



i m p a c t a s s e s s m e n t o f

Energy Audits Programme

Energy Audits Programme funded by the Central European Initiative (CEI) Trust Fund



Central European Initiative



Founded in 1989, the Central European Initiative (CEI) has played an important role in supporting regional co-operation at economic and political level, thus helping transition countries in central and eastern Europe in their effort to integrate further with the European Union. In 1992 Italy signed an Agreement with the European Bank for Reconstruction and Development (EBRD) on the establishment of a CEI Trust Fund at the London headquarters "to assist the Bank's countries of operations in central and eastern Europe in their economic and social transformation process". A Secretariat for CEI Projects was established to manage the Trust Fund and carry out activities of pre-investment capacity building for the identification, promotion and appraisal of projects in the CEI region, as well as activities related to project implementation. A total contribution of EUR 30.6 million has been entirely provided by the Italian Government to support Technical Cooperation (TC) assignments, seen as a vital instrument to raise living standards and help CEI countries of operation move forward in their development and reform process. A total of almost EUR 17.4 million has been committed from 1993 to end of 2008 for 83 projects. A total of EUR 736,450 has been approved for 8 assignments in 2008.

The Energy Audits Programme is funded by the Central European Initiative (CEI) Trust Fund at the European Bank for Reconstruction and Development (EBRD).

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Preface

Preface



Reporting of results is becoming increasingly important to all agencies and institutions working in the EBRD's region.

Our countries of operations face significant challenges in terms of economic transition, environmental improvement and social adjustment, and the projects undertaken by the EBRD, in partnership with the CEI and other donors, are aimed at helping countries meet these challenges. By focusing on the results of projects, we gain a clearer

understanding of which initiatives are working, and how lessons of experience can be applied to help others. This goal is a significant feature of the international assistance agenda in which the EBRD and the CEI participate.

The Impact Assessment of Energy Audits Programmes contained in this report addresses a topic of wide relevance to our countries of operations. Not only is energy efficiency a key factor in competitiveness of firms, it is also an important impact on emissions. The EBRD welcomes the addition to our stock of knowledge that this report brings.

Gary Bond

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The CEI and the Agenda for Clean Energy Initiatives

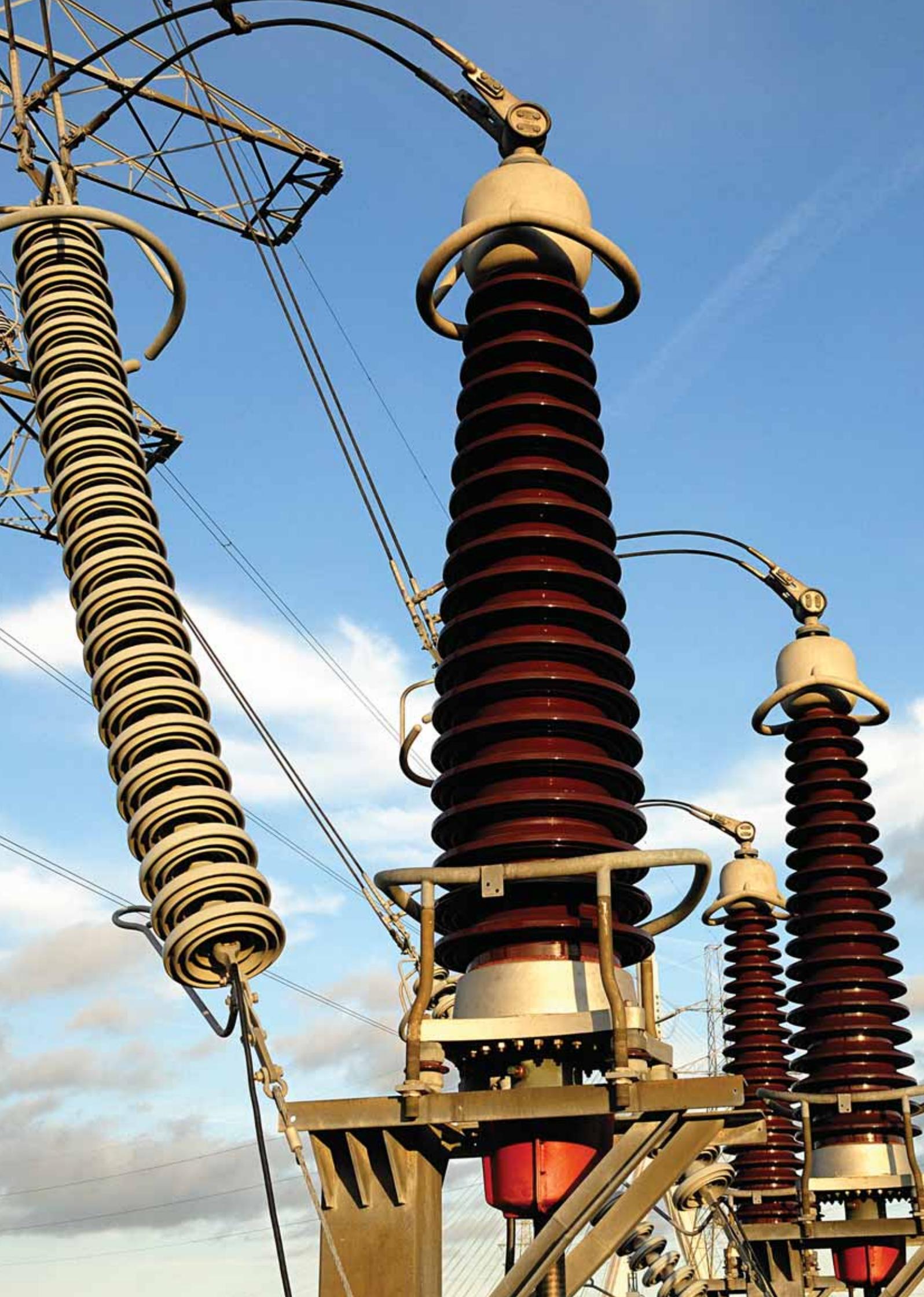
One

The Secretariat for Central European Initiative Projects (CEI-PS), through its Trust Fund at the European Bank for Reconstruction and Development (EBRD), has been committed to promote initiatives supporting energy savings in industrial activities. Working within the strategic parameters established by the EBRD as well as by other Multilateral Development Banks (MDBs), the CEI has in the past few years dedicated much of its resources to operations which promote energy efficiency.

Recent global efforts to tackle climate change have concentrated on three pillars: firstly, ensuring energy for development and access for the poor; ensuring mitigation through transition to low-carbon economies and finally supporting adaptation to the adverse effects of climate change. In December 2008, the United Nations Climate Change Conference in Poznan moved the agenda forward for deepening the negotiations on adaptation, mitigation, technology financing and a shared vision for a new climate change regime. These ongoing debates – concentrating both on the policy as well as the science of climate change – will be instrumental to define a new climate protocol to follow from the Kyoto Protocol, which will expire in 2012. The Climate Conference in Copenhagen at the end of 2009 will provide a platform for governments and relevant stakeholders to define a new protocol to promote actions to prevent global warming and to adapt to climate change globally.

In this context, risk management and risk reduction strategies will underpin the operations of all stakeholders including donor agencies such as the CEI, to contribute to the success of energy efficiency operations. Energy Audits – carried out by external consultants under the management of the Energy Efficiency and Climate Change team at the EBRD – have proved to be invaluable pre-investment instruments for the EBRD. It is in this spirit that the CEI has decided to undertake an evaluation of the first two Frameworks signed in 2004.





The Rationale for Energy Efficiency

Two

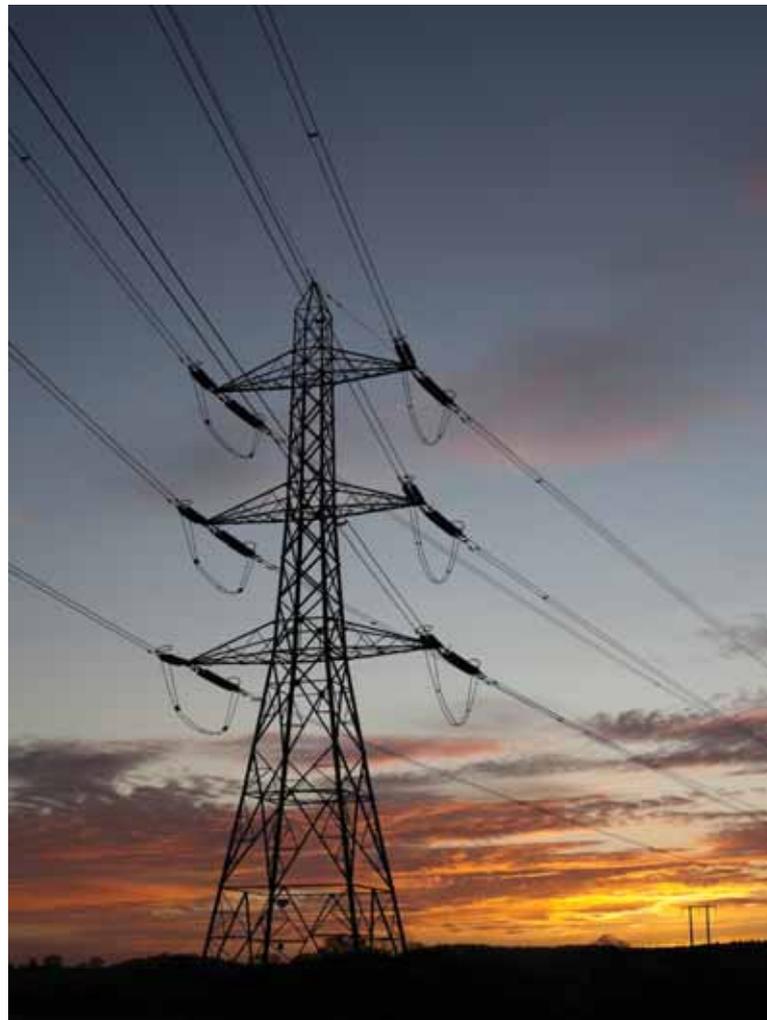
In the countries of operations of the CEI and of the EBRD, energy has typically been cheap to buy. With fewer institutional and market drivers in place, companies have been traditionally slow to consider environmental issues and improve their efficiency. However, as the transition process progresses, companies are becoming more aware not only of the need to increase their efficiency and reduce costs but also the competitive advantage that arise from developing an environmentally positive image in the market place. Indeed, energy efficiency creates opportunities for businesses and consumers to profit from the progressive decarbonising of global economies, by introducing technological innovation which contributes to their long-term profitability.

Despite a significant potential for savings, a wide range of information gaps, market failures, and policy imperfections still hold back investments, providing the ground for the EBRD to become involved by blending its financing with technical assistance for demonstration and pilot projects.

In addition, most of the operations and production facilities in the region lack data on internal energy use and operational parameters of their systems and processes. This information gap hinders the implementation of energy efficiency technologies and jeopardises the ability by companies to optimise the configuration and utilisation of systems and new equipment.

To address this situation the EBRD initiated in 2002 a pilot Technical Assistance Programme designed to provide its clients with dedicated international expertise to help them implement energy efficiency through energy audits and targeted training. Building on this initial experience, the Bank has expanded the programme thanks to the contribution of the CEI starting from 2004. The CEI funded energy audits and capacity building programme have been instrumental in positioning the EBRD as a leading financial institution aiming to promote energy sustainability and pursue

business opportunities associated to energy efficiency investments. It has also helped enhancing the awareness within the Bank about the strategic importance of energy efficiency in improving the competitive profile of industrial operations.





CEI Technical Cooperation and Energy Efficiency

Three

In the past years, the CEI has increasingly been collaborating with the EBRD's Energy Efficiency and Climate Change (EECC) team. This is an important link, since both the EBRD and the CEI have a very strong interest in the Energy Efficiency sector. The EBRD is committed to "attach particular importance to operations which promote energy and resource efficiency, waste reduction, resource recovery and recycling, the use of cleaner technologies and the promotion of renewable resources". Similarly, for the CEI, the promotion and development of energy efficiency, security of energy supply is also recognised as a key priority.

Energy Efficiency Audits Frameworks are carried out as Technical Cooperation (TC) assignments. TC projects are essential instruments that allow for the dissemination of capital and knowledge in the region, as they often stand as the backbone of large investment projects. As part of its

routine work, the Secretariat for CEI Projects promotes and supervises cooperation on investment projects alongside EBRD investments in a number of areas, including energy. Here, Technical Cooperation is offered in the form of grant-type assistance in support of specific components of a project, such as feasibility and pre-feasibility studies, sector and environmental engineering, management training, capacity building, pre-loan audits.

In the past four years, the CEI has allocated EUR 1,155,307 to Energy Efficiency projects, of which EUR 430,000 only in 2008. As far as completed projects are concerned, they have brought about very large investments. The first two Energy Audits Programmes financed by the CEI (Energy Audits Programme Framework Agreements, carried out by consultancy firms D'Appolonia and MWH) have led to a total of EUR 87.3 million of EE investments.



Table 1. CEI funded Technical Cooperation projects in the Energy Efficiency sector

<i>commitment number</i>	<i>commitment name</i>	<i>description</i>	<i>EUR committed</i>	<i>countries of operations</i>
CEI-2004-10-03F	Energy Audits Programme Framework Agreements (D'Appolonia)	These two TC projects intended to identify energy saving opportunities with selected clients of the EBRD by conducting energy audits in plants located in EBRD countries of operations which are part of the CEI. These two Energy Audits have led to a total of EUR 87.3 million of EE investments.	229.000	Regional
CEI-2004-10-04F	Energy Audits Programme Framework Agreements (MWH)		251.000	Regional
CEI-2005-12-09	Market Study for Sustainable Energy in the Slovak Republic	The overall objective of the assignment was to carry out a market study which showed on which basis a facility dedicated to financing sustainable energy projects in the Slovak Republic can be developed and implemented. The CEI TC involved preparatory work for a credit line dedicated to energy efficiency and renewable energy in the Slovak Republic. This TC project led to EBRD investments of EUR 60 million.	49.307	Slovak Republic
CEI-2007-12-08	Assessment of Sustainable Energy Potential in Western Balkans	The overall objective of the assignment is to carry out a market study which will show on which basis a facility dedicated to financing of sustainable energy projects in the Western Balkans can be developed and implemented. The consultant will study the market to assess potential for on-lending via participating banks to finance businesses carrying out sustainable energy projects.	196.000	Regional
CEI-2008-11-09F (D'Appolonia) and CEI-2008-11-10F (MWH)	Energy Audits and Energy Management Training Programme	By providing Energy Audits and Energy Management Training Programmes, the EBRD aims at helping its clients identifying opportunities to save energy and persuading them to prioritise energy efficiency investments. The TC objective is to provide services to selected EBRD clients located in the CEI region with particular focus on Moldova, Ukraine, Belarus, Bulgaria, Romania and the Western Balkans. At least nine plants are envisaged to be audited or receive training support although the actual number will depend on the scope and detail required for each audit.	280.000	Regional
Number to be assigned	Development of the ESCO Market in Public Building Sector in Ukraine	Over the last fifteen years the role of ESCOs (Energy Service Companies) has often been discussed in the context of improving energy efficiency in the countries of central and eastern Europe, in particular in the public buildings sector. ESCOs are fairly well established in western Europe and the United States, but in the EBRD's countries of operations the ESCO sector is relatively under-developed. The present TC aims to address the issues that may have prevented the development of ESCO activity and to propose a course of action that responds the renewed interest in the ESCO model.	100.000	Ukraine
Number to be assigned	Analysis of Multi-storey Apartment Buildings in Ukraine	The second largest energy end-use sector in Ukraine is the residential sector. Energy statistics show that 36% of national final energy consumption belongs to residential and service buildings. The objective of the assignment is to prepare an Analytical Study (AS) for the energy efficiency refurbishment of multi-storey apartment buildings. The AS should provide sufficient information to guide the EBRD through the design and launch of a successful Sustainable Energy Financing Facility in Ukraine, dedicated to energy efficiency refurbishment of apartment buildings.	50.000	Ukraine

