD	Africa	Latin America	Middle East	Non-OECD Europe	FSU[16]	Asia	China
Chemical and Petrochemical	35.1	18.4	0.4	1.5	2.6	0.3	3.2	3.4	5.3
Iron and Steel	25.0	7.5	0.4	1.2	0.1	0.3	3.5	1.6	10.4
Non-metallic minerals	11.2	3.7	0.1	0.4		0.1	0.8	1.4	4.7
Pulp, paper, and printing	6.7	5.1		0.4			0.3	0.2	0.7
Food, beverage	6.1	2.9		1.0		0.1	0.5	0.7	0.9
Non-ferrous metals	3.8	2.0	0.1	0.4			0.1		1.2
Machinery	4.2	2.3					0.3	0.2	1.4
Textile and Leather	2.3	0.8		0.1			0.1	0.2	1.1
Mining and Quarrying	2.2	1.0	0.2	0.1			0.4	0.1	0.4
Construction	1.4	0.7	0.1				0.2		0.4
Wood and wood products	1.1	0.8					0.1		0.2
Transport equipment	1.4	0.8					0.2		0.4
Non-specified	19.8	4.5	2.4	1.8	2.3	0.1	1.3	6.5	0.9
Total final energy	**120.3**	**50.5**	**3.7**	**6.9**	**5.0**	**0.9**	**11.0**	**14.3**	**28**
Total primary energy	**491.5**	**231.8**	**25.7**	**22.2**	**21.9**	**4.5**	**42.6**	**55.7**	**79.4**

[15] IEA 2008 a
[16] Former Soviet Union

Developing countries and transition economies account for 58% of the total industrial final energy use. China alone accounts for 23%, while Asia as a whole (including China) accounts for 35% and Africa accounts for only 3.1%.

Five energy intensive sectors (chemicals and petrochemicals, iron and steel, non-metallic minerals (mainly cement), pulp and paper and food and beverages) account for approximately 70% of the total final energy use.

3.3.3.1 Chemical and petrochemical industry

The chemical and petrochemical industry accounts for 35% of the global industrial energy use and 16% of direct CO_2 emissions.

The two most common petrochemical classes are olefins (including ethylene and propylene) and aromatics (including benzene, toluene, and xylene isomers).

Chemical plants produce olefins by steam cracking of natural gas liquids like ethane and propane. Aromatics are produced by catalytic reforming of naphtha. Olefins and aromatics are the building-blocks for a wide range of materials such as solvents, detergents, and adhesives.

Steam cracking is the largest energy user accounting for more than one third of the sector's final energy use. The energy use of the steam cracking process and the improvement potentials is presented in Table 3-10.

Table 3-10: Energy use of the steam cracking process[17]

	2006 (GJ/t)	International and regional benchmark (2005)	Improvement Potentials (%)
World	16.9	12.5	25
Europe	15.6	13.7	20
North America	18.3	15.8	32
Asia - Pacific	12.6	11.2	1
China	17.1		27
India	17.1		27
Brazil	18.3		32

Anhydrous ammonia is the source of nearly all the synthetic nitrogen fertilizers produced in the world. About 77% of world ammonia production is based on natural gas steam reforming, 14% on coal gasification (mainly in China), and 9% on the partial oxidation of oil products and heavy hydrocarbon fractions (mainly in India).

The average energy use for ammonia production is 36.9 GJ/t, ranging from 28 to 53 GJ/t[18]. Compared to the BAT of 28 GJ/t, the energy saving potential is almost 2 EJ per year.

3.3.3.2 Iron and steel industry

Iron and steel is the second largest industrial user of energy, consuming 25 EJ in 2006 and accounts for about 25% of direct CO_2 emissions. Although considerable improvements have been made in recent years, the sector still has the technical potential to further reduce energy consumption by approximately 20%, saving about 4.7 EJ of energy and 350 Mt of CO2[19].

[17] Saygin et al, 2009, for year 2006; Solomon, 2005 in Leucx, 2008
[18] International Fertiliser Industry Association (IFA, 2006)
[19] IEA "Energy Technology transitions for Industry", 2009

Four methods are currently used worldwide for the production of steel: the blast furnace/basic oxygen furnace (classic method), the direct melting of scrap (electric arc furnace), smelting reduction and the direct reduction.

In 2014, the steel production in the EU-28 was based on the blast furnace/basic oxygen route (approximately 57.4%) and the Electric Arc Furnace route (approximately 42.6 %)[20].

The major processes employed in the iron and steel industries include coke-making, sinter and pellet plants, iron-making, steel-making, and rolling and finishing. The specific energy consumption for each step in the iron and steel industry is summarised in Table 3-11.

Table 3-11: World's best practice final energy consumption[21]

Process		Blast Furnace Basic Oxygen Furnace (GJ/t)	Smelt Reduction Basic Oxygen Furnace (GJ/t)	Direct Reduced Iron Electric Arc Furnace (GJ/t)	Scrap Electric Arc Furnace (GJ/t)
Material Preparation	Sintering	1.9		1.9	
	Pelletizing		0.6	0.6	
	Coking	0.8			
Iron-making	Blast Furnace	12.2			
	Smelt Reduction		17.3		
	DRI			11.7	
Steel-making	BOF	-0.4	-0.4		
	Electric Arc Furnace			2.5	2.4
	Refining	0.1	0.1		
Casting and Rolling	Continuous casting	0.1	0.1	0.1	0.1
	Hot rolling	1.8	1.8	1.8	1.8
Sub-total		**16.5**	**19.5**	**18.6**	**4.3**
Cold rolling and finishing	Cold rolling	0.4	0.4		
	Finishing	1.1	1.1		
Total		**18.0**	**21.0**	**18.6**	**4.3**

The energy consumption has been constantly reduced by introducing energy-saving equipment in iron and steel manufacturing processes and improving the efficiency of energy conversion facilities such as power plants.

For example, since 1980 the specific energy demand has been reduced from 23 GJ/t of liquid steel to approximately 18 GJ/t liquid steel in 2004 for modern integrated steelworks.

3.3.3.3 Non-metallic minerals industry

The non-metallic minerals sector is the third largest energy consuming (11% of global industrial final energy use) and CO_2 emitting sector, with an estimated 1.9 Gt of CO_2 emissions from thermal energy consumption and production processes in 2006[22].

[20] Centre for European Policy Studies, 2013

[21] Lawrence Berkeley National Laboratory (LBNL), World Best Practice Energy Intensity Values for Selected Industrial Sectors, 2008

[22] IEA "Energy Technology transitions for Industry", 2009

The sector includes the production of cement, lime, glass, and ceramics. In most countries, cement and lime production are by far the largest energy users in the sector, accounting for more than 80% of the sector's energy use[23].

Cement industry

The manufacture of cement is a two-step process, notably, clinker production and cement grinding. In the first step, the raw materials are fed to the kiln system to produce clinker. The second step in the cement production process is the crushing of clinker with calcium sulphates (gypsum or anhydrite) and mixing with other minerals (blast furnace slag, natural pozzolanas, fly ash, silica fume or limestone) to produce cement with desired performance such as setting time and strength development.

In 2007, about 90% of Europe's cement production was from dry process kilns, with a further 7.5% of production accounted for by semi-dry and semi-wet process kilns, and the remainder of European production, about 2.5%, from wet process kilns[24].

Clinker production can be split into the electricity required to run the machinery including motors and fans. Best practice for clinker making mechanical requirements is estimated to be 22.0 kWh/t of clinker, while fuel use has been reported as low as 2.85 GJ/t clinker or 97.3 kilogram of coal equivalent per ton of clinker (kgce/t)[25].

Specific thermal energy consumption in the production of cement in Europe ranges from 3,000 MJ/t cement to 6,000 MJ/t cement depending on the type of process (wet or dry), with most cement plants being in the range of 3,300 MJ/t to 4,000 MJ/t. According to the IEA, electricity consumption varies from 90 to 120 kWh/t of cement, except for the United States, Mexico, and Canada where typical figures are all above 120 kWh/t[26].

Grinding may account for a significant part of electricity consumption, up to 100 kWh/t. In a dry process, the electricity consumption share is 38% for cement grinding, 24% for raw material grinding, 22% for clinker production including grinding of solid fuels, 6% for raw material homogenization, 5% for raw material extraction and blending, and 5% for conveying, packing, and loading[27]. The breakdown of energy consumption in cement production for the "world best practice" producer is summarised in Table 3-12.

Table 3-12: World Best Practice Final Energy Intensity Values for Portland cement[28]

Process		Electricity kWh/t clinker	Electricity Kgce/t clinker	Fuel GJ/t clinker	Electricity kWh/t cement	Electricity Kgce/t clinker	Total GJ/t cement
Raw Materials Preparation		21.30	2.62	0.08	20.3	2.49	0.07
Solid Fuels Preparation		0.97	0.12		0.92	0.11	
Clinker Making	Fuel		97.0	2.85		92.0	2.71
	Electricity	22.50	2.76	0.08	2.14	2.63	0.08

[23] IEA statistics
[24] BAT reference document for the production of cement, lime and magnesium oxide, 2013
[25] Park, H "Strategies for assessing energy conservation potentials in the Korean manufacturing sector", 1998
[26]Park. H: "Strategies for assessing energy conservation potentials in the Korean manufacturing sector, 1998
[27] Cement Sustainable Initiative (CSI) & European Cement Research Academy (ECRA)
[28] Lawrence Berkeley National Laboratory (LBNL), 2007

Process	Electricity kWh/t clinker	Electricity Kgce/t clinker	Fuel GJ/t clinker	Electricity kWh/t cement	Electricity Kgce/t clinker	Total GJ/t cement
Cement Grinding						
325 cement				16.0	2.0	0.06
425 cement				17.3	2.1	0.06
525 cement				19.2	2.4	0.07
625 cement				19.8	2.4	0.07
Total						
325 cement				**59.0**	**99.6**	**2.92**
425 cement				**60.0**	**99.8**	**2.92**
525 cement				**62.0**	**100.0**	**2.93**
625 cement				**62.0**	**100.1**	**2.93**

Glass industry

Glass manufacturing is an energy-intensive sector; energy is one of the largest operational costs in glass making. About 0.5 - 0.8 EJ of energy is used for glass making worldwide and the energy used in the production of container and flat glass results in emissions of about 50 - 60 Mt CO_2 / year[29].

There are 4 main glass categories: container, flat, fibre (mineral wool, textile and optical) and specialty glass. The glass industry is dominated by the production of container glass and flat glass.

Glass production typically involves the mixing of raw materials, melting in furnaces, forming and post processing including annealing and finishing. Melting accounts for the largest share (around 80%) of energy use in a glass plant.

Within the EU-27 glass plants, energy levels for melting are typically between 5.2 and 8.7 GJ/ton of melted glass, mainly depending on the size and age of the installation, with an average value of 7.5 GJ/ton of glass. The corresponding figure in the US is around 10.7 GJ/ton of output[30].

The specific energy of glass production depends heavily on the end product type (i.e. chemical composition), the percentage of cullet in the feed, the efficiency of the processes, and the type of furnace.

A summary of the average specific energy use of the major process steps in glass making for container glass and flat glass is presented in Table 3-13.

Table 3-13: Average specific energy use of the major process steps[31]

	Average specific energy (GJ/ton)	
Process steps	**Container Glass**	**Flat Glass**
Batch preparation	0.5	0.3
Melting & Refining	5.8	6.5

[29] IEA: Tracking Industrial Energy Efficiency and CO_2 Emissions, 2007
[30] Worell et al, 2008
[31] Lawrence Berkeley National Laboratory - Energy Efficiency Improvements and Cost Saving Opportunities for the Glass Industry

	Average specific energy (GJ/ton)	
Forming	0.4	1.5
Annealing & finishing	0.7	2.2
Total	**7.4**	**10.5**

Container glass is the largest sector of the EU glass industry, representing between 50 and 60% of the total glass production. The most common size for a glass plant is between 300 and 600 tons produced glass per day.

For the container glass production, the energy necessary for melting glass accounts for over 75% of the total energy requirements of container glass manufacture. Other significant energy use areas are the forehearths, the forming process (compressed air and mould cooling air), and the annealing lehr, as well as factory heating and general services.

Float glass is the second largest sector of the glass industry in the EU-28, which represents around 30% of total glass production. The sector covers the production of float glass and rolled glass. Float glass represents the main product; while rolled glass is only about 3.5% of the total and is declining.

The energy intensity for basic float glass varies between 5.3 – 8.3 GJ/t depending on the size and technology of the furnace, and the proportion of cullet used in batch preparation[32]. The fuel consumption for flat glass in EU-27 in 2007 is presented in Table 3-14.

Table 3-14: Fuel consumption for flat glass in 2007[33]

Member State	Fuel Consumption
EU-27	9.2 ± 15%
France	9.4 ± 11%
Germany	8.5 ± 16%
Italy	9.7 ± 11%
Spain	8.6 ± 16%
UK	Not available
Poland	8.8 ± 11%

3.3.3.4 Pulp and paper industry

Pulp and paper production is an energy-intensive process with high capital costs and long investment cycles. On a global scale, it is the 4th largest industrial consumer of energy, consuming 5.7% of the total industrial energy use[34].

The major processes employed in the pulp and paper industry include raw materials preparation, pulping, bleaching, chemical recovery, pulp drying, paper making and paper recycling.

The sector is a large generator of energy, particularly in Kraft (or chemical or sulphate) pulp mills, in the form of black liquor. Currently around half of the sector's energy demand is met by biomass residues. Mechanical pulping uses energy in the form of power only.

Production of pulp and paper requires energy input in the form of heat and power. Producing one ton of paper requires on average around 11.5 GJ of primary energy depending on the raw

[32] Beerkens et al, 2004
[33] Schmitz et al, 2011
[34] IEA 2007

materials and fibre furnish used, the paper grade and quality manufactured, and the techniques applied[35]. A breakdown of energy used in the pulp and paper industry is presented in Table 3-15.

Table 3-15: Breakdown of energy used in the pulp and paper making industry[36]

Process	% of Energy Use		
	Steam	Electricity	Total
Raw Material Preparation	0	8	2
Pulping			
- Mechanical	15	18	14
- Chemical	0	15	3
- Pulping from Recycled Paper	1	1	1
Chemical Recovery	8	4	7
Bleaching	19	2	18
Pulp Drying	2	1	2
Paper Making	55	36	47
Other process		5	4
Non-Process (lighting, HVAC, etc.)		10	2
Total	**100**	**100**	**100**

World best practice final intensity values for integrated pulp paper mills are presented in Table 3-16. However, the best practice energy figures are indicative as energy use will depend on the specific properties of the raw materials and products.

Table 3-16: World best practice final intensity values for integrated pulp paper mills[37]

Raw Material	Product	Process	Fuel use for Steam		Electricity (kWh/ADt)	Total	
			GJ/ADt	Kgce/ADt		GJ/ADt[38]	Kgce/ADt
Wood	Bleached uncoated fine	Kraft	14	478	1200	18.3	625
	Kraftliner (unbleached) & Bag paper	Kraft	14	478	1000	17.6	601
	Bleached coated fine	Sulphite	17	580	1500	22.4	765
	Bleached uncoated	Sulphite	18	614	1200	22.3	762
	Newsprint	TMP[39]	-1.3	-44	2200	6.6	226
	Magazine paper	TMP	-0.3	-10	2100	7.3	248
	Board	50%TMP	3.5	119	2300	11.8	402
Recovered paper	Board (no de-inked)		8	273	900	11.2	384
	Newsprint (de-inked)		4	137	1000	7.6	259

[35] BREF, Reference document for the production of pulp, paper and board, 2010
[36] IEA, Tracking Industrial Energy Efficiency and CO_2 Emissions, 2007
[37] Lawrence Berkeley National Laboratory (LBNL), World Best Practice Energy Intensity Values for Selected Industrial Sectors, 2008
[38] Air dried ton
[39] Thermomechanical pulping

	Tissue (de-inked)		7	239	1200	11.3	386

3.3.3.5 Non-ferrous metal industry

The non-ferrous metal sector primarily consists of base metal production (aluminium, copper, lead, zinc, and tin) and precious metal production (silver, gold, palladium, and other platinum group metals). It also includes secondary processing and fabrication activities of semi-finished products of aluminium, magnesium, titanium, zinc, etc. and other non-ferrous metals (heavy metal, precious metal and die casting).

The largest economic contributions are delivered by 2 classes: aluminium and copper manufacturing, contributing to approximately 70% and 64% respectively of the annual turnover and value added in 2012[40].

Aluminium

The largest aluminium manufacturers and consumers are China, Russia, and the USA. In 2012, the worldwide aluminium production was 47,878 kt[41].

The main raw material for aluminium is bauxite, which is extracted from bauxite mines and processed into aluminium oxide at alumina plants using an electrolytic process (Bayer chemical process).

Energy consumption is important at every stage in mining operations:

> *Extraction*: energy is used in ventilation, blasting, drilling, digging, and dewatering
> *Materials handling*: electricity is used by conveyors and pumps to transport materials
> *Processing*: crushing, grinding and separation are all highly energy intensive processes
> *Melting and holding*: furnaces for melting and holding use huge quantities of energy. The amount of energy consumed by the furnaces will depend on furnaces' design, shift patterns, burner design, production capacity, charging temperature of the stock and insulation
> *Hot rolling*: the energy required for the motor-driven rollers depends on the degree of deformation, the temperature of the work piece and hardness of the material
> *Cold rolling*: energy is required in mill stands, emulsion, and hydraulics and oil management for drives, fans, and pumps.

About 10 GJ of thermal energy is used per ton of alumina as well as 180 kWh/t of electricity. The direct input and output data for the production of 1 ton of alumina is presented in Table 3-17. The average European figures of the year 2010 can be compared with worldwide figures for the same year.

Table 3-17: Data for the production of 1 ton of alumina in 2010[42]

Inputs	Unit	EAA*	IAI**
Materials			

[40] ICF International, 2015
[41] European Aluminium Association, 2012
[42] European Aluminium Association (EAA) & International Aluminium Institute (IAI)

Inputs	Unit	EAA*	IAI**
Bauxite	kg/t	2,251	2,881
NaOH	Kg/t	53	79
CaO	Kg/t	42	40
Fresh water	m^3/t	3.6	3.5
Energy			
Coal	MJ/t		1,850
Heavy Oil	MJ/t	5,822	3,818
Diesel Oil	MJ/t	1	4
Natural Gas	MJ/t	4,299	5,282
Steam	MJ/t	249	
Total thermal energy	MJ/t	10,371	10,954
Electricity	kWh/t	181	79
Total Energy	**MJ/t**	**11,023**	**11,238**

The specific energy consumption for each step for aluminium making processes is summarised in Table 3-18[43].

Table 3-18: World Best Practice Final Energy Intensity for Aluminium Production

Process	Power	Primary Aluminium		Secondary Aluminium	
		GJ/t	Kgce/t	GJ/t	Kgce/t
Aluminium production (Bayer process)	Digesting (fuel)	12.1	414		
	Calcining kiln (fuel)	6.5	223		
	Electricity	1.4	48		
Anode Manufacture (Carbon)	Fuel	1.0	35		
	Electricity	0.21	7		
Aluminium Smelting (Electrolysis)	Electricity	49.0	1671		
Ingot Casting	Electricity	0.35	12		
Total		**70.6**	**2411**	**2.5**	**85**

Copper manufacturing

In 2014, copper mine production in the EU-27 was 847,000 tons, accounting for around 4.6% of the world total production[44]. About 90% of all copper is produced from sulphide ores and 10% from oxidic ores.

