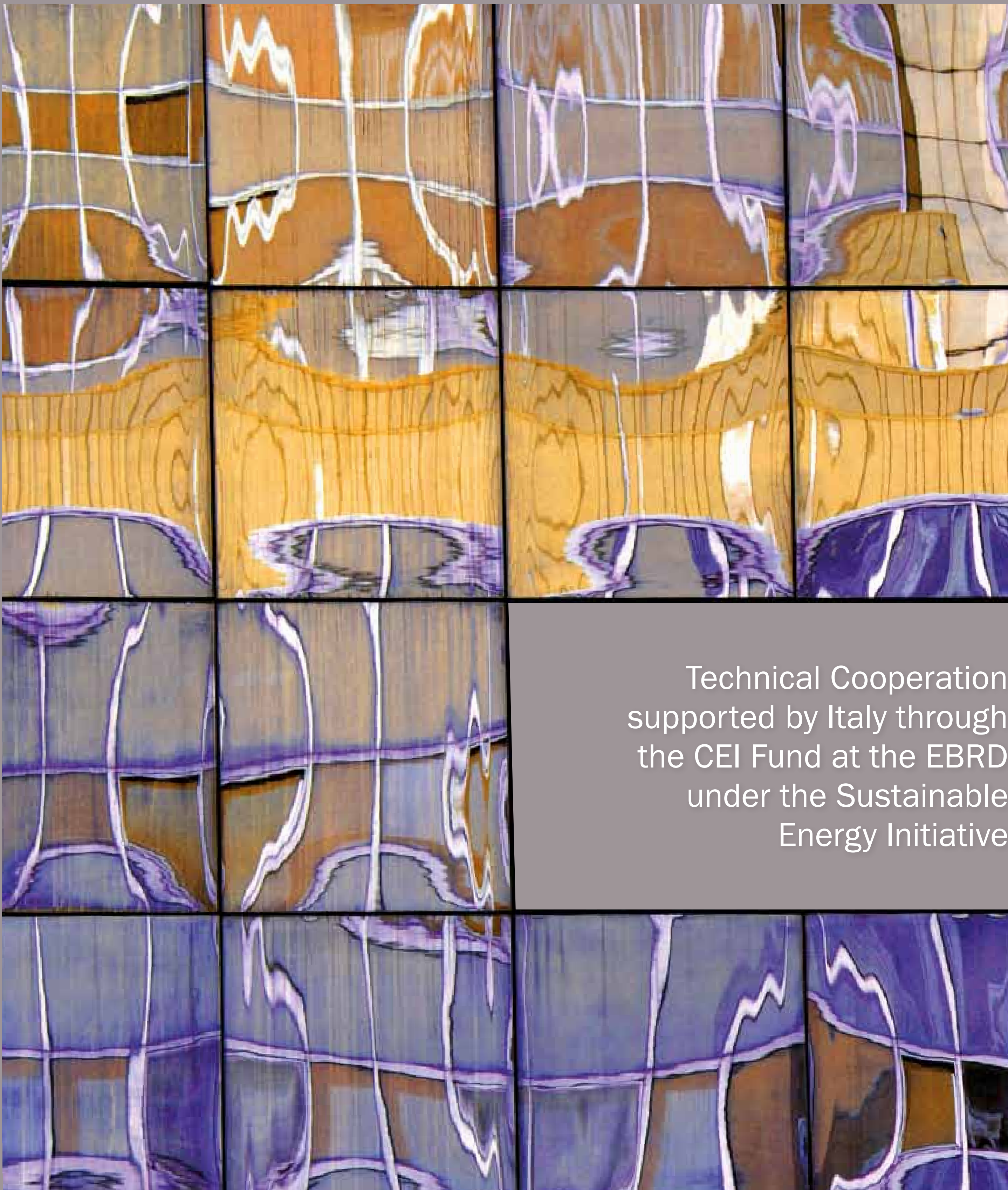
CENTRAL EUROPEAN INITIATIVE

European Bank
for Reconstruction and Development

INTEGRATED SUPPORT FOR ENERGY EFFICIENCY



Technical Cooperation supported by Italy through the CEI Fund at the EBRD under the Sustainable Energy Initiative

The EBRD is changing people's lives and environments from central Europe to central Asia. In 2011 the Bank began laying the foundations for the expansion of its operations to the southern and eastern Mediterranean (SEMED) region. Working together with the private sector, the Bank invests in projects, engages in policy dialogue and provides technical advice that builds sustainable and open-market economies.

The Central European Initiative

Established in 1989, the CEI is a regional forum for cooperation and consultation at political, economic and cultural levels in central and eastern Europe. It has 18 member states: Albania, Austria, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, the Czech Republic,Hungary, Italy, FYR Macedonia, Moldova, Montenegro, Poland, Romania, Serbia, the Slovak Republic, Slovenia and Ukraine.

Since its inception, the CEI's main aim has been to support transition countries in the process of integration with the European Union (EU). The Initiative particularly seeks to strengthen the institutional and economic capacities of its non-EU member states to bring them closer to the Union.

In 1992 Italy signed an agreement with the EBRD on the establishment of a CEI Fund "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 (later renamed Office for the CEI Fund at the EBRD) was established to manage the Fund, undertaking pre-investment and capacity-building operations for the identification, promotion and appraisal of projects, as well as activities related to their implementation.

The CEI Fund, to which the Italian Government has been the sole donor with a total contribution to date of €36.5 million, mainly provides grant-type assistance for specific components of technical cooperation (TC) projects. Since its inception, it has provided more than €22.2 million for TC funding. It has also contributed more than €1.4 million to the Know-How Exchange Programme, which supports transfer of best practice from the EU to the non-EU countries within the CEI and is the Fund's second most important instrument.

Foreword

BY TERRY McCALLION – DIRECTOR, ENERGY EFFICIENCY AND CLIMATE CHANGE

The world needs to improve the efficiency with which it uses its resources. As the urgency of the global climate change challenge increases, it is essential to develop innovative approaches to financing energy efficiency as a key element of climate change mitigation. The EBRD was the first international financial institution to establish a specialised energy efficiency team (in 1994), and has accumulated valuable expertise in this respect. With its transition and environmental mandate, as well as its private sector orientation and regional knowledge, the Bank is well placed to assist its countries of operations in their transformation from energy-intensive to energy-efficient economies.

The EBRD launched the Sustainable Energy Initiative (SEI) in 2006, reflecting the increasing importance of energy efficiency measures to the region and the pressing need for multilateral development banks to address the climate change challenge.

The Central European Initiative (CEI) member countries have traditionally been intensive energy consumers, with some ranking among the highest greenhouse gas (GHG) emitters in Europe. In order to ensure business and economic competitiveness and to reduce reliance on imported energy resources, governments and companies have targeted energy efficiency as a strategic priority.

Italy, which has entirely financed the CEI Fund at the EBRD, and other donors have collaborated with the Bank on sustainable energy activities in a dedicated and systematic way, developing an integrated approach through investments and the introduction of best practice in technology and management techniques.

This is particularly relevant at corporate-level in the industry, agribusiness, transport, retail and real estate sectors, where the EBRD has developed a unique strategy combining technical assistance with tailored financing instruments to promote competitiveness, innovation and productivity improvements.

The Bank integrates traditional tools such as energy audits with sound capital investment appraisals, energy management support and the application of corporate policies addressing sustainability concerns.

The EBRD provides these services by blending its own skills and resources with external specialists funded through the contributions of donors such as Italy through the CEI Fund.

They not only supply sponsors and business owners with information on profitable energy efficiency opportunities, but also help improve market conditions for technology suppliers and service providers and promote innovative skills. They have proven a cost-effective method of translating specific investments into energy efficiency gains.

Thanks to the contributions of the CEI Fund and other donors, the corporate sector has become the main recipient of SEI finance. In 2012 the EBRD provided over €2.2 billion in finance for sustainable energy projects, a third of which in direct lending to industrial and agribusiness corporates and transport operators.

Since 2006 over 250 technical cooperation projects worth €9.1 million (including energy audits, feasibility assessments, technology reviews and energy management assistance) have been implemented with the support of 16 different donors. The audits resulted in 100 new energy efficiency schemes, amounting to over €1.8 billion of investment, in industrial companies, food processing operations, transport operations and the building sector. Of these, 32 audits have been supported by Italian resources through the CEI Fund. These projects are estimated to have cut CO_2 emissions by 6.4 million tonnes per annum.

01

The CEI Fund/EBRD energy efficiency agenda

- The strategies of the CEI Fund at the EBRD, elaborated by the Office for the CEI Fund, and the EBRD in agreement with the Italian Ministry of Foreign Affairs – Directorate General for the European Union, regard Sustainable Energy measures across all sectors as a top priority. In this context, the contribution of the CEI has been instrumental in many respects.

- The Fund, entirely funded by Italy, has provided support to the Industrial Energy Audit Programme of the Bank to help maximise sustainable energy investments and introduce best practice in technology and management techniques.

- It has also supported market demand studies, heralding the establishment of Sustainable Energy Finance Facilities (SEFFs) which provide capital and promote nascent markets for renewable energy generation.

- Through its support for the establishment of the Western Balkans Sustainable Energy Financing Facility (WeBSEFF), the CEI has contributed significantly to the preparation and operation of an innovative financing mechanism in the Western Balkan region.

- Since 2004 the CEI Fund has advanced about €2.3 million to the Sustainable Energy Initiative (SEI), leveraging about €400 million of investments through the EBRD.

- The Fund is set to remain a strategic contributor by providing finance for new areas of planned activity and fostering the development of innovative instruments for pursuing the evolving SEI agenda.

- The strategic vision that Italy has given to the CEI Fund and the flexibility of its funding mechanisms combine well with the aim of the EBRD to strengthen its role as a leading institution in the CEI region, promoting energy sustainability and supporting the introduction of low carbon growth models.

02

Integrated support for increased energy efficiency

In the countries of operations of the CEI Fund and of the EBRD, energy has typically been cheap in past years. Companies have traditionally been slow to consider environmental issues and improve their energy 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 of the competitive advantage that arises 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 long-term company profitability.

Despite a significant potential for savings, a wide range of information gaps, market failures and policy imperfections still hold back investment. However, this has provided the opportunity for the EBRD to become involved by blending its financing experience with technical assistance for pilot projects.

In addition, most of the enterprises and production facilities in the region have lacked data on their internal energy use and the operational parameters of their systems and processes. This information gap hinders the adoption of energy efficiency technologies and jeopardises the ability of companies to optimise the configuration and utilisation of systems and new equipment. Operational energy efficiency is further constrained by the lack of internal competences in managing company energy use through specific energy-saving strategies.

Against this background, the cooperation between the EBRD and the CEI Fund addresses companies' needs through assistance in identifying the necessary measures to be implemented and the best practices to be followed.

The EBRD has expanded its energy-related activity thanks to the contribution of the CEI Fund since 2004. CEI-financed energy audits and capacity-building programmes have been instrumental in positioning the EBRD as a leading financial institution promoting energy sustainability and pursuing business opportunities associated with energy efficiency investments. The CEI Fund has also helped enhance awareness within the Bank about the strategic importance of energy efficiency in improving the competitiveprofile of industrial operations.

> Energy audits aim to identify potential energy efficiency opportunities and investments

In recent years, the CEI Fund has increasingly collaborated with the EBRD's Energy Efficiency and Climate Change team. Both the Bank and the CEI recognise the promotion and development of energy efficiency and security of supply as key priorities.

Integrated Support Initiative

The collaborative services offered by the EBRD and CEI Fund provide integrated support for companies aiming to enhance their energy efficiency.

This support helps companies through the whole energy efficiency implementation process, starting from the initial appraisal of existing energy use, through the identification of the best technologies/practices to be adopted, and finally to their incorporation in companies' core activities.

The fundamental components of integrated support are:

- energy audits
- support in project implementation
- know-how transfer.

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This support helps companies through the whole energy efficiency implementation process

Energy audits aim to identify potential energy efficiency opportunities and investments. Thanks to data collected through dedicated site visits by key experts in specific fields, the existing energy consumption status of a company can be determined. A comparison of the results with international benchmarks enables an evaluation of how a particular company compares with other firms operating in the same specific sector.

Such comparisons are useful for the selection of appropriate technologies to help attain international benchmark levels. Assistance is also provided for project implementation, starting with a feasibility study and definition of the technical specifications related to the measures to be implemented. The support then extends to the preparation of tender documentation for the selection of suppliers, to the technical and contractual evaluation of offers and to supervisory activities during the construction phase.

In addition, technical assistance is provided through dedicated company training aimed at transferring the necessary know-how for the proper operation of newly-installed equipment and implementation of energy management practices.

2.1

Corporate-level integrated support

Case study: Victoria Group (agribusiness company, Serbia)

The following example of integrated support in action focuses on the Victoria Group, which operates three industrial sites Sojaprotein, Veterinarski Zavod and VictoriaOil – in Serbia.

Energy audit

Energy audits were performed by D'Appolonia, an engineering consultancy firm (see Annex), at the three sites in 2007.

Sojaprotein was established in Becej in 1978 in the centre of the Pannonian plain. The plant processes non-genetically modified soybeans at a rate of 900 tonnes per day. Its two main energy sources for the production process are electricity and natural gas, which it buys from national suppliers. It also uses a small amount of diesel for transport purposes.

Veterinarski Zavod is an animal food processing plant located in Subotica. The meal from different types of seeds and other types of raw materials are milled, mixed and packaged at the site. Annual production is 60,000 tonnes. The pet food unit, with mixing, extrusion, drying, granulation and packaging facilities, has a production capacity of 2,000 tonnes per year. The plant also engages in the production on a smaller scale and on request of vaccines, pesticides, distilled water and household disinfectants. Veterinarski Zavod uses electricity and brown coal in its production process and buys both from regional suppliers.

VictoriaOil was established in 1980 and is located in Šid, close to the Croatian border. The plant is divided in two parts. The first is a unit for seeds processing (mainly sunflower, but also soy and rapeseed) to produce crude seed oil and meal for animal feed. The second is a new facility for oil refining and trans-esterification for the production of biodiesel. The new facility started operating in April 2007 and at the time of the site visit was

"The energy audit of VictoriaOil involved analysing the operating equipment and the process efficiency, energy management and consumption levels

still in the commissioning phase. The old plant processes 150,000 tonnes of seeds per year. The new facility receives the crude seed oil from the old plant and from the marketplace, and has a processing capacity of 300 tonnes per day of raw input. The production capacity of biodiesel is about 300 tonnes per day. VictoriaOil uses two external energy sources for the production process electricity and mazout – and one internal source the processing biomass by-products (husks). The plant buys electricity and mazout from regional suppliers. The energy audit of VictoriaOil involved analysing the operating equipment and the process efficiency, energy management and consumption levels, and assessing the potential for the implementation of energy efficiency interventions.

Audit findings

The main findings at each plant are summarised below.