The Energy Efficiency Audits Programme

Four

The Energy Audits which are now considered in this evaluation were conducted over the years 2005 to 2008. The main tasks carried out included:

a) Energy Efficiency Audit

- Assessment of basic energy inputs, indicating main uses of energy;
- Review of supply arrangements, indicating contractual terms, reliability of supply and main supply risks;
- Monitoring and measurement arrangements relating these to supply arrangements and indicating extent and accuracy of monitoring and measurement of energy consumption;
- Assessment of energy use, description of technical requirements relating to production and basic energy requirements;
- Preparation of energy balance for the company subject of the audit, or, where the scope of the company's activities includes areas not related to the proposed projects, an energy balance of the relevant aspects of the company's operations;
- Assessment of the extent to which the implementation of new energy sources (such as on-site co-generation) is appropriate;
- Assessment of the performance or practice in relation to current best practice in comparable leading international business, followed by specific comments and recommendations, where necessary, on how best practice can be achieved either by investments or through alternative operating practices.

b) Prioritised Energy Efficiency Investment Plan

- Prioritised investment plan of least cost alternatives whose implementation will improve the energy efficiency (including

alternative sources of heat and power);

- Analysis of the impact of this Programme on the company's forecast cost structure and fuel procurement contracts;
- Assessment of physical energy savings foreseen as a result of the energy efficiency investment plan;
- Assessment of financial savings resulting from the energy efficiency investment plan, indicating key assumptions relating to energy prices or other relevant data. The analysis should make clear any incremental benefits such as sales of surplus electricity, which may be assumed in the cash flow analysis;
- Preparation of cash flow analysis over at least the life of proposed loans or projects assets, whichever is longer and based on the proposed energy efficiency investment plan and resulting financial savings. The analysis should indicate returns and net present value for each component of the investment plan. All assumptions, such as inflation rates or exchange rates, should be clearly indicated;
- Establishment of financial and technical performance indicators to be monitored over the life of the energy efficiency project; and
- Implementation schedule including the timing and estimated cost of each component and basis of such cost estimates.

c) Energy Management Assessment

- Assessment of the company's organisation in terms of energy management including the allocation of responsibilities and the ways information about energy usage is acquired, processed and used;
- Analysis of the capability to handle energy-saving programmes and initiatives. For the purpose, the Consultant also prepared a framework for training needs in connection with both energy management and energy efficiency development.

d) Local Involvement and Management

One of the key objectives of the assignment has been to transfer skills to local staff. The Consultants has worked closely with the local engineers responsible for energy saving projects and with the management of each company. This has ensured that recommendations were endorsed, thus facilitating prompt and full implementation.

All the Energy Efficiency Actions proposed during the Energy Audits Programme at the relevant industrial facilities have been evaluated in order to identify some key parameters to allow presenting the expected results of the investments. Table 2 shows the average capital expenditure per unit of energy saved in unit of time (GJ/year), the average capital expenditure per unit of Green House Gases (GHGs) emission reduction (tonCO₂/year), the total cost, the total energy saving and the total GHGs emission reduction for the twelve categories of actions identified above.

The Consultants had the opportunity to carry out two Energy Management trainings in a Pulp Mill and in a Sugar Mill. The main objectives of the training activities were to assist the companies in the process of structuring an appropriate energy management organisation through the designation of an energy manager and support staff to provide the required initial training to selected managers. The overall attendance and involvement of the trainees was satisfactory and at the end of the course an evaluation form was filled by all attendees. This gave the

opportunity to verify not only the results but also the usefulness of the management training.

In order to analyse the results and effectiveness of the Energy Efficiency Audits Programme, two plant sites were chosen to verify which of the proposed measures has been implemented and what kind of benefits they provided. These ex-post analyses were performed in the following sites:

- Soyaprotein Plant Victoria Group (Serbia)
- Svishtov Pulp Mill (Bulgaria)

The analysis expands the main findings identified in the previous visits, and mainly consisted in the verification of the energy efficiency improvement actions implemented by the management of the plant. The analysis also looked at any other interesting actions or adopted strategies. A quantitative analysis of energy efficiency and the ensuing economic benefits has been performed by audit teams in respect of the main interventions implemented by the plants, together with the analysis of energy sources price trends. Finally, the impact assessment also considered the management's strategic view and attitude vis-à-vis the implementation of future energy efficiency and technological improvement.

Table 2. Characterisation of Energy Saving and GHGs Emission Reduction Investments

ID	actions category	average EUR/(GJ/year)	average EUR/(tonCO ₂ /year)	total cost (EUR)	total saving (tonCO ₂ /year)	total saving (GJ/year)
1	Energy Management and Measurement	7.29	93.51	4,276,000.00	45,729.65	586,942.20
2	Furnaces	18.80	229.87	15,620,000.00	67,952.00	831,040.13
3	Process	16.11	188.23	63,270,938.24	336,133.64	3,926,339.78
4	Electric System	4.83	46.15	2,150,000.00	46,582.53	444,782.61
5	HW and Steam Systems	8.72	105.19	57,122,659.59	543,039.92	6,549,111.13
6	Air Separation	24.29	330.48	15,178,000.00	45,927.00	624,857.14
7	Compressed Air	4.53	109.96	3,277,140.00	29,801.67	723,215.60
8	Lighting System	12.78	360.32	895,400.00	2,485.00	70,035.43
9	Motors and Pumps	15.63	115.78	3,221,860.00	27,828.51	206,099.50
10	Cooling/Chilling System	16.57	175.18	1,935,000.00	11,045.47	116,805.18
11	Cogeneration	25.36	139.40	13,700,000.00	98,276.77	540,128.38
12	Renewable	26.69	375.14	20,472,083.20	54,571.84	766,945.38
Total				201,119,081.02	1,309,374.00	15,386,302.47

The Energy Efficiency Audits Methodology

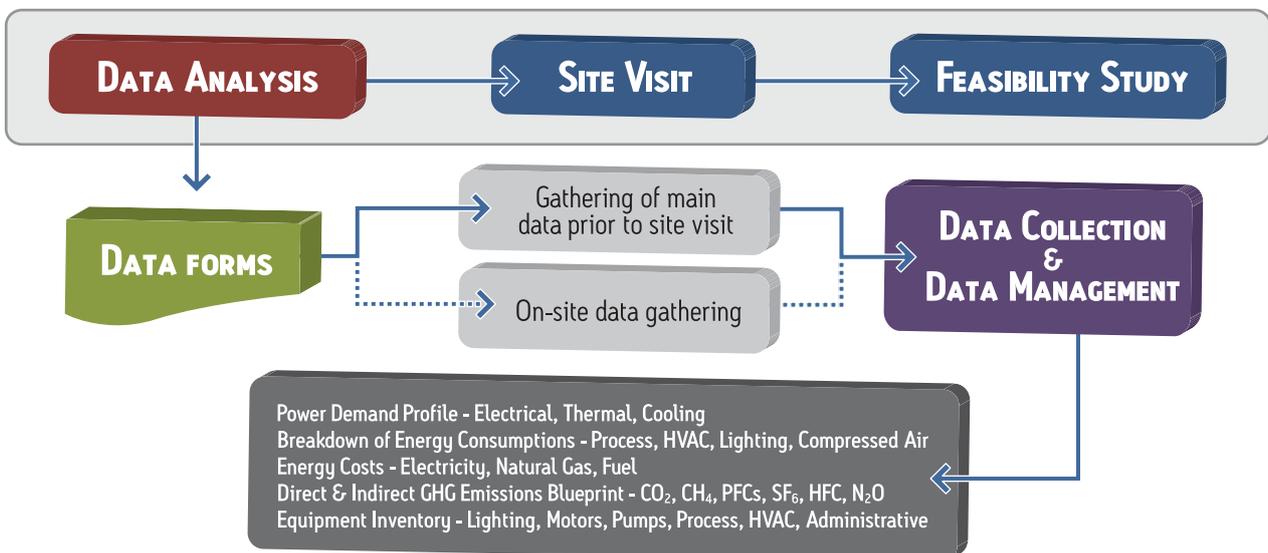
Five

In this section the methodology used to carry out the energy efficiency audits is described, taking in consideration all main steps undertaken for each assignment. In order to achieve maximum benefits from the energy audits, the Consultants also distributed a set questionnaire forms that have been completed ahead of or during the site visit. These forms were used to gain a better understanding of patterns and volumes of energy use. They cover electrical and non-electric energy supply as well as power demand profile, main equipment installed in the facility, breakdown of energy consumption between facility's systems, annual costs for energy usage and energy management policies.

During the site visits, which usually last from 3 up to 5 days, the audit team assessed the energy efficiency level of the site facilities and production areas, and discussed energy efficiency opportunities with the local staff involved in the site energy management.

The site visit usually started with a kick-off meeting in which the project background and the purpose of the audit were presented. Then the Consultants briefly described the Company's profile and each auditor introduced himself, and the site Management described site's main energy intensive processes, critical issues related to energy consumptions, and Programmes already planned. Site walkthroughs and technical meetings with local staff were undertaken, in order for the Consultants to assess the

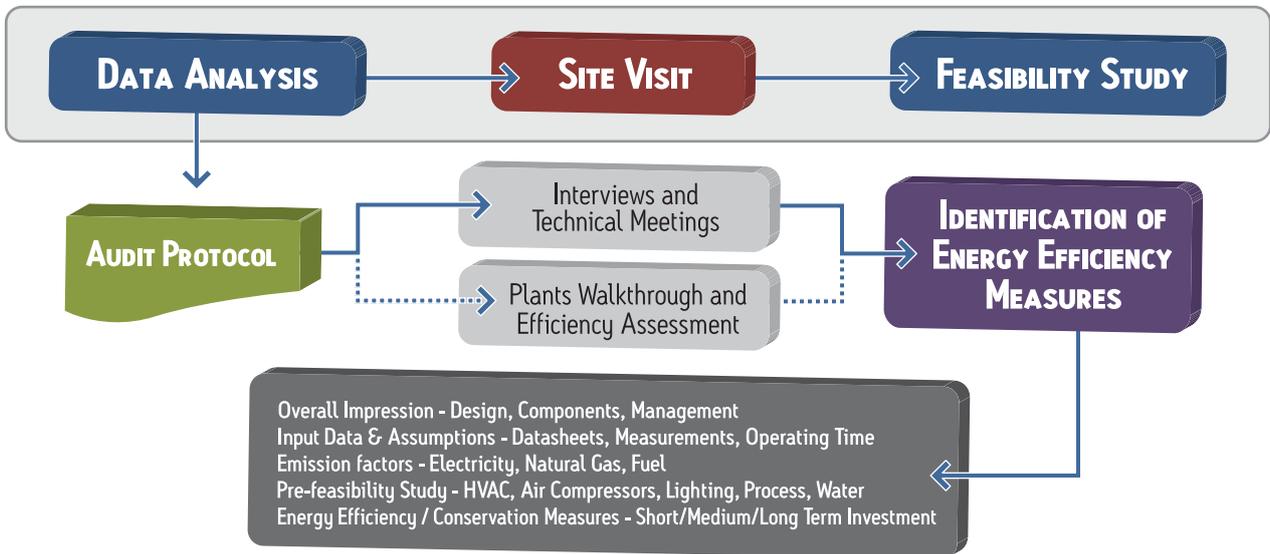
Figure 1. Energy Audit – Data Collection



energy efficiency level of main energy intensive systems. These meetings showed the quality and technical skills of local experts, their openness to evaluate new saving opportunities and their attitude to consider energy efficiency a site's priority. During each site visit, facilities and main

production areas were surveyed to verify the energy efficiency status, the technologies utilised and the energy management practices in place and additional data were gathered to acquire the sufficient amount of information required to perform the desk analyses.

Figure 2. Energy Audit – Site Visit

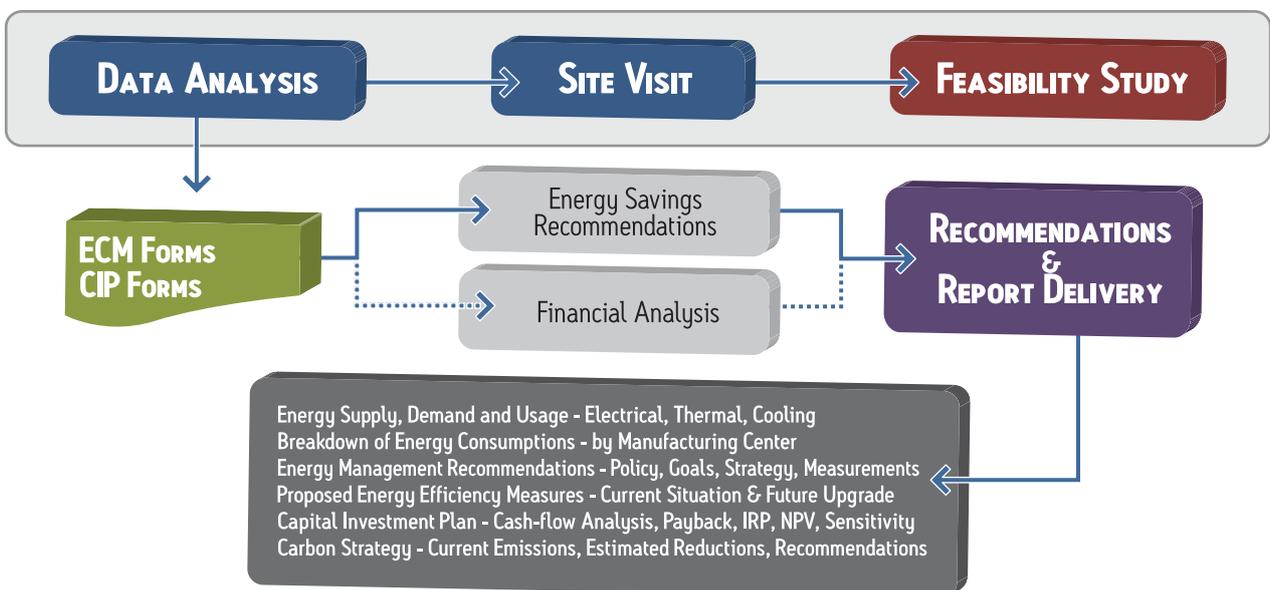


The identified potential saving measures were discussed during the visit with local staff to gain a preliminary response about the interest and feasibility of each of them. All data, drawings and information gathered during the site visit have been carefully analysed by the audit team and specialists, and a set of energy efficiency measures produced.

In the final reports a detailed technical and financial analysis, including pre-feasibility level cost estimates, were developed for several (from 5 up to 12) energy efficiency measures. For each of these measures the team described why the system is not as efficient, the recommended

actions to improve existing situation and the technical solution to implement it. Furthermore, a ranking of the proposed measures has been made utilising financial criteria, and presented as a preliminary Capital Expenditure (CAPEX) Programme that can be used by local management in the decision making process. Once the detailed analyses of the collected data were completed and energy saving measures are evaluated at pre-feasibility level and prioritised, the audit team prepared a final report, outlining data collected, analyses performed, potential savings identified and a ranking of proposed energy efficiency measures.

Figure 3. Energy Audit – Feasibility Study



Six

Relevance of the Energy Efficiency Audit Model

The Energy Efficiency Audits Programme could be considered the first step to develop a global energy policy and to start projects that really impact on the efficiency of an industrial plant. Indeed, there is a growing trend towards increased competition to produce high quality products at comparable or lower cost. Since energy prices are now increasing also in eastern European countries where the energy audits were carried out, and considering that energy cost is a significant part of overall costs of the plant, the companies require to lower energy costs as best practice indicates.

One of the aims of the audits is to foster a change of mentality in senior management's approach to energy efficiency actions. Often, staff knows what to do but requires an external and independent point of view to confirm the measures. What is usually required is:

- a similar case through the presentation of clear information;
- an explanation of the results of the application of the same technology in similar plants;
- a discussion on how this could apply to the company.

If implemented properly, the returns from energy efficiency audit can be very high and the technical risks relatively low also because the production may increase.

The Consultants are independent, as they do not sell any kind of equipment or technology. This choice is fundamental to have an external opinion and impartial result from the Energy Audit.