[43] Lawrence Berkeley National Laboratory (LBLN), World best practice energy intensity values for selected industrial sectors

[44] International Copper Study Group (ICSG)

Copper production requires energy in most stages, but the energy used in the electrolytic process is the most significant. The energy required for a number of processes using copper concentrate is in the range of 14 – 20 GJ/t of copper cathode. The exact figure depends mainly on the concentrate (percentage of sulphur and iron), the smelting unit used, the degree of oxygen enrichment and the collection and use of process heat.

However, the actual Specific Energy Consumption (SEC) is relatively high, typically 30 MJ/kg of refined copper for pyro-metallurgical processes. The primary energy need for copper production is about 33 GJ/t for the smelting process at 3% copper concentration and 64 GJ/t for the leaching process with 2% ore. Primary energy use rises to 125 GJ/t for ore that contains 0.5% copper[45].

Statistics on energy use in copper production are scarce. An energy breakdown for a copper industry in Chile (Chile is one of the world's largest producers and is responsible for 14% of the global primary copper) is presented in Table 3-19.

Table 3-19: Energy use for copper industry in Chile[46]

	Fuel use (GJ/t)	Electricity use (kWh/t)
Mining		
Open pit	5.68	
Underground	0.46	
Concentration		2,029
Drying	1.13	
Smelting	9.56	672
Refining		
Electro-refining	1.18	341
Electro-winning	1.08	2,791
Sulphuric acid plant		141
Services	1.05	32
Others	0.38	
Total	**20.06**	**6,006**

3.3.3.6 Food and beverages industry

Food and beverage processing and manufacturing covers a wide range of products including meat and poultry, fruit and vegetables, dairy products, flour and cereals, bakery products, seafood, sugar, sugar confections, soft drinks, and brewery products.

The food and beverage industry is the largest manufacturing sector in the EU (14.6%) with more than 4.2 million employees and around 286,000 companies (92% of the sector is made up of small and medium enterprises, although there are some sectors, such as sugar manufacturing, which have very large installations). Germany, France, Italy, the UK, and Spain are the largest EU food and drink producers.

Although the food and drink processing is not considered an energy intensive industry, energy still represents a significant cost of doing business and there are opportunities for improving the industry's use of energy, in particular in:

[45] Norgate and Rankin, 2000
[46] Alvarado et al, 2002

- Electricity – where power is required for mechanical processing such as pumping, ventilating, mixing, and conveying) and is used in mechanical compression coolers
- Thermal energy – for both high temperature processing (such as pasteurisation, cooking and evaporation) and low temperature processing (freezing and cooling).

Approximately half of all energy consumed by the industry is used to change raw materials into process – this includes process heating and cooling, refrigeration, machine drive (mechanical energy), and electro-chemical processes. Less than 8% of the energy consumed by the industry is for non-process uses, such as facility heating, ventilation, refrigeration, lighting, facility support, on-site transportation, and conventional electricity generation. Boiler fuel represents nearly 1/3 of consumption. Energy consumption vary according to the process type, its operation, and the size of operation.

Vegetables and Fruits

Processes involving heating, cooling, drying, evaporation, sterilisation, pasteurisation, and blanching consume significant energy. Almost every process requires electricity. For steam production, natural gas boilers can be used. The required energy for processing frozen vegetables is presented in Table 3-20.

Table 3-20: Energy breakdown for processing frozen vegetables[47]

Process	Energy required
Transportation of frozen vegetable	2 – 14 kWhe/t frozen vegetable
Storage of vegetable	20 – 65 kWhe/t frozen vegetable 26,389 kWh/m^2 storage/year in the form of hot water
Sorting/screening, grading, and trimming	0 – 20 kWhe/t frozen vegetable
Peeling	Steam 0.16 – 0.9 t/t frozen vegetables Electricity 2 – 3.5 kWh/t frozen vegetables
Washing	0.5 kWhe/t frozen vegetables
Cutting, slicing, chapping, mincing pulping	Up to 9 kWhe/t frozen vegetable
Blanching	Steam 0.16t/t frozen vegetables Electricity 0.5 – 1.3 kWhe/t frozen vegetable
Belt blancher with water cooling	Steam 0.09 t/t frozen vegetables Electricity 2 – 9 kWhe/t frozen vegetable

Dairy Products

In dairy industry, around 80% of the energy is consumed as thermal energy from the combustion of fossil fuels to generate steam and hot water. It is used for heating operations and cleaning. The remaining 20% is consumed as electricity to drive machinery, refrigeration, ventilation, and lighting.

The most energy consuming operations are the evaporation and drying of milk. Energy consumption for the European dairy industry is presented in Table 3-21.

Table 3-21: Energy consumption in European dairies[48]

[47] Van Bael J. 1998
[48] European Dairy Association, 2002

Energy consumption (GJ/t processed milk)			
Products	**Electricity**	**Fuel**	**Remarks**
Market milk and yogurt	0.15 – 2.5	0.18 – 1.5	Min for liquid milk Max. for specialties
	0.09 – 1.11*		
Cheese	0.08 – 2.9	0.15 – 4.6	Depends on the type of cheese and production run Max. fuel for whey evaporation
	0.06 – 2.08*		
Milk and whey powder	0.06 – 3.3	3 - 20	Max. fuel for whey products
	0.85 – 6.47*		
*Approximate kWh/l (assuming milk density 1kg/l)			

Meat processing

A considerable amount of thermal energy is used in processes involving heat treatments such as boiling, cooking, pasteurising, sterilising drying and smoking. Other large energy consuming operations are chilling, freezing, thawing, and cleaning and disinfection. A summary of energy consumption per ton of canning meat manufacturing in an Italian meat factory is presented in Table 3-22.

Table 3-22: Energy required for Canning meat manufacturing[49]

Canning Meat manufacturing		
Unit Operation	Electrical Energy (kWh/t)	Thermal Energy (kg steam/t)
Materials handling and storage	1 – 2	
Washing and thawing	0.5 – 1.5	
Pasteurisation, sterilization and UHT	2 - 4	800 - 900
Packing and filling	100 – 120	
Cleaning and disinfection	5 – 10	
Overall totals	**150 - 400**	**800 - 900**

The SEC varies across the sector, dependent on the particular sector of industry. International SEC benchmarks for various food products are summarised in Table 3-23.

Table 3-23: SEC benchmarks in Food and Beverage Industry (in final energy)

	Electricity (GJ/t)	Heat (GJ/t)	Total (GJ/t)
Dairy Sector			
Butter	0.5	1.3	1.8
Cheese	1.2	2.1	3.3
Milk	0.2	0.5	2.7
Milk Powder	1.1	9.4	10.5

[49] Italian contribution to BAT, 2001

	Electricity (GJ/t)	Heat (GJ/t)	Total (GJ/t)
Meat Processing			
Beef, Sheep, Veal	0.3	0.5	0.8
Poultry	1.0	0.6	1.6
Pork	0.5	0.9	1.4
Other			
Vegetable Oil	0.2	2.7	2.9
Sugar (Refined)	0.6	5.3	5.9
Coffee	0.5	2.0	2.5

As a conclusion, chemicals and petrochemicals and the iron and steel account for approximately half of all industrial energy used worldwide. Other sectors that account for a significant share of industrial energy use are non-ferrous metals, non-metallic minerals and the pulp and paper sector.

The drivers of EE differ from country to country and from industry to industry. In some other sectors, EE is partly driven by high energy prices. However, the high capital cost of investment in new and efficient plants is a major limitation on the rate of efficiency improvement in industry.

IEA studies[50] have assessed the technical potential on energy saving that would result if the energy intensive sectors adopt Best Practice Technology (BPT). These studies estimated energy saving potentials at process level as being 11.4 EJ to 16 EJ in 2004 and 14.2 EJ in 2006. Adopting BAT would result in a saving of 5% to 15% higher than BPT[51].

Energy savings and reduction of CO_2 emissions from adoption of commercial best practice technologies in manufacturing industries are presented in Table 3-24.

Table 3-24: Energy savings and CO_2 emissions[52]

	Low – High Estimates of Energy Saving Potentials			Total energy savings potential (%)
	EJ/yr	Mtoe/yr	Mt CO_2/yr	
Sectoral improvement				
Chemicals / Petrochemicals	5.0 – 6.5	120 – 155	370 - 420	13 - 16
Iron and Steel	2.3 – 4.4	55 - 108	220 - 360	9 - 18
Cement	2.5 – 3.0	60 - 72	480 - 520	28 - 33
Pulp and Paper	1.3 – 1.5	31 - 36	52 - 105	15 - 18
Aluminium	0.3 – 0.4	7 - 10	20 - 30	6 - 8
Other non-metallic metals, minerals and non-ferrous	0.5 – 1.0	12 - 14	40 - 70	13 - 25

50 IEA 2007, 2009c
51 UN Energy 2009
52 IEA “Tracking Industrial Energy Efficiency and CO_2 Emissions”

	Low – High Estimates of Energy Saving Potentials			Total energy savings potential (%)
	EJ/yr	Mtoe/yr	Mt CO_2/yr	
System / life cycle improvements				
Motor systems	6 - 8	143 - 191	340 - 750	
Combined Heat Power	2 - 3	48 - 72	110 - 170	
Steam Systems	1.5 – 2.5	36 - 60	110 - 180	
Process Integration	1.0 – 2.5	24 - 60	70 - 180	
Increased recycling	1.5 – 2.5	36 - 60	80 - 120	
Energy recovery	1.5 – 2.3	36 - 55	80 - 190	
Total	25 - 37	600 - 900	1900 - 3200	
Global improvement potential – share of industrial energy use and CO_2 emissions	18 – 26%	18 – 26%	19 – 32%	
Global improvement potential – share of total energy use and CO_2 emissions	5.4 – 8%	5.4 – 8%	7.4 – 12.4%	

3.4 Rules, regulations and instruments in selected EU Member States and Energy Community Contracting Parties towards the realization of EE measures – Case studies

3.4.1 Barriers to EE policy development in industry

Before presenting successful instruments and measures in the EU Member States and EnC Contracting Parties, it is also important to present certain difficulties / barriers and challenges that hinder the implementation of EE in the industrial sector despite the fact that there is still a large potential for EE.

Energy policy has traditionally been almost entirely concerned with energy supply and focused in many cases on the electricity system. EE, energy conservation or energy savings has tended only to be given a high priority during periods of crisis due to high energy prices or electricity supply shortages. Until recently, EE policy has always had a lower priority in energy policy development compared to energy supply[53].

Important barriers in industry are presented in brief in the following[54]:

- lack of **information and knowledge** about the **saving potential** and costs of improving EE
- lack of **information and knowledge** about the **existing financial support programmes** for EE investments
- lack or inadequate **financial incentives** to uptake the EE market;

[53] Fawkes, S., Oung, K., Thorpe, D., 2016. Best Practices and Case Studies for Industrial Energy Efficiency Improvement – An Introduction for Policy Makers. Copenhagen: UNEP DTU Partnership, Feb 2016

[54] Lynn K. Price and Aimee T. McKane, Policies and Measures to realise Industrial Energy Efficiency and mitigate Climate Change, UN-Energy

- lack of awareness of the financial or qualitative benefits arising from EE measures
- **Insufficient finance available;** low priority to EE by company management; banks have limited understanding or consider EE investment too small and complicated; difficult to establish a market of energy services/ ESCOs and alternative financing mechanisms
- **policy and regulatory-related barriers** to the implementation of EE investments
- inadequate **skills** of industry's personnel to implement EE measures;
- **fear of the management staff of the negative impact of EE measures** on the quality of products and processes
- lack of **own capital** to undertake the necessary EE investments
- corporate attitude that favours investment in new production capacities rather than in EE investments;
- **greater weight being given to investment costs than to recurrent energy costs**. This can be exacerbated where energy costs are a small proportion of production costs
- **slow rates of capital stock turnover** in many industrial facilities, coupled with the risks perceived to be inherent in adopting new technologies
- **EE technologies are more expensive to buy** comparing to the conventional ones. Emphasis is given in many industrial investment decisions on large, more attractive investment opportunities rather than on the more modest investments needed to improve EE, even where the profits can be relatively large.

However, a number of instruments / measures exist in the industrial sector (either active and on-going or completed) that address the above-mentioned barriers. These instruments can be categorised as cooperative measures (voluntary agreements), financial measures, informative / educational measures, legislative measures, or market-based instruments. In addition, in certain countries policy instruments / measures address different target groups, e.g. SMEs or energy-intensive industries or both. The number of instruments however and their level of adoption differs across the EU Member States and EnC Contracting Parties.

A brief description of each type is presented below accompanied by case studies of certain countries in the EU and the EnC Contracting Parties.

3.4.2 Financial instruments / measures

Financial measures are the most dominating instrument in industry in almost all EU Member States. Approximately, half of the policies addressing EE in industry can be attributed to this type of measure. However, in many countries the remaining part of the existing policies includes a broad mix of other types (including market-based instruments)[55].

Financial measures mostly include incentive programs with the purpose to increase the attractiveness of the investments and gain the attention of the media who promote these favourable short-term projects together with the benefits of EE. Incentives in EE worldwide are mostly given in the demand side. States have realised that supporting EE investments by becoming co-investors (with the incentives that provides a state is like participating to the investment) is more beneficial for the public interest than expecting investors to make those investments years later.

Grants represent a percentage of the total capital cost and are given during or immediately after the completion of the project. Usually, certain conditions should be met concerning eligibility

[55] Energy Efficiency trends and policies in industry / An analysis based on the ODYSSEE and MURE databases, September 2015

(types of investment, size limitations, etc.), goals achieved (percentage of efficiency improvement, etc.), end-user obligations (reporting, use of equipment, etc.). By offering grants, governments reduce the investment cost for the beneficiary, and by doing so improve profitability of the project. EE investments accompanied by grants, become more attractive and although they do not relate directly to financing, render the investments more acceptable for banking support. Provision of grants is among the most **effective strategies to open a market at an early stage** and create a critical mass of investments that mobilise all market actors (materials/ technology producers, suppliers, service providers, banks).

Subsidies for EE refer to a broader spectrum of measures that a government or other donors undertake in order to improve the attractiveness of an EE investment. Instead of contributing a portion of the overall capital cost from the beginning or during the execution of the investment, the end-user is entitled to some benefits of economic nature, for a given period of time after the investments. These measures create a stream of income, in addition to that from the energy cost savings that again make the EE projects more economically attractive. There are several measures that could be utilised to promote EE. To indicate a few:

- **VAT reduction** (or exemption): Immediately reduces the investment cost, makes it more attractive and the funding easier. Vat reduction is aimed mainly for individuals;
- **Accelerated depreciation**: Makes funding easier, while the State has little loss of revenue. It is aimed for companies with profits;
- **Tax rebates**: Improve the profitability of the project grants. The most effective measure but usually requires a complex approval and tracking mechanism.

Like **grants, subsidies have high social cost**. Both measures, although they are the first ones to be utilised in order to open the EE market, usually **phase out over time**. Continuous provision of grants and subsidies is not a sustainable market-based scheme. Amongst others, they create market distortions and expectations from end-users that rely more on incentives and less on EE cost savings. Also, end-users may benefit from support to investments that they would do anyway. Therefore, any grant / subsidy scheme must be carefully designed to minimise market distortions. On the other hand, grants/subsidies for EE remain a powerful policy instrument and quite often, a small grant component accompanies other market-based instruments.

Another way to provide motives for EE is when incentives are included in some of the modalities to be developed to service funding needs of the EE investments. Such incentives can include:

- **Interest rate**: interest rate subsidization is an effective way to reduce funding cost. It makes sense for long term financing, which is necessary for low return EE investments compared to others (thermal insulation is such an example) with long payback periods
- **Risk related subsidies**: a state, donor or other body undertakes part of the risk to help banks decide to get involved
- **Assistance costs**: a third party undertakes necessary costs for the preparation, organisation, and execution of EE programs; often in the form of technical assistance.

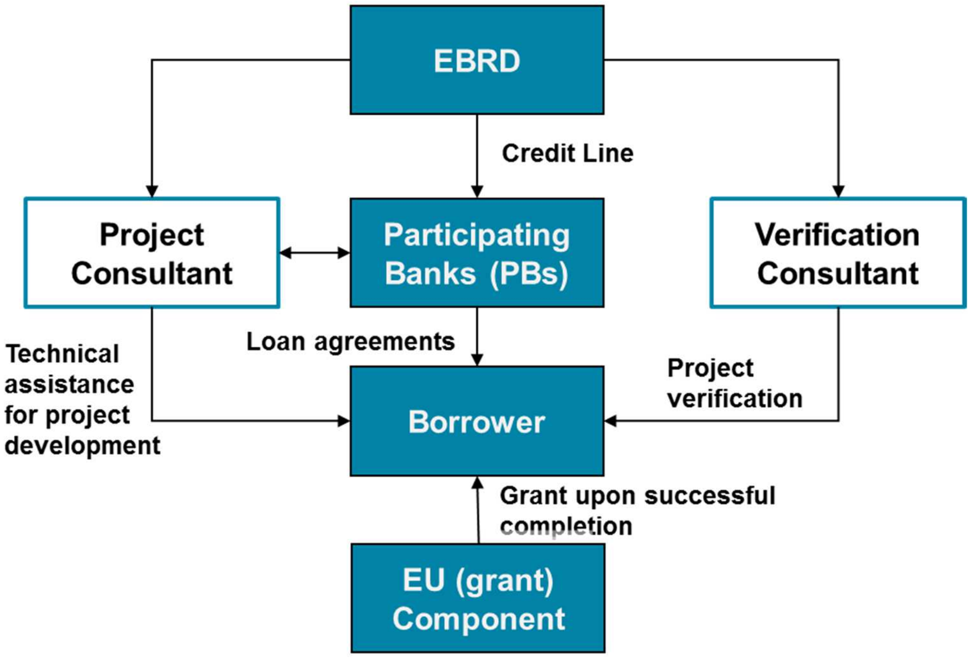
Although grants and subsidies are effective means to influence investor's decision making towards EE investments, by improving attractiveness, the existence of the necessary funds is an additional issue to be addressed. The lack of financing is one of the biggest obstacles to the development of the EE market. The financial modalities developed to provide liquidity are:

- Dedicated Credit Lines
- Revolving Funds

> Green Bonds.

Dedicated credit lines[56] are credit lines established by a public entity (such as a government agency and/or donor organization) to enable financing of EE projects by a private-sector organization (bank or financial institution). Dedicated credit lines have been successful in educating local banks on the characteristics and benefits of EE financing and in enhancing their interest and commitment to finance EE projects. The funds provided by the public partner allow the bank to provide below-market interest rates to the EE project developers. Typical credit lines are considered the sustainable energy financing facilities run by the EBRD's or other IFIs. Figure 3-3 presents the concept of its operation.