- Sojaprotein: there was scope for the installation of a new biomass boiler to replace existing boilers fired by increasingly expensive natural gas, the silos units and the conveyors were old and there was high water consumption. An energy control system had been recently implemented.

- Veterinarski Zavod: most of the processing units and auxiliary services were very old, the energy consumption was not monitored, the existing coal-fired boiler needed to be replaced with a new natural gas (NG) boiler and steam pipes needed insulating or replacing.

> The energy audits showed that there was good potential for energy efficiency improvement and savings at all of the plants

- VictoriaOil: the construction of a new biomass-fired boiler was anticipated, steam lines required better insulation and condensate loss reduction, electric motors were old, the vapour from the toaster could be re-used in the miscellanea distillation, and there was a lack of measuring and monitoring practice regarding the energy supply system.

Proposed energy efficiency measures and investments

The energy audits showed that there was good potential for energy efficiency improvement and savings at all of the plants, although to a varying degree of achievable benefits. Nine major interventions were identified (see Table 1), discussed with the plants' staff during the audits and then studied in detail.

The **Sojaprotein** plant attracted the highest investment proposal (at €3.2 million), envisaging the installation of a new biomass boiler and the replacement of electric motors. The new boiler would cover all the steam needs of the plant, replacing the two existing NG-fuelled boilers (which would be kept in reserve). The biomass would be collected from the area surrounding the plant, while NG consumption would be almost totally eliminated.

The projected investment cost for the **VictoriaOil** plant was about €2 million. The installation of a new biomass boiler (at €1.5 million) in place of an existing heavy fuel oil (HFO) boiler would reduce fuel consumption and greenhouse gas emissions. Lesser investments would include the renewal of the insulation of steam pipes and the optimisation of the condensate recovery system, the re-use of the vapour from the toaster for miscellanea pre-heating, the replacement of electric motors and the installation of a measuring system for energy consumption.

Total investment in the **Veterinarski Zavod** plant was projected at about €1 million, which mainly reflected the replacement of existing old coal boilers with a new NG boiler and would allow a general increase of efficiency, flexibility and a reduction of maintenance costs. Lesser investment would target the renewal of steam piping insulation and the optimisation of the condensate recovery system.

Table 1
Proposed energy efficiency actions for Victoria Group plants

Action	Plant	Estimated cost (€,000)	Energy savings (gigajoules per year (GJ / year))
New biomass boiler installation	Sojaprotein – Becej	3,000	318,402.7
Evaluation of potential for replacement of electric motors	Sojaprotein – Becej	260	5,115.6
Replacement of existing coal boilers with new NG boiler	Veterinarski Zavod – Subotica	1,000	9,809.1
Replacement and optimisation of steam distribution lines	Veterinarski Zavod – Subotica	20	1,891.8
New biomass boiler installation	VictoriaOil - Šid	1,500	169,814.8
Optimisation of steam distribution lines and condensate recovery	VictoriaOil - Šid	50	3,086.9
Re-use of the vapour from the toaster in the miscellanea distillation	VictoriaOil - Šid	320	2,617.2
Evaluation of potential for replacement of electric motors	VictoriaOil - Šid	260	5,115.6
Measuring system for energy consumption installation	VictoriaOil - Šid	200	5,115.6

> Additional support was provided during the selection process of potential suppliers of the identified equipment and systems

Support in project implementation

Following the identification of energy efficiency measures for the Victoria Group plants, project implementation support was provided. The first step of this phase involved the drafting of the technical specifications relating to the proposed investment in order to define the main requirements of each plant's systems.

For example, four boiler houses mass flow balances were carried out in order to ascertain the nominal capacity, the operating pressure level and the temperature necessary to satisfy the plant requirements. In addition, details in terms of weight and dimensions as well as permissible environmental emission values were specified and the appropriate location and space needs for the new installations were assessed. Regarding the optimisation of steam distribution lines, the main technical parameters of insulation were evaluated (type of material, transmittance, amount) as well as the layout for new piping dedicated to condensate recovery.

Additional support was provided during the selection process of potential suppliers of the identified equipment and systems. References and experience in similar projects were evaluated to short-list those suppliers to whom technical specifications could be submitted.

The next step focused on support during the tendering phase, including the evaluation of supplier proposals in terms, for instance, of adherence to technical specifications, capital investment, typology of supply and maintenance contract, implementation schedule, and so on. Support was also provided during post-selection negotiations with suppliers.

Once the improvements had been implemented, a visit to each plant was performed for the purpose of evaluating their operation in the new configuration and assessing potential deficiencies of the installed equipment.

> Upon the completion of the projects, a training programme for the staff of the plants was conducted

Know-how transfer

Upon the completion of the projects, a training programme for the staff of the plants was conducted. It dealt with the most important aspects of energy analysis and technical/ financial evaluation, such as:

- energy auditing principles and different auditing approaches
- financial and economic issues
- data collection and on-site interaction with plant staff
- environmental benefits
- auditing of specific technical issues (electrical systems, motors and drives, boiler houses and steam generation systems, compressed air units, heat recovery options, and so on)

> The training also contained specific instruction in the proper operation of the newly-installed equipment

- benchmarking analysis
- identification of areas for improvement and further energy efficiency measures to be addressed
- general analysis and assessment of achievable energy savings
- calculation of financial costs and savings associated with proposed actions
- audit reporting.

In addition, the training also contained specific instruction in the proper operation of the newly-installed equipment. The programme was based on modern management principles and active learning techniques. The selected topics were demand-driven, and designed to tackle those areas where skills and knowledge of energy management were most required.

03

Technical assistance in identifying energy efficiency opportunities

Body text

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An energy audit aims to define potential areas of improvement with regard to energy use

Energy audits

The process of determining a more energy-efficient means of carrying out a process or activity is based initially on an evaluation of existing circumstances in terms of energy utilisation. An energy audit aims to define potential areas of improvement with regard to energy use. Audits carried out within the framework of the CEI Fund Integrated Support Initiative address the following aspects, depending on the sector:

- **industry:** evaluation of the energy consumption of particular industrial companies and identification of energy efficiency measures with regard to plant processes, utilities and energy management
- **buildings:** evaluation of the energy consumption of certain building types and identification of potential measures to achieve energy savings and improve internal conditions in terms of comfort
- **transport:** evaluation of the energy consumption by particular transport services and identification of possible measures to reduce energy use and improve service quality.

> The site visit is a fundamental aspect of the energy audit procedure

The site visit is a fundamental aspect of the energy audit procedure. It involves a visual assessment of the audit subject (whether a facility, building or form of transport) and is performed by an audit team with expertise in the specific field of the assignment. The visit enables the team to collect all data necessary for an analysis.

The site visit is followed by the energy consumption analysis phase, through which the audit team performs a simulation, on the basis of the collected data, in order to evaluate the consumption of energy sources by the audit subject. The results of the simulation are useful for comparing consumption values with international and/or local benchmarks. This enables an estimation of the achievable improvement in consumption and, as a consequence, the potential investment required to realise it. The technological requirements specifications of proposed efficiency measures are always defined in terms of the best available technologies (BAT) for a specific sector: the implementation of such technologies enable maximum energy savings, which generally exceed those defined by the international benchmarks.

Once the proposed energy efficiency measures are selected and the potential energy savings estimated, a financial analysis is performed. The outcome of this phase is a fundamental element of the final assessment of the feasibility of a project.

3.1

Industry

Case study: KCM (lead and zinc producer, Plovdiv, Bulgaria)

KCM SA is a lead and zinc production company in Plovdiv, Bulgaria, selected under the CEI Fund programme for an energy audit which was conducted by D'Appolonia in 2009. KCM started zinc and then lead production in 1961 and 1963, respectively, and has become the largest supplier in Bulgaria. Both production lines are located in one production site, with the purpose of optimising technological integration and overall consumption of primary and secondary materials. The purpose of the audit was the evaluation of the efficiency of the existing process technology and equipment, the energy management system and the energy consumption trend in order to identify potential efficiency opportunities. Four significant interventions were identified during the site visit and were added to three major modernisation projects already identified by the plant management. The proposed interventions were discussed with the plant staff during the energy audit.

The KCM plant recorded good operating performances, in line with the European average for such an industrial facility. At the environmental level, the standards of EU law have been applicable since Bulgaria's accession to the European Union in 2007. At the time of the energy audit, several investments for increasing the production level and/or the efficiency of some process units had

> “The audit data highlighted significant possibilities for efficiency improvements from all the main energy inputs, with consequent potential for substantial cost savings

been scheduled by KCM or had already been implemented—for example, a new roasting line and sulphuric acid plant for the zinc production line. The management was nevertheless open to further potential energy efficiency improvements aimed at optimising process operations, in particular those which would reduce energy consumption across the board.

Various sources of energy are used for KCM’s operations, namely electricity, natural gas, heavy fuel oil, coke and heat. The company did not have a power generation facility installed on-site, which meant that all the electricity consumed was purchased from the national grid. It had however installed a steam generation system on-site, using waste heat from the production process, natural gas and heavy fuel oil. Lead and zinc production processes are generally highly energy-intensive, incurring significant energy expenditures for companies (more than €30 million in 2008).

An additional €13 million was spent on energy by KCM in 2008 compared to 2006, mainly due to an extra €3-4 million spent on each of three energy sources (natural gas, electricity and coke).

The audit data highlighted significant possibilities for efficiency improvements from all the main energy inputs, with consequent potential for substantial cost savings.

The measures identified took into account existing and future production and energy consumption scenarios, and aimed to reduce energy use and greenhouse gas emissions through the reconstruction, upgrading or replacement of process and/or utilities equipment.

Precise controls on energy consumption values would allow the achievement of significant energy savings

Audit findings

A general modernisation and reconstruction process was already on-going at the KCM plant. Some parts of the zinc facility were being upgraded in order to achieve higher productivity and quality. At the lead plant, meanwhile, there was scope for greater energy efficiency through modernisation of the production lines.

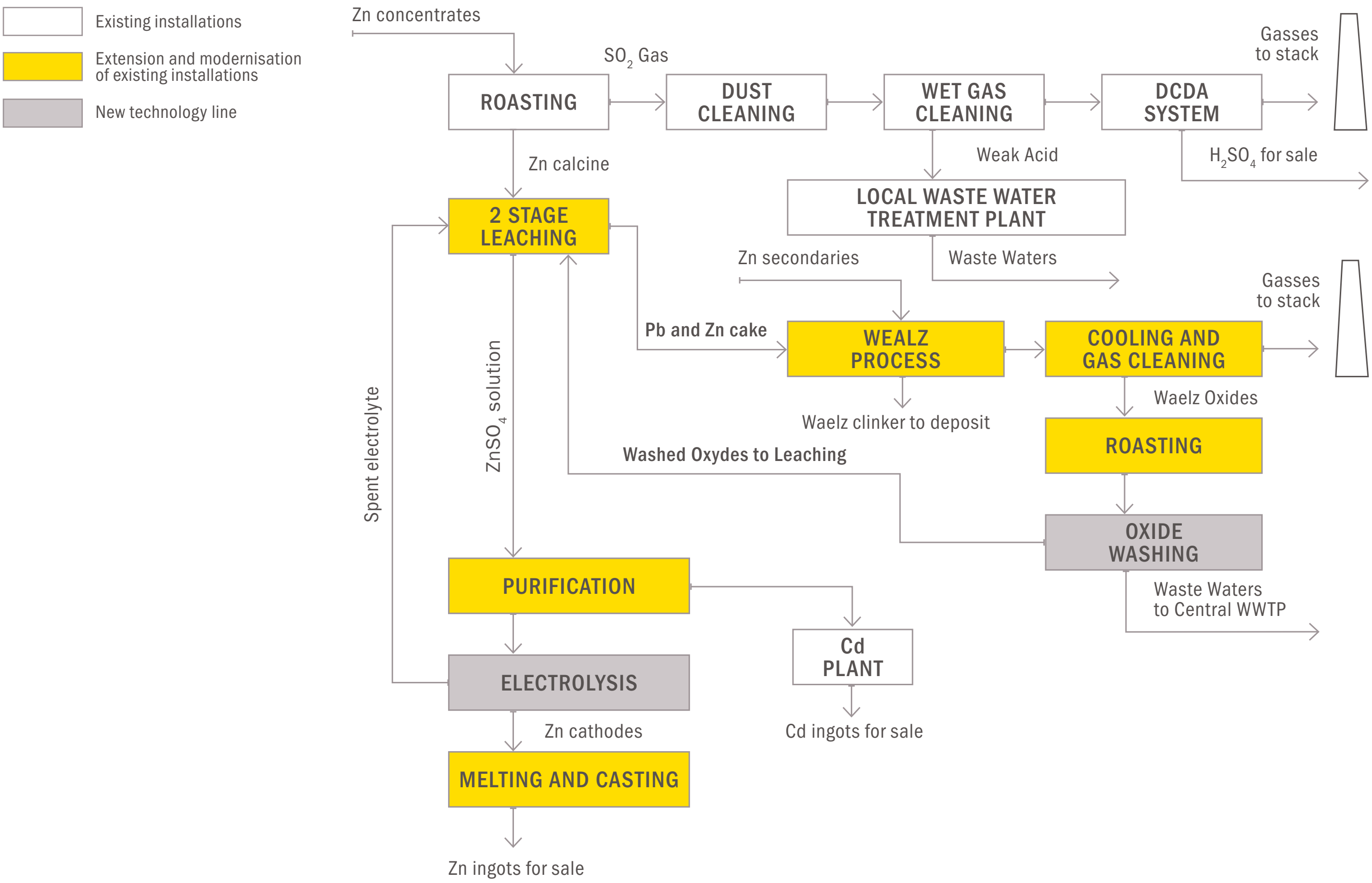
Neither the lead nor the zinc plant had proper electronic systems for measuring and monitoring the consumption of the different energy carriers. Precise controls on energy consumption values would allow the achievement of significant energy savings.

Electromechanical systems (motors, fans, and so on) needed regulating to allow maximum efficiency in terms of energy use, for example, through the installation of variable speed drives (VSDs).

The main electric sub-station had very old transformers—two installed in the 1960s and one in the 1980s—which needed to be replaced by new high-efficiency ones; in addition, the transformation from high voltage (HV) to low voltage (LV) for the electrolysis needed to be transferred in the immediate proximity of the Cell House plant section in order to avoid transmission losses inside the plant.

The lamination of steam produced by the waste heat boiler at the roasting needed to be lowered in pressure for the correct utilisation at the plant; this lamination was being performed by means of throttling valves, therefore dissipating energy which could be better used in a back-pressure turbine at the plant.