Together with the introduction of the Key Performance Index (KPI) this approach is extremely useful because it:

- helps the Management to collect information on the amount of energy used;

- ♦ *The Energy Efficiency Audits Programme could be considered the first step towards a global energy policy*
- ♦ *If implemented properly, the returns from energy efficiency audits can be very high*

-
- informs the Staff about the efficiency level of the system analysed and
 - explains how to improve efficiency to become "best in class".

On the other hand, in order to have results that fit the real situation of the plant, it is necessary to have certain data that reflect the real operation of the plants. Sometimes it is hard to collect this kind of information during the site survey and it is also very difficult to find datasheets of the main auxiliaries such as boilers, turbines, transformers, pumps etc. and that does not allow achieving the best results from the energy audit. In fact this is the main reason why it gets hard to have an accurate estimation of investment costs, savings and pertinence of the proposed measures. As a general suggestion, in order to avoid this kind of problems and reduce risks, a sensitivity analysis could be included in the audit report in order to better evaluate and keep into consideration these risks.

The overall conditions of the countries where the Energy Audit Programme has been carried out enabled the Consultants to face a situation where state-of-the-art equipments were installed next to obsolete auxiliaries that often affect the availability of a certain process.

That is the reason why in some cases it is useful to have an overall approach that keeps into consideration several other aspects of a production plant, such as the certainty of supplying, the environmental

issues and the safety of the operations that are beyond the scope of an energy efficiency audit.

As an example, the replacement of insulating material is essential to avoid energy losses but, in several cases where the insulation was achieved with asbestos, the replacement should be absolutely considered, and not only for energy efficiency purpose. Also the installation of Variable Speed Drive is one of the most proposed measures during an energy efficiency audit to decrease electrical absorptions but the obsolescence of the electrical distribution system may affect on the perfect operation of a Variable Speed Drive: the refurbishment of the electrical line should be considered not only to enhance energy efficiency but also to guarantee the electricity supply and the safety of the operations.

A characteristic of the energy audit and a suggestion in “decision making” is not to consider only the prioritised measures in the investment

plan that keeps into consideration only the energy savings related to the implementation of a measure but also other measures that could improve several other aspects of the plant enhancing its modernity and technological level.

To conclude the energy audit is as a starting point for a real energy efficiency strategy. Follow-up activities should be foreseen and considered in order:

- for the local management, to have further support on the measures, about time schedule, indication of suppliers, further energy management recommendations.
- for the consultants, to better understand which measures have been implemented or if the effort foreseen to carry out the activities was over or under-estimated.



Seven

Site Visits Overall Impression

During the site visits local staff was always available to explain any details requested by the consultants and did their utmost to satisfy the technical requests. The Audit Team was able to have the requested walk-throughs without particular restrictions. In fact the facilities visited were full of talented and motivated staff who showed high interest and commitment in energy efficiency and were open to new ideas and opportunities.

While interviewing site directors and technicians, it always appeared that good knowledge of the plants and technical skills are present in most of the areas. The staff in charge of the operation and management of the factories is in general well trained and has a deep knowledge of process operations.

Since 2004, when the Energy Audits Programme started, the Consultants have perceived an improvement of the overall conditions of the plants, together with a higher interest from the management in energy efficiency issues. In 1990s, fewer investments were made, and most equipment and machinery did not receive the required maintenance. The main equipments such as boilers, turbines, pumps and motors, were often old and ran in poor conditions; their related datasheets were sometimes unavailable. Because of the age of part of the auxiliary systems, the Consultants often observed several sources of waste energy, such as leaks, losses and lack of insulation. The refurbishment of these plants with new technologies resulted in further energy savings and increased profits.

Generally, the Consultants recommended developing and disseminating an energy policy, which was not in place in most of the plants, and to establish quantitative energy savings objectives to be achieved on an annual basis. To facilitate information sharing, the Consultants strongly recommended creating an “Energy Management Team”, where representative of all Departments of the plants could meet periodically to exchange ideas, discuss energy saving opportunities and share information and best practices.

In some cases a list of energy efficiency projects were already identified by site technicians and were further discussed and evaluated at feasibility level in the report. Monitoring of operational data has to be generally modernised, in order to gain full control of operating parameters, most indicative of process efficiency and, where possible, to implement automatic sequence control of process operations.

During the visit the Audit Teams often noted some difficulties in collecting and retrieving historical data of energy consumptions, flow charts, sketches, technical manuals and datasheets of auxiliary systems and facilities equipment: a good data collection system is very important to know the features of each plant, to compare them with the Best Available Technologies and to assess their level of efficiency compared to nominal data guaranteed by manufacturers. Without a good and complete knowledge of the plants, no corporate energy management programme can be defined.

In order to manage the plants more efficiently, the team suggested also to introduce KPI (Key Performance Indexes) and to compare them with other similar sites or with the best available technologies.

Training and advice on specific energy efficient technologies could give to local staff some technical elements to better manage energy efficiency.

Possible training programmes could contain the following topics: electric motors (how motors work, high-efficiency motors performances, usage and maintenance activities, examples of cost-effective motor changes, use of adjustable speed drives); boiler (basics of combustion systems – excess air control, boiler efficiency improvement, combustion controls, process insulation, example of boiler improvement); cogeneration (what is cogeneration, types of cogeneration cycles, examples of cost-effective use of cogeneration, gas piston and gas turbines); insulation (types of insulation, heat flow calculations, economic levels of insulation, process insulation).



Expected Impact of Energy Efficiency Actions

Eight

In the present chapter, the results of the performed industrial energy efficiency investigations are reported. In particular, this section provides the analysis of the foreseen results achievable from the CEI funded activities starting from a statistic evaluation of all the Energy Efficiency actions proposed during the several Energy Audits performed by the consultants on behalf of EBRD.

The section consists in three major sub-sections:

- “Country Level Data and Assumptions”, which exposes the major country level data and assumptions which have been used during the calculation of energy saving and GHGs emission reductions.
- “Energy Consumption Reduction Analysis”, considering the results, specific costs and performances of all the energy efficiency actions in terms of saved primary energy.
- “Greenhouse Gases Emission Reduction Analysis”, considering the results, specific costs and performances of the same proposed actions in terms of achieved Greenhouse Gas (GHGs) emission reductions.

The Energy Efficiency Actions have been divided in twelve categories, in order to take into account the different objectives targeted by each type of intervention; the majority of proposed intervention dealt with the following aspects:

- Energy Management and Measurement
- Furnaces
- Process
- Electric Systems
- HW and Steam Systems
- Air Separation
- Compressed Air

- Lighting System
- Motors and Pumps
- Cooling/Chilling Systems
- Cogeneration
- Renewables

The criterion for the identification of categories is mainly based on type of equipment or process facility the interventions are focused on; “Renewables” category may include interventions related to above mentioned equipment or process facilities: in this case energy source has been considered priority compared to the part of the process involved. “Process” category includes all other process related equipment (as for example paper machines, hammers and presses, cutting machines, etc.) and furthermore actions not strictly related to equipment on their own but aimed at improving production process efficiency (as for example waste heat and gas recovering, improvement of raw material transportation system, fuel switch actions, etc.).

8.1 Country Level Data and Assumptions

Several data have been gathered at country level in order to evaluate the economic performance of the projects proposed in the CEI Energy Audits Programme. In particular, the prices for the different energy carriers played an important role during the energy analyses; for this reason, they have been duly assessed during the field activities in order to apply the most reasonable price to the economical feasibility assessment of the identified projects.

In table 3 is reported also the power generation efficiency which has

been taken into account in order to evaluate the primary energy corresponding to electrical energy. As reported in IPPC reference document Energy Efficiency (June 2008), “Primary energy is the energy contained in raw fuels (i.e. natural resources prior to any processing), including combustible wastes and any other forms of energy received by a system as input to the system”. In case of Wind, Hydro and Photovoltaic energy, the efficiency of the generation system has been considered as unitary, according to the International Energy Agency approach; percentage values present in table below have been calculated starting from specific country generation data from International Energy Agency (IEA).

8.2 Energy Consumption Reduction Analysis

In this sub-section, data of all the Energy Efficiency Actions proposed during the Energy Audits Programme at the relevant industrial facilities have been evaluated in order to identify some key parameters allowing to highlight the expected results of the investments. Before analysing the following tables and figures, it is necessary to highlight that, the total values of energy savings have been calculated as the corresponding primary energy. Electricity has been converted in primary energy according to the Power generation efficiencies reported in sub-section 1 above, in order to make it comparable with the fuel savings directly achieved at the plants. This methodology, as said before, is in accordance to IPPC reference document Energy Efficiency (February 2009), recently issued by the European Commission. The below-reported table shows respectively in its columns the average capital expenditure per unit of energy saved in unit of time (GJ/year), the total cost and the total energy saving for the twelve categories of projects identified above. These results are better visualised in the following figures.

Figure 4 reports the split of the total capital investment for the twelve categories of Energy Efficiency Actions and highlights that the majority of

Table 3. Countries’ Power Generation Efficiency

State/country	Power generation efficiency
FYR Macedonia	47%
Ukraine	35%
Bosnia	52%
Serbia	48%
Czech Republic	37%
Poland	36%
Bulgaria	36%
Romania	44%

proposed funding has been channelled mainly towards Process Actions (about EUR 64 million, 31% of the total), and HW and Steam Systems Actions (about EUR 57 million, 28% of the total). A rather relevant category of interventions is represented by Renewables Actions (about EUR 20 million, 10% of the total). The total capital cost for all the investments proposed in the CEI Programme from the Consultants has been of about EUR 201 million.

The split of the total energy saving (reported as primary energy) for the twelve categories of energy efficiency action is indicated in Figure 5, which highlights that, as for the split of total cost, the two most relevant categories are HW and Steam System actions (about 6.5 million GJ of saving per year, 43% of the total) and Process actions (about 4 million GJ of saving per year, 25% of the total). The total energy saving per year achievable by proposed interventions in CEI Programme framework is about 15 million GJ per year.

Table 4. Characterisation of Energy Saving Investments

ID	Actions Category	Average EUR/(GJ/year)	Total Cost (EUR)	Total Saving (GJ/year)
1	Energy Management and Measurement	7.29	4,276,000.00	586,942.20
2	Furnaces	18.80	15,620,000.00	831,040.13
3	Process	16.11	63,270,938.24	3,926,339.78
4	Electric System	4.83	2,150,000.00	444,782.61
5	HW and Steam Systems	8.72	57,122,659.59	6,549,111.13
6	Air Separation	24.29	15,178,000.00	624,857.14
7	Compressed Air	4.53	3,277,140.00	723,215.60
8	Lighting System	12.78	895,400.00	70,035.43
9	Motors and Pumps	15.63	3,221,860.00	206,099.50
10	Cooling/Chilling System	16.57	1,935,000.00	116,805.18
11	Cogeneration	25.36	13,700,000.00	540,128.38
12	Renewable	26.69	20,472,083.20	766,945.38
TOTAL			201,119,081.02	15,386,302.47

Figure 4. Split of Total Costs

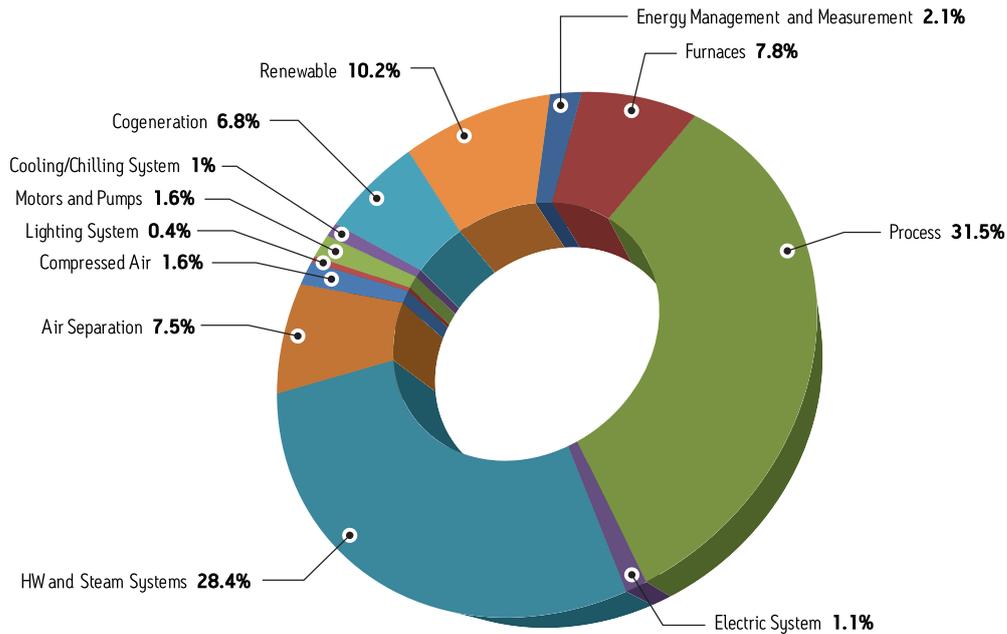


Figure 5. Achieved Energy Savings

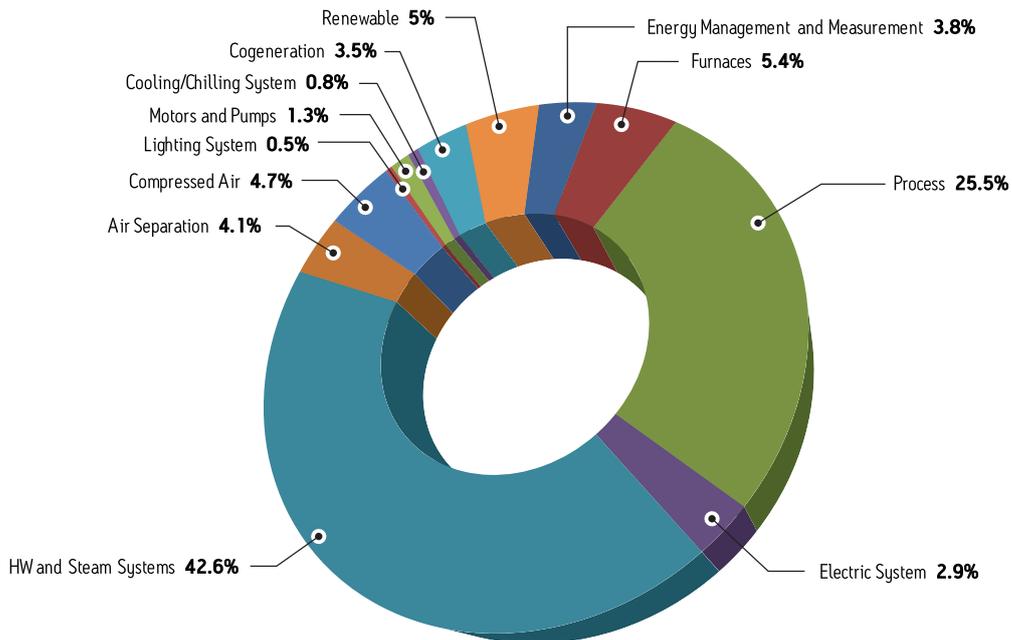


Figure 6 reports the average specific costs required for each of the twelve categories in order to achieve a unit of energy saving (GJ) in the unit of time (year). Therefore, this parameter represents a powerful instrument for evaluating the relative cost for the achieved energy saving: the higher the cost, the most expensive the energy saving.