Figure 3-3: Typical EBRD EE Financing Facility



Dedicated Credit Lines are most appropriate in less mature markets that may be characterised by one or more of the following:

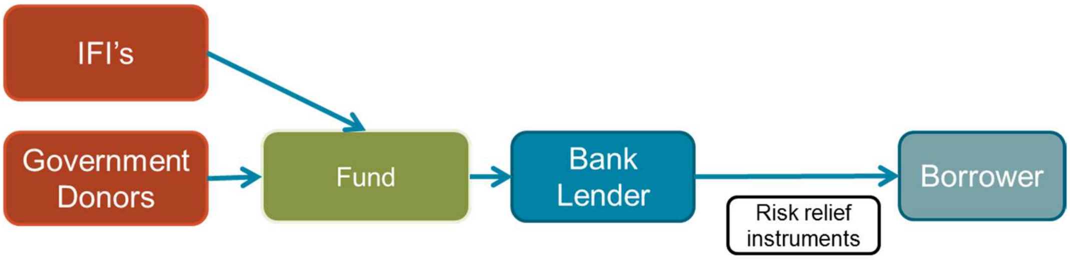
> Limited liquidity, particularly with respect to EE financing
> Limited knowledge and understanding of EE projects on the part of the banking sector, and
> Lack of banks' capacity to appraise EE projects, access and manage risks.

Revolving funds[57] offer credit lines, performance guarantees and engage into technical assistance support activities charging favourable terms to the end-user (interest rates, fees, premium) but sufficient to cover their expenses and losses. The funds returned from loan repayment or released from guarantees can be reinvested in similar activities financing additional projects, thereby allowing the capital to revolve, creating a funding mechanism. **The establishment of a revolving fund generally requires the development of a legal framework comprising national legislation as well as supporting secondary legislation or regulations**

[56] International Energy Agency (IEA), 2011. Joint Public-Private Approaches for Energy Efficiency Finance. Retrieved from https://www.iea.org/publications/freepublications/publication/finance.pdf
[57] Frankfurt School - UNEP Collaborating Centre for Climate & Sustainable Energy Finance (2012). Case Study: The Energy Efficiency Revolving Fund, retrieved from http://fs-unep-centre.org/sites/default/files/publications/fs-unepthaieerffinal2012_0.pdf

that will define the structure of the revolving fund. Options include creating the fund under an existing ministry, energy agency, or development bank; creating a new legal entity (Independent Corporation or new statutory agency); not-for-profit entity; or establishing a Public-Private Partnership (PPP)[58]. A typical structure of a revolving fund is presented in Figure 3-4.

Figure 3-4: Typical structure of a revolving fund



Green bonds are financial instruments in which the proceeds are exclusively applied to (new and existing) “green projects”. Green bonds can finance investments in EE of buildings and industry in two ways: either directly through bonds issued by corporations, or indirectly through bonds issued by banks, which in turn can on-lend to all types of EE project hosts.

Apart from funding modalities, **risk sharing modalities** are also important instruments in EE financing. Various types of guarantees can be used to address different types of risks related to EE projects. In some cases, guarantees may cover risks related to the lack of collateral and the credit risk perception on the part of lenders (credit guarantees, also called partial credit guarantees); in other cases, guarantees can cover uncertainty around the potential energy savings that projects may be able to generate from their performance (performance risk guarantees).

In the cases examined above, the end-user is the entity that undertakes to provide the necessary financing means. To do so, the end-user concludes a contract directly with the source of financing (usually bank). There are other modalities where the investment is undertaken by a third party and the end-user repays the investment cost through a pre-agreed mechanism for a period of time. Such modalities are:

- ESCO Financing
- Leasing
- On bill financing.

An ***Energy Service Company (ESCO)*** or an *“energy service provider”* is as a “natural or legal person who delivers energy services or other EE improvement measures in a final customer’s facility or premises”, while *“energy performance contracting”* (EPC) is understood as a “contractual arrangement between the beneficiary and the provider of an energy efficiency improvement measure, verified and monitored during the whole term of the contract, where investments (work, supply or service) in that measure are paid for in relation to a contractually agreed level of energy efficiency improvement or other agreed energy performance criterion, such as financial savings”. ESCOs offer energy services in the following ways:

[58] Limaye, D., Singh, J., & Hofer, K. (2014). Establishing and Operationalizing an Energy Efficiency Revolving Fund: Scaling Up Energy Efficiency in Buildings in the Western Balkans. Retrieved from World Bank Group: https://openknowledge.worldbank.org/handle/10986/20043

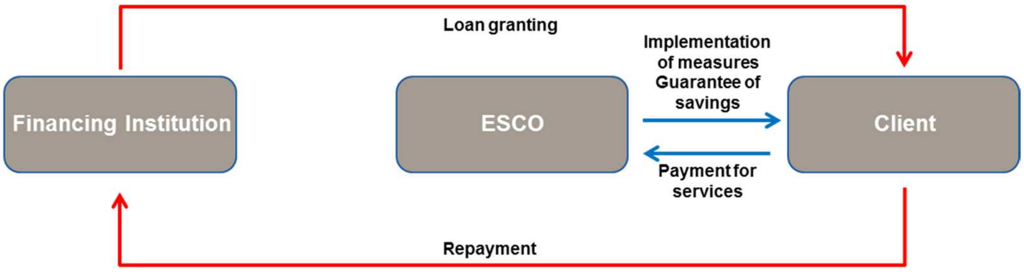
- ESCOs usually undertake to manage the full cycle of project implementation from design and financing to completion and often beyond that point, to operation and maintenance
- ESCOs guarantee the energy savings and/or the provision of the same level of energy service at a lower cost by implementing an EE project. A performance guarantee can take several forms. It can stipulate that the energy savings will be sufficient to repay monthly debt service costs for an EE project, or that the same level of energy service will be provided for less money
- The remuneration of ESCOs is directly tied to the energy savings achieved.
- ESCOs typically finance, or assist in arranging financing for the installation of an energy project they implement by providing a savings guarantee
- ESCOs retain an on-going operational role in measuring and verifying the savings over the financing term.

Therefore, ESCOs accept some degree of risk for the achievement of improved EE in a user's facility and have their payment for the services delivered based (either in whole or at least in part) on the achievement of those EE improvements.

The two basic models that ESCOs operate are the EPC and the Energy Supply Contracting (ESC), also referred to as Energy Purchase Agreement (EPA), with certain variations. An EPC may follow the "shared savings" or the "guaranteed savings" model. This distinction reflects the different distributions of investments, savings, and risks between the client and the ESCO. Figure 3-5 and Figure 3-6 present the relations of the shared savings and the guaranteed savings model respectively.

Figure 3-5: Relations of the Shared Savings model

Figure 3-6: Relations of the Guaranteed Savings model



ESC or EPAs are contracts between an energy producer and an energy consumer / client (industries, public buildings, hospitals, universities, shopping centres, big office buildings etc.). These contracts are focused on the supply of a set of energy services (such as heat, steam, electricity, compressed air, etc.) mainly via outsourcing the energy supply. Figure 3-7 presents the relations between the ESCO, the Financing Institution and the Client.

Figure 3-7: Relations of the EPA model

As regards the ESCO market in the EU, there is a very different level of development in terms of e.g. types of services, size, and turnover of ESCOs, number of ESCOs. These differences are attributed to two important aspects:

- the **required conditions of the contract** (e.g. whether binding amount of savings is a priority, clients' restrictions on ESCO service, scope of the energy/cost savings, etc.) and
- the **legal environment in the respective country**, non-legislative business rules and habits, local arrangements of buildings operation, etc

Several countries however have developed ESCO markets such as Germany, Austria, Czech Republic, UK, France.

The **German** ESCO market is considered as the most established among the EU; the market development started in the early 1990s. Approximately 500 ESCOs are engaged in providing mostly ESC (particularly heat delivery services) and to a lesser extent EPC (under the shared savings model).

Austria has a well-developed ESCO (particularly EPC) market. ESCO services are mainly addressed to the building sector. Around 50 ESCOs (small or medium sized enterprises) exist in the country of which 10-20 are dealing exclusively with EPC contracts (mostly following the shared savings model). The main clients of the ESCOs are the federal governments through the implementation of major renovation programs for the public buildings sector.

The **Czech** ESCO market is amongst the most advanced and mature ones in Europe. The growth and development of EPC market can be attributed almost exclusively to the work of the ESCOs themselves. The ESCOs that are active in EPC projects are approximately 10; most of them are small local companies with only a few sister-companies of large international ESCOs. Around 150 – 200 projects have been developed since the early 2000s where the ESCO market started its operation. The EPC projects (**guaranteed savings model**) are mostly involved in the **heating systems and cooling/air conditioning systems.**

The **UK** ESCO market established itself in 1984, when subsidiaries of large energy and engineering companies started to offer additional services to their clients such as project financing. **Heat supply contracts**[59] are the most dominant in the market, however the volume of shared savings and guaranteed savings contracts is growing.

The **French** ESCO market is considered as mature and stable in the EU. It is a particular market which is not like the other markets in Europe. France is known for its almost exclusive use of "chauffage" type contracts (energy supply contracts), where energy services are based on the combined operation and maintenance of HVAC systems without however explicit obligation to perform EE investments. Comfort services are usually offered at a discounted price and include the energy supply. Recently, energy service contracts have become more complex, integrating a number of relevant services, such as audit, financing, or M&V into the traditional "chauffage" type

[59] In the UK, they are called "Contract Energy Management"

contracts. Around 350 ESCO companies exist, while not more than 10 focus on guaranteed agreements. The sector where ESCOs are mostly involved is the public building sector.

Table 3-25 presents in brief the main characteristics of the ESCO market in the 5 developed countries presented above.

Table 3-25: Main characteristics of the ESCO markets in 5 developed countries[60]

Country	Number of ESCOs	Market size and trend	Existence of ESCO association	Main types of contracts
Germany	- 500 – 550 ESCOs - 10 deal with EPC	**market size**: € 3.5 – 5.0 billion/a (mainly ESC) **market potential**: € 20 – 30 billion/year, referring to the total revenue from energy services, including energy costs	Yes	- 80-85% ESC, - 8-10% EPC (mainly shared savings model)
Austria	>50, 10-20 offer EPC	**market size**: € 15-20 million annual investments **market potential**: N/A	Yes	EPC, shared savings model
Czech Republic	- 10 companies that offer EPC - 10 others that do Energy Contracting, (occasionally with EPC features)	**market size**: € 10-20 million (EPC type projects, including construction and energy management costs) **market potential**: (EPC including construction and energy management costs): € 100 – 500 million	Yes	EPC with guaranteed savings
UK	30 – 50	**market size**: N/A **market potential**: € 1 billion	Yes	- Heat supply contracts - BOOT - EPC (both shared savings and guaranteed savings)
French	350 ESCOs, of which 10 large companies offer EPC (guaranteed savings)	**market size** (including audit, measure implementation and M&V costs): - € 75 – 100 million (EPC type projects) - € 3.2 billion (all ESCO type projects) **market potential**: - € 250 – 500 million (EPC projects) - € 5 billion (all ESCO projects)	Yes	Chauffage (EPC's role is becoming larger though still incomparable

Leasing[61] is a widely-used form of financing where the end-user instead of borrowing and acquiring the equipment he needs, he leases them from a leasing company that acquired them on his behalf. This agreement lasts for a pre-specified period of time (usually 3-7 years) during which the lessee (end-user) pays a fee which compensates the purchase costs, the funding cost, expenses, and profit of the lessor (the leasing company). At the end of this period, the end-user becomes the owner of the asset, at no further cost, or at a pre-agreed final fee. In EE, most of the

[60] JRC, ESCO Market Report 2013, Paolo Bertoldi, Benigna Boza-Kiss, Strahil Panev, Nicola Labanca

[61] International Finance Corporation - World Bank Group. (2014, November). Boosting Energy in Turkey: IFC and the clean technology fund roll-out innovative EE financing model for Turkey's SMEs.

installations are embedded in the assets of the end-user and it is difficult to be dislodged or removed. The latter brings in difficult position the leasing company, in case of default or denial to pay from the part of the end-user.

On bill financing refers to situations where the energy utility provider (electricity or gas, could also be district heating) undertakes to perform and finance certain EE interventions in the premises of the customer end-user. It might be linked from the part of the utility provider to obtain a new customer (convert from heating oil to gas for example) or meet certain emission or energy reduction targets. The repayment of the investment is done with the energy bill, in instalments which usually are fully compensated from the energy savings. On bill financing and repayment is a mechanism that improves the creditworthiness of EE investments by having them repaid within the utility bill and recovered through the existing payment collection infrastructures of utilities.

3.4.3 Informative / educational measures

Informative / educational measures refer mostly to education and training activities regarding the way to enhance EE, resource planning as well as behavioural training of the staff of a facility towards more responsible energy efficient related actions.

3.4.4 Market-based instruments

Market-based instruments can be considered as indirect regulatory instruments such as the EU ETS, the national allocation plans (already described in a previous section) or voluntary agreements. **Voluntary agreements**[62] are tailor-made negotiated contracts between the public authorities and individual firms or groups of firms, which include targets and timetables for action aimed at improving EE or reducing GHG emissions and define rewards and penalties. They differ with respect to their form, legal status, structures and provisions, parties, and enforceability. The International Energy Agency (IEA) defines a voluntary agreement as ''a contract between the government and industry or negotiated targets with commitments and time schedules on the part of all participating parties''.

Voluntary agreements have been a **popular policy instrument for the industrial sector**, especially in developed countries since the 1990s. However, only a few EU Member States have solid experience with the implementation of national voluntary agreements for more than 10 years. At present, the large majority of voluntary agreements across the EU have been focused on reducing the energy consumption in industry.

3.4.5 Legislative measures

Legislative measures are considered those measures that refer to the national implementation / adoption of articles and/or directives. Examples of such measures include for example the mandatory energy audits in large enterprises or the implementation of an EnMS according to ISO 50001.

3.4.6 Case studies

Key instruments / measures in selected countries are presented below. The countries were selected considering the following criteria:

[62] Voluntary agreements in the field of EE and emission reduction: Review and analysis of experiences in the European Union, Silvia Rezessy, Paolo Bertoldi, Energy Policy 39 (2011) 7121–7129, 2011

- **Similarities in the level of development** of the legislative/regulatory framework (new EU Member States, e.g. Croatia, Romania, or Contracting Parties of the Energy Community, e.g. Serbia, FYR of Macedonia)
- **Advanced cases** so as to show the medium to long term development path for EE improvement (e.g. Germany, Denmark)

3.4.6.1 Germany

Besides the shift in electricity production from RES and as fuel substitution, EE plays a key part towards a green energy economy in Germany[63]. Germany introduced a wide range of instruments for increasing EE even before the EED was adopted. Table 3-26 presents the most important EE instruments addressed to the industrial sector.

Table 3-26: Key instruments in Germany for promoting EE in industry

Key policy / instrument	Policy type
Energy Efficiency Fund	Financial (grants, subsidies)
Promotion of EnMSs	Financial (grants, subsidies) & Legislative
Obligation of energy audit for large companies	Legislative
Energy audit funding scheme	Financial (grants, subsidies)
Energy tax	Financial (grants, subsidies)
Energy Efficiency Networks Initiative	Voluntary agreement

In the following, key EE instruments are described.

Energy Efficiency Fund[64]

The Federal Ministry of Economics and Technology has launched in 2008 an Energy Efficiency Fund. Two programmes are included in the Fund; the 1st programme is the "**Promotion of energy-efficient cross-cutting technologies in SMEs**" and the 2nd one is the "**Promotion of energy-efficient and climate-friendly production processes**". The first one provides funds such as **investment grants** for energy-efficient pumps, drivers, or compressed-air systems, etc. Up to 30% of the investment costs will be reimbursed, if the energy savings achieved are at least 25% compared to the old system.

Promotion of EnMSs[65]

The program supports the initial certification of either an EnMS (fulfilling EN ISO 50001) or an energy monitoring system. Additionally, there is option to apply for the purchase of measurement technology and software for EnMS. The funding is in form of grants providing up to 20,000 EUR per industrial company.

[63] http://aceee.org/files/proceedings/2016/data/papers/9_158.pdf
[64] Energy Efficiency trends and policies in Germany, Barbara Schlomann, Wolfgang Eichhammer, Matthias Reuter, Caroline Frölich and Sohaib Tariq, Fraunhofer Institute for Systems and Innovation Research ISI, Karlsruhe, Germany, Nov 2015
[65] Energy Efficiency trends and policies in Germany, Barbara Schlomann, Wolfgang Eichhammer, Matthias Reuter, Caroline Frölich and Sohaib Tariq, Fraunhofer Institute for Systems and Innovation Research ISI, Karlsruhe, Germany, Nov 2015

Obligation of energy audit for large companies[66]

The scheme obliges **large enterprises** to undertake energy audits until 5th of December 2015 and after that, at least every 4 years, in accordance with the energy audit standard EN 16247-1. Companies already implementing, in accordance with the ISO 50001, an EnMS or an Environmental Management System are excluded from the obligation of mandatory energy audits. After the execution of an energy audit, an enterprise is estimated to realise 5% of energy savings.

Energy audit funding scheme[67]

KfW operates the energy audit funding scheme; the program supports initial and detailed energy audits in industry (as well as the service sector). To apply for funding the following criteria must be fulfilled:

- The auditor has to be listed with KfW and certified as EE advisor
- The project must only contain advisory elements that can be subsidised.

Two kinds of audits are covered by the scheme:

- An initial audit. The initial audit lasts for 2 days and is supported with a non-repayable grant of 80% of the consultancy costs
- A detailed audit. The detailed audit lasts for 8 days and is supported with a non-repayable grant of 60% of the consultancy costs.

Only one subsidy per installation can be granted. From 2008 to 2013 approximately 25,000 audits have been carried out by this scheme resulting in 1.5 TWh annual energy savings and 700 million EUR of investments in EE.

Energy tax[68]

In 1999, the federal government introduced the **eco-taxation**, increasing the fuel taxes and introducing a tax on electricity. However, **energy intensive industries** can avoid this tax in case they follow a voluntary agreement to reduce the energy intensity by 1.3% per year and/or introduce a certified EnMS. This measure led to a tremendous increase of ISO 50001 certifications in Germany with nearly 2,500 certifications in 2013.

Energy Efficiency Networks Initiative[69]

The Learning Energy Efficiency Networks (LEEN) is a concept targeting EE in companies from different sectors. It was **firstly developed in Switzerland** in the 1990s. Since then, the concept has been successfully transferred to Germany, France, and Austria. The German LEEN not only

[66] Energy Efficiency trends and policies in Germany, Barbara Schlomann, Wolfgang Eichhammer, Matthias Reuter, Caroline Frölich and Sohaib Tariq, Fraunhofer Institute for Systems and Innovation Research ISI, Karlsruhe, Germany, Nov 2015

[67] Learning Energy Efficiency Networks - Evidence based experiences from Germany, Clemens Rohde, Ursula Mielicke, Lisa Nabitz, Fraunhofer Institute for Systems and Innovation Research ISI, Karlsruhe, Germany Dirk Köwener, LEEN GmbH

[68] Learning Energy Efficiency Networks - Evidence based experiences from Germany, Clemens Rohde, Ursula Mielicke, Lisa Nabitz, Fraunhofer Institute for Systems and Innovation Research ISI, Karlsruhe, Germany Dirk Köwener, LEEN GmbH

[69] http://leen.de/en/ & Energy Efficiency Networks, Policy Brief, Nov 2016, Lead author: Barbara Schlomann (Fraunhofer ISI, Germany)

contributes to energy cost reduction and climate protection, but also **provides opportunities for domestic manufacturers and installation firms**.