Figure 1
Investment for zinc production process proposed by KCM



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The measures aimed to reduce energy use and greenhouse gas emissions through the reconstruction, upgrading or replacement of process and equipment

Table 2
Proposed energy efficiency actions for KCM plant

ID	Action	Total cost (€,000)	GHG emission reductions (tonnes CO_2/year)
L1	Smelting modernisation	49,600	69,179.3
L2	Reconstruction and fuel switch in by-products refining	5,500	2,402.7
Z1	Modernisation of the zinc cell house	56,000	15,937.5
Z2	Co-generation at roasting furnace	1,100	4,405.3
H1	Installation of VSDs on motors in fuming, lead raw materials and Waelz bag filters	299	1,226.4
H2	Main electric substation transformer replacement	3,960	26,551.4
H3	Automation of the energy measurement and management system	923	9,258.6
	Total	**117,382**	**128,961.1**

Proposed measures and investments

A summary of the proposed improvements is listed in Table 2; the measures applicable to the lead plant are identified by the letter L and those to the zinc plant by the letter Z, while more “horizontal” actions (actions that can be applied to those equipments that are not process specific but are present in all industrial plants ‘horizontally’) common to both plants or to utilities are marked with the letter H. The actions L1, L2 and Z1 refer to the production modernisation measures proposed by the KCM management and accounted for about €110 million of which €60 million would be recouped through energy efficiency savings), plus some additional labour, maintenance and operative costs. The remaining four actions Z2, H1, H2 and H3 – were purely energy efficiency measures accounting in total for about €6.3 million (which would be recouped completely by savings).

For lead production the SEC would fall by approximately 35 per cent after implementation of the proposed measures

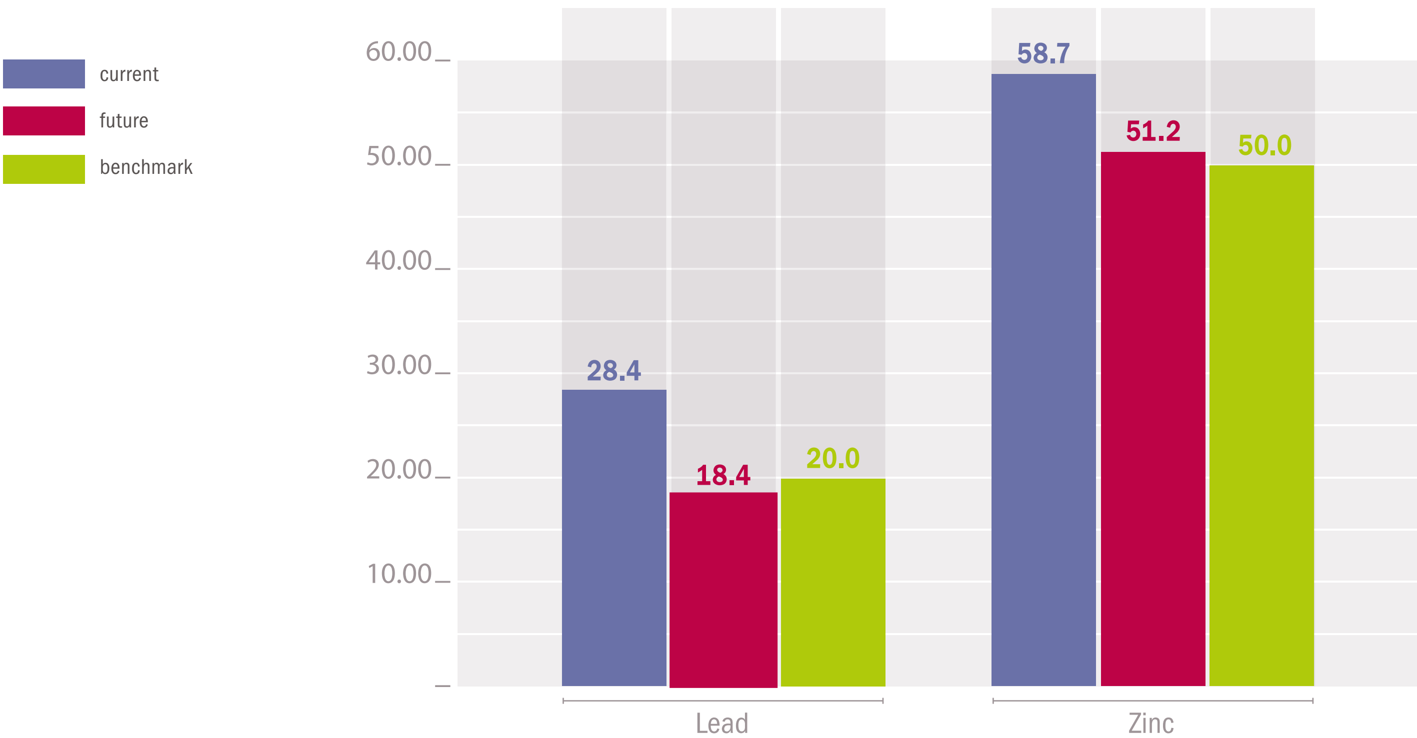
Energy consumption after modernisation

The specific energy consumption (SEC) values of the lead and zinc production lines before and after implementation of the proposed efficiency actions were simulated and compared, and a benchmark comparison was conducted to assess effectiveness of the measures in filling the gap between KCM and best EU standards (see Figure 2).

For lead production the SEC would fall by about 35 per cent after implementation of the proposed measures.It would also be lower than the benchmark for lead production (at 15-20 GJ/t lead).

The SEC of the zinc production line would fall from 58.7 GJ/t to 51.2 GJ/t after upgrading of the cell house and renewal of the main electric station, compared with the benchmark SEC of 40-50 GJ/t.

Figure 2
Comparison of production line SEC values before and after implementation of proposed investment measures (in gigajoules per tonne (GJ/t))



3.2

Buildings

Case study: Bingo (retailer, Bosnia and Herzegovina)

Bingo, whose headquarters are located in Tuzla, started business in 1993 and has become the biggest retail chain in Bosnia and Herzegovina. Bingo employs more than 4,000 workers and has 65 stores, 62 of which are located in the Tuzla region, two in Republika Srpska and one in Brčko District.

About 30 per cent of Bingos' stores are located in new buildings constructed on greenfield sites, while the rest occupy old refurbished premises.

Bingo outlets include hypermarkets (with sales areas between 5,000–10,000 square metres), superstores (1,400– 5,000 square metres), supermarkets (280–1,400 square metres) and convenience stores (less than 280 square metres). Convenience stores make up about 50 per cent of outlets, while hypermarkets and superstores constitute only 34 per cent but cover about 90 per cent of total sales area.

In 2011 an energy audit was conducted to assess performance, to identify cost-effective energy efficiency and sustainable energy opportunities related to facility management, and to review operation and maintenance (O&M) practice for the Bingo retail chain.

> Inadequate maintenance of energy-using systems is a major cause of energy waste in retail outlets

Audit findings

As mentioned above, hypermarkets and superstores constitute most of the sales areas. Such stores are typically located in new buildings, have only one floor and sell both food and non-food goods. Often they may house restaurants, bars and play areas for children, and may rent space to other services such as perfumeries, jewellers and pharmacies.

The typical design characteristics of these buildings can be summarised as follows:

Building structure
The load-bearing structure is made of a mesh of concrete columns and metal beams. The façade and the roof are of pre-constructed sandwich panels (U-value of 0.29 W/m2K).

Windows and doors
Windows are double-glazed with 12–16 mm of spacing. In old buildings the glass is not treated and the gas filling between two glazes is dry air. Typical materials used for frames are aluminium and PVC. A part of the front façade often comprises full-length windows. Such windows are made of selective green glasses which reduce heat gain and glaring. External doors are equipped with air curtains to minimise heat loss due to frequent opening and closure cycles. Sometimes, where space allows, there is also a lobby with a second door.

Lighting
T5 fluorescent tubes constitute 80 per cent of indoor lighting used in the Bingo chain, while T8 tubes make up the rest. The oldest buildings are still using T8 tubes with electromagnetic ballast,

> Food refrigeration is one of the most important sectors in terms of energy consumption in supermarkets

while newer ones are adopting more advanced T5 tubes with electronic ballast. The typical installed power supply for lighting (including external lighting) is around 60 kW. Lamps used for this purpose are mainly high-pressure sodium (80 per cent) and metal halide (20 per cent).

Food refrigeration

Food refrigeration is one of the most important sectors in terms of energy consumption in supermarkets.

In the Bingo chain about 70 per cent of fridges operate at medium temperature (above 0°C) and the remaining 30 per cent at low temperature (-18°C). In the typical store, the total installed power is about 30 kW for medium temperature fridges and 2.5 kW for low temperature.

Medium temperature fridges are usually connected to a centralised system fed by three compressors, while each freezer is provided with an independent plug-in system. About 95 per cent of low temperature fridges are closed to minimise heat loss, but are equipped with traditional electrical defrosting systems. Medium temperature fridges, on the other hand, are always open (for marketing purposes) and do not have a second air curtain installed. To improve their performance, they are usually provided with night blinds that reduce losses when the store is closed. The most common refrigerants used by the Bingo chain are R404 and R22.

> Regarding specific GHG emissions, the reason mainly lies in the widespread use of poor quality coal, both in power generation and in the production of thermal energy

Heating, ventilation and air-conditioning
Conventional air handling units are not commonly used in Bingo stores for heating, ventilation and air conditioning. Air changes are generated by uncontrolled natural ventilation through open doors and other air intake grills located in walls. In the Tuzla region, where most of the stores are located, air temperature control is not generally a significant issue, as critical climatic conditions are usually only recorded during winter. Internal air is heated or cooled through aerotherms evenly located in the store sales area. The aerotherms are, in turn, fed with hot or chilled water produced in the central boiler plant or in the chillers. About 80 per cent of boilers are coal-fired, while the rest run on natural gas or are connected to district heating. Only three stores use wood pellet as fuel.

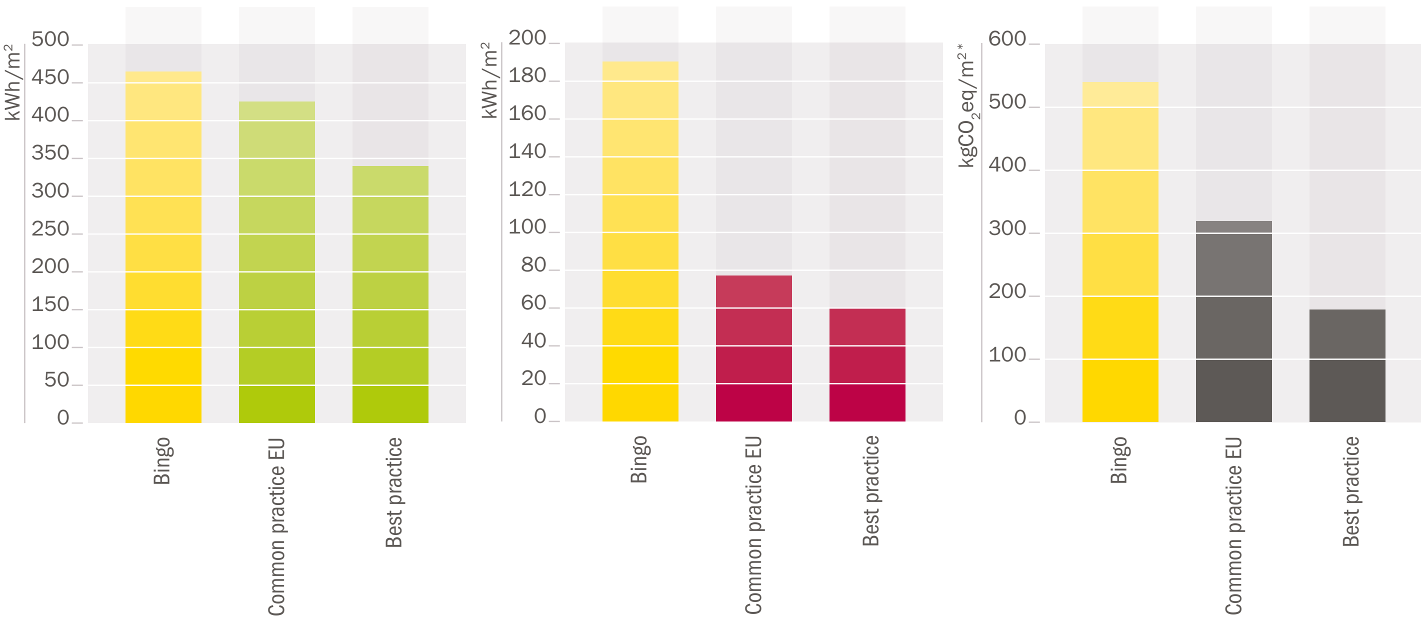
Domestic hot water
In typical Bingo outlets, domestic hot water (DHW) is heated by stand-alone electric boilers or by heat exchangers connected to the central boiler.

Energy performance assessment

As superstores constitute most of the sales area surface in the Bingo chain, an energy performance assessment was carried out for a typical superstore with an area of 3,000 square metres. The assessment sought to evaluate the energy consumption and GHG emissions of the superstore on the basis of the data collected through the site visit and staff interviews. The assessment results are shown in Figure 3 below, which includes EU and international benchmarks.

It can be seen that the electricity consumption in the Bingo superstore was similar to European common practice, while the thermal energy and GHG emission values and heating consumption were much higher. In respect of heating consumption, the difference could reflect harsher climatic conditions, poor insulation of old buildings and/or the low efficiency of coal-fired boilers. Regarding specific GHG emissions, the reason mainly lies in the widespread use of poor quality coal, both in power generation and in the production of thermal energy.

Figure 3
Energy consumption and emissions comparison between Bingo superstore and EU/international benchmarks: electricity (left), thermal (middle), GHG emissions (right)



* Amount of emissions of CO_2 equivalent per square metre

"It can be seen that the electricity consumption in the Bingo superstore was similar to European common practice, while the thermal energy and GHG emission values and heating consumption were much higher

Table 3
Proposed energy efficiency measures for assessed Bingo superstore

Action	Total cost (€)	Energy savings (MWh/year)
Replacement of T8 lamps with T5 lamps	16,200	17.4
Installation of electronic expansion valves	7,500	21.3
Heat recovery in food refrigeration systems	7,000	31.5
High-efficiency fans for display cases	2,700	11.5
Double air curtain in display cases	3,700	12.3
Total	**37,100**	**9,373**

Table 4
Proposed energy efficiency measures for new Bingo stores (including new outlet in Mostar)

Action	Total cost (€)	Energy savings (MWh/year)
Installation of PV panels	640,000	235.0
Installation of LEDs	30,000	50.2
Installation of water source heat pump in new Mostar store	40,000	41.3 (electricity); 308.2 (coal)

Proposed energy efficiency measures

The proposed energy efficiency measures for existing and new Bingo stores are detailed below and the achievable savings and financial parameters are summarised in Tables 3 and 4.