The analysis highlights that categories of Electric System Actions and Compressed Air Actions generally achieve the energy saving unit with the minimum expenses (little less than 5 EUR per GJ/year saved), as categories

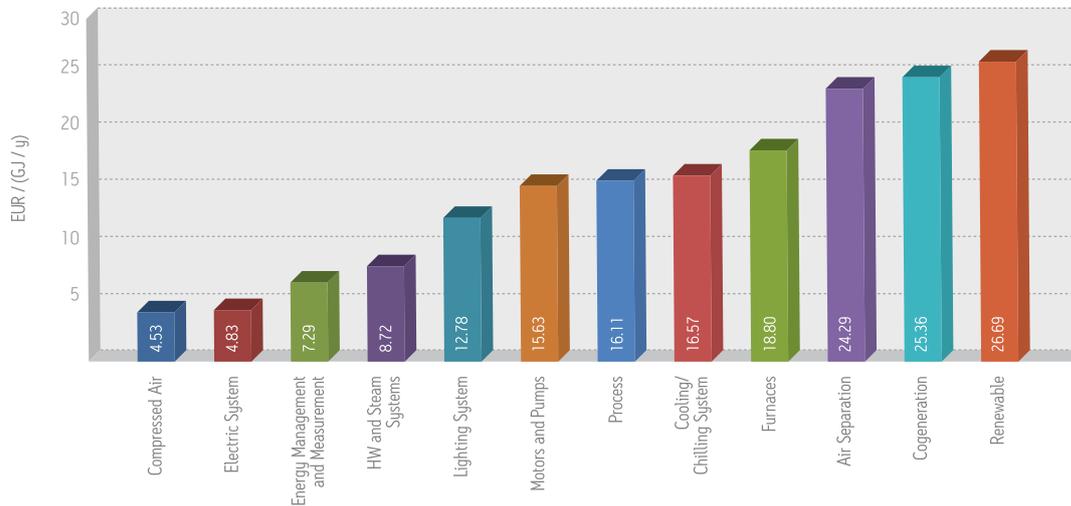
of Air Separation, Cogeneration and Renewable actions have generally the highest specific cost (ranging about from 24 to 26 EUR per GJ/year saved) to achieve energy saving unit. The high specific cost of Renewable Actions is due to the fact that, as previously mentioned, this category includes also equipment and large facility replacement and installation. In particular, there are three expensive interventions, related to a new incineration plant (investment cost of EUR 13,500,000) and two boilers. Also concerning Cogeneration Actions, the high specific cost is due to required expensive equipment and

technological intervention on process facilities, as for example new turbines installation. Air Separation Actions often consist of full replacement or ex-novo installation of the whole oxygen dedicated plant; in many cases in fact, oxygen generation facilities can be old and/or in bad conditions, requiring subsequent relevant actions towards better technological performances and

major energy efficiency.

Energy Management and Measurement Actions have a quite low specific cost, as they are mainly based on corrections of the management of energy sources and carriers, more than in the replacement of high-cost equipment and processes.

Figure 6. Specific Cost of Energy Savings



In figure 7 and 8 the split of electricity and fuel saving for each category of intervention is presented. It can be noticed that categories saving both types of energy sources are Process Actions and HW and Steam System Actions, as the remaining categories are mainly focused on one source saving. Process Actions and HW and Steam System Actions are also the most relevant categories in terms of energy saving both for electricity and fuel; concerning electricity, Compressed Air Actions presents a relevant amount of saving (about 260,000 GJ), as concerning Renewable Actions achieves a considerable saving (about

800,000 GJ). Cogeneration Actions represent a particular case, as the electricity is produced internally at the plant by use of fuel (for example NG): this explains why in figure 8 the fuel saving for Cogeneration Actions is negative; electricity saving in this case represent the amount of electricity the plant can produce internally without external supplying need. Nevertheless Cogeneration Actions increase fuel consumption, considering the efficiency of internal production and the resulting heat energy, comprehensively a good amount of CO₂ can be saved.

Figure 7. Split of Electricity and Fuel Saving

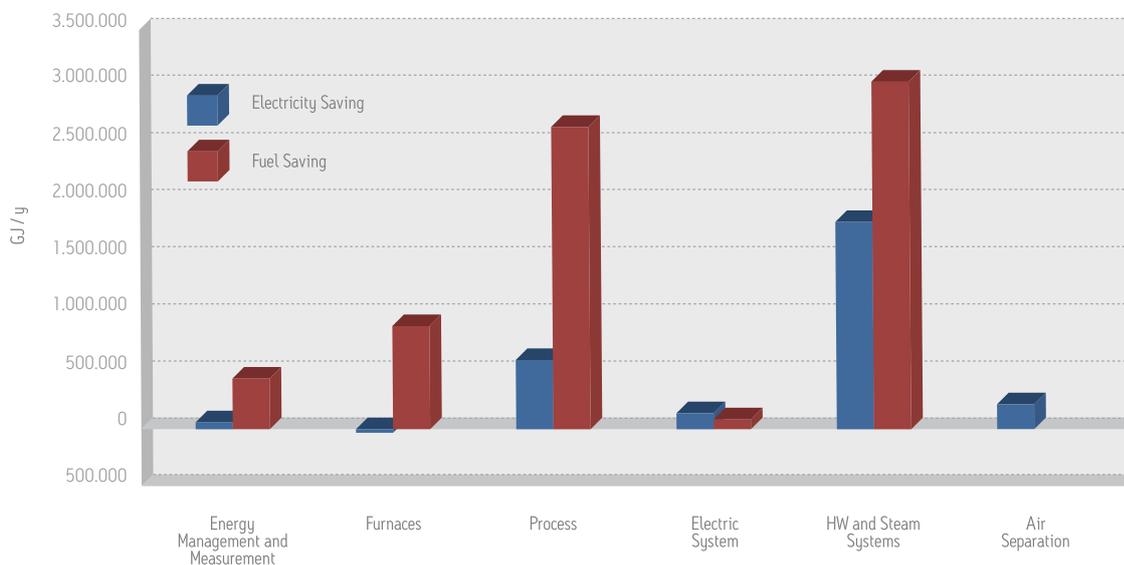
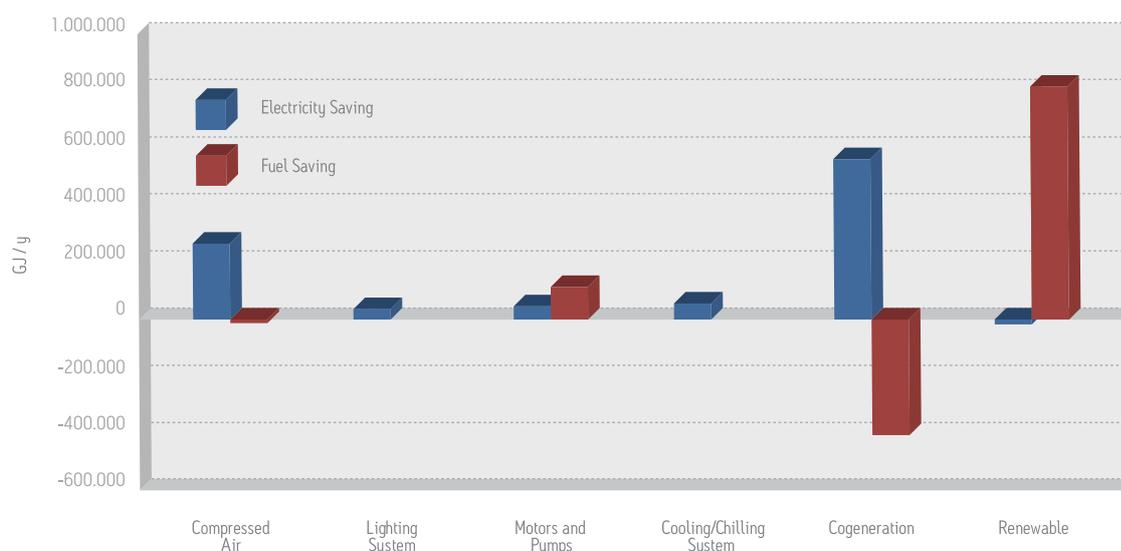


Figure 8. Split of Electricity and Fuel Saving



8.3 Greenhouse Gases Emission Reduction Analysis

In this sub-section data of all the Energy Efficiency Actions proposed during the Energy Audits at the relevant industrial facilities have been evaluated in order to identify some key-parameters to show the expected

results of the investments in terms of GHG abatement potential and cost.

The below-reported table shows the total investment cost, the total GHGs emission abatement and the average capital intensity per unit of GHGs emission reductions achieved in unit of time (EUR / [ton CO₂ equivalent/year]), for the twelve categories of actions identified above. Its results are better visualised in the following figures.

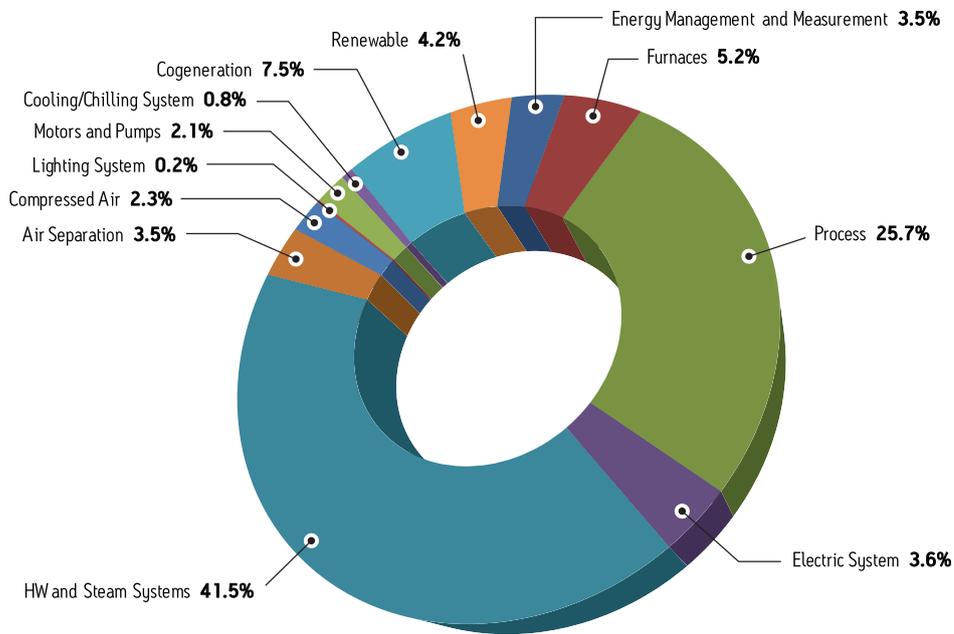
Table 5. Capital Intensity and GHG Emission Reduction Potential for Energy Efficiency Investments

ID	Actions Category	Total Investment Cost (EUR)	Total Abatement (tonCO ₂ /year)	Capital Intensity EUR/ (tonCO ₂ /year)
1	Energy Management and Measurement	4,276,000.00	45,729.65	93.51
2	Furnaces	15,620,000.00	67,952.00	229.87
3	Process	63,270,938.24	336,133.64	188.23
4	Electric System	2,150,000.00	46,582.53	46.15
5	HW and Steam Systems	57,122,659.59	543,039.92	105.19
6	Air Separation	15,178,000.00	45,927.00	330.48
7	Compressed Air	3,277,140.00	29,801.67	109.96
8	Lighting System	895,400.00	2,485.00	360.32
9	Motors and Pumps	3,221,860.00	27,828.51	115.78
10	Cooling/Chilling System	1,935,000.00	11,045.47	175.18
11	Cogeneration	13,700,000.00	98,276.77	139.40
12	Renewable	20,472,083.20	54,571.84	375.14
Total		201,119,081.02	1,309,374.00	

Figure 9 reports the split of the total GHGs emission reductions achieved for the twelve categories of Energy Efficiency Actions and highlights that, similarly to the energy saving analysis, the two most relevant categories are HW and Steam System Actions (about 540,000

ton of CO₂ per year, 41% of the total) and Process Actions (about 340,000 ton of CO₂ per year, 26% of the total). The total CO₂ emission reduction achievable by application of proposed interventions in CEI Programme Framework is about 1,300,000 ton of CO₂ per year.

Figure 9. Split of Achieved GHGs Remission Reductions



The next figure reports the average specific costs required for each of the twelve categories in order to achieve a unit of GHGs emission reductions (tonnes of CO₂ equivalent) in the unit of time (year).

The results present analogies compared to what already found in the analysis of energy saving specific cost: Electric System, Energy Management and Measures, HW and Steam Systems and Compressed Air Actions are generally the interventions that have the lowest specific cost (about from 46 to 110 EUR per ton of CO₂) to achieve GHGs emission

reduction unit. Furthermore, as for energy saving specific cost analysis, Air Separation and Renewable Actions presents a quite high specific cost (about from 330 to 375 EUR per ton of CO₂); differently from analysis described in sub-section 2, Lighting System is the second most expensive category in terms of GHGs emission reduction (about 360 EUR per ton of CO₂), as Cogeneration Actions present a specific cost lower than the average one of the twelve categories (about 140 EUR per ton of CO₂).

Figure 10. Capital Intensity of GHGs Emission Reductions

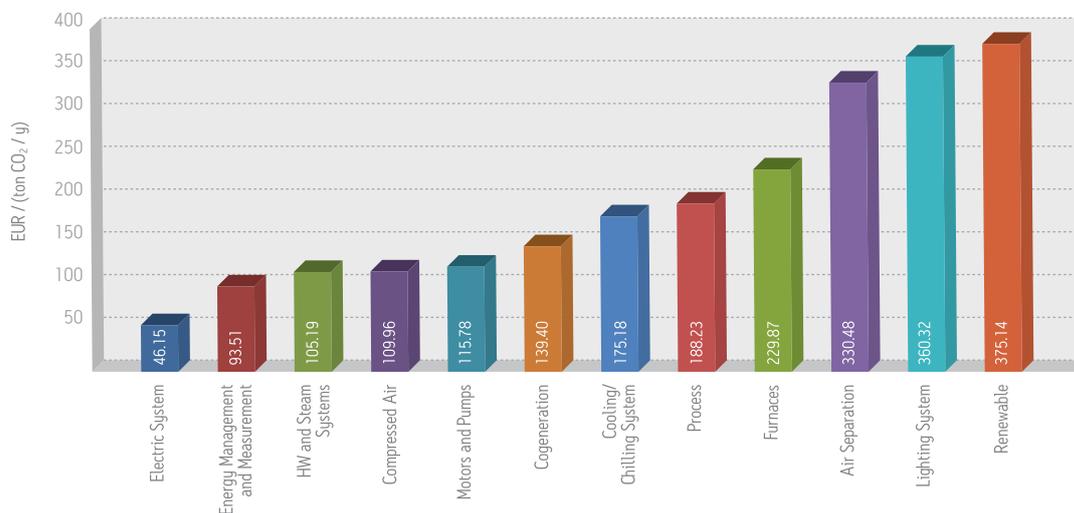


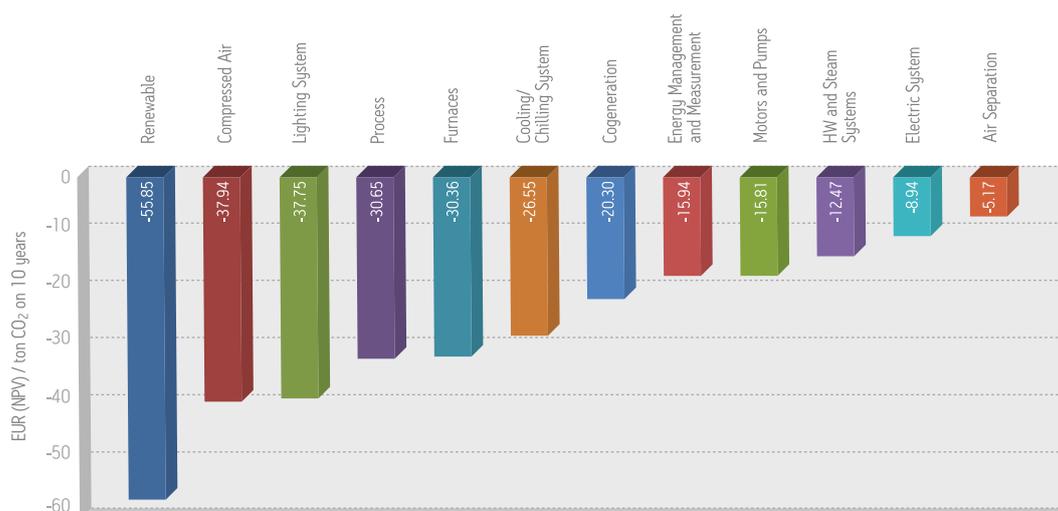
Table 6. Abatement Costs and Investment Costs of GHGs Emission Reduction Investments

	<i>Abatement Cost (NPV 10 years)</i>	<i>Abatement Potential (ton CO₂/10y)</i>	<i>Specific Abatement Cost EUR(NPV) / (ton CO₂/10y)</i>
Energy Management and Measurement	- 6,931,146	457,296	- 15.16
Furnaces	- 20,633,368	679,520	- 30.36
Process	- 95,574,558	3,361,336	- 28.43
Electric System	- 4,163,000	465,825	- 8.94
HW and Steam Systems	- 17,326,558	5,430,399	- 3.19
Air Separation	- 2,373,000	459,270	- 5.17
Compressed Air	- 10,627,540	298,017	- 35.66
Lighting System	- 938,000	24,850	- 37.75
Motors and Pumps	- 4,400,700	278,285	- 15.81
Cooling/Chilling System	- 2,932,979	110,455	- 26.55
Cogeneration	- 19,949,142	982,768	- 20.30
Renewable	- 30,477,401	545,718	- 55.85

In the next figure the Abatement Cost divided by the total CO₂ emission reductions has been reported. In particular, the Abatement Cost for each category is the sum of the 10-year horizon NPVs of the single

interventions and the total CO₂ emission reductions are considered as a double sum on the plants of a category and on a 10-year period.