A LEEN network usually consists of **10 to 15 participants from different sectors**, which together determine a network target for increasing EE. The companies come usually from different sectors; in this way, they avoid sharing their operational information in the network meetings. However, experience in recent years has shown that LEEN networks comprised of companies from uniform sectors can also be successful. Every participating company should have annual energy costs of at least 200,000 EUR in order to guarantee the profitability of the cooperation in the network. However, the energy costs should be less than 20 million EUR. Furthermore, it is important that all participants share a **common set of cross-cutting technologies**, so as to **guarantee an effective exchange of experiences** during the meetings.

The parties involved in the network are:

> *The* ***network host***: The network host (e.g. a city, chamber of commerce, energy distributor) operates as contracting party and project manager of the participating companies, the consultant engineer and the moderator and has the overall responsibility. The host is responsible to find and select the network's participants and manages schedules, budgets, invoicing and controlling. He assigns external stakeholders, such as the consultant engineer and the moderator, and he is also responsible for public relation activities such as the communication of the project to the public.

> *The* ***moderator***: The moderator chairs the network meetings, including preparation and follow-up, informs the companies and supports the consultant engineer with respect to monitoring. He serves as the main contact for the companies and promotes dialogue so as to exchange experiences between the network's participants (for the organization and management of the network meetings).

> *The* ***consultant engineer***: The consultant engineer performs the initial consultancy as well as the monitoring. He supports the moderator in finding experts for papers and presentations and serves as technical contact. In order to be engaged in the network, the consultant engineer has to complete the LEEN-Training successfully. In addition to this, experience in power engineering consultancy in the industrial area is mandatory.

The usual network process consists of three phases:

> ***Acquisition phase – Phase 0***: this phase involves the initial establishment of the network. During this phase, the network host must undertake to gather the companies for the network, organise information meetings, and select the consultant engineer and the moderator. To be successful in the network, the companies have to be committed to the process; therefore, a strong support of the top management is crucial.

- ***Initial consultancy phase – Phase 1***: Under this phase, a trained consultant engineer performs an energy review involving a complete technical evaluation of potential energy saving measures and a calculation of the profitability of these measures. All findings are included in a standardised report; the report forms the basis for the company's own program to reduce energy costs. After the completion of the reports from all participating companies **two targets** for the three- to four-year network operating period are first suggested by the consultant engineer, and then discussed with the participants and jointly determined. The 1st target concerns the progress towards EE and the 2nd concerns the reduction of CO_2. This phase concludes with a **mutual agreement by all participants regarding the targets for increased EE and reduced CO_2 emissions**.
- ***Network operation phase – Phase 2***: The network phase starts at the same time as the initial consultancy phase in order to establish the contact between the participating companies. The meetings take place at one of the companies participating and the moderator chairs the meeting. After a site inspection with information on the energy situation, expert papers and presentations are produced and information between the participants is exchanged. For instance, network participants report on implemented measures and lessons-learned which serve as good examples for the other participants. **This information exchange is a central success factor**.

The pilot project

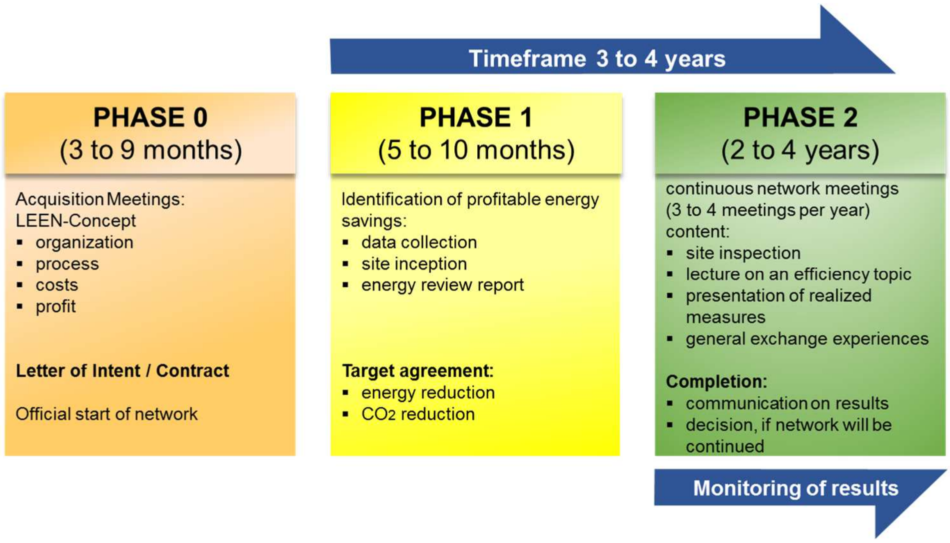
- From 2008 to 2014 a pilot project named "30 Pilot Networks" for the implementation of EE networks has been conducted in Germany.
- The project was funded by the Federal Ministry for the Environment
- The participants of the "30 Pilot Networks" project account for total energy costs of approximately 1 billion EUR / year, total energy consumption of more than 15 TWh / year and CO_2 emissions exceeding 5 million tons / year.
- The implemented measures were clearly on **cross-cutting technologies** and more than 30% of the measures addressed **process heat and space heating**.
- The average payback period is between 2.2 years for the compressed air systems and 4.3 years for air conditioning
- Annual energy costs of the companies range from 150,000 EUR to 43.5 million EUR.

The entire energy review and monitoring process is in compliance with the energy review outlined in EN ISO 50001. The compliance has been certified for the following steps:

- energy review (ISO 50001, chapter 4.4.3)
- energy baseline (ISO 50001, chapter 4.4.4)
- energy performance indicators (ISO 50001, chapter 4.4.5)
- energy objectives, energy targets (ISO 50001, chapter 4.4.6)
- monitoring and measurement (ISO 50001, chapter 4.6.1)
- input to management review ((ISO 50001, chapter 4.7.2)

Figure 3-8 presents in a schematic way the stages of the LEEN concept.

Figure 3-8: Stages of the LEEN concept



In December 2014, a voluntary agreement was signed by the German Government and 18 associations of industry to generate 500 EE networks until 2020. By mid-2016, 75 new EENs had been established under the "500 Energy Efficiency Networks Initiative".

3.4.6.2 Denmark

Denmark has been engaged in energy policy development since the first oil crisis in 1973. Over the years, numerous actions have been taken by the Danish Parliament to reduce the energy consumption by increasing EE and the share of renewable energy. A systematic EE policy addressing the industrial sector began in **the early 1990s**. The energy consumption in industry had increased steadily until then.

Table 3-27 presents the key EE instruments in the country.

Table 3-27: Key instruments in Denmark for promoting EE in industry

Key policy / instrument	Policy type
Voluntary Agreement Scheme for EE	Voluntary agreement & Financial (tax relief)
Energy Efficiency obligation scheme for utility companies	Market based
Energy audit and management system	Legislative
Renewable energy for production processes	Financial (grants, subsidies)
Centre for energy savings in industry	Informative / educational
International cooperation on EE in industry	Voluntary agreement & Informative / educational

In the following, key EE instruments are described.

Voluntary Agreement Scheme for EE[70]

The Danish voluntary agreement scheme on EE for **energy intensive industries** was launched in 1996 and has been a cornerstone to stimulate EE in this type of industries. The scheme is administered by the Danish Energy Agency.

[70] Energy Policy Toolkit on Energy Efficiency in Industries, Experiences from Denmark, Danish Energy Agency, 2015

The agreement scheme for energy intensive industries is **voluntary**, but it is based on the stick and carrot principle, meaning that companies that enter the scheme will have economic incentives from extra work that needs to be performed. Under the Danish legislation, the immediate economic benefit has been chosen to be an **energy tax relief**.

The Danish voluntary agreement scheme is applicable to companies with the following characteristics:

> The company should operate certain energy intensive processes or
> The energy taxes exceed 4% of the company's value added.

The agreement is a 3-year contract between the company and the Danish Energy Agency. The main obligations for the companies are:

> They must implement and maintain a certified EnMS according to EN ISO 50001
> They must carry out special investigations and projects focusing on their primary production processes, including thorough productivity analysis, optimization analyses and analyses of the control of the central process equipment.
> They must implement all EE projects with a simple payback period of 4 years or less.

Energy Efficiency obligation scheme for utility companies[71]

The overall objective of the scheme is that utility companies (for electricity, gas, district heating and oil) should support energy savings efforts in all sectors. This scheme is based on a **market-oriented approach**, where utility companies recover the costs of the savings through the tariffs imposed on the energy bills of the consumers. The utility companies involved, are under an obligation to use these funds to identify and implement a certain amount of energy savings. The utility companies report their savings to the Danish Energy Agency via their branch organizations each year. There are no limitations regarding geographical areas, sector focus or energy sources from which energy savings can be reported.

The scheme was **launched in 2006** (long time before the adoption of the EED) with an annual target to implement energy savings of 2.95 PJ. This target, which has been gradually increased, amounts to 12.2 PJ per year from 2015 until 2020, equivalent of approximately 3% of total final energy consumption in Denmark (without considering the transport sector).

The Energy Efficiency Obligation Scheme is based on the following principles:

> An agreement is entered between the Danish Minister of Energy, Utilities and Climate and distribution companies represented by the professional bodies within electricity, natural gas, oil, and district heating (DH) regarding an annual obligation to implement and report energy savings
> The professional bodies of the utility companies distribute the sector's target among the respective utilities (the energy saving obligation is in practice proportional to their annual energy sales) and the utilities shall document the implemented energy savings
> The utility companies are allowed to finance the costs to implement the savings by charging an extra cost on the energy prices to all consumers
> Each utility can choose a strategy for which measures to apply and report implemented energy savings, for instance:

[71] Energy Policy Toolkit on Energy Efficiency in Industries, Experiences from Denmark, Danish Energy Agency, 2015

- To enter partnerships with external consultancy and affiliated service companies to deliver projects. These companies can e.g. provide advice at a reduced price or free of charge, provide subsidies or a combination
- To operate a subsidy scheme supporting EE investment projects

> Each utility company shall participate every year in a benchmarking of costs related to operate the scheme – next to reported savings.

Energy audit and management system[72]

On 29 January 2014, the Danish Government presented a bill to the Danish Parliament containing the general rules for the implementation of the EED's requirement for mandatory energy audits. The Act was adopted by the Danish Parliament on 1 April 2014. It contains an obligation for enterprises to carry out a mandatory energy audit every 4 years. The enterprise can also satisfy the obligation by using and maintaining a certified energy or environmental management system that includes an energy audit as part of the management system. The Act also provides a legal basis for the Minister for Climate, Energy and Building to lay down detailed rules on, among other things, the content of energy audits and qualification criteria for energy auditors.

Renewable energy for production processes[73]

In the political agreement of 22 March 2012, the Danish Parliament decided that renewable energy must account for 35% of the final energy consumption in 2020. Due to domestic tax policy towards the industry sector, fossil fuels are less expensive than renewables and incentives to include renewables in the energy mix are not in place. To compensate the industry, a **subsidy scheme** has been set up to promote the use of RES in industrial production processes.

The subsidy scheme will bridge the price gap between renewables and fossil fuels. It will support industries to convert to RES or DH by:

> Replacing fossil fuels with renewable energy to power manufacturing processes
> Replacing fossil fuels by DH e.g., horticulture will be able to change from coal-fired boilers to DH
> Investing in EE measures.

Centre for energy savings in industry[74]

As part of a new political agreement which is in force since June 2014, 5.4 million EUR were allocated to run a new **centre for energy savings in enterprises**. This amount was given for the period 2014 – 2017. The centre is in the process of being fully established. However, the aim of the centre is to identify and exploit the EE potential already existing **within primarily SMEs**. The large companies are covered by the mandatory energy audit scheme.

International cooperation on EE in industry[75]

Denmark is a pioneer in spreading the EE concept in enterprises not only in the country but in other countries as well. The aim is to spread and transfer Denmark's experience with EE, focusing on, among others, **industry**. The international work is based on a specific cooperation agreement with China and the setting up of a Low Carbon Transition Unit (LCTU) under the Ministry of

[72] Energy Efficiency trends and policies in Denmark, Danish Energy Agency, January 2016
[73] Energy Efficiency trends and policies in Denmark, Danish Energy Agency, January 2016
[74] Energy Efficiency trends and policies in Denmark, Danish Energy Agency, January 2016
[75] NEEAP, Denmark, April 2014

Climate, Energy and Building. In Klimapuljen 2012 (the Climate Envelope for 2012), the Government allocated a total of DKK 20 million to the LCTU, which shall assist selected growth economies in the transition to low emissions over two years. The cooperation with China is based on, among other things, Denmark's experience with EE in energy intensive Danish businesses, including experience with the voluntary agreement scheme and other tools to promote RE and EE.

3.4.6.3 Romania

The Romanian industry is a complex area that comprises large energy intensive industrial facilities (such as metallurgy, building materials industry and chemical industry) and small, but energy intensive energy consumers (such as the food industry, the beverages industry, the tobacco industry, the wood processing industry, and the paper and paper products making industry). In 2012, the final energy consumption of the first category and the second category amounted to 69% and approximately 22% of the total industry consumption, respectively[76].

In Romania, the industrial sector contributes to approximately 15% of the total GHG emissions. Therefore, improving EE in the sector has a major potential for reducing GHG emissions[77].

Table 3-28 presents the key EE policies / instruments in the country.

Table 3-28: Key instruments in Romania for promoting EE in industry

Key policy / instrument	Policy type
Grant-supported credit lines (EE Financing Facilities)	Financial (grants, subsidies)
Romanian Energy Efficiency Fund	Financial (grants, subsidies)
Energy audit and energy management	Financial (grants, subsidies) & Legislative
RO 05 “Energy Efficiency” Program	Financial (grants, subsidies)

In the following, key EE instruments are described.

Grant-supported credit lines (EE Financing Facilities)[78]

Three Sustainable Energy Financing Facilities were in operation in Romania. These were:

- **EEFF**: This facility, which closed in June 2015, has supported financing of 129 EE investment projects, lending, through six of EBRD's partner banks, more than 75 million EUR towards implementing investments of more than 110 million EUR. **Private companies used EEFF** to reduce their electricity and fuel costs, with:
  - Free technical consultancy to plan an EE investment
  - Loans of up to 2.5 million EUR per company from participating banks
  - 15% EU grants - up to 375,000 EUR per grant - when the investment is successfully completed.
- **MFFEE**: This facility was a small experimental facility which provided 10 million EUR in loan financing towards the cost of three municipal investments, and
- **RoSEFF**: This facility, which closed in April 2016, has supported financing of EE and RE investments projects by SMEs. 341 investments were supported totalling 69 million EUR.

[76] NEEAP Romania, 2014
[77] http://eeagrants.org/programme/view/RO05/PA05
[78] https://www.seff.ro/

These investments included EEFF credits of 57 million EUR from four of EBRD's partner banks.

Romanian Energy Efficiency Fund[79]

The **Romanian Energy Efficiency Fund** is a financing institution providing commercial financing of investments projects aiming to the rational use of energy. The Fund assists **industrial companies** and other energy consumers in adopting modern technologies for efficient use of energy.

The main characteristics of the Romanian Energy Efficiency Fund, as a financial institution are:

- body of public interest, legal person, independent and financially autonomous
- client-oriented financial institution
- funds revolving operation
- private-public partnership promoter
- well-balanced investment portfolio
- transparency and equal treatment for all Fund clients
- support for all implemented EE investments.

During the period between September 2004 – December 2010, FREE concluded 24 loan contracts of 13,198 million USD for total investments of 35.8 million USD.

Energy audit and energy management[80]

According to the Romanian Law no.121/2014 on EE, the economic operators whose annual consumption exceeds 1,000 toe must:

1. appoint an energy manager authorised by the Romanian Energy Regulatory Authority (ANRE) or conclude an energy management contract with a natural or legal person accredited by ANRE
2. carry out an energy audit every year developed by a natural or legal person authorised by ANRE and
3. develop EE programs including measures on short, medium, and long term.

Financing of EE projects is performed through the Romanian Fund for Energy Efficiency, and EEFF - European funding program “fast track” - used by private sector companies to invest in equipment, technology, or rehabilitation of buildings in order to improve EE.

RO 05 “Energy Efficiency” Program[81]

The Program is financed by the Financial Mechanism of the European Economic Area (EEA, 2009-2014) and is aimed at increasing EE in the **industrial sector**, in particular **industries with high level of pollution and energy consumption**. Eligible applicants are **industrial SMEs** in accordance with the provisions of Law No 346/2004.

Projects financed by the Financial Mechanism EEA should be in line with the national strategic priorities of Romania and should comply with relevant EU and national legislation.

[79] http://www.free.org.ro/index.php?option=com_content&task=view&id=96&Itemid=112&lang=en
[80] Energy Efficiency profile: Romania, August 2015, http://www.odyssee-indicators.org/
[81] NEEAP Romania, 2014

SMEs should implement a project aimed at improving EE and energy savings in line with Emergency Government Order No 22/2008 on EE and promotion of RES at the end-users. Under this program, a partnership between SMEs from Romania and partners from donating states (Norway, Iceland, and Liechtenstein) is encouraged. The projects can be submitted in partnerships if both the beneficiary and the partner are eligible applicants for the areas affected by the project and the objectives of the program are met.

The **total value of the subsidy/grant amounts to 8 million EUR plus a share of 15% (1,411,765 EUR) co-financed from national funds**.

EE shall be measured by an institution authorised by ANRE as part of an energy audit based on measurements using measurement instruments.

3.4.6.4 Croatia

The share of industry in the total final energy consumption in Croatia in 2012 amounted to 17%. The rate of reducing energy consumption in industry is 7.3% per year, and the trend of reduction is achieved in all industrial sectors. Unfortunately, the reduced energy consumption is not the result of increased EE, but the result of recession and economic crisis[82]. Table 3-29 presents the key EE policies / instruments in the country.

Table 3-29: Key instruments in Croatia for promoting EE in industry

Key policy / instrument	Policy type
Industrial Energy Efficiency Network	Voluntary agreement
Environment Protection and Energy Efficiency Fund	Financial (grants, subsidies)
High-efficiency cogeneration	Financial (grants, subsidies) & Legislative
Introduction of efficient electric motor drives	Financial (grants, subsidies) & Legislative
Energy audits for SMEs	Financial (grants, subsidies) & Informative / educational

In the following, key EE instruments are described.

Industrial Energy Efficiency Network (IEEN)[83]

As of 1997, the IEEN has been active in Croatia; its goal is to promote EE in industry by **linking energy consumers, experts, state institutions and other interested parties in a functioning scheme**. The basic objective is to increase the awareness and knowledge of the management and employees of the industries towards EE.

According to IEEN, management of energy consumption should be established at company level and at industrial group level, monitoring and analyses of energy consumption should be introduced, and targets should be set. By employing this method, a comprehensive database on energy consumption in industry was created and indicators were developed, to be used for benchmarking against companies in the same sector in both Croatia and the EU.

