An Integrated Approach to Improving Operations and Energy Efficiency at the Tufon Foundry in Craiova, Romania

Project Title: Efficient Energy Consumption: Minimum Climatic Changes
Leader: Tufon Company (Craiova, Romania)
Partners: March Consulting spol, (Czech Republic), Thermal Desorption Group, LLC (Hungary)
Location: Craiova, Romania
Project Duration: April 2001 – January 2002
EcoLinks Project Investment: Total Project Investment: $ 73,214; EcoLinks Grant Support: $ 44,819; Project Team Cost Share Contribution: $ 28, 395.

Best Practice: Transferable Solution

This project is a Best Practice because it involved the development of concrete measures for simultaneously improving foundry processes, product quality, and energy efficiency. With the support of an EcoLinks Challenge Grant, Tufon along with cross-border partners from Czech Republic and Hungary assessed options to increase operating efficiencies of the melting process and to reduce energy consumption. Tufon, formerly a part of The Enterprise of Tractors and Agricultural Engines of the 1970s, strives like many other plants in the region to downsize and adjust the former equipment and technology to the current scale of foundry operations, to become more competitive, environmental friendly and cost efficient.

Project Summary

Tufon is one of the largest iron casting facilities in Romania. It was founded in Craiova, Romania in 1991 and took over casting installations after the separation of the Entreprise of Tractors and Agricultural Machines Craiova. It is a foundry that produces grey cast iron and nodular cast iron parts used to manufacture equipment and cars. The foundry operates three induction furnaces (a soaking furnace, a molding line in metalic flasks, and a molding line of single parts), ten core making machines, five stations for sand preparation, and other ancillary equipment. Tufon inhereted casting installations from the 1980s and seeks to modernize its operations to improve environmental and economic performance. As part of this process, Tufon is focused on improving its energy efficiency and reorganizing the production process in order to reduce greenhouse gas emissions and production costs.

Tufon is a high energy consumer due partly to the nature of iron casting and partly to the fairly old and inefficient equipment. Tufon's current electricity consumption is approximately 1,000 MWh /month costing a total of US $ 436,000/year, representing roughly 40 % of the total energy used in the plant. Natural gas is used for limited purposes and amounts to approximately 920,000 nm^3 /year, costing approximately US$ 63,000. Heat is purchased from the city heating company, and amounts to approximately 6,800 Gcal/year, costing US $79,000.

Tufon operates at approximately 41 % of the plant's full capacity. This makes it especially challenging to maintain low costs per unit of production. With high energy consumption, significant amounts of greenhouse gases associated with global warming trends are emitted. In addition to the environmental impacts, there are economic losses. Energy costs comprise a minimum of 30 – 32% of production costs and make it difficult for the company to compete in the open market.

Tufon's electric energy, used largely for melting iron, is generated by an external thermal power plant fueled by lignite coal. Approximately 250-300 tons of coal are burned each month and emit high levels of carbon and sulphur dioxide as well as nitrogen oxide and ash particles into the environment.

In addition to the external air pollution problems, worker health is threatened inside the plant by dangerous emissions and high noise levels. The allowable concentration of SiO_2 in the work environment is 2.06 mg/m^3. The average concentration of free SiO_2 at Tufon is 7.63 mg/m^3, reaching 11.49 mg/m^3 in some work areas. The noise level exceeds 80 dB.

With support from the EcoLinks Challenge Grant Program, Tufon collaborated with March Consulting from the Czech Republic and Thermal Desorption Technology Group of Hungary to increase the efficiency of their production process, to reduce energy consumption (and greenhouse gas emissions), and improve environmental working conditions. The project involved multiple objectives including conducting an energy audit, developing solutions for reducing energy consumption from heating production halls and iron casting, and producing an information-sharing campaign involving brochures and a seminar.

With full implementation of the measures developed in this project, several important benefits are accrued. Energy consumption is potentially reduced by 20-30% resulting in an economic savings of up to 25-30%. The emission of several pollutants including sulfur dioxide, carbon dioxide, and ash is reduced by several hundred kilograms per year (a breakdown is provided in Environmental Benefits section). The local and workplace environmental conditions can be improved significantly. Work productivity can be increased by 15% and production costs can be reduced by 20%. The reduction in energy consumption and production costs is approximately US$ 187,000/year with full implementation of all the proposed energy saving measures. Through the information-sharing campaign, other companies were inspired to conduct similar projects.

Project Activities

The project activities included an energy audit and an evaluation of multiple environmental and economic factors. Energy consumption patterns and rates were analyzed and solutions for reducing consumption were generated. For this purpose, EcoLinks provided support to the leader to purchase a Raytek 31 pyrometer manufactured by Raynger Inc. of USA. This is a portable device that can measure temperatures ranging from (200 – 3000^0 C) from a distance, and was used in this project to measure the temperature of the cast iron liquid. Spectral standards, also purchased with EcoLinks funds, were used to determine more accurately the concentrations of carbon and silicon in the cast iron, and hence improve product quality. An energy analyzer was purchased to allow detailed power measurements within the foundry. With the purchase and installation of environmental monitoring equipment, continuous monitoring of the molten cast temperature and energy consumption was conducted to improve the efficiency of operations.