Measures for existing stores

- Replacement of existing T8 lamps with T5s without changing existing fixtures and using an adapter. T5 lamps have 10 per cent higher performance in terms of lumen per watt (lm/W) than T8s and have longer lifespans
- Installation of electronic expansion valves for controlling the flow of refrigerant in order to increase the fridge efficiency through the possibility to modify condensing temperature (and consequently compressor load) according to outside temperature
- Replace existing motors and fans in fridge display cases with high-efficiency motors (that is, PCS or ECM) and fans with longer lifespans
- Installation of heat recovery from food refrigeration systems, which can be used for water pre-heating for the production of DHW. (As shown in Figure 4, the refrigerant goes through the heat exchanger, between the compressor and the condenser, and transfers heat to water)
- Installation of double air curtains in display cases in order to reduce the heat exchange between the fridge and the ambient atmosphere.

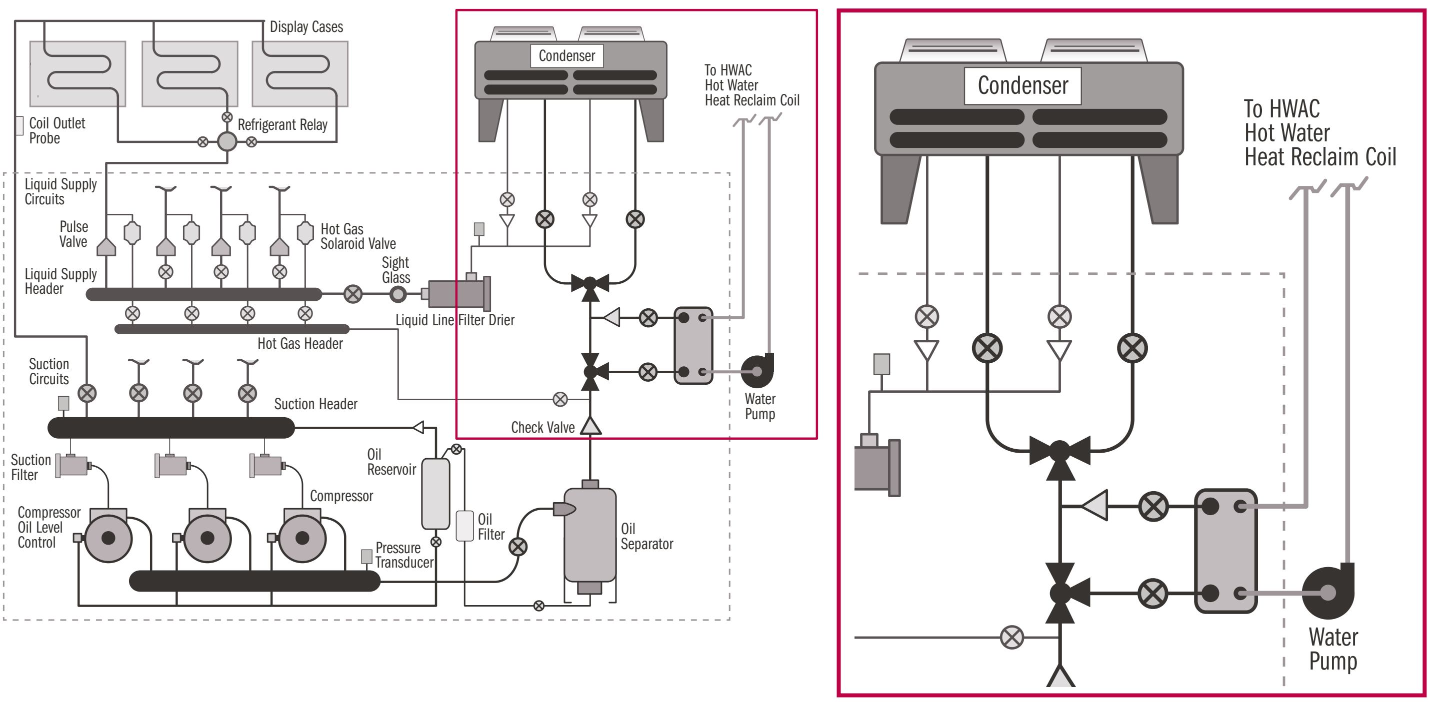
> “Regarding specific GHG emissions, the reason mainly lies in the widespread use of poor quality coal, both in power generation and in the production of thermal energy

Measures for new stores

The audit team also identified a set of additional energy efficiency measures (see Table 4) to be implemented in new stores.

- Installation of photovoltaic (PV) panels on the roof for electricity generation in a 20,000 square metre store
- Installation of light-emitting diode (LED) lamps instead of T5 fluorescent tubes for internal lighting. (LEDs would assure a higher efficiency and longer lifetime than T5 lamps)
- Installation of a water source geothermal heat pump in a new store in Mostar. (This is an efficient and environmentally-friendly system for heating and cooling buildings: fluid is circulated through a loop into the geothermal units serving the building, providing heating in cold months and cooling in hot periods see Figure 5).

Figure 4
Heat recovery from food refrigeration systems



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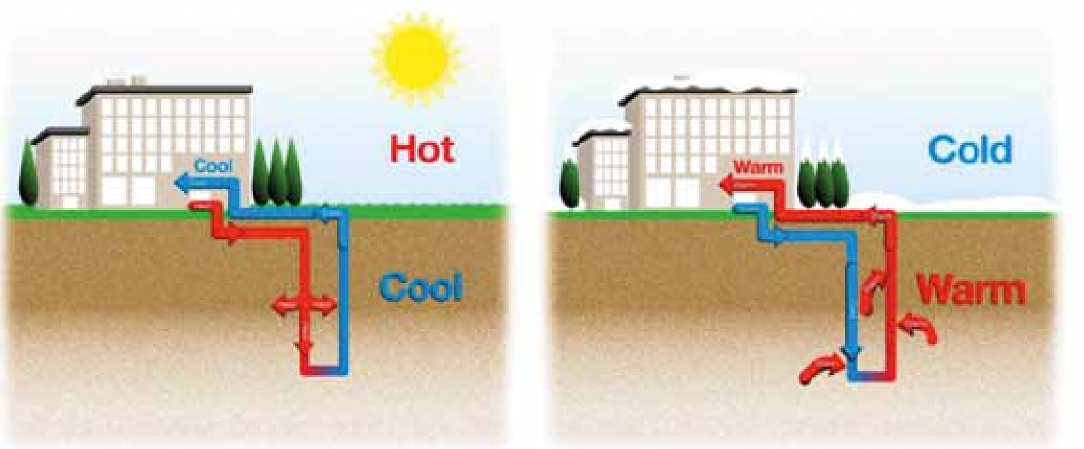
Installation of a water source geothermal heat pump in a store is an efficient and environmentally-friendly system for heating and cooling buildings

Figure 5
Geothermal heat pump: thermal exchange in summer and winter



Review of operation and maintenance practice

In order to improve the overall energy performance of its stores, it was recommended that the Bingo chain aim to adopt international energy and O&M management best practices.

Effective O&M is one of the most cost-effective methods for ensuring reliability, safety and energy efficiency. Inadequate maintenance of energy-using systems is a major cause of energy waste in retail outlets.

Metering and submetering of energy and resource use is a critical component of a comprehensive O&M programme: it provides the necessary data for making informed decisions on how best to operate mechanical/electrical systems and equipment.

It has been estimated that O&M programmes targeting energy efficiency can save between 5 per cent and 20 per cent on energy bills without a significant capital investment. From small to large sites, such savings can translate to thousands of euros each year.

Resulting investment

On the basis of the energy audit, the EBRD has provided a €5.4 million loan to finance the implementation of energy saving measures in the Bingo retail chain. The loan, part of the Bank’s Western Balkans Sustainable Energy Financing Facility (WeBSEFF), was extended to Bingo’s subsidiary, Hekom, which manages the company’s energy efficiency programmes. Bingo is a reputable retailer that should serve as a successful local example to other privately-owned businesses.

The EBRD investment was deemed to provide a demonstration show-case for advanced energy efficiency and building-integrated solutions incorporating best international practice techniques. The technologies to be applied have had very low market penetration rates in Bosnia and Herzegovina or the wider Western Balkans region to date. Implementing these technologies will attract the attention and interest of other retailers, as well as operators of commercial buildings more generally, and increase the market demand for advanced sustainable energy products and know-how.

“

To date, WeBSEFF has financed eight projects in the region with a total loan volume of €29.4 million. These projects alone are estimated to save 76,000 tonnes of CO_2 emissions per year

The EBRD loan is financing the installation of energy efficiency measures such as water source heat pumps, LED lighting, chillers, high-performing refrigeration with heat recovery and insulation panels in Bingo’s outlets. It was estimated that CO_2 emissions would be reduced by approximately 4,700 tonnes, which is equivalent to a saving of 51 kg of CO_2 per square metre of retail space per year.

The project will transform Bingo’s store network into a show-case of advanced sustainable energy solutions in the retail industry and will enable the company to minimise operating costs and strengthen its competitiveness.

“Our successful cooperation with the EBRD shows that Bingo can meet all requirements and fulfil all conditions of such an important international financial institution. This project is of great importance for us. Through its implementation we will stand side by side with international companies that are using the newest energy efficiency technologies. We hope that other companies in the country will follow our lead. This project also shows our awareness of environmental protection and air emissions. We are glad that we can improve the business environment in Bosnia and Herzegovina in this way as well,” said Mr Senad Dzambic, the owner of Bingo.

The investment built upon a previous EBRD loan in 2010 of €6.5 million to Bingo to support the retailer’s expansion in Bosnia and Herzegovina and to help it achieve nationwide coverage.

WeBSEFF

WeBSEFF is part of an EBRD programme to address the sustainable energy financing needs in the Western Balkans. It is dedicated to financing medium-sized renewable energy and energy efficiency projects. To date, WeBSEFF has financed eight projects in the region with a total loan volume of €29.4 million. These projects alone are estimated to save 76,000 tonnes of CO_2 emissions per year.

3.3

Agribusiness

Case study: Obolon Brewery (Kiev, Ukraine)

Obolon Brewery is located in Kiev, the capital of Ukraine, and covers an area of 160,000 square metres in a densely populated area.

The total production capacity of the plant has increased significantly over the years, from about 1 million hectoliters (hl) in 1980 to 11 million hl in 2008. As a result, Obolon has become the largest brewery in the country and one of the largest in Europe.

The brewery has its own malting plant to supply about 30 per cent (corresponding to about 50,000 tonnes per year) of the raw material needs of the beer production. The malting plant is divided into the steeping compartment, the germination compartment and different kilns used to dry the germinated barley.

The brewery has five brewhouses for wort preparation, each with the same major process units: mashing, lautering, boiling and whirlpool.

The production line is completed by the fermentation/beer processing and packaging stages.

Energy audit

The Obolon facility uses three types of energy:

- electricity (mainly consumed by chillers and for beer processing)
- natural gas
- steam (50 per cent of which is produced at the plant).

> Obolon has become the largest brewery in Ukraine and one of the largest in Europe

According to 2007 data, natural gas was the main energy source used by the plant, representing about 44 per cent of overall energy consumption; steam purchased externally constituted 36 per cent; and electricity 20 per cent.

An energy audit was performed at the brewery by D'Appolonia in 2009. It sought to analyse and assess the energy consumption patterns of the different processes and to identify areas where substantial savings could be achieved and where opportunities for energy efficiency investment existed. It also considered the potential for GHG emission reductions associated with the implementation of identified investments and how the sale of carbon credits generated by the project would affect the profitability of those investments.

Audit findings

Obolon brewery is a well-organised and well-managed production facility, with good maintenance levels and a highly experienced staff. The management is open to possible energy efficiency or technological improvements aimed at optimising process operations, particularly interventions to reduce overall energy consumption.

The main findings identified by the audit team during the site visit were as follows:

> The brewery has its own malting plant to supply about 30 per cent of the raw material needs of the beer production

- the external steam supplier was no longer available, obliging the management to reduce production and try to make the plant self-sufficient in term of its thermal energy needs
- an efficient condensate recovery system is a major requirement in a plant characterised by such a high dependence on steam, and the plant's management agreed with the audit team on the need to improve condensate recovery at some point in the distribution network
- the ageing malting unit and its major components were characterised by low levels of production and energy efficiency, and were in need of general improvement and a technological upgrade
- the plant's management was keen on improving energy efficiency in the key process phases, such as wort boiling. Several steam/condensate recovery systems had already been installed on some boiling lines to reach BAT (best available techniques) level performance and further similar systems were planned for the remaining lines

A general review and upgrade of the plant's electricity distribution network was recommended

- one of the key problems highlighted by the plant's management was the disposal of wastewater, which was discharged into the municipal sewage system (effective but highly expensive and environmentally unfriendly) after some simple mechanical treatments. One option proposed by the audit team was the installation of a treatment unit able to digest wastewater anaerobically, in turn producing natural gas that could be used to partially meet the energy needs of the boiler house

- a general review and upgrade of the plant's electricity distribution network was recommended, in particular the replacement of two aged and obsolete transformer stations and other old electrical equipment (insulators, for example) which had not been replaced since the plant started operations.

Proposed measures and investments

The energy efficiency investments recommended for Obolon brewery are detailed below and summarised in Table 5.

- A new vertical wastewater treatment plant (costing €5 million) to digest the water anaerobically, with the advantages of a low energy requirement, low sludge production, the absence of odour problems (since the process is enclosed), and the ability to produce biogas that can be used as fuel

- Two new natural gas boilers (with a capacity of 16-18 tonnes per hour (tonne/h) to replace the previous external steam supply (costing €2.6 million) that would reduce the total fuel consumption as they would work at higher efficiency levels and losses due to transmission of steam from the external supplier to the plant would be avoided

Table 5
Proposed energy efficiency actions for Obolon Brewery

Action	Total cost (€,000)	GHG emission reductions (tonnes CO_2eq/year)
Heat recovery at wort boilers 2 and 3	1,300	3,828.0
Wastewater treatment system and biogas production	5,500	7,982.9
Replacement of centralised ice water production chillers with new units at the malting plant	500	453.7
Installation of new NG boilers in place of previous external steam supply	2,600	2,277.9
Condensate recovery improvement	330	860.2
Replacement of old transformers and renewal of distribution system at two sub-stations	438	531.3
Malt drying kilns reconstruction	662	2,631.4
Total	**10,830**	**18,565.4**

> The management is open to possible energy efficiency or technological improvements aimed at optimising process operation, particularly interventions to reduce overall energy consumption

- Heat recovery at wort boilers 2 and 3. Wort boiling is a complex process during which a wide range of chemical, physical and biochemical reactions occur. Brewhouses equipped with old technology require a lot of energy to heat up the wort and are characterised by a long boiling process. Obolon had already installed a vacuum evaporation plant in brewhouse 5 as an additional module. The combination of a relatively short boiling phase with a low evaporation rate and the vacuum evaporation would result in a system with a low energy cost, a reduced thermal load and sufficient stripping of unwanted volatiles such as DMS (dimethyl sulphide). It was proposed that this system should be installed in brewhouses 2 and 3 (at an investment cost of €1.3 million).