Activities as part of the IEEN include:

[82] http://www.fzoeu.hr/en/energy_efficiency/energy_efficiency_projects_in_industry/
[83] 3rd NEEAP, Croatia, July 2014

- institutional coordination (cooperation between state and professional bodies involved in IEEN development)
- recording consumption (status overview of energy consumption and use by branches of industry)
- development of tools (Energy Management, M&T, energy audits, benchmarking, demonstration projects)
- selection of key branches of industry and target companies for demonstration projects
- establishment of energy management (proposal of appropriate EE measures for each industrial branch and implementation plans)
- managing financing (developing financing aspects, considering possible “pipeline” projects, developing possible application of ESCO principles)
- monitoring programme implementation and results.

The source of financing of the IEEN will be the EPEEF (see below). Financing may also come from EU funds.

Environment Protection and Energy Efficiency Fund (EPEEF)[84]

The EPEEF was established in 2003 as a non-budgetary institution. Financing is secured through environmental charges and is allocated to legal and natural persons through **loans, subsidies, financial aid, and grants**.

The EPEEF finances the preparation, development and implementation of programmes, projects, and similar undertakings in the fields of environmental protection, waste management, EE and use of RES.

In particular, EPEEF:

- Acts as an intermediary in relation to the financing of environmental protection and EE from foreign funds, international organisations, financial institutions and bodies, as well as national and foreign legal and natural persons
- Maintains the database of programmes, projects and similar activities in the field of environmental protection and EE, and of the required and available financial resources for their implementation
- Promotes, establishes and carries out cooperation with international and national financial institutions and other legal and natural persons, for the financing of environmental protection and EE in accordance with national strategies and action plans.

As regards the industry sector, co-financing is provided for performing energy audits, as well as introduction and certification of EN ISO 50001. For the companies that wish to improve EE in their production process, the Fund is co-financing the preparation of design documentation, as well as the implementation of EE projects covering all measures, apart from works on the building envelope and construction of new plants.

High-efficiency cogeneration[85]

[84] http://www.fzoeu.hr/en/about_us/activities_of_the_fund/

[85] 3rd NEEAP, Croatia, July 2014

In addition to the system of incentives for the production of electricity from high-efficiency cogeneration, this measure also includes the adoption of appropriate regulations for stimulating the production of heat from cogeneration.

The regulations on stimulating heat energy production were adopted through the Heat Energy Market Act (NN No 80/2013) and the Rules on acquiring the status of eligible producer (NN No 132/2013).

The planned funds for this measure are expected to come from the Croatian Energy Market Operator and from the incentive prices defined in the tariff systems according to the relevant laws.

Introduction of efficient electric motor drives[86]

Electric motor drives account for the largest share of electricity consumption in the Croatian industry (up to 90%). This area has a great potential for energy savings, but systematic measures or programmes have not been implemented. The introduction of efficient electric motor drives involves the installation of high efficiency electric motors and the introduction of Variable Speed Drives (VSD). Depending on the power category of the motor, this measure can achieve electricity savings exceeding 16% and financial savings exceeding 10%.

The source of financing is expected to be included in the detailed work programme of the IEEN.

Energy audits for SMEs[87]

The objective of this measure is to provide **financial support to SMEs** in order to introduce and implement measures for improving EE, and primarily for conducting high-quality energy audits and introducing energy management systems (introduction of international standards such as EN ISO 50001), as well as for promoting EE and promotional / educational activities for employees.

3.4.6.5 Serbia[88]

Serbia has a significant potential for EE. Inefficient use of energy represents a major concern in the country. Consumption of primary energy per GDP is significantly higher than that in the EU (13 times higher than in Germany, 10 times higher than in France, five times that in Slovenia and almost twice that of Romania)[89]. Table 3-30 presents the key EE policies / instruments in the country.

Table 3-30: Key instruments in Serbia for promoting EE in industry

Key policy / instrument	Policy type
EnMS for large energy consumers in the industry sector	Financial (grants, subsidies) & Legislative
Incentive rates for the use of highly efficient combined heat and power generation in the industrial facilities	Financial (grants, subsidies)
Mandatory regular control of the combustion process of boilers and other combustion chambers with the capacity over 20 kW, and air conditioning systems with the capacity over 12 kW	Financial (grants, subsidies) & Legislative

[86] 3rd NEEAP, Croatia, July 2014
[87] 3rd NEEAP, Croatia, July 2014
[88] 2nd NEEAP, Serbia 2013-2015
[89] http://bankwatch.org/campaign/coal/Serbia

In the following, key EE instruments are described.

Introduction of EnMS for large energy consumers in the industry sector

This measure is implemented in the frame of the Law on Efficient Use of Energy (EUE) and it involves the achievement of energy savings through EE measures, in accordance with the target savings set forth by the state bodies. Designated organisations will be required to appoint a licensed energy manager, who will be responsible for monitoring and analysing energy consumption data, planning and implementing the EE measures, as well as regular annual reporting on behalf of EnMS to the Ministry of Energy, Development and Environmental Protection. The designated organisation is required to conduct energy audits at least once every 5 years.

Funds for the implementation of the EE measures are provided by:

- a designated organisation from its own funds
- favourable credits disbursed by IFIs,
- the Budget Fund for EE, and
- loans extended by commercial banks or other sources. The implementation of measures may also include an ESCO.

Incentive rates for the use of highly efficient CHP generation in the industrial facilities

Industries that are engaged in efficient CHP generation are entitled as privileged electricity producer and have an incentive purchase price for electricity delivered. Industry has a continuous need for thermal energy throughout the year (usually as steam for energy and technology processes), therefore, there is a great potential for the application of combined CHP in all industrial areas.

Incentive rates are included in the Regulation on the amount of special fees for incentives in 2013 and the Regulation on the method of calculation and distribution of funds collected from the fees to stimulate privileged power producers.

Mandatory regular control of the combustion process of boilers and other combustion chambers with the capacity over 20 kW, as well as air conditioning systems with the capacity over 12 kW

The Law on EUE stipulates the obligation of the owners of:

- boilers and other combustion plants with installed capacity over 20 kW to periodically conduct control of the combustion process, with simultaneous control of the heating systems in accordance with the EPBD requirements;
- air conditioning systems with installed cooling capacity over 12 kW to conduct regular periodic controls of these systems.

In order to implement the measure, the Law on EUE prescribes that the Ministry of Mining and Energy (MRE) will establish the procedure of authorisation of persons eligible to perform these activities. The control of the implementation will be carried out by the inspection services of MRE.

In the initial phase, the Budget Fund for EE will be one source for obtaining incentives.

3.4.6.6 FYR of Macedonia[90]

The industry sector in the country is the largest energy consumer holding the biggest share (~34%) of the available final energy. The sector accounts for more than 28% of GDP. Table 3-31 presents the key EE policies / instruments in the country.

Table 3-31: Key instruments in FYR of Macedonia for promoting EE in industry

Key policy / instrument	Policy type
Project INDEF: Energy Management	Informative / educational & Voluntary agreement
Introduction of efficient electric motors	Financial (grants, subsidies)
Waste heat utilization/ CDM	Financial (grants, subsidies) & Legislative
Project COGENPRO: Cogeneration	Financial (grants, subsidies) & Legislative

In the following, key EE instruments are described. It is noted that priority is given to low energy intensive technologies.

Project INDEF: Energy Management

The INDEF project aims at establishing a **network of industrial companies** for promotion and faster implementation of EE. The purpose is to develop a structure which liaise large groups of energy consumers from industrial sector, public and commercial service sector and connects them with expert and national organizations for the realization of EE measures. The program will start with implementation of EN ISO 50001 in industry.

As an added value of this project is the direct “on-line” monitoring of the implementation of measures. This measure provides support for the assessment of potential energy savings in industrial companies through an implementation of an energy audit. The audit scheme for the industry should include:

- mandatory energy audits for companies with an annual energy consumption of more than prescribed with the law
- voluntary scheme for other companies, especially for SMEs and
- Introduction and implementation of EN ISO 50001 in industry.

The financial source of this measure will come from the Private sector, Financial institutions and ESCOs.

Introduction of efficient electric motors

This measure includes the broader introduction of smart drives to the whole industry on national level. Smart drives include the installation of:

- new high-efficiency electric motors and
- devices for frequency/number of revolution control of existing electric motors.

One of the most important actions to support this measure is the **provision of access to soft loans for the purchase of EE equipment of this type** (using funds from the EEF).

[90] 2nd NEEAP FYR of Macedonia, April 2014

The financial source of this measure will come from the Private sector, Financial institutions and ESCOs.

Waste heat utilization / CDM

The aim of this measure is the utilization of waste heat in various industrial processes. A number of **SMEs have been considering the utilization of their waste heat**. Usually these are small projects that do not qualify for an investment through Clean Development Mechanism (CDM).

Actions that support this measure are the following:

- The Ministry of Economy/ Energy Agency will launch a programme for waste heat utilization for small scale projects (not qualifying for CDM) and creates a mechanism for control of projects' implementation
- The Ministry of Finance and the Macedonian Bank for Development Promotion in cooperation with the Ministry of Economy and the Energy Agency will provide support by the provision of financial incentives (**fiscal measures**/ **soft loans**) for efficient use of waste heat
- Given the existence of an institutional framework to support projects in the CDM, the most important steps in the following period should be the realization of any of addressed case studies in the National Strategy for CDM.

Project COGENPRO: Cogeneration

The main objective of this project is to provide the necessary preconditions for the distributed production of heat and electricity for **small and micro energy consumers in the industrial sector**, but also in public buildings. This measure is strongly correlated with the EED.

The realization of this project mainly depends on the faster introduction of natural gas to the whole territory. Meanwhile the country should establish feed-in tariffs for electricity produced by CHP plants and should remove barriers in the administrative sector which jeopardise their development.

One of the main actions that support this measure is the **preparation of the necessary preconditions to obtain soft loans**.

3.4.6.7 Successful key policies / instruments in other countries

Apart from the measures presented per country, this section presents successful key instruments / measures in the industrial sector of other countries.

Finland has a long tradition of **successful energy auditing**. There are three guidance levels:

- guidelines
- models for client groups, and
- handbooks.

More stringent minimum requirements are set for buildings, while minimum requirements for other sectors are under bilateral negotiations. The audit model contains requirements for a comprehensive audit and its results, including a spreadsheet template to be completed with data, delivered to the national energy agency and uploaded to a database. This database is used, inter alia, to calculate the average saving potential of different measures, to evaluate the audit programme, and to inform users. Between 1992 and 2006, subsidy decisions were made for 748 energy audits in the industry sector (with 1,139 facilities). By the end of 2006, the estimated annual savings in energy and water costs achieved through audits in the service and industry sectors (excluding process industry) was estimated to be approximately 25 million EUR. **The audit subsidies totalled 1.5 million EUR**, and the total cost of the audits was 3.5 million EUR in industrial facilities with annual energy use less than 500 GWh/year. The percentage of realised savings out of the potential savings were, on average, 52% for heat and fuels, 59% for electricity and 67% for water[91].

In the **Netherlands**, the "**Friendly energy audit**" program (in the framework of a voluntary agreement) started in 2004 and focused on the **paper industry** which decided to cooperate to survive in the highly competitive international environment. Their vision for 2020 is to become a "world champion", **reducing their consumption by half**. Many paper industries were ready to implement an energy management system. ISO 50001 was chosen to become the standard for the paper industry. However, no experienced consultants were available or trained for this industry. A **working group** was formed to ensure that ISO 50001 would not become excessively bureaucratic to implement but would raise awareness. One of its activities was the **organisation of friendly energy audits**, with 8 companies participating in the pilot phase. The 8 paper industries were visited for one day and a report was prepared at the end of each visit and shared in the working group. Such a report included the vision (target) of every paper industry. Many ideas were also shared on ways of communicating with the personnel. After this first experience, the paper industries asked to repeat the friendly audit again in the following year. This program was financed by a National subsidy for the Energy Transition Paper Industry[92].

EnMS light is a Swedish EnMS guide developed by the two research institutes. Its purpose is to make it easier for SMEs to be engaged with energy management. The "EnMS light tool" is an interactive guide of the process of implementing a simplified EnMS. It was produced in a network called ENIG (Energy Efficiency Network), which was formed with the purpose of promoting EE in the Swedish industry. The main purpose of ENIG is to support SMEs in the engineering industry to reduce their energy use. The organisations behind ENIG are Swerea Swecast, Swerea IVF and FSEK (a cooperation between local municipality energy offices). The ENIG project has also developed a benchmarking database with more than 250 companies. Financing of ENIG was mostly provided by the Swedish Energy Agency [93].

Voluntary agreements for EE improvement have been a popular policy instrument for the industrial sector since the 1990s in **Belgium**. These voluntary agreements are essentially a contract between the regional governments and industries with negotiated targets, commitments and time schedules. These agreements have a long-term outlook, covering a period between 6 to 10 years, so that strategic EE investments can be planned and implemented. The essential steps for reaching a voluntary agreement with an industrial sector are the assessment of the EE potential of the industrial facility as well as target-setting through a negotiated process. They share all the ultimate goal of reducing primary energy consumption compared to projections for 2010 (first generation of agreements) and 2020 (second generation). Especially, the region of **Wallonia in Belgium,** since 2003, put in place voluntary agreements in the **energy intensive industry**. In the first period (2003-2010), 16 agreements covering 80% of industry consumption resulted in

[91] Commission Staff Working Document, Good practice in energy efficiency, Brussels, 30.11.2016 SWD(2016) 404 final, Part 2/4 (COM(2016) 761 final)

[92] Commission Staff Working Document, Good practice in energy efficiency, Brussels, 30.11.2016 SWD(2016) 404 final, Part 2/4 (COM(2016) 761 final)

[93] Swedish Energy Agency, Swedish experiences from Energy Management Systems in industry, 2013

7,94 TWh of energy savings and 2,29 Mt of CO_2 reduction. A simplified version of sectorial voluntary agreements has been developed for SMEs[94],[95].

The Irish Large Industry Energy Network (LIEN) scheme[96] is a voluntary agreement program with the overall aim to support companies to develop or to further improve an EnMS and to achieve ISO 50001 certification. Furthermore, the LIEN supports companies to identify implementation gaps, broaden the existing technical knowledge, and exchange experiences between the participants. The LIEN was founded in 1995 and is operated by the Irish energy agency Sustainable Energy Authority for **energy intensive businesses**. Companies can participate if they have energy expenditures of more than 1 million EUR. Members of the LIEN have to introduce an EnMS, define individual energy saving targets, conduct annual energy audits and publish annual reports. Workshops and seminars are organised on special issues of EE improvements. The focus of these educational measures is on energy efficient technologies, awareness raising, monitoring & evaluation and energy management approaches. Some technologies, which were already discussed within the network, are e.g. energy efficient refrigeration, lighting, compressed air, building management systems and CHP.

The **UK's** Energy Savings Opportunity Scheme (ESOS)[97] came into force on 17 July 2014 and requires all **large organizations** to identify, evaluate and report cost-effective opportunities to improve EE by 5 December 2015 and every 4 years afterwards. All enterprises that do not belong to SMEs definition (over 250 employees or annual turnover more than EUR 50 million and balance sheet of EUR 43 million) are required to carry out an energy assessment by the compliance date. It is estimated that up to 10,500 enterprises will have to participate. These enterprises currently consume 596 TWh, representing 27% of UK's energy consumption. Approximately 35% of that is in buildings, 22% in industry and 41% in transport.

The design of ESOS was based upon the requirements of EED. Enterprises are required to:

- Assess their business operations to confirm if they are required to comply with ESOS
- Define the boundary of its energy assessment based on recent 12-months data and covers at least 90% of its energy consumption
- Appoint a lead assessor to oversee the energy audits, if 100% of the enterprises' energy consumption is not covered by a certified ISO 50001 EnMS.
- Directors are required to review the findings of the energy assessment and energy audits.
- Notify the enforcement agency on the enterprises' compliance and retain all information as record and for future review.

To support enterprises complying with ESOS, a **wide range of tools and information were developed**. These include:

- Letters to all enterprises explaining ESOS

[94] Institut de conseil et d'etudes en developpement durable, http://www.icedd.be/I7/index.php?option=com_k2&view=item&id=1256:assistance-in-the-elaboration-of-voluntary-agreements-for-energy-efficiency-in-the-industrial-and-tertiary-sectors-including-renewable-energy-sources-and-using-a-life-cycle-approach&Itemid=677&lang=en

[95] Commission Staff Working Document, Good practice in energy efficiency, Brussels, 30.11.2016 SWD(2016) 404 final, Part 2/4 (COM(2016) 761 final)

[96] *Energy Efficiency Watch (2015): Case study: Large industry energy network. Available at:* http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Case_Studies_EEW3/Case_Study_LIEN_Ireland_final.pdf

[97] Fawkes, S., Oung, K., Thorpe, D., 2016. Best Practices and Case Studies for Industrial Energy Efficiency Improvement – An Introduction for Policy Makers. Copenhagen: UNEP DTU Partnership, Feb 2016

- Awareness raising events
- Guidance document on complying with ESOS
- Best practice guides on energy auditing
- Guidance document on implementing energy saving opportunities
- Simplified on-line reporting templates
- A Q&A helpdesk for enterprises and lead assessors.

The Intensive Energy Consumption Management System (SGCIE)[98] in **Portugal** has specific provisions for **energy-intensive companies**. The SGCIE applies for all companies and facilities (also named “Operators”) that have an annual consumption over 500 toe/year, imposing binding energy audits every 6 years in energy intensive facilities with consumption above 1,000 toe/year, and every 8 years for energy audits to facilities with energy consumption between 500 and 1000 toe/year. Intensive energy users are obliged to elaborate and execute Energy Consumption Rationalization Plans, establishing targets for Energy and Carbon intensity and SEC, which also outlines energy rationalization measures.

4 Responsibilities of Member States (and EnC Contracting Parties) towards the certification of energy auditors

Efficiency in energy consumption and its conservation is one of the most important means of energy cost reduction and meeting climate change targets.

A well conducted energy audit would reveal the areas of energy wastage and suggest cost-effective energy saving measures. Energy audits conducted by certified energy auditors or auditing companies having a pool of certified energy auditors is expected to help industry to achieve significant reduction in energy consumption levels.

4.1 Energy auditors – responsibilities and duties

As already mentioned, according to article 8(4) of the EED, an energy audit must be carried out in an independent and cost-effective manner by qualified and/or accredited experts and supervised by independent authorities under national legislation.

The energy audits can be carried out by external energy experts or by in-house auditors provided that a State has put in place a scheme to assure and check their quality, including, if appropriate, an annual random selection of at least a statistically significant percentage of all the energy audits they carry out. EU Member States and EnC Contracting Parties are free to define schemes to ensure that energy auditors have a relevant educational background and appropriate work experience.

Responsibilities and duties of energy auditors are the following:

- Carry out an energy audit
- Verify energy consumption and establish baseline energy information

[98] Energy Efficiency trends and policies in industry, An analysis based on the ODYSSEE and MURE databases, September 2015

- Develop energy and material balance
- Perform efficiency evaluation of energy and utility systems
- Compare energy norms with existing energy consumption levels
- Identify and prioritise energy saving measures. Analysis of technical and financial technologies and alternative sources
- Report writing, presentation and follow up for implementation.

The characteristics of energy auditors are presented in Table 4-1.