1. Conducted an energy audit.

Action: Energy consumption and economic values from 1998-2001 were analyzed. The consumption patterns and related costs involving different energy sources (electrical energy, natural gas, and thermal energy) were determined. The total energy consumption at Tufon in 2001 was 28,535 MWh costing a total of US$ 572,000, approximately 30 % of the total production costs. Energy efficiency indicators per ton of product and type of energy were determined and analyzed for the years 1998-2001. They varied significantly from one year to another, but also remained by as much as 8 % higher than the EU industry average.

Product(s): 1) Data on the monthly consumption of electrical energy, natural gas, and thermal energy for the years 1998-2001 2) A breakdown of the consumption and costs involving the different energy sources and major energy consumers 3) Energy efficiency indicators per ton of product

2. Analyzed power consumption and space heating system.

Action: A “Network Analyzer”, purchased during the project, was used to measure the power distribution at the major power consumers at Tufon. The findings indicated the key places where priority attention was needed. For example, the iron foundry operates at a much lower power level than that supplied by the transformers which results in a poor power factor (the ratio of active to apparent power in a network) and a higher need for compensation of the reactive power. Ideally the power factor is close to 1 (penalties are applied by the power company if this factor exceeds the Romanian threshold of 0.92). Improving the power factor enhances cost efficiency and reduces electricity loss in the network when operating the induction furnaces. The power factor at the main switchboard was even poorer. The amount of electricity consumed was, therefore, much higher than needed. Electric motors operate presently at approximately 75 % of the installed power, and hence their efficiency is also low. The results ultimately indicated that there was a high potential to improve energy efficiency and hence reduce costs within the facility.

The space heating system, another major energy consumer in the form of heat, was also investigated. The system's efficiency status was concluded, and recommendations for improvement were made. An important conclusion was that classical heating systems using warm water are especially inefficient for large workspaces. It was subsequently recommended that the system should be replaced with infrared ray local heating installations, largely used in the EU countries.

Product(s): Identification of critical energy consumption areas and proposed remedies for reducing consumption and improving energy management in the plant

3. Monitored energy consumption and the molten cast temperature.

Action: The project activities simultaneously addressed "global climate change" issues as well as opportunities for cleaner production. Energy consumption and the molten cast temperature were adjusted and monitored achieving better efficiency and product quality. The old, high inertia thermometers were replaced with a Raytek pyrometer that was purchased as part of the project improving control over the temperature of the molten cast. Additionally, the elaboration time (approximately 4 hours) was reduced by as much as 15 to 30 minutes. This reduced the level of energy consumption per load and refractory ware by as much as 6.25 % and the amount of refuse, and ultimately produced a better quality product.

Product(s): Monitoring programs for the molten cast temperature and overall company energy management in the induction furnace workshop

4. Developed measures to improve energy efficiency.

Action: Based on the energy audit, several measures for improving energy efficiency were developed. They included the following:

- Updating electrical drawings
- Implementing reorganization strategies for achieving optimal load of transformers (e.g., increasing use of the special iron foundry)
- Installing "off-load" sensors on machine-tools
- Replacing over-sized motors with smaller ones
- Installing condensers for power factor correction
- Replacing incandescent or fluorescent lamps with more long-lasting, energy efficient lighting

- Improving heating system by using radiant tubes
- Replacing old micro-power station for sewage heating with a modern system

Product(s): Measures for improving energy efficiency

5. Evaluated measures for improving energy efficiency.

Action: An environmental and economic analysis of the different measures was conducted. The economic evaluation involved grouping the measures according to the particular energy supply sources: electrical energy, gas, and thermal energy. For each energy source, the cost savings, investment costs, investment costs during evolution period and life expectancy, payback period, discounted payback period, NPV, and IRR were calculated (see Table 1. in the Economic Benefits section). An environmental evaluation included a review of the emission levels of different pollutants in relationship to the different energy sources (see Tables 2. and 3. in the Environmental Benefits section).

Product(s): Economic and environmental evaluations

6. Prepared a customized Environmental Assessment Model (TEAM) and an Integrated Environmental Assessment and Production Model (TEAM-PRO).

Activity: An assessment of the main environmental factors at Tufon was performed including an evaluation of the environmental impacts from current and past operations. Material flows, waste management including the internal transportation of waste, and emission values for 1999 and 2000 were analyzed. Based on these, an environmental evaluation was made and conclusions presented to the management at Tufon.
An environmental SWOT matrix was also developed for the Project Leader. The Hungarian partner in the project prepared a "TEAM" – Tufon Environmental Assessment Model with the purpose of enabling the Leader to identify the most important environmental problems on the site and find the optimum solutions. The Environmental Site Assessment comprised: a records review; site recognition; interviews with the owner, personnel, and local government officials; and a report.