Other minor investments (amounting to about €2 million in total) included the replacement of centralised ice water production with new more efficient units at the malting plant, condensate recovery improvement, renewal of the electricity distribution network and reconstruction of obsolete malt drying kilns.

The total investment cost amounted to about €10.8 million, with a total anticipated saving from reduced fuel and electricity consumption of €4.1 million per year. The payback period of the whole investment was estimated as 2.64 years.

3.4

Transport

Shipping case study: Ukrrichflot (Ukraine)

Ukrrichflot Joint Stock Shipping Company is the largest ship operator in Ukraine. Its principal business is domestic and international transportation of small to medium-sized dry bulk cargoes on river, river-sea and short sea routes. It deals essentially with the transport of ore materials, both on the Black Sea and (mainly) on the Danube River. In addition, the company operates its own passenger fleet and owns its own river port facilities in Ukraine. There is increasing demand for local and international cargo transport services on the Danube River as an alternative to road haulage for trade between eastern and western Europe. Given that many vessels in Ukrrichflot's existing Danube fleet of 105 barges and tug boats are over 25 years old, the company was planning to upgrade with three new tugs and 24 barges.

The audit conducted by D'Appolonia focused on the energy and environmental benefits associated with the implementation of the proposed upgrade.

> There is increasing demand for local and international cargo transport services on the Danube River as an alternative to road haulage for trade between eastern and western Europe

Energy and environmental benefits assessment

The assessment entailed a comparison with other modes of transport following a life cycle assessment (LCA) approach. LCA is used internationally by governments and industry to obtain a complete picture of interactions between an activity and the environment. In this study it was used as a methodological guideline to evaluate the environmental consequences of the proposed increase of the fleet across its entire life cycle, so that all the relevant parameters could be taken into account.

The assessment compared the level of emission of each of a range of modes of transport trucks, diesel trains, electric trains and diesel vessel convoys operating on the Danube for a fixed route length (1,059 km) as well as their energy consumption.

For the comparison, the specific composition of the barge train was assumed at one tug and six barges with a total capacity of 12,000 tonnes.

The diesel barge train's total CO_2 emission was less than 50 per cent of those of the road diesel convoy

The equivalent cargo capacity of the different modes of transport is given in Table 6.

Compared to other modes, inland navigation offers higher transport capacity per transport unit. One barge with a cargo capacity of 2,000 tonnes carries as much as 40 railway cars at 50 tonnes each or 100 trucks at 20 tonnes each.

The amount of emissions (kg) for the different modes of transport is shown in Table 7. The calculation was performed on the basis of emission factors taken from sources available in literature[1]. The pollutants covered included all major emission contributions from transportation: ozone precursors (CO, NOx, NMVOC), greenhouse gases (CO_2) and particulate matter (PM).

The diesel barge train's total CO_2 emission was less than 50 per cent of those of the road diesel convoy and the existing vessel convoy and about 60 per cent of those of the rail diesel convoy and the rail electric traction convoy. Also, the diesel barge train's NO_x emission value was lower than those for the other land transport modes.

The energy consumption of the different modes of transport in conveying one tonne of goods is calculated on the basis of the engine power and the travel time.

Barge trains can transport greater amounts of goods in the same convoy, so reducing significantly the energy consumed per tonne compared with the other modes of transport.

Table 6
Equivalent transport capacity

	Cargo capacity per unit (tonnes)	Number of equivalent units per 1 barge	Number of equivalent units per 6 barges (12,000 tonnes – 1 barge train)
Barges	2,000	1	6
Vessel+2 barges (vessel convoys)	5,500	0.4	2.2
Railway cars	50	40	240
Trucks	20	100	600

Table 7
Emissions for trucks, trains, existing vessel convoy and barge train with equivalent tonnage (in kg)

Pollutant	Road diesel convoy	Rail diesel convoy	Rail electric traction convoy	Existing vessel convoy	Diesel barge train
CO_2	571,321.36	336,678.40	348,842.95	472,698.86	204,923.42
NO_x	3,544.95	2,838.24	-	4,673.53	2,068.42
CO	78.44	1,655.64	-	3,709.15	1,641.60
NMVOC	n.a.	236.52	-	667.65	295.49
PM	16.77	94.61	-	148.37	65.66

[1] *EMEP/CORINAIR Emission Inventory Guidebook - 2006*, prepared by the UNECE/EMEP Task Force on Emissions Inventories and Projections, which provides a comprehensive guide to state-of-the-art atmospheric emissions inventory methodology and the Operational Guidelines for Project Design Documents of Joint Implementation Projects, a study of the Ministry of Economic Affairs of the Netherlands.

> Barge trains can transport greater amounts of goods in the same convoy, so reducing significantly the energy consumed per tonne compared with the other modes of transport

Table 8
Energy consumption for one tonne of goods – kWh/t

Action	Energy consumption for one tonne of goods [kWh/t]
Barge diesel train	27,36
Vessel diesel convoy	61,82
Railway diesel convoy	39,42
Railway electric traction convoy	78,84
Road diesel convoy	214,45

Additional environmental impact

The improvement of rivers and inland waterways for navigation generally entails substantial engineering work, which may involve additional infrastructures. Such work, together with the presence of more vessels and their operations, can impact on the broad ecosystem of the waterways.

The new Ukrrichflot fleet will operate between the port of Izmail and that of Smederevo.

Izmail is the largest Ukrainian port on the Danube Delta, located in the Odessa Oblast in the south west of the country. It is the centre of the food processing industry and a popular regional tourist destination.

Smederevo, in central Serbia on the Danube River, is an industrial city and the core of the steel industry.

Both ports are already equipped with the necessary infrastructures and facilities to receive the new fleet and the new volumes of cargo. However, for the port of Smederevo, some further development works are foreseen, specifically in respect of bulk cargo handling for the iron and steel industries. This would entail new gantry cranes (with lifting capacity of 16-32 tonnes and 16-56 tonnes) for bulk cargo, and new facilities and terminals with open storage for iron, steel and coal in bulk (1-2 million tonnes capacity).

3.5

3.5 Transport

Railways case study: Public Enterprise Railway Infrastructure PERI (FYR Macedonia)

Makedonski Železnici (Macedonian Railways or MZ) was divided in 2007 into two companies: the Macedonian Railway Transport Company, operating freight and passenger services and intended for partial privatisation, and the Infrastructure Manager PERI (Public Enterprise Railway Infrastructure).

An energy audit was performed by D'Appolonia in 2011 to review energy performance and management practices within PERI and to propose an energy efficiency investment plan aimed at reducing the energy use and environmental impact.

The Macedonian railway network has 792 km of line, 327 km of which are electrified with a 25 kV 50 Hz AC system. The network includes sections of two different trans-European railway corridors:

- Corridor VIII (309 km), which runs from the Bulgarian border through Macedonia to connect with Albanian railways (and which is under construction)
- Corridor X (215.7 km), an electrified line running from the Serbian to the Greek border (through Tabanovce, Skopje, Veles and Gevgelija). Corridor Xd is the branch from Veles to the Greekborder (through Bitola and Kremenica) and is 145.3 km long.

The Macedonian railway network has 792 km of line, 327 km of which are electrified

Audit findings

The site visit assessed the condition of some stations on Corridor X (at Skopje, Miladinovci and Ilinden) and of the Trubarevo Complex, which is the main rail freight facility and includes administrative, control and boiler buildings and areas for shunting brake operations and loco/coach maintenance. Information was also collected through questionnaires on seven stations along Corridor VIII and Xd.

The data collected from the site visit and questionnaires highlighted numerous and similar shortcomings:

- single glazed windows or badly-insulated double-glazing
- absence of building envelope thermal insulation
- use of electric radiators for heating
- absence of cooling and mechanical ventilation systems
- use of incandescent and poor-quality fluorescent lamps.

> In general, the comparison showed quite high energy consumption by buildings managed by PERI in relation to station and office benchmarks

The Trubarevo Complex had many deficiencies in its audited buildings, such as inefficient cast iron radiator heating, incandescent-lamp lighting, insufficient or absent ventilation and the absence of an energy monitoring system.

Energy consumption analysis

An analysis was conducted in order to define yearly energy consumption (both primary and non-primary) in respect of heating, cooling, ventilation and internal lighting. The actual consumption values of buildings were compared with relevant benchmarks for the railway sector, relative to comparable climatic zones, in order to evaluate the potential improvements achievable through energy efficiency measures.

In general, the comparison showed quite high energy consumption by buildings managed by PERI in relation to station and office benchmarks. The analysis highlighted significant margins for improvements in energy saving and the need for a tailored building refurbishment programme.

Due to the similarities between the stations reviewed, in terms of energy systems and envelope characteristics, the results of the analysis were applied to all stations managed by PERI (a further 101) by means of a proportional comparison based on station area.

Energy efficiency and management opportunities

On the basis of the site visit and collected data, a three-phase investment plan targeting energy efficiency measures and management practices was recommended, as follows:

- the establishment of a dedicated Energy Efficiency Department within PERI, tasked with coordinating strategy across the organisation
- the conception, design and implementation of an Energy Management Information System (EMIS) for monitoring, recording and displaying the consumption of energy and power absorption by rolling stock and fixed installations and buildings for traction and non-traction purposes. The EMIS would be fundamental to the work of the Energy Efficiency Department
- a review of the contractual arrangement for the provision of electricity for traction purposes, as the existing arrangement posed a serious obstacle to other railway interests (other than the Macedonian Transport Company) accessing the railway network managed by PERI (and therefore undermined railway liberalisation reforms that had already taken place in the country)
- a refurbishment programme for stations and administrative buildings
- the monitoring of energy use at major stations outside Corridor X. In the first phase of implementing the EMIS, only stations on Corridor X were expected to be monitored (on a pilot basis for the whole system). In the second phase, it was recommended that the scope of the EMIS be extended to stations on the rest of PERI network

> A three-phase investment plan targeting energy efficiency measures and management practices was recommended

Table 9
Building refurbishment programme: outcomes

Action	Primary energy saving (kWh/year)	GHG emission reduction (tonne CO_2/year)	Investment cost (€)
BEI	1,618,029	465	845,641
HVAC	830,646	234	417,106
Lamps	447,859	129	239,856
BMS	197,748	57	192,407
Platform lighting	189,544	55	507,174
Total	**3,283,826**	**940**	**2,202,184**

- the implementation of energy efficiency measures for the signalling system, including the replacement of lamps with LEDs (with longer lifespans) to achieve significant reductions in maintenance and energy costs
- the modernisation of electric substations (including replacement of power transformers, relay circuits with PLC and oil switchgears with vacuum-type switchgears)
- completion of the electrification of the whole Macedonian network and the introduction of electric locomotives and multiple units (EMUs) instead of diesel locomotives and diesel multiple units (DMUs).

Identified energy efficiency interventions for buildings were as follows:

- improvement of building envelope thermal insulation (BEI)
- improvement of heating, ventilation and air-conditioning systems (HVAC) with the installation of new air handling unit (AHUs) and/or heat pumps
- replacement of internal incandescent lamps with high-efficiency LED lamps
- adoption of building management systems (BMS)
- replacement of mercury lamps for platform lighting systems with LED lamps on all network stations.

The costs and projected energy and GHG emissionsavings from the building refurbishment programme are detailed in Table 9.

04

Support during project implementation

Within the framework of the CEI Fund/EBRD Integrated Support Initiative, back-up for the implementation of energy efficiency projects is provided through:

- feasibility studies and drafting of technical specifications/requirements for systems to be installed
- financial analysis to allow proper investment planning
- assistance with tender document preparation and selection of potential suppliers of systems/equipment required.

4.1

Transport

Railways case study: Serbian Railways Energy Management Information System

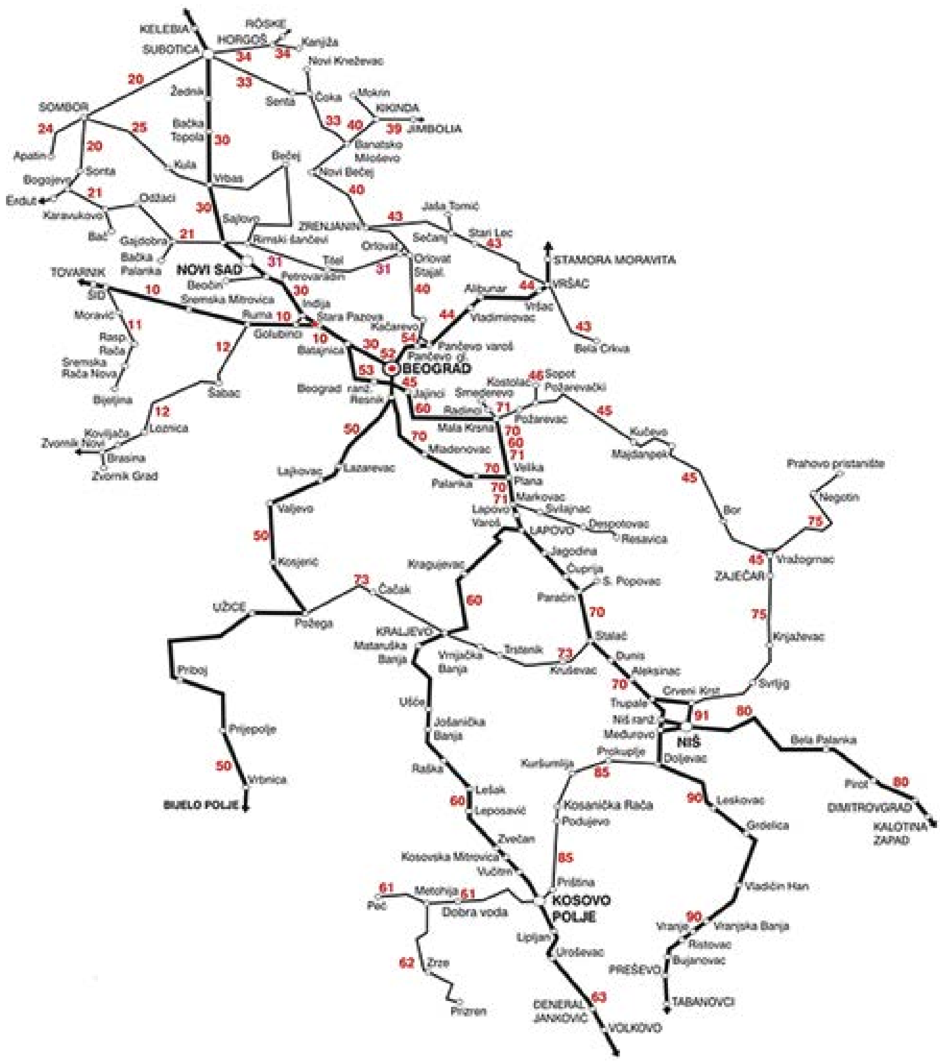
Serbian Railways (ŽS) is the public enterprise responsible for rail operations within Serbia. ŽS manages a network of approximately 3,000 km, operating passenger and freight services. It is also responsible for the maintenance of traction units, trains and rolling stock, track maintenance and inspection, and station structures and installations.