Table 4-1: Characteristics of energy auditors

Quality	Description
Professional ethics	Impartial, truthful, sincere, honest
Openness	Willingness to consider alternative ideas and opinions
Diplomacy	Tactful in dealing with people
Adaptation	Ability to adapt to different situations
Persistent	Ability to concentrate on achieving the objectives
Determination	Timely conclusions based on logical conclusions and analyses
Self-confidence	Ability to act independently, while also effectively cooperate with others
Organizational capacity	Effectively use the basics of time management, planning and the ability to prioritise savings,
Ability to work in team	Ability to collaborate with other team members

4.2 Qualification criteria for energy auditors

Table 4-2 presents an overview of qualification criteria of energy auditors for most of the Member States.

Table 4-2: Qualification criteria of energy auditors per Member State[99]

Member State	Educational background	Work experience	Special requirements for internal auditors
Austria	Completion of adequate training	and 3 – 5 years energy management experience depending on the level of education	3 years of employment
Bulgaria	Degree in engineering (at least secondary education)	and 2 – 6 years energy management experience depending on the level of education	
Czech Republic	Degree in engineering (at least technical school level)	and 3 – 6 years energy management experience depending on the level of education	
Denmark	External experts must be registered as energy consultants or be employed with an accredited company		Internal auditors need to prove the same level of qualification as external experts
Finland	Completion of training and degree in engineering or	At least 3 years of experience in the fields of	

[99] Eurochambres – Transposition study, Energy audits for Europe, assessment of the transposition of Article 8 of the Energy Efficiency Directive (2012/27/EU) into Member State legislation, June 2015

Member State	Educational background	Work experience	Special requirements for internal auditors
	energy (at least polytechnic level)	energy, manufacturing, property, environment or similar	
France	Level 1, Level 2 or another diploma	3 - 7 years energy management experience depending on the level of education	Minimum energy management experience of 2-5 years and understanding of EN 16247
Germany	University/master craftsman/state certified technician degree	At least 3 years energy management experience	
Ireland	Completion of approved training course	Not defined (accreditation scheme under development)	
Italy	Audits can be conducted by energy service companies, experts in energy management or energy audits and the Institute for Protection and Environmental Research (ISPRA)		
Lithuania	Bachelor or equivalent degree	3 years of professional experience in energy efficiency activities	1 year of professional experience
Malta	Bachelor or higher degree in engineering or in a related applied science	or employment by a reputable firm with expertise and track record in energy management	Need to have suitable experience and training
Portugal	No minimum requirements	3 years' work experience in an energy-intensive company or 1-2 years energy consulting/energy auditing experience	
Romania	Either Master degree in EE, Doctorate degree in energy-related engineering or completion of a training course	2-3 years energy management experience depending on the level of education	
Slovakia	University or secondary technical vocational education degree in certain fields	2-5 years energy management experience depending on the level of education	
Slovenia (only defined for persons carrying out energy audits for buildings)	Degree in relevant discipline and completed training	and at least 2 years of relevant work experience	
Sweden	No minimum requirements	3-10 years energy management experience depending on the level of education	
United Kingdom	Professional status of Principal Environmental Audit or Full Member of the Institute of Environmental Management and Assessment (IEMA) and status of an Environmental Audit	At least 2 years professional energy assessment and energy audit experience and involvement with two or more EE assessments/audits	

4.3 Certification / accreditation schemes for energy auditors

Member States should put in place certification schemes for the providers of energy audits to make sure that a sufficient number of reliable professionals are available.

Accreditation is a public authority activity that ensures the continuous control of the technical competence of conformity assessment bodies. It ensures that auditing is carried out by experts that meet the requirements of the EED (Annex VI). Accreditation/certification schemes provide transparency to consumers, are reliable and contribute to national EE objectives.

The benefits of professional certification are the following:

- Professional achievement is recognised in the eyes of colleagues as well as in prospective employers and clients
- Certification establishes a standard of professional development competence which is recognised throughout the industry
- Certification fosters professional development through encouragement of long-term career goals
- Promotes quality through continuing education to assure a high level of competence in constantly changing fields.

A detailed review of implementation of Article 8 on accreditation / certification schemes for energy auditors in all EU MS is presented in Table 4-3.

Table 4-3: Certification / accreditation schemes for energy auditors per Member State[100]

	Accreditation schemes/tools and training	Register of energy auditors	Mutual recognition
Austria	Auditors need to obtain at least 20 points in three areas of qualification (buildings, industrial processes and transport) when applying for registration. The points are based on the educational background, current professional positions, and participation in specific training courses and demonstrated practical experience. Energy auditors need to renew their license every 3 years. Specific training courses are organised by national certification companies, like Quality Austria, for internal energy auditors. The course "Internal Energy Auditor according to Energy Efficiency Law" has a duration of two days and focuses on the EN 16247 standard (Part 1-5).	A register of qualified energy auditors is available on the website of the Federal Ministry of Science, Research and Economy.	Auditors certified in other MS are not automatically allowed to carry out audits in Austria: they need to be registered and meet the national requirements.
Belgium Walloon region	According to Decree on 2 February 2012, energy auditors need to fulfil the new requirements under the AMURE programme[101] in order to be accredited to carry out energy audits in large enterprises. Candidates must demonstrate their industrial experience, must be approved as an AMURE auditor for at least 5 years and follow a one-day training course provided by Pirotech, who is the technical expert 'Accords de Branche' appointed by the Walloon government. Auditors need to follow the detailed methodology "Methodologie des Accords de Branche de deuxième generation de l'industrie Wallonne".	A register of qualified energy auditors is available on the website of the Walloon Region-DGO4.	There is no mutual recognition of auditors from other MS (or other regions of Belgium).

[100] Report on the qualification of energy auditors in all Member States, DNV GL, Oct 2015

[101] The AMURE program subsidizes an energy audit or pre-feasibility study that assesses the appropriateness of an investment or develops an overall plan to improve company's EE.

	Accreditation schemes/tools and training	Register of energy auditors	Mutual recognition
Belgium Flanders region	No accreditation is needed to conduct energy audits in Flanders region. However, there are available different recognition schemes for auditors. Energy experts must have technical and commercial knowledge of the site to be audited, enough experience and expertise, and must be able to satisfy the requirements of the 3rd Flemish Energy Efficiency Action Plan. For auditors carrying out energy audits for large enterprises in general, no special requirements (education, experience, etc.) have been defined. Auditors need to be registered (online) with VEA (Vlaams EnergieAgenstchap).	No available information.	Auditors accredited in other EU MS are allowed to carry out energy audits in Flanders, provided that they are registered with the VEA.
Belgium Brussels	Auditors need to fulfil the qualification requirements regarding education, experience and acknowledgement by the Brussels Institute for Environmental Management. The qualification has to be renewed every 5 years. In addition, the auditor should maintain a register including energy audits carried out over the past 5 years. This information has to be sent annually to Brussels Environment via a data collection platform “Irisbox”. A guidance describing the different steps of the audit approach is available on the Institut Bruxellois pour la gestion de l’environnement (IBGE) website.	A register of qualified energy auditors is available via the website of Brussels Environment.	A certificate or a diploma issued in another MS is recognised, as long as it fulfils the requirements set by the Brussels Institute for Environment Management.

	Accreditation schemes/tools and training	Register of energy auditors	Mutual recognition
Bulgaria	Energy auditors obtained approval from the Sustainable Energy Development Agency (SEDA), an executive agency under the Ministry of Energy which is responsible for the register of energy auditors. A guidance document sets out the details about the registration process and the documents which need to be submitted. The accreditation is valid for 3 years. There are no official tools (such as guidelines or calculation tools) available for energy auditors.	Only registered auditors are allowed to conduct energy audits (as defined by ordinance RD-16-301).	Experts from another MS are allowed to conduct audits provided that they meet the requirements adopted by the Bulgarian Higher Technical School.
Croatia	Accreditation is granted to qualified energy auditors for a period of 5 years, according to Article 19 of the Energy Efficiency Act. Separate training schemes and qualifications for buildings, processes and transport are foreseen. 10 educational institutions were granted authorisation to conduct training for energy certifiers.	The Ministry of Economy will keep a register of authorised energy auditors for large companies and issued energy audit reports.	Croatia will likely recognise accreditations from other MS, but the specifics have yet to be determined.

	Accreditation schemes/tools and training	Register of energy auditors	Mutual recognition
Cyprus	There are three categories of energy auditors specified in the current legislation (category A for buildings, category B for industrial processes and category C for transport). With the new Decree, energy auditors of categories A and B should apply the standards CYS EN 16247-1, EN16247-2 and CYS EN 16247-3 when carrying out energy audits. There is a Technical Guide of Energy Audits which must be implemented by energy auditors during audits. For certification, auditors must participate in an 80 hours training course and practice for categories A and B and 32 hours of classes and practice for category C (70% theoretical training and 30% practice) plus an exam.	Energy auditors applied for registration in a register which is posted on the Ministry of Energy, Commerce, Industry and Tourism and managed by the Ministry of Energy and an independent expert panel (5 people).	Energy auditors from other MS can settle in the Republic and practice as long as they are enrolled in the energy audit registry.
Czech Republic	Energy auditors for accreditation must have a university degree in engineering and three years of energy management experience, or a technical school degree and six years of energy management experience and successfully passed specific oral and written exams. The Association of Energy Auditors together with the Czech Chamber of Certified Architects is in charge of the training and education for energy auditors. Auditors must participate in continuing education programmes.	Auditors apply for registration in a public register. This register of auditors is maintained by the Ministry of Industry and Trade.	No information available.
Denmark	DANAK is the national accreditation body. Energy auditors need to be employed by a company accredited by DANAK or an equivalent body or be approved under similar schemes recognised by the Danish Energy Agency. The Danish Technology Institute (DTI) provides an overview of the requirements to become a registered energy auditor. A-level energy consultants need to have at least 3 years of experience within the last 6 years and B-level energy consultants need to have at least 5 years of experience within the last 10 years and have knowledge of energy, environmental or quality management. B-level energy consultants are allowed to carry out audits on their own while A-level consultants must work with partners to undertake audits. Training classes are voluntary but highly recommended. The auditor needs to have carried out at least two audits under the supervision of an experienced auditor.	The Danish Energy Agency and other organisations (DTI and SparEnergi) maintain the register of certified auditors, which is available on line.	Auditors accredited in other EU MS are not automatically qualified to carry out audits in Denmark, but when the Danish requirements are met.
Estonia	An accreditation system has been in place in Estonia since 2007 and is run by the Estonian Association of Heating and Ventilation Engineers (EKVÜ). There is a separate qualification system set up for industry auditors. The accreditation is valid for 5 years; afterwards the auditor needs to retake the exams in order to renew the certification. Training courses are arranged by EKVÜ, in collaboration with the Tallinn University of Technology. Qualification exams take place throughout the year.	The EKVÜ maintains a register of qualified energy auditors (available on EKVU's website) of 8 different levels of the German Qualifications Framework following the EN standards.	Auditors accredited in other EU MS are not automatically qualified to carry out audits in Estonia but need to meet the same criteria as the local ones.

	Accreditation schemes/tools and training	Register of energy auditors	Mutual recognition
Finland	Energy auditors in Finland need: • to be registered with Energiavirasto; • have an appropriate lower-university or polytechnic degree in engineering, environmental or energy, or have relevant work experience (at least 3 years in energy, manufacturing, property or environment) replacing this educational qualification; • follow a Motiva (a state-owned company responsible for the development of energy audit models, guidelines and procedures) training course; • be familiar with the implementation of energy audits for companies, demonstrated by a successfully completed test on energy audits. All auditors need to be authorised by Energiavirasto before they can carry out a valid energy audit. Authorisation lasts for 7 years (unless it is revoked by Energiavirasto if the auditor violates the minimum requirements or proves to be incompetent), after which it has to be renewed.	Motiva maintains a directory of auditing firms that have auditors with heat and fuels or electrical auditing competency.	No information available.
France	Three qualification bodies - OPQIBI (OrganismeProfessionnel de Qualification de l'Ingénierie Bâtiment et Industrie), LNE (Laboratoire National de métrologie et d'essais) and AFNOR - offer accreditation of external auditors. Those qualification bodies have to be accredited by the national accreditation body (COFRAC). Organisations whose employees are entitled to perform external energy audits in France have to be "qualified" by one of these qualification bodies. A specific accreditation scheme has been set up by COFRAC for this purpose. ADEME regularly organises trainings for the qualifications of energy auditors.	There is no central register for energy auditors.	Auditors certified in other European MS do not automatically qualify to carry out audits in France; they need to be certified in France first.
Germany	Energy auditors have to fulfil requirements in three areas: education, professional experience and independence. The applicant has to submit the reports of 10 audits conducted during the last 3 years at the time of the submission of the application to BAFA. Training for educating energy auditors is offered by different companies (e.g. TÜV). Training is voluntary. There are no standardised manuals or guidebooks available, except the guideline from BAFA.	Energy consultants who have passed the BAFA exams are registered in a list which is publicly available. It is not mandatory for auditors to be included in this list in order to be allowed to carry out energy audits, as long as they provide BAFA with necessary documentation about their expertise and reliability.	Energy consultants from countries outside of Germany may register at BAFA as long as they meet the same requirements.

	Accreditation schemes/tools and training	Register of energy auditors	Mutual recognition
Greece	The administrative body for energy auditor accreditation is the Hellenic Accreditation System under the overall supervision of the Department of Inspections for the Environment, Construction, Energy and Mines. The draft legislation specifies 3 categories of energy audits (residential building up to 2000 m^2, office buildings more than 2000 m^2 and industrial and commercial facilities with a total installed capacity of 1,000 kW) and 3 broad categories of energy auditors (buildings, heating systems and cooling systems). The Centre for Renewable Energy Sources and Saving (CRES) is responsible for the dissemination and promotion of EE applications. The Technical Chamber of Greece (TEE) offers examples of energy audits and has developed the necessary technical instructions.	Energy auditors will be enrolled in the Energy Auditor Register (electronic form), publicly available. The Department of Inspections for the Environment, Construction, Energy and Mines is responsible for the register.	Energy auditors from other MS are allowed to carry out energy audits as long as they meet the same requirements and they get approval from the Ministry of Reconstruction of Production, Environment and Energy.
Hungary	The Hungarian Energy and Public Utility, MEKH supervises registration for energy auditors. Accreditation will not expire for Hungarian auditors; foreign auditors' accreditations will be valid for five years. The registration body will develop a tutorial for auditors to prepare them for the accreditation exam. This training is optional.	There will be a register of auditors, but no details are available.	Energy auditors qualified in other MS are allowed to carry out audits provided that they meet the same requirements on education and experience and are registered with MEKH.
Ireland	To become a registered energy auditor, an expert must apply for registration to Sustainable Energy Authority Ireland (SEAI), pay an accompanying fee and meet all other requirements specified by SEAI. The applicant should be sufficiently qualified or should have successfully completed an approved training course in relation to different classes of energy audits. SEAI has developed a wide range of tools and resources to support energy auditors and organisations during the auditing process. This material includes technology assessment tools, energy saving calculators and a list of best practices per application.	SEAI maintains a registration scheme for energy auditors to guarantee the quality of the audits. SEAI has established an interactive online register of auditors.	Energy auditors from other countries must become a Registered Energy Auditor under the Irish scheme.

	Accreditation schemes/tools and training	Register of energy auditors	Mutual recognition
Italy	After 19 July 2016 energy auditors need to be certified by a body that is accredited to UNI CEI 11352, UNI CEI 11339 or other requirements (technical standards for voluntary certification of energy auditors for industry, services, transport and buildings) provided in Article 12 of the Decree related to energy auditors. ACCREDIA (l'EnteItaliano di Accreditamento) is the accreditation body in charge of the accreditation of energy auditors. Energy auditors' accreditation is valid for five years. There are mandatory training schemes in place for energy auditors seeking accreditation and there are number of guidelines available for audits in different sectors.	There are multiple registers for auditors (each region has its own accreditation system) A master register is under development. All completed audit reports must be sent to the National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), where they will be stored in a national database.	Energy auditors accredited in another EU MS are allowed to carry out audits in Italy without additional Italian accreditation.
Latvia	The Latvian National Accreditation Bureau of the limited liability company "Standardisation, Accreditation and Metrology Centre" is responsible for assessing the applications for energy auditors and for organising the qualification exams. Each year, qualified energy auditors are required to submit a report to the Ministry of Economics on the industrial energy audits they performed during the previous calendar year. The recommendations published by the Ministry of Energy include instructions for energy auditors on the requirements to be followed when they carry out an audit.	A list of energy auditors is kept updated by the Latvian National Accreditation Bureau (LATAK) and is accessible on its website. Initially, accreditation is granted for four years and after a repeat accreditation procedure the term is 5 years.	No information available.
Lithuania	According to the secondary legislation 1-148, energy audits need to be carried out by energy auditors that hold a university degree in the field of "sciences and technology" or equivalent education and they have at least 3 years of professional experience in energy efficiency activities. Energy auditors need to complete a training course in order to be certified. Training courses are only provided by educational institutions that have been approved by the Lithuanian Ministry of Energy.	There is a register of energy auditors, which is publicly available through the website of the Lithuanian Ministry of Energy.	No information available.

	Accreditation schemes/tools and training	Register of energy auditors	Mutual recognition
Luxembourg	Anyone conducting energy audits must be certified to issue energy performance certificates. Individuals must be registered architects or consulting engineers. Alternatively, auditors can apply for a permit from the Ministry of the Economy and demonstrate their qualifications. Auditors are encouraged to participate in training classes on EE in buildings, but this is not required. These training classes are provided by the Ministry of the Economy. The Professional Association of Architects and Consulting Engineers and CRP Henri Tudor (public research centre) also organises a series of advanced training classes in construction and energy.	Individuals who have participated in the expert training classes are added to a register as experts on residential or non-residential buildings.	No information available.
Malta	External auditors need to be registered at the Malta Resources Authority (MRA) and qualified at least to Malta Qualifications Framework level 6 or higher in engineering or in a related applied science or be employed with a reputable firm with expertise and a track record in energy management, in which case the audit must be signed by a person qualified and registered as above. MRA requires that energy auditors follow appropriate training courses as in Government Notice 1302 and are certified as such. The validity of the certification issued to energy auditors is restricted for a period of time of 10 years. Training courses are mandatory for auditors to be accredited and they are organised and held by private companies.	Since March 2015, there is an online register available for companies to search for energy auditors and is available on the MRA website.	There is no mutual recognition for energy auditors certified in other MS.
Netherlands	The Dutch government does not have an accreditation scheme and does not have specific requirements for energy auditors. There are a number of training programmes, many of which have been accredited by independent organisations such as Foundation for Quality Assurance in the Installation Sector (KBI) or the Platform for Certification of Environmental and Occupational Health & Safety Management Systems (SCCM). The Accreditation Council (Raad voor Accreditatie) supervises the certifying bodies.	There is no register, however there is a register of the data used and the results of each energy audit performed. Audited enterprise is obliged to upload the audit results to the register.	Energy auditors qualified in other MS are automatically allowed to also carry out energy audits in the Netherlands.
Poland	According to the Energy Efficiency Law (EEL), energy audits need to be carried out by an independent external auditor who has sufficient knowledge and professional experience. Energy audit reports will be randomly verified by the Energy Regulatory Office. Polish-Japanese Energy Conservation Technology Centre (PJCEE), organises training sessions for persons involved in energy management and for managerial staff of enterprises, to increase the competences of persons carrying out energy audits. Training courses are organised by third level educational institutions (public and non-public), by research institutions, and by foundations, associations, and private enterprises.	No information available.	No information available.