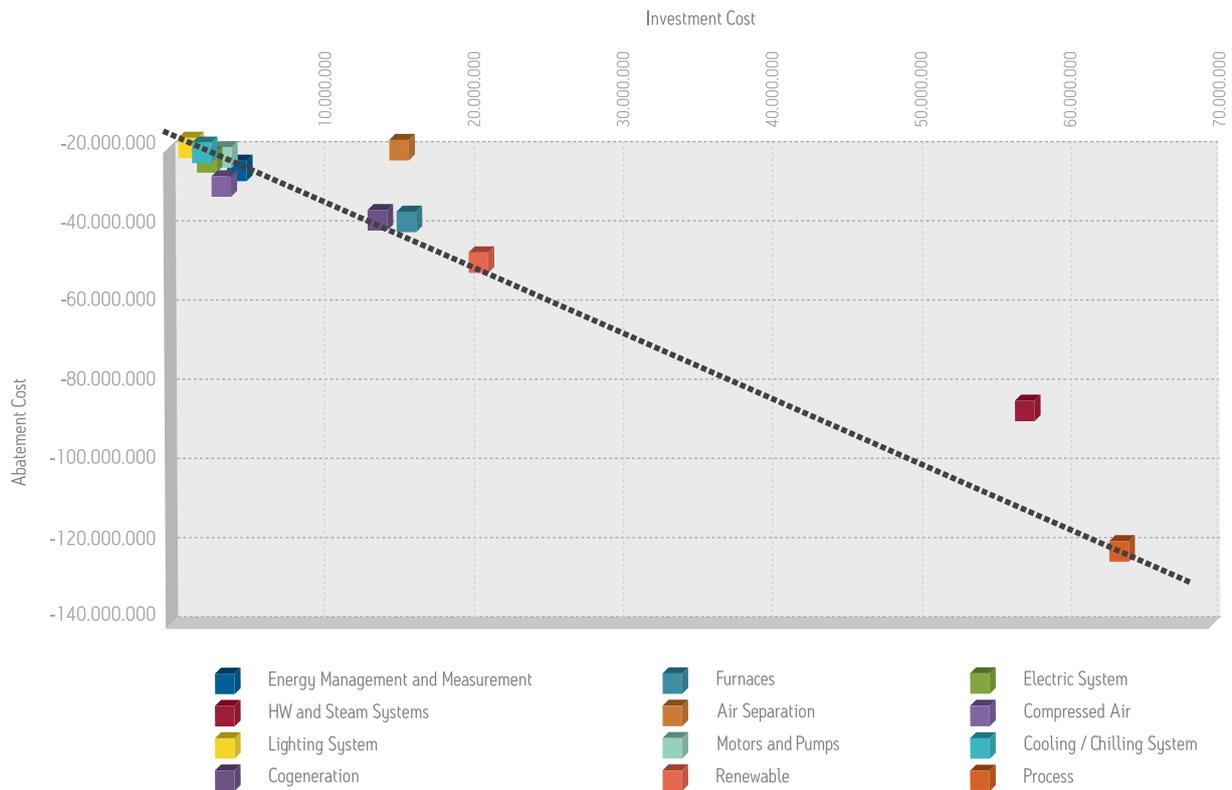
Figure 11. Specific Abatement Cost by Measure



The scope of figure 12 is to represent the simplified net cost at the end of the project time (10 years standard time), which has been required for the unit of GHGs emission reductions achieved along the 10 years of

the project, for each Energy Efficiency Action category. In particular, it is easy to see how the most capital-intensive categories (see previous figures) generally present at the same time the highest negative abatement cost.

Figure 12. Capital Investment and Abatement Cost



The above-reported figure shows in particular the distribution of the various categories of Energy Efficiency actions on a Cartesian graph (whose 'x' axis reports the total investment for each type of actions, and the 'y' axis reports the [negative] abatement cost). It is possible to see on the figure that most of the categories are near to a linear trend line (negative slope of about -1.5 EUR/EUR).

It is important to highlight that the proposed simplified economical analysis takes into account costs and revenues based on only Energy Efficiency aspects, and do not consider all other economical variables affecting the real cost/incomes (i.e. production quality, quantity-related aspects, financing costs, fuel price volatility, etc.).

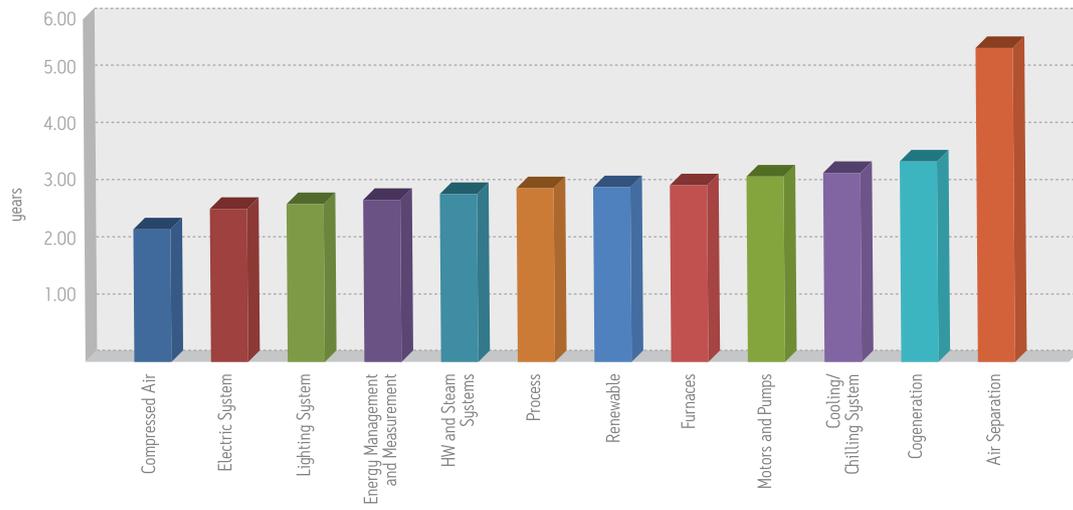
8.4 Suggested Actions Profitability Analysis

In this sub-section profitability analysis in terms of payback period for each category of proposed action is presented in table 7. The same results are then presented graphically in the figure 13. As it can be seen, Compressed Air Actions presents the lowest average payback, with 2.5 years for return of investment. In general all categories present an average payback varying in a strict range (from about 2.5 to 3.7 years). Only category of Air Separation Actions presents an average payback quite different from the other categories (about 5.7 years), due to the very high cost of investment for the interventions, whose reasons have been already explained previously.

Table 7. Average Payback for each Interventions Category

ID	Actions Category	Average PB (year)
1	Energy Management and Measurement	3.09
2	Furnaces	3.33
3	Process	3.26
4	Electric System	2.94
5	HW and Steam Systems	3.23
6	Air Separation	5.73
7	Compressed Air	2.54
8	Lighting System	3.00
9	Motors and Pumps	3.48
10	Cooling/Chilling System	3.54
11	Cogeneration	3.74
12	Renewable	3.29

Figure 13. Average Payback for each Interventions Category





TROPISCHE KAS A

TROPISCHE KAS B

TROPISCHE KAS C

TROPISCHE KAS D



TROPISCHE KAS A

TROPISCHE KAS B

TROPISCHE KAS C

TROPISCHE KAS D



SAVANNEN KAS

SUBTROPISCHE KAS

SUCCULENTEN

SAVANNEN KAS



SAVANNEN KAS

SUBTROPISCHE KAS

SUCCULENTEN

SAVANNEN KAS



MOESON KAS

GEBERGTE KAS

BINNEN



Common Patterns in the Investigated Plants and Energy Efficiency Findings

Nine

In the previous section, a complete picture of the set of Energy Efficiency Actions proposed by the Consultants during the development of the Audits Programme has been proposed, showing the great variety of industrial sectors that were assessed and the wide range of opportunities for energy efficiency increase that were suggested.

It is possible to identify some major common patterns within assessed production processes, technological systems and energy management practices and equipment at the audited plants, allowing for the identification of the areas which required major improvement or technological renewal.

A first common pattern that was widely encountered during the Energy Audits Programme is a lack of measurement systems and instruments and adequate procedures for data storage and analysis. In several cases it has been found that an energy management structure was not existing or newly created, so that the record of energy data was very limited in time, as well as the presence of defined lists of medium/small energy consumers as motors, small transformers etc.

In general, as anticipated, the major technical weakness assessed was usually the utilisation of very old measurement systems, often based on mechanical/manual reading instruments, not able to collect data in an automatic way and linked to manual/pneumatic or other non electronic systems of transmission. In some cases, the data collected with non-electronic measurement system were converted manually into electronic files, with significant losses of real-time regulation. In all these cases the mix of more organised energy management at top level in the company and the replacement/upgrade of the measurement system (often involving the use of Wi-Fi data transmission systems and ad hoc software for data monitoring and analysis) was proposed.

A second major common finding is represented by renewal/upgrade and in most cases replacement of old “horizontal” systems like utilities and

services, in particular old motors, pumps, insulation systems for hot water and steam piping, compressors, boilers, electric transformers and switches, and other equipment which are commonly installed at all industrial plants.

Considering common patterns related to the processes of the audited plants (“vertical actions”), it is necessary to proceed clustering the different industries in some groups, which generally show similar process characteristics or industrial treatments. In particular, for each of them we can identify the most common findings and the BATs more frequently proposed.

In Steel and Iron Plants, including Steelworks, Hot Rolling Mills, Cold Rolling Mills, and more in general in all metal processing plants (as forges, hammers, thermal treatments etc.), the most commonly identified actions involved substantially the improvement or replacement of existing furnaces (both treatment furnaces and steelmaking furnaces), including fuel switches, heat recovery systems installation, etc. This identifies furnaces as one of the major elements which have shown poor or old technology during the audits, and which most needed the introduction of BAT technology.

In agro-industries, a major role has been often covered by “horizontal” equipment, with a remarkable role of chilling systems, taking into account the particular nature and needs of the alimentary industrial products for both process and conservation reasons. Several interventions on “vertical” process segments were proposed, but the most of them involved heat recovery systems applied to the existing process. However, in several cases ENE actions were proposed implementing a direct modification of the process and introducing BAT technologies (a notable example is the replacement of old-technology kilns in malting plants with best technology “tandem-type” kilns).

The third major type of industry which has been object of the audit Programme is represented by the Pulp and Paper Industry. In this case the

The third major type of industry which has been object of the audit Programme is represented by the Pulp and Paper Industry. In this case the interventions on process equipment have been rather important, since the revitalisation/revamping of paper machines and some changes in technology as refurbishment of soda recovery boilers and shift of production have been proposed with subsequent introduction of new BAT technologies in the process.

In all these three groups of plants, as in the case of other less representative investigated sites, the introduction of BAT at both “horizontal” and “vertical” level has been a major component of the Energy Efficiency Audits together with the upgrading of management/measurement systems and with the substitution/replacement of old equipment/ processes. In several cases, synergies between BAT installation and plants reconstruction have been pursued,



Ten

Energy Management Training

The Consultants had the opportunity to carry out two Energy Management training activities in a Pulp Mill and in a Sugar Mill. The Consultants reckon that the explanation of energy efficiency issues to plants' local management is fundamental to foster an 'energy oriented mentality'. This different kind of approach could affect the reduction of energy losses as much as the replacement of old and not efficient equipment since many sources of energy waste can be identified and related to bad employment, maintenance and management of the equipments. Energy Management Training could give some technical elements to help manage energy efficiency, especially in the case some of the measures proposed by the Consultants would take place. The main objectives of Management Training were to assist the companies in the process of structuring an appropriate energy management organisation through designation of an energy manager and support staff, to provide the required initial training to selected managers including strategic, organisational, training, awareness and motivation issues and to transfer skills related to energy efficient technologies that can be implemented within the companies' plants and processes in order to save energy and improve the economic and environmental sustainability of its operations.

The energy management training Programme was focused on the following modules:

- Energy Management: the energy management module provided administrative and technical training for energy managers, operators and others responsible for efficient facility operation.
- Performance monitoring and targeting: performance monitoring is a critical aspect to achieving real and lasting improvements in energy consumption. This module assisted attendees in understanding how to develop achievable targets, their relationship to financial

improvement, and the monitoring required to measure and verify those improvements.

- Acquisition and utilization of energy information and data: this module focused both on data acquisition techniques and equipment as well as utilization of data once collected.
- Energy considerations specific to the processes used: focus on benchmarking and comparison of process against other companies with similar processes.
- Energy efficiency in day-to-day activities including managerial, technical and financial aspects: this module focused on the inter-relation of managerial, technical and financial decisions on the day-to-day performance of the plant.
- Training and advice on specific energy efficient technologies: this module focused on issues such as high-efficiency motors, proper sizing techniques, and best available technologies (BAT).



The overall attendance and involvement of the trainees was very good and at the end of the course an evaluation form was fulfilled by all attendances that gave the opportunity to evaluate the overall results and

usefulness of the management training.

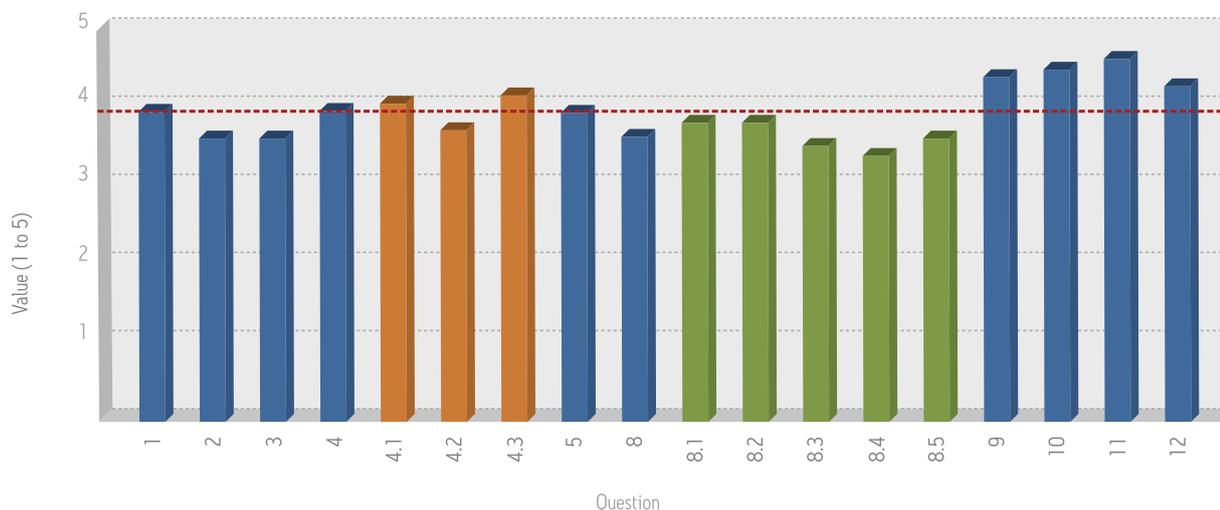
The questionnaire forms contained the following questions:

Table 8. Energy Management Training

1	What is your overall rating of the course?
2	Do you believe the knowledge and skills you have gained will help you improve your performance on the job?
3	How effective was the course in terms of the long term benefits versus time away from your desk?
4	To what extent did the course achieve its stated objectives:
4.1	Equip participants with the skills to understand and analyse energy consumption information
4.2	Develop practical and relevant actions to control and possibly reduce energy use
4.3	Equip participants with up to date information on energy efficiency technologies and methodologies
5	How did you find the pace of the course?
6	In your opinion, will the training lead to concrete actions for improving energy management practices in the company?