As part of a restructuring process, in August 2010 ŽS established an energy efficiency unit (EEU) at a department named the Centre for Sustainable Development. This unit is responsible for monitoring energy use, identifying energy efficiency project opportunities and coordinating the introduction of energy savings measures.

In 2011 the EBRD tasked D'Appolonia with the preparation of a plan for an energy management information system (EMIS) for monitoring energy use across the Serbian rail network, and also an assessment of the potential for the application of regenerative braking solutions to reduce energy consumption and costs. The results of the study are summarised as follows:

- the implementation plan included a description of the EMIS "architecture", its technical specifications, an assessment of the economic and financial feasibility of the investment, and details of its actual application to the ŽS system. It also included the preparation of tendering documentation
- the evaluation of the regenerative braking potential involved an assessment of the amount of energy that could be recovered through the application of that solution on

Figure 6
Serbian railway network



> Energy management information systems are key to determining the energy profile and consumption of complex systems such as railways

the traction of locomotives and electric multiple units (EMUs). The assessment was carried out by means of simulations that compared the energy consumption of the current ŽS fleet with that of a revamped fleet with traction rolling stock equipped with regenerative braking. The introduction of batteries for energy storage on the track side was investigated and a cost-benefit analysis for that option was performed. In addition, the incorporation of the energy recovered from regenerative braking into the electricity transmission network was analysed and possible measures for optimal exploitation were recommended.

EMIS implementation plan

Structure and technical specifications

Energy management information systems are key to determining the energy profile and consumption of complex systems such as railways. An EMIS does not include any energy efficiency improvement features. However, it enables managers to take appropriate action, at strategic and operational level, to reduce energy consumption. An EMIS combines energy consumption data acquired from meters or other sources with information relevant to the actual operation, in order to profile energy use and its efficiency across a whole system. Operational data may be provided by corporate databases, other interfaced IT systems, or may be inserted manually, depending on the degree of automation of an existing information system. The architecture of the EMIS for ŽS

> The information would reflect key performance indicators (KPIs) tailored to the users' perspectives and profiles

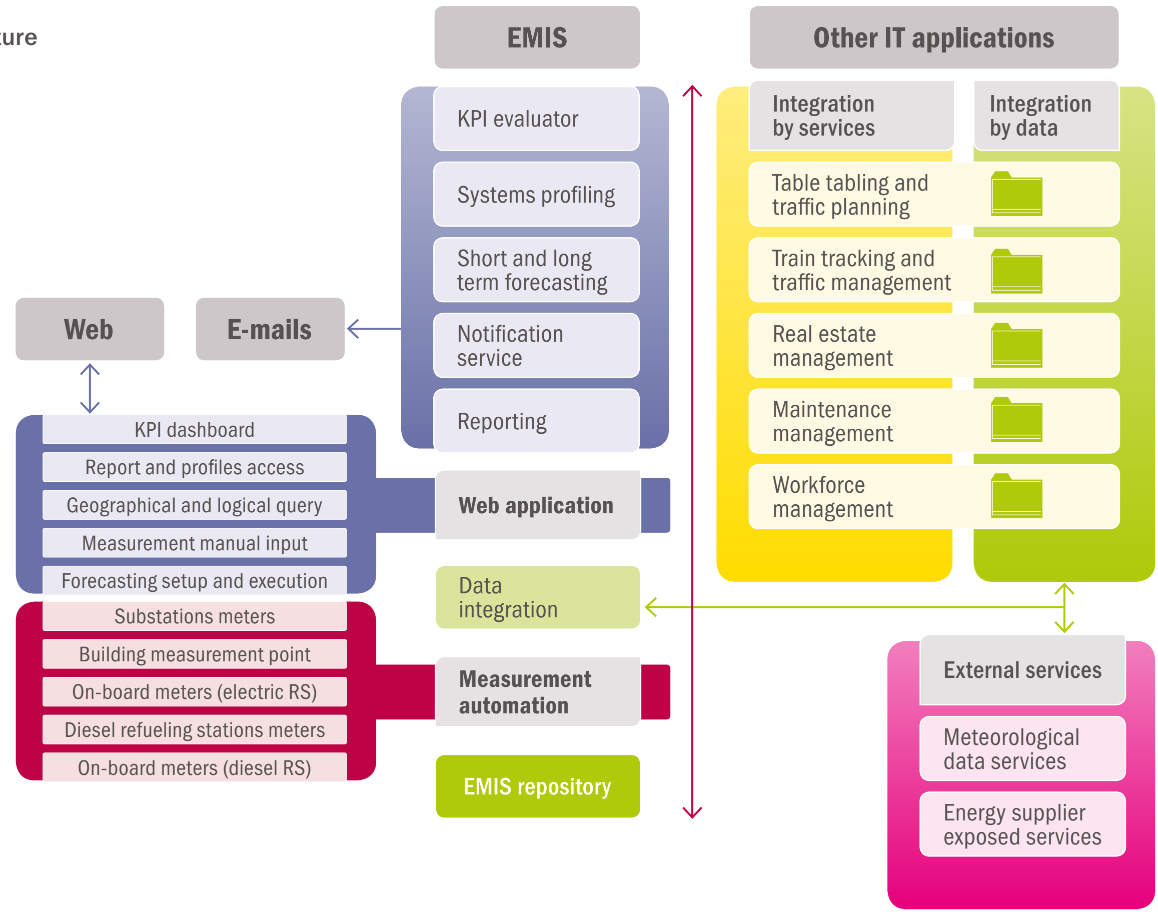
was conceived in the form of a service oriented architecture (SOA), integrating different elements – called services which share, exchange and communicate information through web-based protocols and interfaces. Services are used to acquire and integrate data, perform calculations, and present results to the users of the system. The visibility of the information provided is managed by user profiling, so that users may only access information relevant to their role, position and function in the railways.

A generic EMIS architecture is illustrated in Figure 6.

The specifics of the energy consumption information to be provided by the EMIS were defined in close cooperation with those ŽS representatives concerned with improving energy efficiency. The information would reflect key performance indicators (KPIs) tailored to the users' perspectives and profiles. Selected KPIs would include, for traction purposes, primary and final energy consumption per traffic output per offered transport[2], the energy recuperation rate and specific costs, while KPIs for non-traction purposes would cover energy consumption per surface unit and per passenger, and the consumption of other energy sources used by ŽS.

The EMIS would collect data and information from energy meters mounted on traction rolling stock and at significant locations (such as electric substations, major load spots, main buildings, fuel stations, and so on). This would then be integrated with operationally-relevant information (for example, train tracking data, timetabling, network topology, and so on), derived automatically from existing ŽS software systems (databases, repositories and tools) or inserted manually, in order to provide a more complete picture of the corporate energy performance. The combination of data from energy meters and information from ŽS systems would allow detailed calculations of energy consumption and enable forecasts of consumption and efficiency performance.

Figure 7
A generic EMIS architecture



[2] Traffic output is measured as the number of kilometres a train runs. Offered transport is the product of the capacity of the train (in terms of passenger that can be transported) and the kilometres the train runs.

> The EMIS would collect data and information from energy meters mounted on traction rolling stock and at significant locations

Table 10
Cost-benefit analysis for the investment implementation

Item	Unit	Value
Total investment	€	5,700,000
Potential for primary energy savings	GJ/year	247,000
GHG emission reductions	tonne/year	18,900
Pay Back Time (PB)	year	6

Implementation phases

The progressive implementation of the EMIS in four phases was proposed, ranging from a base case or first phase up to more comprehensive energy monitoring and management systems enabling larger savings. For each of the implementation phases, the steps for design, delivery and installation of components and the timing of each activity were carefully considered, along with a cost-benefit analysis to enable proper investment planning.

1. The first phase, or base case, was the simplest and included: distance and real-time monitoring of 21 traction electric substations; distance monitoring of fuel delivery and consumption at fixed and mobile fuel stations; and the creation of electronic databases on energy consumption and costs relating to electricity for traction, to diesel fuel for traction, and to electricity and fossil fuels for the built environment. In this phase, the most significant projected savings related to electricity for traction (a 2 per cent saving on total consumption in 2011) and diesel oil (similarly a 2 per cent saving for traction and 2 per cent for non-traction), due to the installation of distance meters.

2. For the second phase, the installation of on-board meters on all electric locomotives and electric multiple units operated by ŽS was proposed. Besides continuous distance monitoring per substation of the electricity used for traction (as in the base case), the consumption of each single traction rolling stock would be constantly monitored and the collected data sent to a central collection system. Compared to the first phase, the percentage of projected energy saving relating to electricity used for traction was higher (an 8 per cent saving on total consumption in 2011). The continuous monitoring of electric traction by on-board meters could achieve considerable electricity savings by indicating the optimum and most energy efficient driving style to the train operative.

3. The third phase included the installation of on-board meters on all ŽS diesel vehicles. Again, besides continuous distance monitoring of diesel fuel use at main fuel stations (as in the base case), the consumption of each single diesel vehicle would be constantly monitored and the collected data similarly sent to a central collection system. Compared to the second phase, the percentage of projected energy saving relating to diesel oil used for traction was higher (an 8 per cent saving on total consumption in 2011 instead of 2 per cent). The continuous monitoring of diesel traction made possible by on-board meters could achieve diesel oil savings in traction operations comparable to that for electricity.

> The implementation plan also included guidance in the preparation of supporting documents for the tendering phase

4. The final phase included the installation of distance electricity meters to measure and control energy consumption at main buildings managed by ZS. The percentage of projected energy saving relating to non-traction electricity use was higher than in the first phase (a 5 per cent saving on total consumption in 2011 instead of 1 per cent).

Cost-benefit analysis

The implementation plan was supported by a full analysis of the economic and financial outlay and investment returns (see Table 10). Projected costs during the implementation, commissioning and operation of the system covered engineering services, IT hardware (mid-sized server and workstation) and software licence, meters, communication equipment and EMIS maintenance costs.

Projected benefits took into account revenues deriving from savings on both traction and non-traction energy use from different sources. Knowledge of the existing energy profile enabled the determination of new practices and strategies (either short or long-term measures), such as energy efficient time-tabling, real-time commands to train operatives for energy-efficient driving, definition and support of incentive schemes based on energy use measurement, modernisation of fixed installations, and so on.

Support in tender documents preparation

The implementation plan also included guidance in the preparation of supporting documents for the tendering phase. This was in order to determine the main contractual requirements for the finalisation of the procurement process, protect the interests of ŽS, and ensure a balanced allocation of responsibilities and clear definition of deliverables, performance standards, liabilities and penalties.

Regenerative braking

An assessment of the amount of energy that could be recovered through the application of regenerative braking was carried out to evaluate its potential contribution to a reduction in the energy consumption across the railway network. The analysis took into account the possibility of using regenerative braking features on new or revamped EMUs and locomotives.

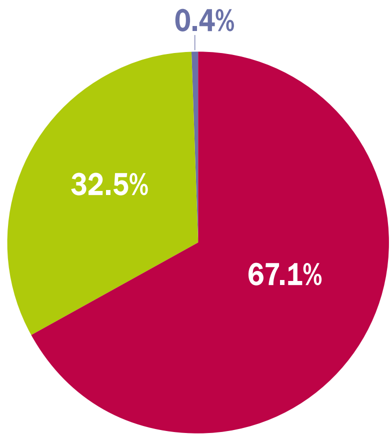
The assessment was based on two simulations performed on a 400 km-long subsection of the national network: one, without energy recovery, representing the existing performance of the network and providing a comparator, and the other, with energy recovery from regenerative braking, deriving from new EMU trains and a new generation of locomotives. The results of the simulations were compared to evaluate the amount of regenerated energy and to identify the rail line sections where it was concentrated (see Table 11).

Of the total amount of regenerated energy that trains and locomotives injected at the pantograph, almost two-thirds was used by other trains operating on the network, reducing the absorption, while one-third could be returned to the transmission grid or stored for further use.

Table 11
Results of the simulation

	Absorbed energy at pantograph [kWh]	Regenerated energy at pantograph [kWh]	Net energy at pantograph [kWh]	Regenerability [%]
Freight	114.600	-7.000	107.500	-6.1
Intercity	22.100	-600	21.500	-2.7
Regional	19.600	-3.000	16.600	-15.3
Urban/suburban	11.700	-2.500	9.100	-21.3
Total	168.000	-13.100	154.700	-7.8

Figure 8
Distribution of the recuperated energy through regenerative braking



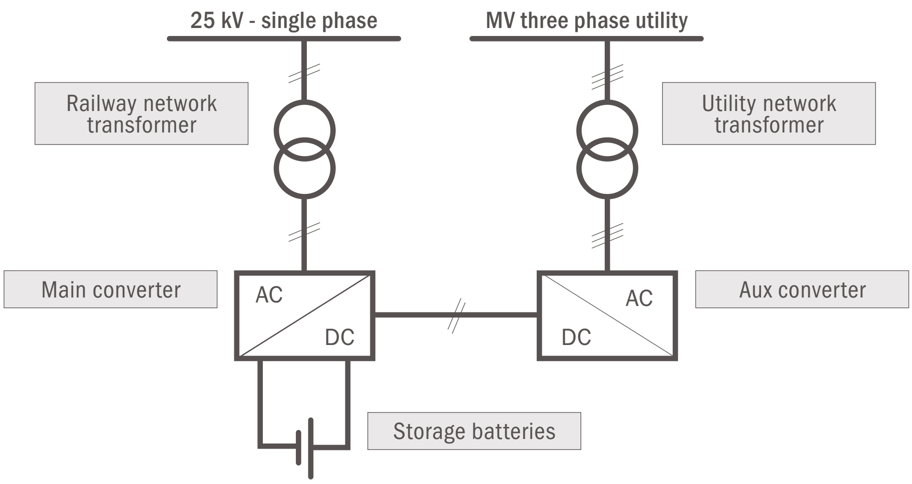
The simulations showed that the option of returning energy to the grid at the electric substation was definitely viable, following the establishment of proper contractual arrangements with the electricity supplier. The configuration of the Serbian transmission network and its interconnectivity anneal any flickering effects[3], while the possible imbalances in the phased implementation system were estimated to be within the tolerances defined by the applicable standards. Moreover, the quality of energy (low harmonics content) returned to the grid was good, due to the performance of the power drives (that is, IGBT-based 4-quadrant converters) used in regenerative braking. The power factor of the energy returned at the pantograph by power drives was 1, with harmonics content lower than the one generated by earlier generations of traction that is, based on diode-bridges or Gate Turn Off (GTO) converter (a low-harmonic converter). The resilience of the distance protection relays was also investigated, showing proper performance without any major intervention or investment.