	Accreditation schemes/tools and training	Register of energy auditors	Mutual recognition
Portugal	Energy audits must be conducted by an engineer recognised either by the “Ordem dos Engenheiros” or by the “Associação Nacional dos Engenheiros Técnicos”. The recognition schemes require certain levels of competence to be met through qualifications and experience in conducting audits. For the industrial audits, the auditor must have a university education in the field of energy auditing, a proof of having performed energy consulting or energy auditing activities for one year; otherwise, proof of having worked as an engineer in an energy-intensive company for three years or having performed energy consulting or energy auditing activities for two years. Energy auditors are required to pass a specific exam organised by the entity responsible for the Portuguese energy certification system (SCE).	A list of competent auditors is provided on the Ministry website.	Accreditations for energy auditors from other MS are not recognised in Portugal
Romania	Auditors need to hold a degree in EE or related engineering and have two to three years of energy management experience. Auditors also need to complete a training course approved by the Romanian National Regulatory Authority (ANRE) unless they hold a master’s degree in EE or a doctorate in engineering. Auditors should also have a clean criminal record. The authorisation to conduct audits is issued by ANRE. The accreditation is valid for three years and can be extended by another three years. Responsible authority for energy auditors for buildings is the Ministry of Regional Development and Public Administration (MDRAP), while for industrial sector is ANRE. For each type of energy auditor, a register exists which is managed by the authority mentioned above. A mandatory training class is provided by 10 universities, approved by ANRE.	Once accredited, energy auditors are recorded in a register managed by ANRE and MDRAP. ANRE maintains a separate register of the audit results.	Energy auditors authorised in another EU MS can be recognised if they prove knowledge of Romanian legislation by undertaking an interview.
Slovakia	The requirements to become a registered energy auditor in Slovakia are defined in paragraph 12 of the Energy Efficiency Act 321/2014. Every 3 years accredited auditors need to take a refresher training course.	Energy auditors must report their audits to a monitoring system.	According to the legislation it is possible for auditors who are certified in other MS to perform audits in Slovakia, however the recognition process in not yet well defined.

	Accreditation schemes/tools and training	Register of energy auditors	Mutual recognition
Slovenia	The Ministry of Infrastructure is responsible for EED implementation. The Ministry has not yet set the criteria for energy auditors. The Chamber of Commerce and Industry has organised several conferences to promote energy audits in Slovenia.	No information available.	No information available.
Spain	Energy audits must be carried out by energy auditors qualified in accordance with the provisions of the Royal Decree (NEEAP III Spain, 2014). Auditors should be accredited by the National Accreditation Body ENAC (Entidad Nacional de Accreditacion). There is not an official training scheme, or guidance document provided by the government at this stage. In the absence of a central training scheme offered by the government, ENACE (Entidad Nacional de Auditores y Certificadores de Edificación) has taken the initiative to develop a unique training scheme referring to the European standards, and uses best practice examples from Germany, Malta and Finland.	The energy auditors will be enrolled in the Energy Auditor Register, in the form of an electronic database. Ministry of Industry, Energy and Tourism is responsible for control and management of the register.	To be defined in the new legislation.
Sweden	The Swedish Energy Agency (STEM) and the Swedish Board for Accreditation and Conformity Assessment (SWEDAC) are currently working on a certification scheme for individuals. A guidance document (September 2015) for energy audits in large companies was published by STEM and describes the requirements that apply to certified energy auditors. Energy auditors also need to pass both a written and oral exam. The accreditation is valid for a period of 5 years.	No information available.	Auditors certified in other EU MS are allowed to carry out audits in Sweden without additional Swedish accreditation.
United Kingdom	An ESOS compliant energy audit must be carried out by an ESOS lead assessor or by an auditor but the signature of a certified lead assessor is required. To become an ESOS lead assessor, experts need to members of an approved professional body register (i.e. Certified Energy Manager International the Chartered Institution of Building Services Engineers, Energy Institute, the Energy Managers Association, etc.). All professional register bodies follow the same accreditation process that has been developed by the Environment Agency. The UK market provides a wide range of training and qualification opportunities for energy auditors, including post-graduate level qualifications in energy and environmental management.	On the webpages of the approved professional bodies' registers there are lists of contact details and specialisms for approved lead assessors who are willing to act as lead assessors for third parties.	Mutual recognition is not applicable in the UK.

4.4 Support programmes for audits in industrial SMEs

According to article 8(4) of the EED, enterprises that are not SMEs are required to perform an energy audit by 5 December 2015 and after 4 years afterwards.

Member States shall develop programmes to encourage SMEs to undergo energy audits and the subsequent implementation of the recommendations from these audits. On the basis of transparent and non-discriminatory criteria, Member States may set up support schemes for SMEs, including if they have concluded voluntary agreements, to cover costs of an energy audit and of the implementation of highly cost-effective recommendations from the energy audits if the proposed measures are implemented.

SMEs definition

SMEs are defined as enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million (Commission Recommendation 2003/361/EC). This harmonised definition allows consistent requirements for companies operating in different EU Member States. It is noted that this definition applies in EU Member States; **each EnC Contracting Party may define otherwise SMEs based on national legislation.**

So far, few programmes have been developed specifically to support SMEs to undertake energy audits. An overview of support programmes for each Member State is presented in Table 4-4[102].

Table 4-4: Support programmes in Member States for energy auditors per Member State

Member State	Support programmes
Austria	There are no programmes to encourage SMEs to undergo energy audits.
Belgium Flanders	> SMEs can benefit through the SME portfolio for co-financing training, consulting and innovation > There are under development benchmark tools, “mini-agreements” and developing ESCO’s in order to raise awareness among SMEs.
Bulgaria	There are no programmes to encourage SMEs to undergo energy audits.
Croatia	> Established the Industrial Energy Efficiency Networks (IEEN) in order to raise awareness and knowledge of SMEs on EE and energy conservation > Financial support of HRK 2 million (270,000 EUR) to SMEs for conducting high quality energy audits and improve EE through introducing energy management.
Czech Republic	> For 2015, under the public programme (EFEKT), around 1,094 million EUR are available to promote EE measures and introduce EnMSs to SMEs and municipalities. SMEs can be (co)financed by up to 100% and a maximum amount of 10,900 EUR > Programmes supporting energy savings are financed by the Ministry of Industry and Trade (182 million EUR).

102 Eurochambres – Transposition study, Energy audits for Europe, assessment of the transposition of Article 8 of the Energy Efficiency Directive (2012/27/EU) into Member State legislationJune 2015

Member State	Support programmes
Denmark	According to the Danish Energy Efficiency Obligation Scheme, Danish energy companies promote energy saving measures by providing advice, energy audits, and subsidies to companies and households in order to ensure energy savings of 12.2 PJ/year in 2015-20.
Finland	The Ministry of Employment and Economy subsidises up to 40% of the energy auditing costs for industry, commercial and public buildings and the energy sectors. Companies that have joined the EE agreements can obtain subsidies on a case-by-case basis for carrying out conventional technical savings investments.
France	ADEME (Energy and Environment Agency) provides financial support to SMEs to undertake an energy audit. Subsidies cover up to 70% of the cost for SMEs and the maximum eligible budget of the action cannot exceed 50,000 EUR. Funding is also available for assisting SMEs implementing the recommended EE actions and investments (maximum eligible budget of the action cannot exceed 100,000 EUR).
Germany	The BAFA (Energieberatung Mittelstand) is a support program specifically designed for SMEs to inform and advise companies on their economically viable EE potentials. SMEs with annual energy costs of more than 10,000 EUR may profit from benefits covering up to 80% of their eligible energy consulting costs. The maximum aid that a company may receive is 8,000 EUR. Energy audits based on DIN 16247-1 can be conducted only by energy experts that have been approved by BAFA.
Ireland	The SME Support Centre of the Sustainable Energy Authority of Ireland (SEAI) provides free on-site advice and different training courses for SMEs, energy-intensive SMEs and large companies.
Italy	Supporting the implementation of energy audits in SMEs by co-financing energy audits up to 5,000 EUR and the introduction of ISO 50001 EnMS up to 10,000 EUR.
Malta	The Minister is planning to develop support programmes to encourage SMEs to undergo energy audits. Energy audits SME’s will be partly financed through Malta Enterprise Schemes funded from national funds.
Portugal	SMEs can apply for a refund of 50% of the costs of an energy audit – limited to EUR 750 (Decree No. 71/2008).
Romania	There are no programmes to encourage SMEs to undergo energy audits.
Slovakia	There are no programmes to encourage SMEs to undergo energy audits.
Slovenia	There are no programmes to encourage SMEs to undergo energy audits.
Sweden	There are no programmes to encourage SMEs to undergo energy audits.
United Kingdom	There is no national programme that supports energy audits of SMEs. Around a third of SMEs are home-based and are therefore covered by the Green Deal initiative.
Cyprus	The Organisation for Standardisation holds information events to raise awareness among enterprises on the benefits arising from introducing EnMS.
Estonia	The Energy Efficiency Coordinator promotes information and awareness-raising and training initiatives in order to inform residents of the benefits of EE improvement measures.
Greece	Financial support for EE measures through a “Green Fund”. Funds are available to all providers of EE improvement measures (ESCOs, independent energy consultants, energy distributors, distribution system operators, retail energy sales companies and installers, as well as the final customers).
Hungary	There are no programmes to encourage SMEs to undergo energy audits.
Lithuania	There are no programmes to encourage SMEs to undergo energy audits.
Luxembourg	Energy audits can be co-financed by up to 50%. An applicant can only benefit once from such a grant. Based on “Voluntary Agreement on improving energy efficiency in Luxembourg industry" industrial companies which perform regular energy audits, are co-financed by the Ministry of Economy.

Member State	Support programmes
Netherlands	Companies participated in the Long-Term Agreement can benefit from the expertise and experience of advisers from the Dutch Energy Agency.
Poland	Funds provided for EE investments in SMEs (14.3 million EUR) and in large businesses (35.7 million EUR).
Spain	There are no programmes to encourage SMEs to undergo energy audits.

5 Overall methodology and procedures for conducting energy audits in the industrial sector

The EED sets out a series of measures to help the EU reach its targets for reducing energy consumption (20% EE target by 2020 as compared to business as usual energy use) by ensuring a more efficient use of energy at all stages of the energy chain: from production to final consumption.

Article 8 (already analysed) and Annex VI “Minimum criteria for energy audits” of the EED provide the framework for energy audits in the EU.

According to Annex VI “minimum criteria for energy audits” the energy audits should be based on:

- Up-to-date, measured, traceable operational data on energy consumption and (for electricity) load profiles
- Comprise a detailed review of the energy consumption profile of buildings or groups of buildings, industrial operations or installations, including transportation
- Build, whenever possible, on life-cycle analysis instead of Simple Payback Periods (SPP) in order to take account of long-term savings, residual values of long-term investments and discount rates
- Be proportionate and sufficiently representative to permit the drawing of a reliable picture of overall energy performance and the reliable identification of the most significant opportunities for improvement.

The industrial sector accounts for around 26% of total final energy consumption in the EU-28 in 2012[103]. In developing countries, the portion of the energy supply consumed by the industrial sector is frequently in excess of 50% and can create tension between economic development goals and a constrained energy supply.

[103] Odyssee-Mure

Energy demand is dominated by the energy intensive industries (for example, primary metals, chemical industry, non-metallic minerals, paper, pulp and printing industry and food industry), which are responsible for almost 80% of industry's final energy demand.

5.1 Energy audit – definition and purpose

According to the EN 16247-1 "Energy audits – Part 1: General requirements", *Energy audit is the systematic inspection and analysis of energy use and energy consumption of a site, building, system or organisation with the objective of identifying energy flows and the potential for EE improvements and reporting them*[104].

The energy audit exercise must be carried out accurately enough to identify and quantify the energy and cost savings that are likely to be realised through investment in an energy saving measure.

The first step in implementing EE is to conduct an energy audit to understand the current situation. The benefits of conducting energy audits are:

- lower energy costs
- improved environmental performance
- benefits of active energy management
- energy audit will result in a list of energy saving opportunities.

Energy audits shall allow detailed and validated calculations for the proposed measures so as to provide clear information on potential savings.

The data used in energy audits shall be storable for historical analysis and tracking performance[105].

Energy audits are carried out for **different purposes** such as:

- To develop a pipeline of EE investments for the implementation of a National incentives programme or programmes of International Financing Institutions
- To provide data for a market assessment of EE potential in an economic sector
- On ad-hoc basis by a company that wishes to reduce its energy cost or because it is obliged to do so by the Law (e.g. mandatory energy audits to large enterprises)
- As a part of an EnMS
- As a part of an ESCO development project, etc.

[104] EN 16247-1 "Energy audits – Part 1: General requirements"
[105] Principles of Annex VI of the Energy Efficiency Directive

5.2 Classification (types) of energy audits

There are three levels of energy audits:

The ***preliminary energy audit*** is essentially an initial data gathering effort. It is also referred to as “walk through audit” or “brief audit” The preliminary audit normally uses available data and is completed without or with very simple measurements.

The output consists of technically zero and low-cost EE measures. Because of time and budget constraints, only experienced auditors can successfully conduct a preliminary audit that identifies the need for a detailed audit.

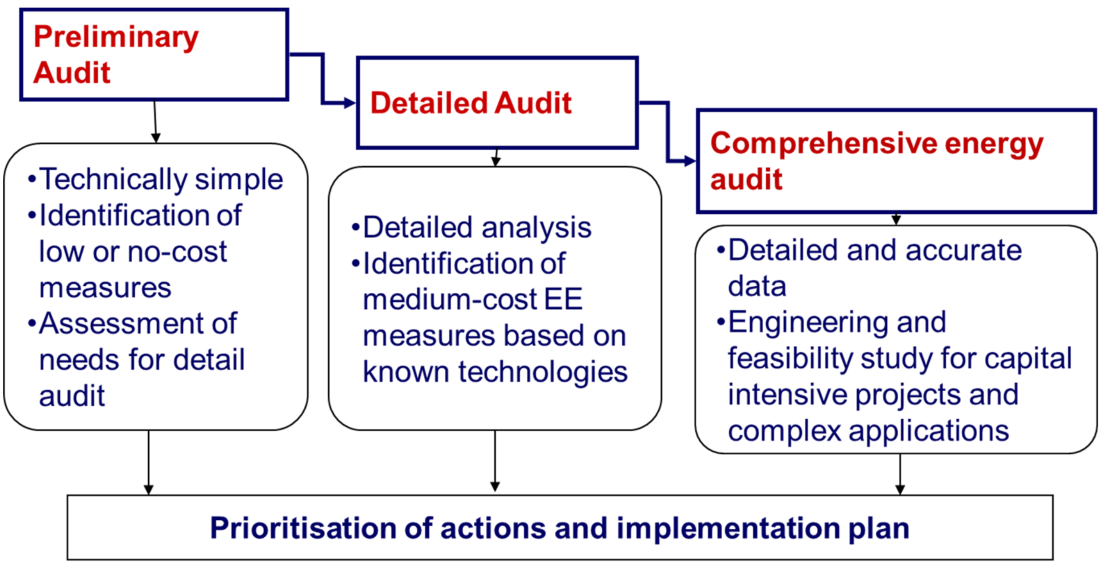
The ***detailed audit*** is an instrumental data collection of all energy consuming equipment and processes in a site, followed by a detailed energy and cost analysis of the different processes.

A detailed audit focuses mainly on capital intensive EE opportunities, which have been identified in a preliminary audit. Metering of energy flows using simple but accurate equipment is an essential part of a detailed audit.

The ***comprehensive energy audit*** study focuses on capital intensive measures and includes techno-economic analysis. The technical part contains the conceptual design of the proposed measure, a detailed estimate of capital expenditures and operation and maintenance costs. The financial and legal parts consist of the financing scheme, contractual framework and tender documents for contractors and suppliers.

Figure 5-1 presents the 3 types of audits.

Figure 5-1: Types of energy audits



5.3 The energy audit approach

Before energy audits are conducted, the energy auditor should obtain the following information to assist in planning and define the potential work scope:

- description of the site and the nature of operations
- records of energy use (energy consumption bills, tariffs applicable to the site, profile of energy usage)
- detailed characteristics of the audited object(s) including known adjustment factors and how the organisation believes they influence energy consumption
- a survey of available drawings including a schematic layout of the operations on the site
- operational history and past events that could have affected energy consumption in the period covered by the data collected
- short and long-term plans for the processes and equipment, which may affect energy saving recommendations
- design, operation and maintenance documents
- energy audits or previous studies related to energy and EE
- status of the EnMS.

When investigating the energy use of a particular unit within the factory, it will be necessary to carry out measurements with portable instruments. The typical equipment needed for an energy audit is presented in Table 5-1.

Table 5-1: Typical equipment for an energy audit

Equipment	Portable instruments
Motors and drives	Multi-power meter Power analyser Strobo-tachometer
Lighting illumination	Illuminance meter
Compressed air, air flow	Air velocity meter Air leakage indicator Pressure meter
Steam distribution systems	Ultrasonic steam trap tester Ultrasonic flow meter
Temperature and humidity	Thermocouples, thermometers
Combustion systems, Boilers, Furnaces and Kilns	TDS meter True-spot smoke meter Combustion analyser Pressure meter Infrared thermal camera
Auxiliary equipment	Multi-channel data logger Digital camera Computer

The energy audit can only be carried out in close cooperation with the factory staff that is responsible for the energy use. The technical personnel are the most important factory personnel for the auditing exercise and must have direct access to senior management and should be seen to have their total support and commitment.

The **approach of the auditing work** includes the following steps:

- Agreement with the factory
- Kick-off meeting (presentation of the objectives and the auditing team)
- On site survey
- Data collection and evaluation
- Identification / discussion of energy saving opportunities

- Description/evaluation of measures
- Audit report presentation
- Follow-up implementation.

More information is presented in Annex I.

Table 5-2 presents an example of an energy audit methodology applied in Germany.

Table 5-2: Energy audit methodology in Germany (according to DIN EN 16247-1)

Energy audit stages	Remarks
Initial contact	Discussion with the company its goals, expectations, requirements, time limits, audit boundaries, criteria for the evaluation of measures to improve EE
Kick-off meeting	> Inform all participants/stakeholders on the audit goals, scope and area of work, audit boundaries. > Agreement on the actual implementation and schedule of the audit
Data collection	List of energy consumers, data on energy consumption (past and present), influencing factors, etc.
On-site visit	On-site inspections and data collection, verification
Analysis	> Determination of current situation regarding energy consumption and performance > Identification and definition of energy efficiency measures > Ranking of EE and energy saving measures according to the pre-defines criteria
Report	Normal report contains: 1. Summary, 2. Background, 3. Energy Audit (results of data analysis), 4. Possible EE measures, 5. Conclusions
Concluding discussion	> Handover of report > Presentation of results

Remarks to DIN EN 16247-1

In general, companies are free to choose the energy audit methodology. However, if companies would like to benefit from certain fiscal incentives / support mechanisms, they have to conduct the energy audit according to EN 16247-1 standard.

Since 01.01.2013, SMEs should contact an energy audit in accordance to the DIN EN 16247-1 in order to benefit from tax incentives (under the Top Level / Energy and Electricity Act).