7	Do you think useful to have a follow up training?
8	Please, rate how useful each module was
8.1	Energy Management in Industry (What, Why, How)
8.2	Bulgaria Energy Context and Climate Change
8.3	Economic and Financial Aspects of Energy Efficiency Projects
8.4	Outcome of the Energy Audit
8.5	Technical Aspects in Optimizing Energy Efficiency
9	How effective were the trainers overall?
10	Did the trainers have the relevant subject expertise?
11	Were the trainers responsive to participants' needs and questions?
12	How was the trainers' ability to involve the audience?

Figure 14. Questions' Average Scoring



Visual results of average scoring for each individual question are shown in the picture. The red dotted line represents the overall average score of the training course.

As a further suggestion, it could be useful to verify, after a few months from the energy training, if the local management received any kind of benefits and put in practice any of the suggestions of the energy training.

Finally it must be underlined that the capacity building activities

performed toward plants' technicians during the CEI financed Energy Audits Programme are in line with the great attention that is in the last times paid to Energy Management issues at international level. The International Organisation for Standardization (ISO) is in fact currently working on the development of an international standard on energy management that should come in force by 2010. This future ISO 50001 standard will establish a framework for industrial plants, commercial facilities or entire organizations to manage energy.

Eleven

Ex-post Analysis

In this section the detailed description of two ex-post visits at industrial facilities already audited previously in the CEI framework is presented. The aim of the site visits was to verify the results and effectiveness of the Energy Efficiency Audit Programme, and for this scope two particularly significant industrial plants – from the point of view of energy efficiency potential improvement – have been selected:

- Soyaprotein Plant Victoria Group (Serbia)
- Svishtov Pulp Mill (Bulgaria)

The analysis expanded from the main findings identified in the previous visits, and mainly consisted in the analysis of the implemented actions in those plants. A quantitative analysis of energy efficiency and economic benefits has been performed by audit teams for all main interventions implemented by the plants, together with the analysis of energy sources price trends. A further step has been identifying and analysing the orientation of plant's management for the future in terms of energy efficiency and technological improvement.

In the following sub-sections a detailed description of the two ex-post visits is provided.

11.1 Soyaprotein Plant Victoria Group (Serbia)

D'Appolonia team performed an ex-post visit at Soyaprotein facilities, in Becej, on 18th and 19th February 2009. The survey represented a follow up to the visit already performed at Soyaprotein facilities in July 2007. The new visit was mainly aimed at evaluating all measures – in terms of energy efficiency interventions and adopted strategies - that have been

implemented by the plant's management during these two years. The Audit Team included Mr. Danilo Bosia, team leader and energy efficiency expert, and Mr. Marco Martinelli, energy efficiency expert. The Audit has been performed in strict cooperation with plant's management and staff, and specifically with:

- Mr. Miroslav Petkovic, Technical and Development Department Manager
- Mr. Stevan Rausavljevic, Technical and Development Department Deputy Manager

The on-site visit allowed the collection of significant amount of data.

The most relevant performed energy efficiency intervention is the installation of a new biomass fed boiler, which covers all current steam needs of the plant; the new boiler has been in operation since 13th October 2008. Before the installation of the new biomass boiler, the plant's steam needs were covered by two natural gas (NG) boilers, which have been currently put in stand-by as hot reserve.

The boiler is fed with three types of biomass fuel:

- straw
- sunflower shells
- soybean shells

Straw is harvested in an area of approximately 50 km radius. In the year 2008 about 9,000 ton of straw has been harvested to feed biomass boiler; the total straw harvesting potential of the area is approximately 20,000 tons per year. Biomass fuel is, as already mentioned, a mixture of straw and shells, which may present three different components combination: 100% straw, 50% straw and 50% shells, 70% straw and

30% shells. Proportions of the two components have been defined on the basis of tests conducted on the combustion efficiency inside the combustion chamber.

The new biomass boiler has a steam production capacity of 15 ton per hour at 12 bars pressure.

The Audit Team has estimated the energy consumption to produce one ton of steam both for new biomass boilers and NG boilers, resulting in about 2.91 GJ per ton of steam for biomass boiler and 3.63 GJ per ton of steam comprehensively for the two NG boilers. The minor specific energy consumption of new biomass boiler compared to NG boilers leads to an estimated annual energy saving of about 60,000 GJ; the most relevant issue is that new boiler allows the plant to be almost independent from natural gas. The saving is much more important also considering two critical issues: the potential obstacles and barriers for the supply of natural gas in Serbia, and the increasing price of natural gas in the country.

The new biomass boiler has also represents a financial savings thanks to increased efficiency compared to the old NG-fired boilers, and the cheaper cost for biomass compared to NG. The potential yearly CO₂ emission reduction is estimated in about 16,700 ton of CO₂ per year.

Since the previous site survey performed in July 2007, Sojaprotein management has introduced other actions oriented to save energy and improve energy efficiency at the plant premises. Specifically, those are:

- Condensate recovery optimisation: only 20% of condensate was recovered at the plant at the time of the first visit. Since then management has implemented a detailed condensate recovery system, installing different local condensate recovery tanks at the major process buildings. The new system, connected both with the old boilers circuit and with the new biomass boiler, allows a condensate recovery of about 80%.

- New lines equipped with modern and energy efficiency technologies: three new lines for specific parts of production process have been recently modernised and updated to improve energy efficiency, in particular: new extrusion line, for the preparation of food, now including electric motors equipped with Variable Speed Drives (VSD); new pelletizing line, no longer consuming steam for process operation; new flour production line, now including electric motors equipped with Variable Speed Drives (VSD).

Sojaprotein intends to continue to evaluate and adopt energy efficiency intervention and strategies. In particular, various interventions for energy efficiency and technological improvement have already been planned, as described in the following:

- Cogeneration/trigeneration: two cogeneration units composed of two gas motors Jenbacher J320 GSB 05 and two electric generators Stamford Newage GmbH have been installed in the year 2000 and are able to generate about 1.3 MWel and about 1 MWth each. Currently they are not in operation, due to the fact that electricity price compared to NG price does not economically justify cogeneration applications. However, cogeneration application could be implemented in the short-term. In the specific case of Sojaprotein, it would be a trigeneration process, i.e. generating from recovered heat energy also a chilling source for extraction unit.
- New compressors: currently five compressors are installed at the plant, aged about 25 years old; Plant's management has already elaborated a progressive replacement plan of the five old compressors with four new compressors, more efficient, reliable and producing better quality compressed air; one new compressor per year should be installed, as to Plant's management plan.
- Close circuit for water cooling at extrusion line.



11.2

Svishtov Pulp Mill (Bulgaria)

On 25-26 February 2009, the MWH team met the pulp mill Management in Svishtov, Bulgaria, to appraise the status of implementation of the energy efficiency projects suggested during the energy efficiency audit, to verify the actual impact of the projects implemented in terms of reduced energy use, reduction of emission of GHG gases and in relation of any other relevant performance parameter and to review the impact of the services provided in terms of energy management and awareness about energy efficiency.

Local staff was always available to further explain and discuss the requests of the consultants providing the MWH team with most of all information required.

Between several site technicians and responsables, the following personnel attended at the different meeting and discussions with MWH team of experts:

- Mr. Atanas Papazov, Managing Director
- Ms. Bilyana Borisova, Professional Assistant

MWH team verified the status of implementation of the energy efficiency projects that were suggested during the last energy efficiency audit: as the following table suggests, most of the energy efficiency measures proposed by MWH have been implemented.



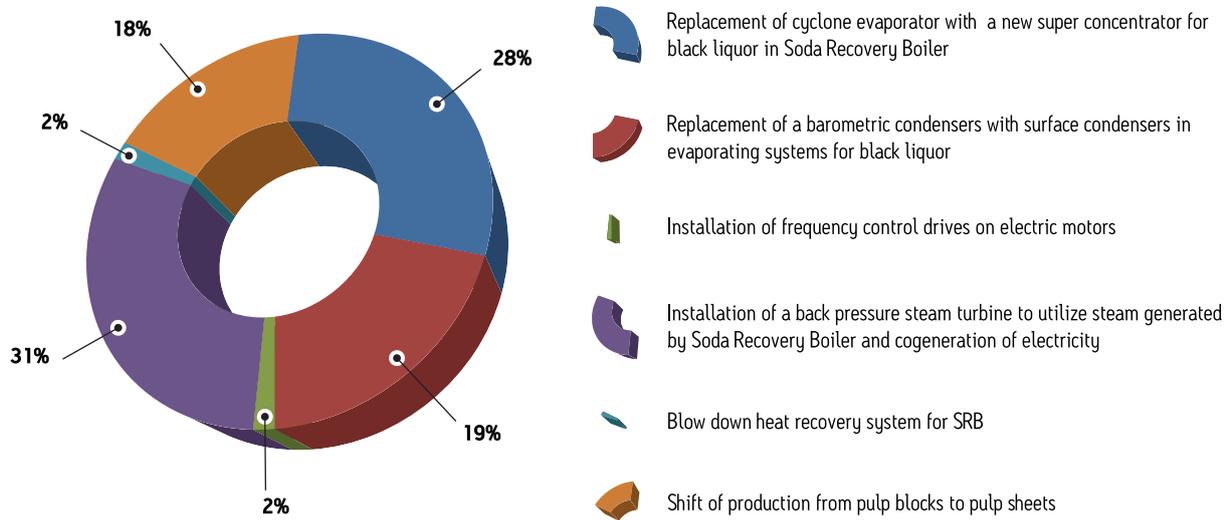
Table 10. Implemented Energy Efficiency Measures

Measures	Implemented? Y/N	Status / Picture /Why not implemented
Reconstruction of SRB, replacement of cyclone evaporator with a new super concentrator for black liquor	Yes	 <p>The super concentrator for black liquor is in operation. The construction of the plant has been completed between the 1st November 2007 and the 1st January 2008.</p>
Implementation of dry debarking unit	Yes	 <p>The implementation of the unit has been carried out during November 2007. The capacity of the debarking unit is 500 m³.</p>

<i>Measures</i>	<i>Implemented? Y/N</i>	<i>Status / Picture /Why not implemented</i>
Upgrading of washing unit and replacement of condensers with plate heat exchangers in evaporating systems for black liquor	Yes	 <p>The installation has been completed between November 2007 and December 2007.</p>
Installation of frequency control drives on electric motors	Yes	 <p>The frequency control drives have been installed in induction motors with capacity from 0.75 and 800 kW. The installation has been completed between November 2007 and December 2007.</p>
Installation of back pressure steam turbine to utilize steam generated by SRB	Yes	 <p>The turbine successfully started its operation on 9th February 2009 and since then it produced 143 MWh. The construction occurred between August 2008 and January 2009. The size of the Back Pressure Turbine is 12 MW and it has been provided by a local supplier.</p>
Blow down heat recovery system for SRB	Yes	 <p>The blow down heat recovery system has been implemented between August 2008 and January 2009. The heat exchanger has a surface of 2.9 square meters.</p>
Replacement of the old refrigeration units with new absorption units and optimization of water cooling system	Yes	 <p>The old and obsolete refrigeration units have been replaced with 4 brand new and more efficient units (500 kW each) installed at the end of 2007. Two units 250 kW each should be installed in the next months.</p>
Replacement of old piston air compressors with new units and optimization of compressed air supply system	Yes	 <p>The compressed air supply system has been optimized and the old piston air compressors have been replaced with 3 new units with screw compressors that provide 25m³/hr each.</p>
Shift of production from pulp blocks to pulp sheets	Yes	 <p>The new line for dewatering, drying and packing of the pulp that consists of wet screen section drying machine and cross section cutter is in place since January 2007.</p>

Due to reduced combustion of fossil fuels and electricity consumptions associated with energy savings, the Company has reduced emissions of about 75.617 tonnes of CO₂ in 2007.

Figure 15. Effective percentage of Emission Reduction per kind of intervention



The next pie charts represent how the share of energy costs has been changing from 2006 and 2008.

The MWH team verified also that the energy prices have been doubling in the last four years underlining the importance to improve the energy management of the whole plant.

An important Key Performance Index is the specific energy consumption per tonne of final product produced: as it can be noticed from the following chart, the trend lines indicate that in 2008, when some of the

energy efficiency measures proposed have been implemented, the specific energy consumption per tonne of pulp and CMC produced has been clearly decreasing from 2007, with particular reference to the heat specific and electric specific consumption. Moreover, due to the implementation of the last two energy efficiency measures in 2008 and 2009, the future specific consumptions should further decrease, with particular reference to the installation of the backpressure turbine.

Figure 16. Effective percentage of Emission Reduction per kind of intervention

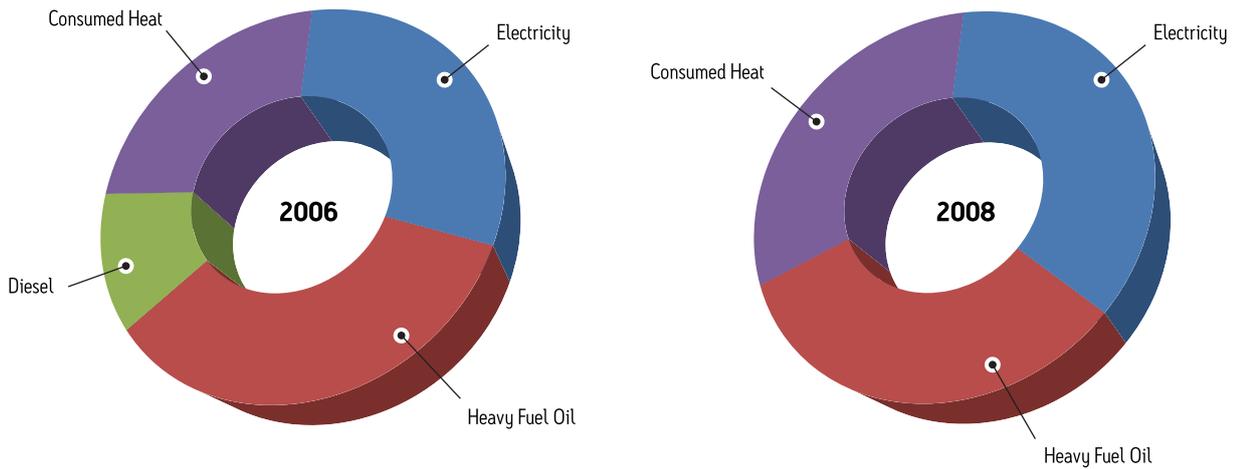
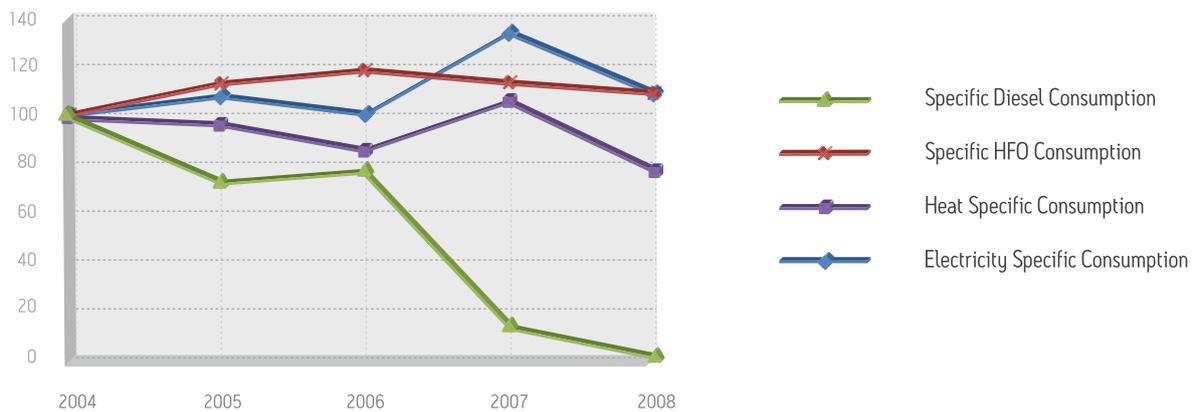


Figure 17. Evolution of Specific Energy Consumption (2004=100)



During the Energy Efficiency Audit the Consultants underlined the importance of defining an energy policy: in fact an Energy Team is now in place with two full-time Energy Managers and, depending on future market opportunity, this team will increase.