The option of storing energy was also studied, and a system to store and then dispatch the recuperated energy to the grid was designed accordingly (see Figure 8).

The storage battery system was based on Li-ion cells, composed of two parts for a total energy capacity of 870 kWh to be charged and discharged at 6000A (peak times) and 4600A (continuous). It was recommended that the Li-ion cells be built using Lithiated Nickel-Cobalt-Aluminium oxide (NCA) in their positive electrodes, with the negative built on graphite. NCA technology provides a long life-cycle, high energy density and may operate at any stage of charge. Moreover, the recycling and end-of-life decommissioning process of NCA batteries is already available and offered by the manufacturers. The batteries should be installed in cabinets mounted in 20' ISO containers, which allow for proper functioning, monitoring and control.

The study found that the amount of energy in place in the energy balance and its cost did not justify the adoption of this solution; however, its applicability might yet be of interest in the event of a growth in railway traffic, renewal of the full fleet of rolling stock and possible increases in energy costs (above the favourable tariffs currently applied in Serbia).

Figure 9
Architecture of system for storing and dispatching recuperated energy



[3] Fluctuation in the voltage of the power supply. Power-line flicker is a visible change in the brightness of a lamp

05

Know-how transfer

The implementation of energy efficiency measures often requires additional integrated support in terms of transferring know-how related to international best practices and energy efficiency technologies.

In some cases, this transfer is conveyed through the results of an energy audit aimed at identifying technological and management shortcomings. A company being audited is made aware of its existing status in terms of energy consumption, of the necessary measures and practices required to increase energy saving and enhance comfort and health and safety, and of the potential for improvements.

5.1

Buildings

Case study: Municipal schools and nurseries (Tirana, Albania)

On the EBRD's behalf, D'Appolonia carried out a study in 2009 to assess existing conditions and review energy efficiency opportunities in a set of educational buildings managed by the Tirana Municipality in Albania. The aim was to provide technical assistance in order to transfer know-how on international best practices with regard to energy source usage, thermal comfort and health and safety.

The investigation focused on kindergartens, nurseries (crèches or day-care centres) and primary and secondary schools. Most of the 69 schools, 42 kindergartens and 26 day-care centres in the Tirana municipal area were subject to full or partial renovation between 2000 and 2007. The energy audit team selected a representative samples of buildings in terms of energy efficiency improvement opportunities and needs, and also on the basis of a review of available preliminary data and suggestions from the Tirana Municipality. The audit enabled the team to identify the deficiencies in the status and management of the buildings, the corrective measures to be implemented and the management practices to be transferred.

The audit was performed on eleven selected educational buildings, categorised (1-4) as follows:

1. schools without a centralised heating system
2. schools with centralised heating
3. kindergartens and crèches without centralised heating
4. kindergartens and crèches with centralised heating.

> Classrooms were, for the most part, only heated though decentralised electric radiators, which were insufficient to guarantee required comfort standards for occupants and were characterised by low efficiency levels

The specific institutions and their characteristics are detailed in Table 12.

Audit findings

The level of comfort and warmth inside the audited buildings was often not optimised, reflecting a lack of appropriate equipment and/or facilities and an inefficient use of existing systems. The audit team selected a set of parameters (see Table 13 and footnote) to gauge the estimated energy savings that could be achieved in comparison with the existing buildings performance.

The analysis of these numbers, calculated from the data collected during the on-site inspections, revealed that ventilation losses were homogeneous for buildings used for schools on the one hand and crèches and kindergartens on the other, and that envelope energy performance affected efficiency levels of the four categories in the same way. Greater impact was determined by the heating systems in use. In fact, while the Hv value was in the range of 0.7 and 1 W/m3K, indicating similar construction features and related thermal properties, Gv varied from 1.40 W/m3K for schools with centralised heating to 2.00 for schools using electric heating devices; in the same way, kindergartens with centralised heating presented a value of about 2.1 W/m3K, while those without had a much higher coefficient (about 3.9). This indicated clearly that isolated electric equipment used to provide heating in classrooms was significantly less efficient and that large rooms for increase energy efficiency usage levels are present, jointly with the possibility to increase significantly the internal environment comfort status.This means that the proposed measures would bring energy efficiency increases together with an improvement of comfort conditions in the internal spaces (rooms).

The main audit findings and recommendations were as follows:

Schools
Classrooms were, for the most part, only heated though decentralised electric radiators, which were insufficient to guarantee required comfort standards for occupants and were characterised by low efficiency levels. In cases where centralised heating was in place, the operational modes were not optimised and did not ensure efficient space heating and energy usage. In addition, all the classrooms were in need of ventilation systems and controls. Electric heat pumps represented the most appropriate solution for those schools without centralised heating systems.

Table 12
Building characteristics by category

ID	Audited institutions	Heating system	Hot water	Kitchen	Energy sources Used	Ventilation
Category 1	Ismail Qemali School Mihal Grameno School Dora D'Istria School	Electric radiators (decentralised units)	No	No	Electricity	Manual
Category 2	Hasan Pristhina School	Fuel oil centralised system	No	No	Fuel oil Electricity	Manual
Category 3	Kindergarten No.18 Kindergarten No.6 Crèche No.50	Electric radiators (decentralised units)	Yes, by electrical boilers	Yes, liquid petroleum gas (LPG) and electricity consumption	Electricity LPG	Manual
Category 4	Kindergarten No.52 Kindergarten No.56 Crèche No.10 Crèche No.8	Fuel oil centralised system	Yes, by electrical boilers	Yes, LPG and electricity consumption	Fuel oil Electricity LPG	Manual

“

Thermal insulation of building envelopes (walls and windows) was insufficient, necessitating complete restructuring

Table 13
Energy parameters (existing buildings performance)[4]

ID	Gv (W/m³K)	VL (kW)	Hv (W/m³K)
Category 1	2.00	12.51	0.72
Category 2	1.40	11.62	1.03
Category 3	3.92	6.10	1.20
Category 4	2.16	6.86	1.09

- Where a centralised heating system was installed, consumption values were high in relation to the achieved standard of internal comfort; a general optimisation of heating systems management and operation was required.

- Thermal insulation of building envelopes (walls and windows) was insufficient, necessitating complete restructuring.

- Lighting systems were, in the majority of cases, old and poorly maintained; most lamps were of incandescent or neon type, and inadequate for ensuring a safe environment. Classroom computer suites were subject to a high heat load, requiring additional cooling equipment such as small spot-cooling units and/or dehumidification to offset it.

- Middle and secondary school laboratories and science facilities needed to be equipped with fume hoods with special exhaust systems, and also with a dedicated makeup air system (providing fresh air to the indoors) if several fume hoods were to be fitted within one room. If there were no fume hoods fitted, an exhaust system was recommended for odour removal, depending on the type of activities conducted in the room.

- The office area needed an individual temperature control system because of its occupation both during and outside school hours. Given that offices were also occupied before school started in the fall, it was recommended that the installation of air conditioning should be considered or provision be made for a future upgrade.

- Gymnasiums are generally used after regular school hours for evening classes, meetings and other functions, and may also be used at weekends for group activities. Such occasional use needed to be taken into consideration when selecting and sizing new systems and equipment.

[4] GV: this coefficient expresses the energy efficiency of a building system as a whole, including the energy performance of the envelope (walls, windows, and so on), the energy efficiency of the heating equipment and the ventilation and winter losses, including thermal bridges.
VL: this coefficient quantifies the thermal energy that is required to compensate the losses determined by the normal ventilation practice within the built environment.
HV: this coefficient expresses the energy performance of the building system in terms of the envelope properties (walls, windows, thermal bridges, and so on) but without considering the efficiency of the installed and operative thermal equipment.

> Increased heating efficiency from about 30% to more than 90%

Kindergartens and crèches

- When kindergartens and crèches were closed during weekends, heating systems needed to supply only enough heat to prevent freezing; where buildings incorporated administrative offices or eating facilities, these needed to be partitioned with separate systems for flexibility, economy, and odour control, and with a shut-off capability. Where they shared common refrigeration and heating sources, heat pumps could be considered as an appropriate option, especially in premises without a centralised heating system.

- No specific ventilation system was present in the classrooms. Each room needed to be ventilated, heated or dehumidified independently and, in this respect, an HVAC unit represented a good solution.

- Thermal insulation of building envelopes (walls and windows) was insufficient, necessitating complete restructuring.

- Lighting systems were, in majority of cases, old and insufficiently maintained; most lamps were of incandescent or neon type, and inadequate for ensuring a safe environment. A general restructuring needed to be implemented, taking into account the opportunity to improve management systems by introducing centralised control systems and dividing buildings in functional zones.

- Since these facilities were not occupied at all times, for flexibility purposes each unit's ventilation and cooling provision needed to be adjustable or capable of being shut off independently (except when humidity control was required).

Proposed measures

The technical solutions proposed by the audit team for increasing energy efficiency, comfort and health and safety levels for each building category are summarised in Table 14.

Reduction of existing electricity consumption for lighting and improved internal lighting level

Table 14

Proposed measures	Effect	Action Type[5]	Building Category
Installation of electrical direct expansion (DX) multi-split systems and centralised direct digital control, based on occupancy levels. This would replace existing individual electric heating devices in operation in wintertime in each classroom	Increased heating efficiency from about 30% to more than 90%	ENE	1,3
Installation of dedicated thermostats for night/weekend temperature setting (wintertime)	Improvement of internal comfort condition and 3% energy saving	ENE / C	1
Installation of thermostat valves on individual radiators to increase efficiency levels in existing installed centralised heating systems, modulating or switching off thermal energy supply in unoccupied or under-occupied rooms	Increased efficiency of the heating distribution system from about 65% to more than 68%	ENE	2, 4
Installation of ventilation distribution systems to provide fresh air to internal spaces, equipped with air-to-air thermal energy recovery devices	Improved internal comfort conditions, better ventilation cycles and increased health and safety status of buildings	C	1,2
Installation of solar thermal panel systems for hot sanitary water production	Improved internal comfort conditions	C	1,2
Improvement of thermal properties of building envelopes, improvement of roof insulation and replacement of windows, installing double glazed PVC frames in place of existing single glass and aluminium framed windows	Reduction of heat losses (particularly in wintertime) of about 35%	ENE.	1,2,3,4
Improvement of lighting systems through installation of high-efficiency fixtures, replacement of all incandescent lamps with CFL low-consumption lamps and installation of presence detector switches	Reduction of existing electricity consumption for lighting and improved internal lighting level	ENE	1,3,4
Recalculation of building energy profile needs (where boilers are oversized), adjustment of boiler burners to better match thermal requirements of buildings, replacement of hot water pumps with more fitting ones and improvement of general management of boiler operations	Increased efficiency of the heating distribution system from about 65% to more than 72%	ENE	2
Installation of new LPG boilers to replace existing diesel oil-fed ones, using them to also produce hot water in place of decentralised electrical boilers	Increased heating efficiency from about 66% to more than 74%. In addition, hot sanitary water production would be transferred from electricity to LPG and be centralised instead of decentralised, so achieving substantial increase in efficiency	ENE	4
Completion of hot water distribution grids, where necessary, leading the hot water to all the users inside an institution	Increased efficiency in hot sanitary water production	ENE	4

[5] ENE: Energy efficiency measure
C: Comfort /health and safety improvement measure

06

Experimental and innovative products: a view on the future – ‘resource efficiency’ approach

> Through the SEI, the EBRD has become a major source of finance and expertise on climate change mitigation

Sustainable Energy Initiative (SEI)

The EBRD launched its SEI in 2006, reflecting the increasing importance of energy efficiency to its region of operations and the call of the G8 group of major industrialised countries at their 2005 summit to multilateral development banks to scale up their activity to address climate change.

Through the SEI, the EBRD has become a major source of finance and expertise on climate change mitigation. From 2006 to 2011 SEI financing reached €8.8 billion for 464 operations with a total project value of €46.9 billion. This was expected to deliver an estimate reduction of 46 million tonnes of CO_2 per year.

The third phase of the initiative (SEI 3) was launched in 2012. Covering the period 2012-14, it is operating in a complex environment against a background of challenging climate change, difficult short and medium-term economic prospects, increasing energy security concerns and the expansion of EBRD operations into the southern and eastern Mediterranean (SEMED) region.

The Bank's countries of operations remain highly inefficient in terms of energy use, although SEI experience demonstrates that the region provides some of the most cost-effective CO_2 mitigation actions anywhere in the world. Furthermore, several EBRD areas are vulnerable to the impacts of climate change, particularly the SEMED region.

“the EBRD intends to combine continuity with innovation through SEI 3 and other forthcoming initiatives

Building on its strong record and the experience acquired during the first and second SEI phases, the EBRD intends to combine continuity with innovation through SEI 3 and other forthcoming initiatives to address the challenges of environmental sustainability, economic growth and competitiveness.

The Bank's operational and financing approach is rooted in, and guided by, its transition mandate. The EBRD has developed specific competences in financing energy efficiency and renewable energy. SEI 3 and the Bank's other initiatives will continue to be based on the EBRD business model, which is transition-driven, private sector-focused and market-oriented.

The SEI operational model combines the following elements:

- financing for specific energy efficiency or renewable energy projects with clear estimates of energy savings and carbon emission reduction
- technical assistance to support project preparation, project implementation and capacity building
- policy dialogue to support the development of an enabling environment for sustainability energy.

> The Bank will focus on building and consolidating partnerships with donors during SEI 3

The third SEI phase will build incrementally on SEI 2 through:

- the further development of energy efficiency and climate change mitigation activity, reflecting the experience gained and opportunities identified in SEI 2
- increased emphasis on climate change adaptation, reflecting the likelihood of a significant rise in temperature independently of further mitigation action and the particular relevance of adaptation issues in the SEMED region.

Thanks to strong donor support and commitment, including from Italy through the CEI Fund, the successful implementation of the SEI 2 funding strategy mobilised €108 million for technical cooperation (TC) activities and €332 million in investment grants. The Bank will focus on building and consolidating partnerships with donors during SEI 3 rather than setting specific TC and grant mobilisation targets.

The Bank will also report on the transition impact of SEI 3 projects, and will develop a set of specific impact measures to reflect the benefits of SEI activities more comprehensively.