For large companies, state subsidies or tax incentives, such as the Special Equalization Act already applied under section 40 of the Renewable Energy Sources Act, are linked to the operation of a systematic EnMS according to ISO 50001.

Table 5-3 presents another example of the energy audit methodology applied in Ukraine.

Table 5-3: Energy audit methodology in Ukraine (according to 20.05.2010 No 56 Order National Agency of Ukraine)

Energy audit stages	Remarks

Contractual	> Meeting with the customer > Familiarization of the energy auditor with the facility / visit of the energy auditor to the facility > Obtain of primary data > Analysis and development of a plan for the energy audit.
Organizational/ preparatory works	This stage includes the approval of energy audit conducting plan with the customer, signing a contract for conducting the audit, identification of personnel from customer's side to participate in conducting the audit, preparation of the energy audit group.
Data Collection	Familiarization with documentary information and measurements at the site.
On-site visit	On-site inspections and data collection, verification
Processing - Analysis	> Performance analysis of the results > Evaluation of potential energy saving measures and the main technical and economic indicators > Analysis of the efficiency of the EnMS > Development of recommendations for energy savings - should include development and feasibility evaluation of the effectiveness of the priority list for energy saving measures.
Report	Provide a report and energy audit recommendations
Presentation of energy audit results	> Submission of energy audit report and conclusions to the customer > Presentation of the main energy audit results to the customer.

Remarks to Order No 56 dated 20.05.2010

The order applies to state budget enterprises and those private companies which are interesting to participate in projects financed by the state. In general, private companies are free to choose their energy audit methodology.

6 Conclusions

Exploiting the potential for EE has been proven a difficult and long-lasting process. In Europe, the effort started some 50 years ago, and despite the very significant progress achieved, there is still substantial potential for EE improvement.

During the early years (70's – 90's) EU and individual Member States focused on supporting the EE market opening and development. This support focused mainly in:

- **capacity building and awareness raising** including training of engineers and energy auditors, preparation of EE guides and information campaigns for the
- **research and development** of EE materials and equipment, new construction and other techniques, demonstration/experimental projects, development of technical standards, calculation methodologies, development and promotion of energy management techniques, such as Monitoring and Targeting, etc.
- **efforts to open and create a critical mass for the EE market** through technical assistance programmes (e.g. energy audits) and support schemes, mainly based on the **provision of grants and subsidies**. Industry was particularly targeted by these initiatives.

In addition, **"innovative" financing mechanisms,** such as third-party financing / ESCO development, etc. as well as other instruments e.g. **voluntary agreements** with industry, were promoted.

Since 2000 onwards, with the EE market being more mature, EU gradually imposed legislative/ regulatory measures. Milestones in this process can be considered the adoption of:

- the 2002 Energy Performance of Buildings Directive (recast in 2010) that for first time imposes, i.e., minimum energy performance requirements for buildings and their main energy systems
  the 2005 Eco-design Directive that set the grounds for banning from the EU market energy inefficient products
- the 2006 Energy Services Directive that, i.e., introduced the obligation for availability of energy services / energy audits and for adoption and implementation of 3-year NEEAPs with concrete energy savings targets, and
- the 2012 EE Directive that repealed Energy Services Directive and introduced more stringent obligations such as the EE obligations scheme, mandatory energy audits for the large industrial facilities, etc.

The EU acquis on EE reflects the accumulated experience and lessons learnt over the past decades. Several policy measures provided in the Directives had already been tested before in pioneer countries (e.g. the EE obligations scheme provided by the EED has been applied in Denmark since 2006, while certification of energy auditors and mandatory energy audits where already applied in several countries before the adoption of the EED). Despite the experience and know-how available in some countries, enforcement of regulatory measures for EE proved to be a difficult task for many EU Member States. However, even the poor initial enforcement of the EE acquis, helped the EE market to mature further. Market actors recognised new business opportunities in EE and promoted them. On the other hand, better informed energy users started asking for more EE solutions. Manufacturers, construction-engineering companies and energy service providers responded to the increasing market demand by offering such solutions at more affordable prices. This way, several mandatory / regulatory provisions of the EU Directives and Regulations gradually became "standard engineering practices" that are "enforced" by the market itself.

In parallel, the development and adoption of the EN 16247 and ISO 50000 series of standards streamlined the energy auditing and Energy Management Systems (EnMS) respectively. Nowadays, certification schemes for energy auditing and EnMS are widely available in EU. It is expected that **EnMS will become a common practice in industry**, if not mandatory.

However, barriers to EE still exist and new policies and promotion schemes are being developed to overcome them. **The trend is to gradually phase out the grants and subsidies** that are not sustainable and entail high social cost and **replace them with more market-based instruments and legislative measures**. **The EU Emissions Trading System (ETS),** launched in 2005, is an example that combines both, the legislative obligations with the market-based emissions trading scheme that, in turn, promotes EE in power generation and industry.

Easier access to financing for EE is also a well-established and growing instrument, promoted mainly by IFIs, States through EE Funds and ESCOs, while the banking sector gradually becomes more familiar and active in EE investments and broader, in "green-banking".

Additionally, a number of EU countries have introduced **voluntary agreements.** These agreements are considered a **popular policy instrument for the industrial sector**, especially in developed countries since the 1990s; however only a few countries have solid experience with the implementation of national voluntary agreements for more than 10 years. Successful voluntary agreements are considered the Learning Energy Efficiency Networks (LEEN) concept in **Germany**, the **Danish** voluntary agreement scheme on EE for **energy intensive industries,** the **Irish** Large Industry Energy Network (LIEN) scheme for **energy intensive industries** and the voluntary agreements signed in the region of **Wallonia in Belgium** addressing again energy intensive industries, etc.

The overall **trend** however, as regards the promotion of EE in industry, is the introduction and implementation of **energy management systems**, **mandatory energy audits and EE obligations** triggered also by EED. These measures are important instruments leading to the development of a strategy to achieve EE targets. In other words, **instead of promoting EE technologies and investments, several countries promote the introduction of EnMS (according to EN ISO 50001) as a mechanism that generates EE investments and promotes continuous and systematic EE improvement.**

However, **grants and subsidies remain a powerful tool**, especially for boosting EE in targeted markets and sectors. Many market-based instruments and financing mechanisms still include a grant component either in the form of free of charge technical assistance or a limited financial incentive. For example, in Germany there is a grant of 20,000 EUR per industrial company that supports the initial certification of either an EnMS (fulfilling EN ISO 50001) or an energy monitoring system.

EnC Contracting Parties started the effort to improve EE about 10-15 years ago with the implementation of several technical assistance projects financed by EU and other donors. The systematic effort to adopt the European EE acquis started with the Decision of the Ministerial Council of 18/12/2009 for the implementation of certain Directives (Energy Services Directive, Energy Labelling, Energy Performance of Buildings). Since then, the transposition work progressed quite satisfactory, but enforcement and implementation of the legislation lags behind. EnC Contracting Parties benefit from the vast EU policy experience and know-how, as well as the wide availability of EE technologies and best practices in the market. However, **enforcement / implementation of legislation and EE market development require institutional strengthening, development of local know-how and awareness raising that must be done locally in each country.** The significant technical and financial assistance provided so far helped to a certain extent towards this direction, but the key role in EE improvement is with the local authorities and market players.

Annex I – Categorization of EE measures and steps of an energy audit

Categorization of EE measures

Energy saving measures can be achieved from three levels of practical measures that involve zero/low cost, medium cost and high cost investments. Industries have the option of implementing the measures according to their priorities by selecting the preferred ones, or by combining all the measures.

Experience has shown that the critical factor in the success of zero cost measures is the effective involvement of factory staff and management. Staff morale will increase the moment they have a personal stake in carrying out energy saving measures.

a) Zero cost measures (good housekeeping)

Factory staff is normally capable of implementing these measures and the emphasis is on using the existing equipment efficiently. This implies that people are aware, motivated and empowered. Examples of zero cost measures include resetting controls and switching off equipment when not in use.

b) Low cost measures

These measures represent a move towards technology for solutions, but substantial input from personnel is required. Some examples of low cost measures include insulation, sub-metering as well as monitoring and targeting.

c) High cost measures

Such measures place emphasis on technology to achieve energy savings. A high cost measure must be subject to a careful technical and financial analysis before a decision is taken to invest capital. Therefore, a subsequent feasibility study may be necessary.

High cost measures are mainly new technologies (CHP, use of RES) or process modifications that consist of new processes (infrared drying, regenerative burners, etc).

The output of the audits may also include recommendations for more in-depth analyses such as laboratory tests, trial operation with different materials and feasibility studies for high cost measures as follow-up activities after the audit is completed.

In general, zero and low-cost measures are mainly implemented by the factory without or with little external help. Industries are usually more reluctant to invest in high cost measures, which often require longer payback time if energy savings are not their core business. This is a business role for ESCOs who will implement them with special financing schemes in cooperation with the industries.

Steps of an energy audit

Kick-off meeting

The overall objective of the kick-off meeting is to ensure a smooth start-up to the auditing work. Of particular importance is that senior staff members from both sides attend the meeting. During the kick-off meeting the following goals should be achieved:

- Ensure cooperation;
- Obtain info on factory business and process;
- Obtain info on process flow diagrams, brochures, etc.;
- Understand the process;
- Obtain info on weak points and production problems;
- Obtain info for planning of future activities;
- Ensure confidentiality of audit and audit outputs;
- Agree on a time schedule for the on-site survey

Crucial in an energy audit is respect of confidentiality as the client may demand that the auditor does not reveal any information obtained from the energy audit

On-site survey

The overall objective is to collect all the necessary information, to conduct metering and to identify the inefficient use of energy (i.e. oversized equipment, leaks, idle equipment, etc.).

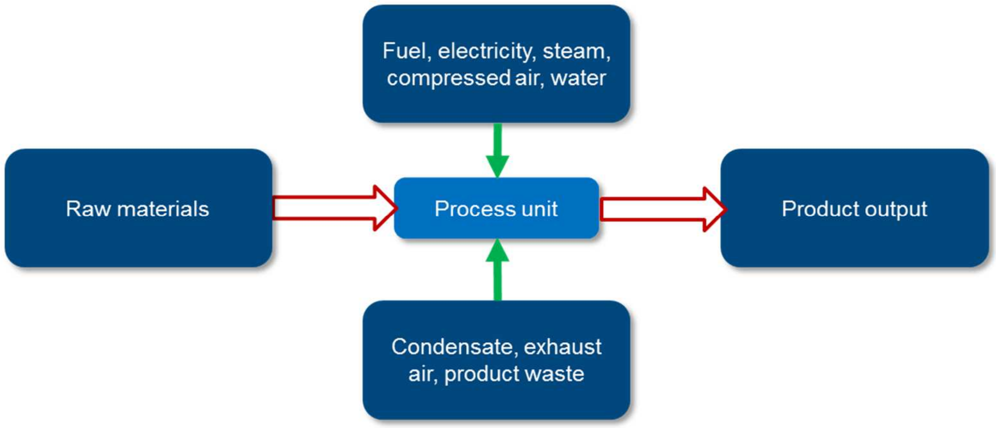
The on-site survey takes one to three days depending on the size of the company and the complexity of the process. A walk-through inspection of the factory can be conducted on the first day.

The following equipment should be checked by the energy auditors as potential sources of energy improvement:

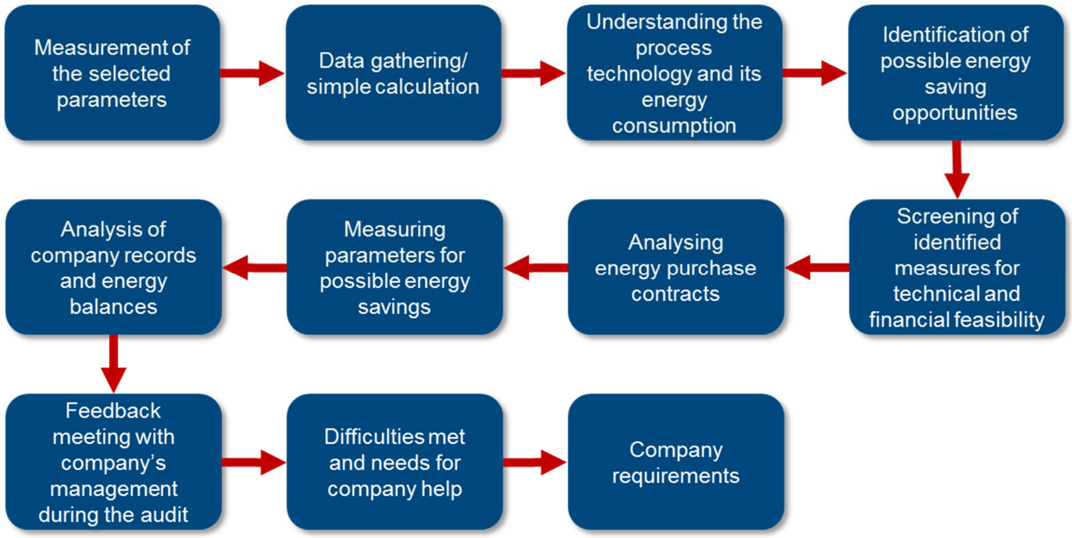
- Energy intake stations for electricity and natural gas;
- Boiler house;
- Compressed air stations;
- Refrigeration systems;
- Lighting and large ventilation systems;
- Motors;
- Water supply and water treatment facilities;
- Distribution systems for electricity, steam, compressed;
- Kilns/furnaces/ovens;
- Dryers;
- Grinding and milling equipment;
- Cooling tower

To get a good idea of where and how energy is being used within the factory, it is needed to have a good understanding of the production process. This involves a thorough study of the process flow diagram and discussions with the production plant managers during the inspection.

A typical mass and energy balance for an energy audit programme is shown in the figure below:



A detailed list of activities during the on-site survey is shown below.



Analysis of data and information

The energy auditor shall establish the existing energy performance situation of the audited object.

The existing energy performance situation becomes a reference against which improvements can be measured. It shall include:

- a breakdown of the energy consumption by use and source;
- energy flows and an energy balance of the audited object;
- pattern of energy demand through time;
- relationships between energy consumption and adjustment factors;
- one or more energy performance indicators suitable to evaluate the audited object.

Based on the existing energy performance situation of the audited object, the energy auditor shall identify EE improvement opportunities.

The energy auditor shall evaluate the impact of each EE improvement opportunity on the existing energy performance situation based on:

- the financial savings enabled by the energy efficiency improvement measures;
- the necessary investments;
- the return on investment or any other economic criteria agreed with the organisation;
- the other possible non-energy gains (such as productivity or maintenance);
- the comparison in terms of both cost and energy consumption between alternative energy efficiency improvement measures;
- technical interactions between multiple actions.

Energy saving actions shall be ranked upon the agreed criteria.

In those cases where it is appropriate to the agreed scope aim and thoroughness of the energy audit, the energy auditor shall complement these results with:

- requirements for additional data;
- the definition of need for further analysis.

The energy auditor shall:

- evaluate the reliability of data provided and highlight defaults or abnormalities;
- use transparent and technically appropriate calculation methods;
- document the methods used and any assumption made;
- subject the results of the analysis to appropriate quality and validity checks;
- consider any regulatory or other constraints of the potential energy efficiency improvement opportunities[106]

It is very important that the industries make available all energy use records to the energy auditors. Usually questionnaires are sent to the factory before the start of the auditing exercise. However, auditors must be very careful and should ask information that is necessary to identify and evaluate energy saving opportunities. Auditors must exercise extra care to ensure the confidentiality of the information given.

At the same time development of plant efficiency indicators can be developed through:

- **Specific Energy Consumption (SEC)** – specific energy consumption values are usually generated to compare the efficiency of similar systems of different size or activity. High SEC values characterise low efficiency. A comparison can serve as a first hint for energy saving potentials
- **Mass and Energy balance** – it is critical to know exactly how much material and energy is being utilised and wasted. By calculating the mass and energy balances we are able to reduce the plant energy and material wastage

[106] EN 16247-1 Energy Audits – Part 1: General requirements

Benchmarking

Benchmarking is an effective tool to assist industries detect their EE by measuring and comparing the energy intensity at process level and overall company level against peers or industries recognised as the leader.

Monitoring benchmarking has two separate functions:

- To prove that energy saving goals are being achieved;
- To enable the management to understand what is happening in the company

Generally, there are two different types of benchmark:

- ***Internal benchmark*** – based on the performance of the audited company. It is used to establish the level of improvement
- ***External benchmark*** – based on external factors. External benchmarks are used to establish how well the company performs relative to others, and may be used to set targets for future performance

While both types of benchmark have their own use, energy auditors are advised to give priority to internal benchmarking. Even though companies may manufacture the same product, management policies and manufacturing processes may differ significantly, therefore the differing conditions may not provide an accurate direct comparison of a company's performance level. This is especially true when comparing benchmark against internationally obtained benchmarks.

Preparing the energy audit report

The length of an energy audit report varies according to the depth of the energy audit, but it should not exceed 50 pages. As a general rule, the audit report should contain information under the following chapters:

- Chapter 0: Executive summary
- Chapter 1: Introduction and scope of work
- Chapter 2: Operational review of the factory
- Chapter 3: Technological description of the processes
- Chapter 4: Energy supply and demand
- Chapter 5: Technical-financial framework and constraints
- Chapter 6: Energy saving opportunities
- Chapter 7: Attachments

Executive summary – synthesises the findings of the energy audit and energy saving measures recommended. It includes a priority list of the measures, which have been found to be cost effective and are recommended for implementation. Executive summary is mainly addressed to the top management and the decision-makers and is therefore the most important chapter with regard to follow-up and implementation.

The executive summary must be a stand-alone document. It provides a complete picture of the entire auditing work without making any reference to the main part of the report. It is advisable that this chapter does not contain or refer to tables or figures from the main report.

Introduction and scope of work – contains a list of metering equipment used during the on-site survey. This chapter is common in all audit reports with minimal changes involving details of the audited companies

Operational review of the factory – contains a brief outline of the companies' profiles and products as well as the energy consumption for the base-year. The overall objective of this chapter is to present the specific energy consumption figures, to compare them with benchmarks and to make a first rough assessment of the energy savings potential as a whole. Energy profiles and breakdown are also included.

Technological description of the processes - contains the process flow diagram and a description of the individual stages of the process. The overall objective is description of the process and identification of inefficient energy usage. This is done by evaluating observations during the on-site inspection, discussions with the operation staff, analysing data obtained by records of the companies and sub-metering

Energy supply and demand – the energy supply and demand structures of all energy related facilities of the factory are investigated and evaluated.

Technical and financial framework and constraints – this chapter is common in all audit reports. Tables are presented with the main technical parameters and pricing for energy and fuels and utilities and a brief description of the evaluation scheme for energy saving measures.

Energy saving measures – contain a technical description and evaluation of the savings for each of the identified energy saving opportunities.

Presenting the energy audit report

The presentation is the last opportunity for the auditor to "sell" the proposed measures for improved efficiency to the decision makers. It is also a change to press for changes and secure follow-up.

The following hints are useful for the energy auditors before making the audit report presentation:

- Make sure that key persons are present to make decisions;
- Keep presentation short and concise;
- Try to sound positive about the operation of the company;
- Emphasise the benefits and try to "sell" the results;
- Emphasise the contribution of company's staff in the auditing work and their cooperation.