Moreover the Consultants verified that the collection of all the datasheets of the facilities equipment is well managed.

Since the performance monitoring and targeting is a critical aspect to

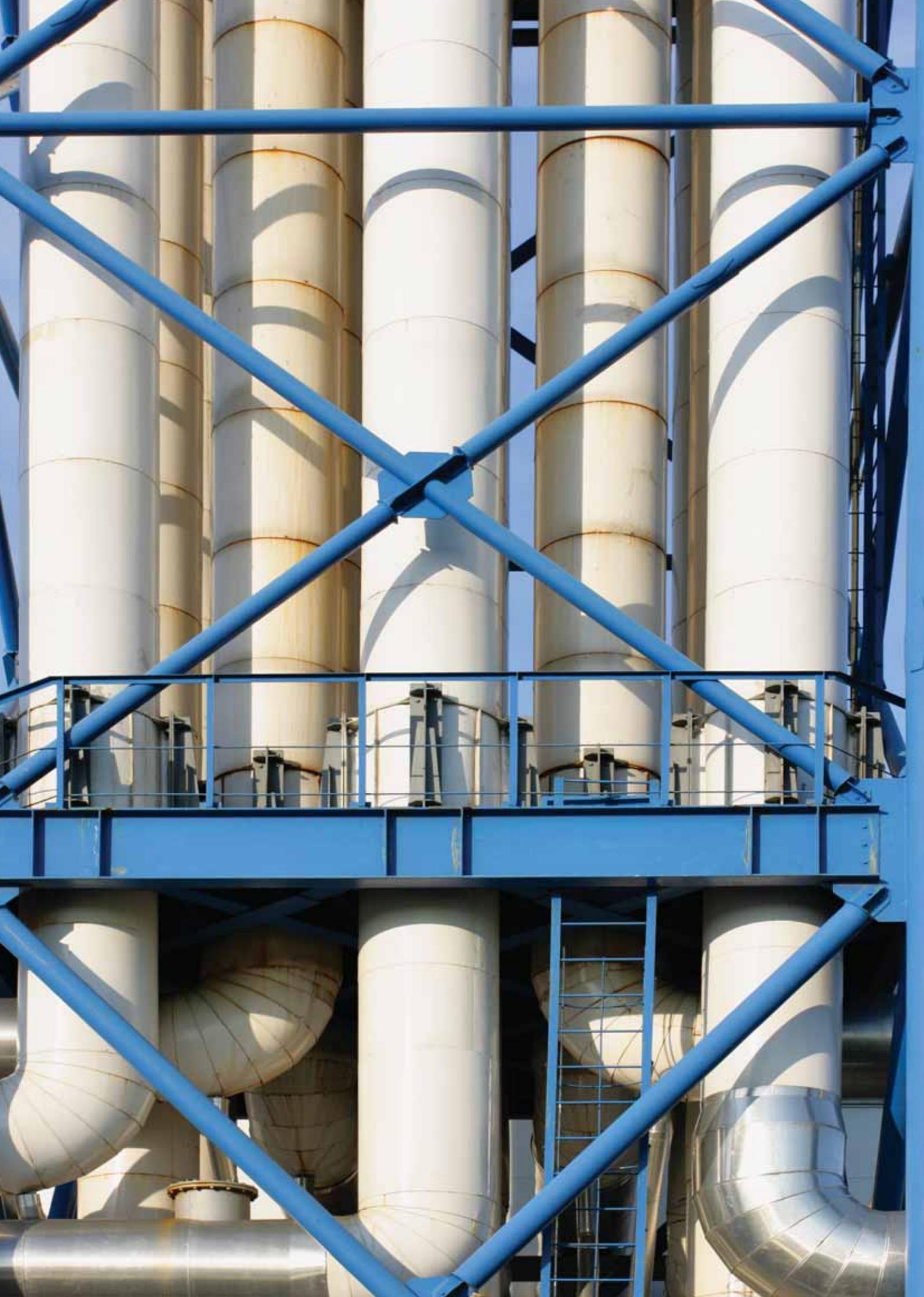
achieve improvements in energy consumptions developing achievable targets, a Daily monitoring of Energy Consumption is in place and each month the overall situation is audited to understand the deviations from the budget.

An Energy Management Training was carried out in the production plant in spring 2006 and the consultants have been able to verify the benefits of the training. The local management explained that the training

was very useful to implement the basic guidelines to handle energy and the creation of an Energy Team is surely the most relevant result of the training. They also developed a number of environmental and energy policies and, starting from spring 2008, the employees had the opportunity to attend seminars and training in order to foster an 'energy-saving culture'.

The Energy Management training underlined also the relevance of considerations on specific energy consumption related to the processes used: the company is focusing on energy benchmarking against other companies with similar process also because after wood supply, energy is the main cost of the pulp mill. They are well aware that saving energy it's the best way to be cost effective and to be more competitive in the market and even if the pulp mill is very old they are making many efforts to reach excellence.





Energy Audits: a Great Leap to the Future

Twelve

As a conclusion of the present Energy Audits Impact Assessment, that marks 5 years of fruitful collaboration between the EBRD and the CEI in the energy sector, it is time to thank all the people who gave substantial contribution to this report (EBRD, consultants, and the Secretariat for CEI Projects staff) and put the basis to make this kind of audits a true success for the future of the CEI region.

Climate change has been recognised as a global issue for more than a decade (the United Nations Framework Convention on Climate Change entered into force in 1994 and the Kyoto Protocol was adopted in 1997). In recent years, particularly following the G8 meeting at Gleneagles in 2005, it has become a global priority which only the current financial and economic crisis has temporarily removed from the top spot. However, increasing awareness about the consequences of climate change on the environmental, economic and social spheres have not prevented emissions of Green House Gases (GHG) to increase. All major research organisations and institutional agencies confirm that concentration of carbon dioxide (CO₂) in the atmosphere is accelerating. As a likely result, the world is experiencing unprecedented extreme weather conditions, including droughts, heavy precipitation, heat waves and the increased intensity of tropical cyclones. It has been estimated that GHG emissions have increased by about 20% from 2000 to 2005 including in the countries of the CEI region where carbon emissions reductions occurred in the 1990s due to the economic decline are now growing again as the economic output of the region grows and life conditions improve. At the global level, growing concerns are emerging about the possibility of containing by 2050 CO₂ concentration in the atmosphere within 450 parts per million, the level experts suggest will be needed to prevent the global mean temperature from rising by more than 2° C. This temperature increase would prevent global warming to have catastrophic consequences on global economies and communities.



Virtually all scenarios developed by research organisations suggest that achieving this result would require a fundamental technology shift including by developing technologies such as carbon capture and storage which are still untested and achieving systemic changes in the energy sector. Experts suggest that early actions are required particularly in areas such as energy efficiency (both on the supply and demand side) where carbon emission reductions can be achieved at low and possibly negative cost.

Accelerating the rate of implementation of these early actions is crucial in order to anticipate the inflexion of GHG emissions which scientists suggest should be achieved as early as the second half of the next decade in order to increase the likelihood of temperature increase to be controlled within the mentioned 2° C. So it should not be surprising that energy efficiency has risen rapidly to the top of the climate change agenda as the instrument with the largest potential for carbon reduction in the short to medium term. From this perspective the EBRD is particularly well positioned due to its early focus on this area linked to the very significant energy efficiency opportunities which its region offer due to the high energy intensity of most of the economies where the Bank operates.

The EBRD during the years because of this feature of its countries of operation and in relation to its mandate, has promoted efficient use of energy as a way to accelerating transition. Actually, high energy intensity can be linked to the enduring legacy of centralised planned economies with the associated wide range of information gaps, market failures, and policy imperfections.

In this context, the policy objectives of the CEI have found a natural alignment with the activity and transition mandate of the EBRD. In fact, while most of the countries of the CEI region, especially in central Europe, have managed to start the decoupling of their economic growth from carbon emissions, energy intensity has remained significantly higher than the average in the EU, especially in Ukraine and in some of the economies of the Western Balkans which remains among the most energy intensive economies in the world. The activities of the EBRD in the area of energy efficiency fit very well also with the agenda of the EU which has issued in recent years a wide range of Directives aimed at pursuing the energy efficiency potential within its members states and defined also some targets in this area (including on carbon emissions) within the 2020 timeframe.

Most of the EU countries have set initiatives in the area of energy efficiency, also in response to the global economic crisis. This alignment of interests between the CEI and the EBRD goes beyond the climate change dimension considering the strategic importance of energy efficiency in improving the competitive profile of companies and organisations but also in relation to the employment opportunities created by the development of markets for energy efficiency equipment and systems and in relation to the skills required to develop energy saving programmes and projects. The support provided to the EBRD which have materialised around the Energy Audits Programme analysed in this report and other initiatives (such as the energy efficiency market demand studies) have also positioned the CEI as a key contributor to the EBRD for its Sustainable Energy Initiative which is now entering its second phase.

The success of the CEI funded Programme has been confirmed by the response of the Banks clients in incorporating opportunities identified through the audits in their capital investment programmes. While it should be noted that the analysis presented in this report does not represent an assessment of the actual impact of the energy efficiency projects implemented as a result of the energy audits the two case studies which have been analysed in detail confirm the benefits brought by the investments and their contribution to reduce the carbon footprint of the related operations

The report contains also a useful review of technical characteristics, common patterns and expected benefits of the energy efficiency projects identified during the various activities funded through the programme. On this subject, the aggregated analysis shows as noted earlier and in line with the analysis of leading international research institutions (such as e.g., the abatement cost curves recently issued by the McKinsey Global Institute in its "Pathways to a Low-Carbon Economy") the effectiveness of energy efficiency in achieving carbon abatement in a cost effective manner.

The results of the analysis show the importance of Technical Assistance in raising the priority of energy efficiency projects within companies and to ensure that viable projects are incorporated into the companies long-term investment plan. Through its Technical Assistance Programme the CEI has complemented the long-term funding provided by the EBRD, in this way enabling investments in projects that would otherwise be postponed or not implemented, and helping clients to increasingly unlock the potential for energy saving.

London, May 2009

Guido Paolucci

Programme Manager, Secretariat for CEI Projects



Audited Facilities Description

Annex A

In this section all the industrial facilities benefiting from the Energy Audits Programme are presented with their main data, impression, major results and activities undertaken.



A.1 Skopje Rolling Mill FYR Macedonia

A.2 ISTIL Donetsk Mini-steel Mill Ukraine



In November 2004, D'Appolonia was responsible for carrying out an energy audit at a steel works located in Skopje, FYR Macedonia. This steel plant comprises the Hot Rolling Mill (HRM) and Cold Rolling Mill (CRM) facilities.

The performed Energy Audit (EA) showed a significant potential for energy efficiency improvement and energy savings. The starting point of the analysis was the evaluation of the relative energy consumption contribution of the different process units; the second phase of the analysis was the evaluation of the specific consumptions of the most energy intensive process units, and the split among the different energy sources. The analysis allowed the team to find the main areas for energy efficiency opportunities and elaborate an Energy Efficiency Improvement Plan (EEIP). EEIP could be implemented in one year, and through its realization an energy saving of about 400,000 GJ per year could be achieved. The capital investment required for the implementation of the proposed measures was estimated at EUR 4,500,000, while the average payback estimated in 2.5 years. The proposed measures will also enable the site to reduce its CO₂ emissions of about 423,000 tonnes over 10 years.

A particularly relevant intervention included in the EEIP is the *Fuel Switch at the Pusher Furnaces*. This intervention foresees the fuel switch of the two pusher furnaces at the Hot Rolling Mill from mazut to natural gas. The mazut handling and feeding system is complex and energetically expensive; this system is heated using steam produced both in the skids evaporative cooling system and in the flue gases boilers. The installation of new natural gas combustion system and relevant control systems will improve the energy efficiency of the furnaces and make all the generated steam available to other technological units.

Another relevant proposed measure is the *Improvement of Heating Efficiency of Acid Tanks at the Pickling Line in the Cold Rolling Mill*, by the replacement of the heating system based on direct injection of steam into the acid solution, with a more efficient heating system to achieve energy and HCl savings.

In March 2005, D'Appolonia was retained to carry out an energy audit at the "ISTIL Ukraine Mini-steel Mill" (ISTIL), a steel plant located in Donetsk, Ukraine.

ISTIL plant is composed of three shops: Scrap Yard Shop, Electric Arc Furnace Shop and Blooming Mill Shop.

The performed Energy Audit (EA) showed a significant potential for energy efficiency improvement and energy savings at ISTIL Donetsk. The starting point of the analysis was the evaluation of the relative energy consumption contribution of the different process units. Referring to the total energy consumption for the year 2004, EAF Shop is surely the most energy intensive part of the plant (57.8%). The second phase of the analysis was the evaluation of the specific consumptions of the most energy intensive process units, and the split among the different energy sources. The analysis allowed D'Appolonia Team to find the main areas for energy efficiency opportunities and in elaborating an Energy Efficiency Improvement Plan (EEIP), composed of four main interventions. EEIP could be implemented in three years, and through its realization an energy saving of about 550,000 GJ per year could be achieved. The capital investment required for the implementation of the proposed measures is approximately EUR 17,900,000, while the average payback is estimated in 2.5 years. The proposed measures will also enable the site to reduce CO₂ emissions by more than 100,000 tonnes a years.

A particularly relevant intervention included in the EEIP is the *Installation of a New Oxygen Unit*, which would provide the necessary oxygen, nitrogen and argon quantity to the Plant.

Another relevant proposed measure is the *Installation of new EAF Transformer of 87 MVA*.



A.3 Steel Plant Bosnia and Herzegovina

A.4 NATRON HAYAT Maglaj Pulp and Paper Mill Bosnia and Herzegovina

In June 2005, D'Appolonia was responsible for carrying out an energy audit at a steel plant located in Bosnia and Herzegovina.

The joint company which owns the plant developed a detailed investment Programme for restoration and modernization of integral production. At the end of this Programme the plant will operate through 5 production shops: Coke Oven Plant, Blast Furnace, Steel Making Plant, Rolling Mills, and Forge Shop. In addition a specific power generation and utilities management plant will be completely revitalised.

These investments provide significant opportunities for the implementation of energy efficiency actions and for the establishment of dedicated structures aimed at improving energy efficiency and upgraded environmental protection.

The Energy Audit (EA) showed a significant potential for energy efficiency improvement and energy savings at the steel plant. The most part of the energy analysis was based on the careful evaluation of the future development plan of the Company in particular concerning the possibilities offered by the complete restructuring and upgrade of the Power Plant and of all the equipment of the integral cycle. The analysis has allowed D'Appolonia Team in finding main areas for energy efficiency opportunities and in elaborating an Energy Efficiency Improvement Plan (EEIP), composed of four main interventions. EEIP could be implemented in about two years, and through its realisation an energy saving of about 2,800,000 GJ per year could be achieved. Capital investment is estimated at EUR 26,800,000, while average payback is estimated to be less than 4 years.

A particularly relevant intervention included in the EEIP is the *Reconstruction and Upgrade of the Power Plant* with the utilisation of COG/BFG as boiler fuel for the steam and electric generation.

Another relevant proposed measure is the *Basic Oxygen Furnace Waste Gas Heat Recovery*. The intervention will imply the installation of a steam turbine and electric power generator with a capacity of about 15 MW to produce electricity for internal use.

In November 2005 D'Appolonia was assigned to carry out an energy audit at the "Natron Hayat Maglaj Pulp and Paper Mill", a pulp and paper plant located in Maglaj Municipality, Bosnia and Herzegovina. Natron Company, recently acquired by the Turkish holding Hayat Group, is mainly composed of Paper Producing Lines, a Corrugated Board Plant and an Energy Production Department. Since the acquisition, the new management has taken serious initiatives to restart paper production and to complete the reconstruction of plant, which suffered great damages during the war period.