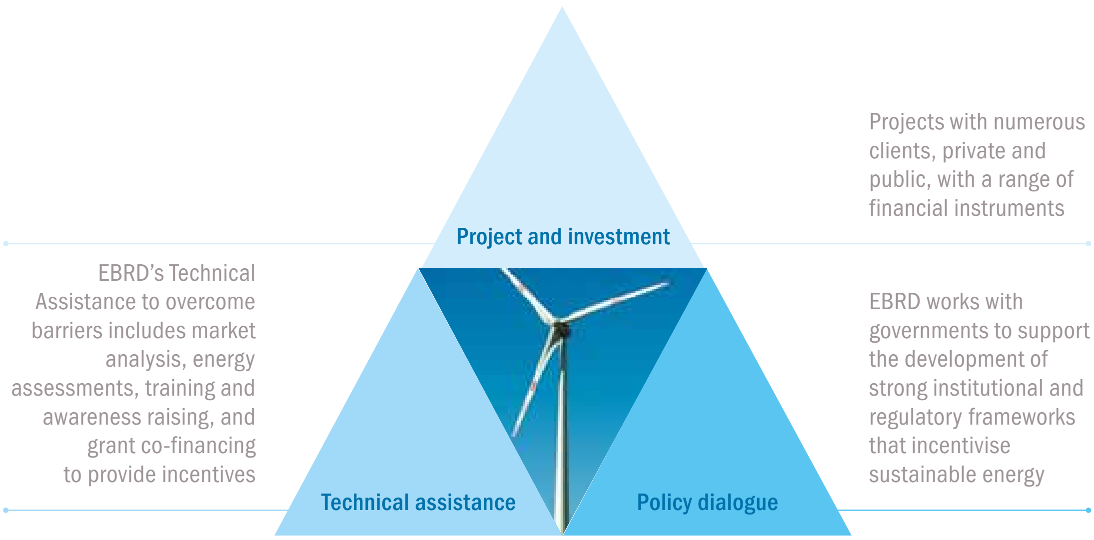
Some of the EBRD's innovative instruments and approaches to induce market transformation, blending finance and technical assistance, are described below. These aim to promote the introduction of best practice in terms of technologies and corporate policies and practices.

Energy Efficiency Management Systems (EEMS)

In 2009 the EBRD launched a programme to support clients implementing integrated EEMS, with funding up to €4.5 million. These funds are used for co-finance up to 50 per cent of the cost of EEMS equipment, instrumentation and installation. Eligible countries are Armenia, Azerbaijan, Belarus, Georgia, the Kyrgyz Republic, Moldova, Mongolia, Tajikistan, Turkmenistan, Uzbekistan and ODA (official development assistance) countries.

- EEMS can be applied to any process or operation involving the generation, transformation and use of energy (including manufacturing processes and buildings). They comprise hardware (for example, meters, sensors, actuators, cables) and software (data processing, automation, control) which allow dynamic automatic control of energy use across operations and processes. They are designed to reduce energy consumption, improve rate of utilisation, increase reliability/availability of equipment and processes, predict performance of technical systems, as well as optimise the

Figure 10
The SEI operational model



> Resource efficiency has risen as a global priority in a manner that few would have predicted even a decade ago

use of other resources (for example, water) and reduce operation and maintenance costs. They also provide reliable data that optimise longer-term energy management and improve decision making on related investments.

- EEMS have a low penetration in transition countries compared to advanced economies, and provide an opportunity to address the known information gaps (in the efficient use of resources) which prevent the implementation of best practice and resource-saving investments.
- The programme targets existing and prospective clients of the Bank in the manufacturing, agribusiness, property, tourism, transport and municipal services sectors.

Resource efficiency

The core mandate of the Bank is to advance transition to a market economy in its countries of operations and support the region in addressing the competitive challenges of the global economy. One area of increasing relevance is related to the availability and use of resources such as water and materials which, together with energy, represent the key inputs in any economic activity. Resource efficiency has risen as a global priority in a manner that few would have predicted even a decade ago. For most of the 20th century, companies were able to plan their businesses based on the assumption that resources were essentially limitless, that real resource prices would be constant or fall and that the environment could absorb all waste products with little or no impact. Such an approach led to a business culture where little attention was paid to resource efficiency and waste generation went unchecked. This was exacerbated in the EBRD countries of operations by decades of central planning and mispricing

> The EBRD has a unique mandate to promote environmentally sound and sustainable development through projects which support EU strategies for energy and resource efficiency and waste reduction

of resources. As a consequence, since 1970 materials productivity (input per unit of value added) has only improved at around half the rate of labour productivity.

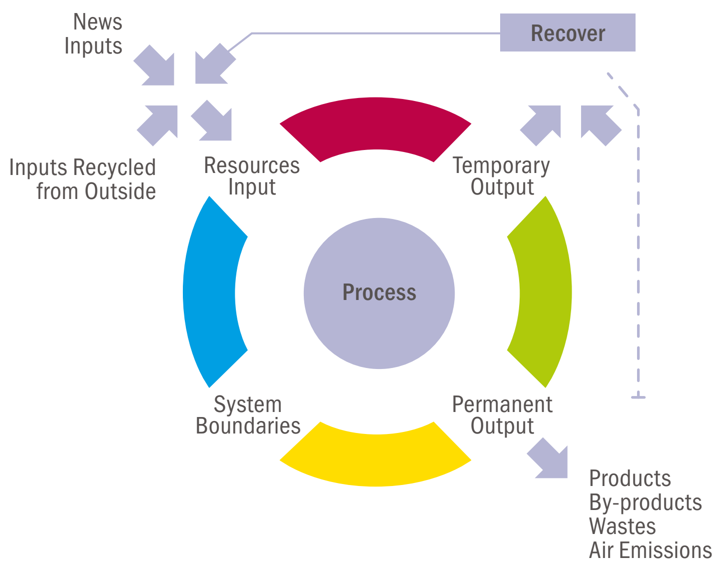
The Bank is therefore developing a dedicated approach to addressing resource efficiency by building on the operational experience acquired during the first and second SEI phases and its existing commitments to promote sustainable resource use.

The EBRD has a unique mandate to promote environmentally sound and sustainable development through projects which support EU strategies for energy and resource efficiency and waste reduction. It can also draw from its broad expertise in policy dialogue and project-level environmental and social due diligence and assessments.

The proposed approach intends to look deeper into production processes with a more comprehensive emphasis on total system efficiency, taking into account all the main resources involved. It aims to optimise the use of multiple resources in production processes with a special emphasis on waste reduction and valorisation of by-products.

For this purpose the Bank is developing a methodology to specifically define a multi-dimensional approach for combining sustainable use of resources and process efficiency.

Figure 11
Main areas of investigation relevant to a resource efficiency assessment



Major areas of investigation

Four main areas of investigation are relevant to a resource efficiency assessment of a specific producing facility:

- resource input (raw materials, water, energy): the aim of the analysis is to achieve the same performance with reduced inputs or to identify inputs that produce less undesired by-products.
- productive process/infrastructure (existing plant, equipment, logistics, delivery systems): the goal here is to apply new approaches/technologies with the potential to extract greater economic value from existing manufacturing and utility infrastructure by reducing input material costs and the production of waste.
- permanent output (waste and non-recoverable materials that would otherwise be disposed of or released into the environment): in this area the aim is to recover and recycle materials to their best and highest value use by either re-introducing them to the originating production cycle or redeploying them to entirely new uses (that is, the development of return markets).
- temporary output (by-products and scrap that are already recycled): the goal in this respect is to recover and convert low-value materials through "up-cycling" to their best and highest value use. This is achieved by disaggregating composites into streams, extracting the most valuable materials, and producing high-end materials that can either be reintroduced to the originating production cycle or redeployed to entirely new uses.

> As with energy audits, the basic data collection tool for resource efficiency audits is a questionnaire

Methodology

The multi-dimensional methodology applicable in principle to any industrial sector and service has to take into account the following key aspects:

- *system boundaries*

It is important to follow defined guidelines in setting the limits of the upstream/ downstream processes/ activities in terms of a company's operational capacity. These guidelines must be general enough to be applied to any industrial sector, as well as to any specific variant of a sector under consideration, without losing their efficacy.

- *areas of interest for the resource efficiency assessment*

Particular areas of interest in assessing process, energy and environmental performance are:

- energy consumption and waste
- material consumption
- water consumption
- greenhouse gas emissions
- production levels
- emissions to the air
- by-products
- waste materials (solids and liquids)
- recycling.

Other aspects, such as a social dimension, can be considered in an assessment, but are limited to a simple indication of relevance (qualitative approach), when applicable, in order to facilitate methodology application.

- *identification and definition of key performance indicators (KPIs)*

The methodology requires a comparison of industrial companies' operations, processes, inputs and outputs with defined reference benchmark values. The areas of interest listed above can therefore be matched with selected KPIs, allowing the EBRD to identify those areas where there is potential for targeting investments.

- *definition of economic-related KPIs (Econ-Re KPIs)*

In most cases KPIs are the sum of mass/energy flows, analysis of the number of unit operations and other similar considerations, all of which are quantitative and closely related to the process flow-sheet, a diagram which describes the process performed by the plant, while also representing the flow of material (from raw material to final product). They are all related to physical dimensions and provide a clear indication of process and resource efficiency increase margins.

It has often been considered that there is a need to apply an additional parameter to these quantitative indicators, indicating the related cost/revenue deriving from the implementation of proposed investments across different areas of interest in order to compare different investment options. For each identified KPI, an economic value can be ascribed to raw materials, energy, water, and so on, in terms of unit costs. It is possible in this way to achieve a set of Econ-Re KPIs which can be aggregated to provide a single significant economic parameter.

This single parameter (expressed in economic/ financial units) enables a comparison between two different configurations of a company process/status (for example, before and after the proposed investment, or two different investment options or two different operating scenarios).

- *dedicated methodological tools*

As with energy audits, the basic data collection tool for resource efficiency audits is a questionnaire, which can be used for remote collection of data before a site visit or for information gathering on-site as a guideline or check-list.

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The assessment will allow the project team to perform a gap analysis on the basis of a comparison with pre-defined reference benchmarks

The questionnaire normally aims to ascertain the input balance of materials, water and energy, and any other input necessary for the determination of the whole set of selected KPIs and related Econ-RE KPIs.

In addition, a set of analytical tools can be applied in order to achieve:

- detailed energy, mass and water balances
- an estimation of selected KPIs and Econ-Re KPIs
- a graphical presentation of calculated KPIs.

Application

The resource efficiency audit will generate, for each investigated company, a comprehensive picture of the producing facilities, and will include at least the following elements:

- a flow diagram of the process
- a description of the technologies in place
- a raw materials list and usage data
- energy source usage levels (based on provided data)
- a description of the most important utilities (electric systems, compressed air, steam boilers and steam distribution system, technical gases, and so on), including data on their operation
- water usage levels, water balance (plant level) and systems in place for wastewater collection and treatment
- major environmental parameters, relating to air, water and soil emissions
- by-products, waste generation levels and collection/management/disposal practices in use (taking into account the recycling options)
- main logistical arrangements related to raw materials/energy/utilities and finished products
- corporate attitudes to sustainability and the environmental, energy and waste management systems in place.

The assessment will allow the project team to perform a gap analysis on the basis of a comparison with pre-defined reference benchmarks, and consequently to identify areas where substantial improvement can be achieved, for example in:

- raw materials supply and usage
- industrial process efficiency (production yield)
- energy source usage efficiency (based on specific energy consumptions – SECs)
- main utilities (electric system, compressed air, steam system, boilers, water system, and so on)
- by-product or waste (solid and liquid) generation and their recycling or disposal
- wastewater collection and treatment
- emissions to the atmosphere and abatement systems
- logistics (supply chains of resources, and so on)
- corporate sustainability (environmental, energy and waste management systems).

From the project ideas generated by resource efficiency assessments, audit teams can identify the most promising options for bankable investments projects or preliminary feasibility studies.

The future of the EBRD – CEI Fund partnership

Based on its strong partnership with the CEI Fund, which has been entirely funded by Italy, the EBRD looks forward to further collaboration on experimental and innovative approaches. The support given by the CEI Fund for energy efficiency initiatives outlined in this report is just a sample of a large and substantive body of work, and illustrates its readiness to contribute to a wide range of instruments leading to visible and sustainable results. The Fund has already actively supported the EEMS programme through some of the components of its energy audit frameworks. Promoting the introduction of integrated EEMS was also part of the objectives of other technical cooperation assignments financed by the Fund, such as helping Macedonian Railways in developing a sustainable energy action plan.

Furthermore, in 2012 the CEI Fund provided more than €400,000 for technical cooperation in developing a comprehensive methodology for assessing the opportunities for integrated resource management and process efficiency improvement. This methodology will enable the EBRD to benchmark the production facilities of its clients according to a wider set of performance indicators across the production cycle, and to help clients identify the areas where specific actions can be implemented to improve resource and process efficiency. The methodology will be applied to many industrial facilities, in cooperation with existing or potential clients of the Bank, to develop relevant business case studies. These are considered a crucial basis in the dialogue with the clients eventually provide templates for an entire industry to follow.

This assignment, titled *Resource and Process Efficiency in Manufacturing Sectors*, involves a combination of high-level research (for identifying the most suitable methodological approach) and technical expertise (to study the most advanced and sustainable technological innovations). The assignment includes work on horizontal and cross-sector studies that will be instrumental for developing transition impact multidimensional indicators, which can support the Bank in implementing new and more comprehensive projects in the various industrial sectors. CEI Fund resources will therefore allow the development of a new means of screening projects and identifying opportunities to further reduce transition gaps in the CEI countries of operations.

The resources channelled by the Italian government through the CEI Fund have contributed to the Bank's accumulation of experience with energy audits and to its development of new transition instruments. CEI-funded technical cooperation in support of the Sustainable Energy Initiative (including energy audits, capacity building, project implementation support, introduction of integrated EEMS and, most recently, resource and process efficiency) has been instrumental in positioning the EBRD as a leading financial institution championing energy sustainability and business opportunities associated with energy efficiency investments. It has also helped to enhance awareness of the strategic importance of energy efficiency in improving the competitive profile of industrial operations.

Annex

D'APPOLONIA

D’Appolonia is an engineering consultancy firm with recognised international experience in providing technical assistance to international financial institutions and their donors for environmental and energy projects and initiatives. Its team of experts provide quality services worldwide in a variety of engineering sectors.

The company is proud to have had the opportunity to provide technical assistance for EBRD/CEI Fund integrated support to energy efficiency initiatives, and its contribution has been integral to the successful results achieved to date.

The cooperation between the CEI Fund, the EBRD and D'Appolonia started in 2004. D'Appolonia, with its technical assistance input, has since contributed to a range of energy efficiency projects. Client satisfaction was always considered a priority, and the quality of the results achieved by the company in partnership with the CEI Fund and the EBRD has undoubtedly proved that this goal has been met.

Since 2004, D'Appolonia's experts have addressed many different technical challenges in different countries with different cultures, not only applying their knowledge, experience and know-how in support of EBRD clients but also learning from new contexts and situations.

This enduring collaboration has allowed the company, EBRD and CEI to develop a simple and effective methodology for assessing energy efficiency investment potential across all sectors. Moreover, the optimisation of industrial operations in the EBRD region will no longer be solely an energy efficiency issue, but will be encompass improvements in the use of water, raw materials and by-products, yield maximisation and all other actions that can determine process enhancement and a lower impact on the environment.

The collaboration between the EBRD, the CEI Fund and D'Appolonia, and the specific skills contributed by each party, have been fundamental to the positive results achieved to date and may it long continue.

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