Product(s): 1) Models TEAM and TEAM – PRO, 2) Transaction Screen Questionnaire.

Project Benefits

As a result of the project's energy audit and recommendations made based on the audit findings multiple capacity building, environmental, and economic benefits are generated including: the initiation of similar efforts to improve energy efficiency at other companies, a reduction in energy consumption, lowered greenhouse gas emissions, improved worker conditions and productivity, and reduced production costs.

Capacity Building Benefits

The capacity building benefits generated by this project include the project leader's strengthened ability to assess, develop, and implement a model for making improvements in factory operations and energy efficiency. The project results were well disseminated making the project benefits available to other similar operations in the region.

With the assistance of the multiple, regional partners and local associate, the project leader gained knowledge and experience in 1) generating a reorganization strategy to improve production efficiency and 2) applying technology that allowed the company to reduce energy consumption.

The Environmental Assessment Model that was developed during the project established the capacity for Tufon to conduct environmental self-assessments. The Environmental SWOT Analysis can be used by the management to identify the company's strengths, weaknesses, challenges and opportunities from an environmental standpoint.

Additional capacity building resulted from an information sharing strategy that involved the production and dissemination of a brochure on the project accomplishments and a workshop involving numerous participants from other similar companies. As a result of this information sharing effort, efforts to improve energy efficiency and reduce greenhouse gas production in other companies are facilitated.

Environmental Benefits

This project made it possible to achieve reductions in energy consumption and greenhouse gases. Energy consumption may be reduced by approximately 20-40%. With implementation of the proposed measures developed by this project, greenhouse gas emissions are reduced. Solid particles are reduced by 253 t/year; and carbon dioxide is reduced by 8,500 t/year.

The energy audit and proposed measures developed by this project produce notable reductions in the emission of various pollutants. Potential emission reductions are outlined in Table 1.

Table 1. Potential emission reductions

Source of pollution	**Solid Particles (t/year)**	**Ashes (t/year)**	**SO_2 (t/year)**	**NO_x (t/year)**	**CO_2 (t/year)**	**CO (t/year)**	**C_xH_y (t/year)**	**% of the total emissions**
Electrical Energy Use	191	2.4	9.6	11.8	6,070	166	37	42
Gas Use	8.8	0	0	0.6	726	124	0.050	30
Thermal Energy Use	53.6	0.7	25.4	3.3	1,702	46	10	29
Total	254	3	116	15.7	8,500	213	47	NA

Economic Benefits

Multiple cost savings are generated with the implementation of the measures outlined by this project. Table 2. outlines the financial data associated with the different energy sources.

Table 2. Financial data given different energy sources

Energy Source	Cost Savings (US$/yr)	Investment Costs (US$)	Simple Payback Period (years)	Discounted Payback Period (years)	Net Present Value (US$)	Internal Rate of Return
Electrical energy	66,334	189,875	3.9	4.1	341,074	0.98
Gas	25,849	27,000	0.5	0.5	322,358	1.5
Thermal energy	95,531	115,000	1.2	1.2	1,126,225	0.8
Total	187,714	331,875	1.8	1.8	2,107,069	1.35

Table 3. outlines a breakdown of some of the organizational and procedural improvements and energy efficiency measures and their respective benefits and financial considerations.

Table 3. Improvements, benefits, and financial data

Measure	Benefit	Savings (MWh)	Savings (US $)	Investment Costs (US $)	Payback Period (years)
Reorganization of factory equipment, production lines, and power distribution	Improves production efficiency	454	22,158	106,250	5.3
Installation of "off-load " sensors on selected machinery	Reduces energy consumption	130	5,772	6,250	1.08
Installation of condensers	Reduces energy loss	209	9,280	9,375	1.01
Replacement of over-sized motors	Reduces energy consumption	120	5,328	30,000	5.6
Replacement of incandescent or fluorescent lamps with more efficient lighting	Reduces energy consumption	221	9,812	1,800	1.8
Replacement of classical heating system with radiant tubes	Increases building heat efficiency	7,108	95,531	115,000	1.2

Replacement of the micro-power station for sewage heating with a modern micro-power plant	Reduces energy consumption; Improves labor conditions; and Reduces the need for maintenance and monitoring personnel	2721	25,849	27,000	1.04

Lessons Learned

The following lessons were learned during this project:

- The trans-boundary partnership between Romania, Czech Republic, and Hungary promoted an important exchange of diverse expertise from the region.
- Monitoring and record keeping on company operations, especially related to environmental issues, are critically important to improving or sustaining environmental performance.
- It is important to take into account multiple energy factors. Successfully implementing multiple small-scale energy saving measures can produce high benefits.
- The credibility of the business was improved by employing experts to conduct economic feasibility studies and environmental assessments.

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