These new conditions provide significant possibilities and opportunities for the implementation of energy efficiency investments and for the establishment of dedicated structures aimed at improving energy efficiency and upgraded environmental protection.

The Energy Audit (EA) showed a significant potential for energy efficiency improvement and energy savings at Natron Hayat Maglaj. An Energy Efficiency Improvement Plan (EEIP), composed of 6 main interventions, has been proposed; EEIP could be implemented in about one year, and through its realization an energy saving of about 1,300,000 GJ per year could be achieved. The capital investment required for the implementation of the proposed measures is approximately EUR 11,000,000, while the average payback is estimated to be less than 3 years.

The most relevant proposed intervention is the *Revitalisation of recovery boiler LUKO 4 in the pulp production process*.

A.5 Malting Plants Regional

A.6 VICTORIA Group Agro-Industrial Sites Serbia



In May-June 2007, D'Appolonia was assigned to develop a set of energy audits in six Malting Plants in the Czech Republic, Poland and Serbia.

D'Appolonia energy efficiency team has analyzed installed equipment and process efficiency levels, energy management and consumption levels in the audited plants and has assessed the potentials for the implementation of interventions aimed at the increase of energy efficiency.

Six major energy efficiency interventions have been identified, preliminary discussed with the plants' staff during the audits and then studied in detail. The capital investment required for the implementation of the proposed measures at the different malting plants is approximately EUR 7,200,000, with estimated payback of around 8 years.

The most relevant proposed intervention is the *Kilns Replacement*, which foresees the replacement of two of the kiln systems with a new larger two floors round type kiln.

The possibility of adopting a cogeneration system in the plants has been analysed by the Project Team as a specific issue. A standard idea of cogeneration in a malting plant is to install a gas engine (turbine) to generate mechanical, thermal and electrical energy.

In July-August 2007, D'Appolonia was retained by the EBRD to develop a set of energy audits in three agro-industrial sites of the Victoria Group:

- Sojaprotein, Becej
- Veterinarski Zavod, Subotica
- VictoriaOil, Sid

D'Appolonia energy efficiency team analyzed operating equipment and process efficiency levels, energy management and consumption levels in the audited plants and has assessed the potentials for the implementation of interventions aimed at the increase of energy efficiency.

Nine major energy efficiency interventions have been identified, preliminary discussed with the plants' staff during the audits and then studied in detail.

The most relevant proposed intervention is the *new biomass Boiler Installation* at Sojaprotein, Becej, which foresees the installation of a biomass fed boiler that will cover all the steam needs of the plant. This boiler is expected to produce 15 tons/hr of 12 bars saturated steam, sufficient to cover the current steam needs of the process. This intervention will minimize or totally eliminate the Natural Gas consumption required by the two operating steam boilers. Through the implementation of this measure an energy saving of about 320,000 GJ per year could be achieved. The capital investment required for the implementation of the proposed measures has been estimated at EUR 3,000,000, with average payback of about 2 years. The proposed measure will also enable the site to reduce its CO₂ emissions of about 125,000 tonnes over 7 years.

Another relevant measure is the *new biomass Boiler Installation* at VictoriaOil, Sid, which foresees the possibility to substitute the two old mazout boilers with a new biomass fed unit (straw and hulls) with the same capacity.



A.7 Forging and Mechanical Plant Ukraine

A.8 Sevojno Brass & Copper Mill Serbia

D'Appolonia has been assigned to develop an Energy Efficiency and Process Optimisation Audit in the facilities of a Forging and Mechanical Plant located in Ukraine. The Energy Audit and process assessment activities included two on-site missions and a detailed process analysis aimed at identifying areas of technological improvement and optimisation at the relevant plant.

D'Appolonia's Audit Team has analysed the efficiency levels of the operating equipment and processes, has evaluated the energy management and consumption levels in the audited plant, has analysed the installed technologies and compared them to the best practice in Europe and has assessed the potentials for the implementation of interventions aimed at increasing energy efficiency levels and at improving the product-quality.

Twelve major interventions have been identified, preliminary discussed with the plants' staff during the audits and then studied in detail at D'Appolonia headquarters. Result of the studies is the proposed Energy Efficiency and Technological Improvement Investment Plan (EETIIP), which could be implemented in about two years. Through its realization an energy saving of about 990,000 GJ per year could be achieved. The capital investment required for the implementation of the proposed measures is approximately EUR 52,000,000, while the average payback is estimated in 3.5 years.

One of the most relevant proposed interventions is the installation of *New NG Heating Furnaces at Forging departments.*

In December 2004, MWH was retained by the EBRD to perform an energy audit of Valjaonica Bakra Sevojno Brass and Copper Mills, located in Sevojno, Serbia.

Valjaonica Bakra Sevojno Brass and Copper Mill was founded in 1955. With the annual capacity of 60,000 metric tonnes, it is the biggest producer of copper and copper alloys semi-finished products in the country. It is ranked among few top-class highly reputable large factories in its field, both in Europe and throughout the world. About 90% of its production is exported.

A three-member team, coordinated by MWH, toured the plant and as a result of the site survey, a list of energy efficiency measures was developed. Nine of the most promising measures were selected for analysis.

The study identified a total of approximately EUR 1,500,000 worth of potential energy savings from the recommended measures, equivalent to a reduction in energy consumption of 25,000 MWh, which represent approximately 25% of total energy consumptions. The capital investment required for the implementation of the proposed measures is approximately EUR 3,500,000, while the average payback before taxes is estimated in around 3.8 years. The proposed measures will also enable the site to reduce its CO₂ emissions by more than 30% annually.

The measures included a rehabilitation of electrical system, and the implementation of a Monitoring Control System. The system will be made up of several Control Process Units (CPU) installed strategically in the factory and connected each other with a bus line. Each CPU will manage independently several control loops maintaining the set up assigned for each parameter (temperatures, pressures, etc.).

A.9 Svilosa Pulp Mill Bulgaria

A.10 Starobeshevo Thermal Power Plant Ukraine



In May 2005, MWH completed the energy audit of Svilosa Pulp Mill, located in Svishtov, Bulgaria.

The Company is one of the very few market pulp producers in south-eastern Europe.

The site survey included a review of process operations and deeper analyses of those systems and processes that were identified to have the highest potential savings opportunities during the initial data review.

The company took the strategic decision to invest in the expansion of capacity at the site to allow production to almost double to meet the growing international demand for Svilosa's products. The staff was supportive and motivated and has already taken the initiative to define several opportunities to improve site energy efficiency through refurbishment of production processes.

The study identified potential energy savings from the recommended measures, equivalent to a reduction in energy consumption of 360,000 MWh. The capital investment required for the implementation of the proposed measures is approximately EUR 15,000,000, while the average payback before taxes is estimated in around 3.2 years. The proposed measures will also enable the site to reduce its CO₂ emissions by approximately 100,000 ton/year.

The site had several opportunities to improve the overall energy efficiency through review of the main auxiliary system design (chilled water system, compressors, oxygen and nitrogen production plant), refurbishment of some production processes (soda recovery boiler, debarking unit, washing unit), and replacement of old low-efficient equipment (pumps, motors, chillers and cooling towers, electrical transformers, and back-up compressors).

The Team recommended to develop and disseminate a global energy policy, and to establish quantitative energy savings objectives.

In June 2005, MWH performed an energy audit at Starobeshevo Thermoelectric Power Station, located in Donetsk Region, Ukraine.

The Starobeshevo thermoelectric power station supplies electricity to the Dombas area and heat to the village of Novy Svet, situated nearby the plant. The power station was constructed in three phases starting in 1954.

The station reached its maximum capacity of 2,300 MW in 1970s, then in 1980 three older units were decommissioned, leaving the total installed capacity at 2,000 MW.

The Management had identified in the refurbishment of one unit its principal objective to improve plant's overall efficiency.

The MWH team recognised the validity of a "vertical" approach (unit by unit) and confirmed that several actions planned for the unit could contribute to increase the electricity production yield. However, also a "horizontal" approach, where focus is kept on less capital intensive and short-term measures to improve auxiliary systems' efficiency, could be valuable in a short-term perspective. In fact several sources of waste energy were observed during the site visit such as: air leakages and suction on ductworks and heat exchangers, losses and lack of insulation materials.

The study identified potential energy savings from the recommended measures, equivalent to a reduction of 56,000 ton of equivalent fuel. The capital investment required for the implementation of the proposed measures is approximately EUR 8,000,000, while the average payback before taxes is estimated in 3.5 years.

The main measures identified included the Modernization of Low Pressure Cylinder of the turbine to increase the installed electric power and economic efficiency of the turbine, and decrease its heat rate. Moreover the Elimination of air cross flows to the air ducts of boiler and the VSD installation on feed water pumps were indicated as valid efficiency measures.



A.11 Food and Beverage Company Romania

A.12 Boni Holding Meat Processing Bulgaria

A food and beverage Company located in Romania was developing an expansion programme of the manufacturing capacity of some of its production plants.

The site Management had identified some energy efficiency opportunities such as the switching from Heavy Fuel Oil to Natural Gas, a cogeneration plant and CO₂ recovery from the process.

In December 2005 an energy audit was completed by a four-member team, coordinated by MWH.

The overall impression is that the management involved during the visit was very interested in achieving efficiency goals and managing complex multi-projects modernisation programmes.

As a result of the site survey, a list of eleven energy efficiency measures was developed, with a capital investment of approximately EUR 37,000,000, and average payback estimated at 2.5 years.

In May 2006, MWH carried out an energy audit at Boni Holding in Bulgaria.

The Boni Group started its activities in meat processing in 1992.

The activities carried out by the team focused on the analysis and the energy efficiency assessment of future projects rather than the identification of energy efficiency opportunities for the existing plants.

The staff met in the production facilities showed a good interest and enthusiasm in the activity and participate actively in order to collect as much data requested as possible.

As a result of the site survey, a list of energy efficiency measures was developed. The technical analysis was divided in two types: the assessment of the future project in respect to current situation from energetic and economic point of view, new recommendations identified by MWH team in order to improve the energy efficiency, considering as baseline the future situation.

The energy efficiency measures included the replacement of the existing boiler station at one of the meat processing companies with a new boiler with higher efficiency, the replacement of the old refrigerator units with an optimisation of the whole cooling system and also a plant for the biogas production.

The capital investment required for the implementation of the proposed measures was approximately EUR 765,000, while the average payback before taxes was estimated in almost 3.7 years.

A.13 LCA of Truck Refrigeration System Ukraine

A.14 Tiles Plant Ukraine



In truck refrigeration sector, to achieve accurate, cost effective temperature control of commodities and maximum product quality under all operating conditions, the choice of refrigeration system designs, refrigerants selection, materials and operating methods is critical. The right selection requires considerations on the refrigerant effect on energy use, environmental impact and operational safety.

Traditional systems use electric components that are powered by either a plug-in connection or, when over the road, by a separate diesel generator set providing the required electricity.

New technologies in truck refrigeration mostly refer to cryogenic methods that use liquefied gases for freezing applications (e.g. liquid carbon dioxide [L-CO₂] and liquid nitrogen [L-N₂]). These units have several advantages over the diesel powered TRU, including near-silent operation, lower emissions, no fluorocarbon refrigerant, and fewer moving parts.

The main purpose of this activity was to identify and to analyse the benefits of the envisaged technology from the energy saving and environmental viewpoint, with particular focus on the effect of carbon emissions.

Comparison of energy consumptions and emission productions was implemented under a "Life Cycle Analysis" approach.

In refrigeration systems of Cryogenic gases, the only source of energy and GHG emissions is related to electricity consumption for the air liquefaction and following separation of liquid nitrogen from the oxygen.

The extraction and oil refining of diesel are considered for the estimation of energy consumption and calculation of GHG emissions.

It can be concluded that, compared to the technologies commercially available, cryogenic refrigeration using LN₂ contributes to a significant reduction of GHG emissions.

In particular, compared to diesel-driven TRUs, emissions are reduced by a factor 4, while compared to eTRU technologies, emissions are reduced by a factor 2.5.

In April 2007 MWH performed an energy audit at a Tile Plant in Ukraine.

The Company was planning to install new manufacturing lines and new state-of-the-art technologies and equipment with the aim of expanding the existing production and to become one of the world's leading players in the ceramic industry.

The production is focused on the manufacturing of the following market sectors:

- Floor tiles
- Wall tiles
- Ceramic borders

The ceramic industry is overall thermal energy intensive, as key parts of the process involve considerable high temperatures.

The Management of the Company showed a good interest in improving energy efficiency.

As a result of the site survey, a list of energy efficiency measures was developed. For each measure proposed a feasibility study was undertaken. These studies analyzed current status of the system/process, with particular focus on main reasons of inefficiencies, technical recommendations on how to obtain energy savings, cash flow analyses to estimate financial parameters and GHG gas emissions reductions that can be achieved by implementing the specified measures.

The financial analysis showed that the capital investment required for the implementation of the planned and proposed measures is approximately EUR 16.5 million, while the average payback before taxes is estimated in almost 2.9 years. The proposed measures will also enable the Company to reduce its CO₂ emissions of approximately 90,000 tons per year.

Some of the project measures included were the *replacement of batch mills with continuous mills* that is the best technology at the moment available on the market for grinding ceramic bodies.



A.15 Astarta Sugar Mill Ukraine

A.16 Ukrtransnafta Ukraine

MWH undertook an energy audit at Astarta sugar mills in Ukraine in 2007. The Firm “Astarta-Kyiv” was established in March 1993 and is one of the leaders of the Ukrainian sugar sector. The Company focuses its operations on production and sales of sugar from sugar beet, sugar by-products and related services.

During the site visit, held from 7th to 11th May 2007, the MWH team visited three of the five Astarta sugar mills located in the Poltava Region. The average capacity of the sugar factories visited was included between 2,500 and 4,000 tonnes of sugar beet processed per day.

The main energy consumption of the Astarta sugar factories was concentrated in the boiler-house. The boiler-house generates the steam both to produce electric energy for process equipment, and to provide process heat to the entire factory. The core of the process is the Evaporation System. The total capital investment required for the implementation of the projects was worth EUR 10,000,000.

The estimated pay-back of the Energy Conservation Plan was estimated in about 2 years.

In terms of energy efficiency, after the implementation of the Energy Conservation Plan, Astarta Company could reduce the specific consumption by around 25% with CO₂ emission reduction of about 50,000 ton/year.

The consultants recently completed a further Energy Management Training to Astarta Management.

MWH carried out an energy audit at Ukrtransnafta, the national operator of the Ukrainian oil pipeline network. In March 2008, the MWH team met with the Ukrtransnafta Senior Management in Kiev assessing the energy management system, and visited the main pumping stations, identifying the most relevant energy saving opportunities.

The total length of the main pipelines on Ukrainian territory is 4,600 km, the input capacity is up to 114 million tonnes per year and output capacity is 56.3 million tonnes per year.

Ukrtransnafta introduced in 2001 a new monitoring and control system, which is in charge of managing the entire pipeline network. The system monitors flows, pressures, temperatures, cathodic protection, and it controls tanks and pipelines.

The facilities visited were well maintained and operated to meet the requirements of the process.

The energy saving projects identified during the site visit were associated to the improvement of the performance of the pumping sets, particularly aimed to allow operation closer to maximum efficiency.

List of Acronyms

Annex B

All-electric Trailer Refrigeration Unit	eTRU
Basic Oxygen Furnace	BOF
Best Available Technology	BAT
Central European Initiative	CEI
Control Process Unit	CPU
Electric Arc Furnace	EAF
Energy Audit	EA
Energy Efficiency Improvement Plan	EEIP
Energy Management System	EMS
European Bank for Reconstruction and Development	EBRD
Facilities Monitoring and Control System	FMCS
Green House Gas	GHG
Hot Water	HW
International Energy Agency	IEA
Integrated Pollution Prevention and Control	IPPC
Internal Rate of Return	IRR
Joint Implementation	JI
Key Performance Index	KPI
Multilateral Development Banks	MDBs
Soda Recovery Boiler	SRB
Technical Cooperation	TC
Trailer Refrigeration Unit	TRU
Variable Speed Drive	VSD

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