Ukraine: Emerging Market for Industrial Energy Efficiency Opportunities

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ABSTRACT

As part of the energy assistance program to help Ukraine shut down the Chornobyl nuclear reactors, the U.S. Department of Energy (DOE) asked the Pacific Northwest National Laboratory (PNNL) to identify and appraise industrial energy efficiency projects in Ukraine. The industrial sector currently accounts for over 60% of Ukraine’s energy consumption. Most industrial enterprises in Ukraine use energy very inefficiently because the former Communist system provided few incentives to conserve energy or even account for its cost. Since 1994, however, the country’s energy prices have risen close to world levels, and Ukraine finds itself saddled with very high energy costs. The Ukrainian Government is also under pressure to lower natural gas imports and reduce the country’s trade imbalance with Russia. As a result, incentives to save energy in Ukraine are now great, and the market for energy efficiency products is growing. The Ukrainian Government estimates that this market will generate from $700 million to $1 billion of new product sales by the year 2000. However, few industrial enterprises have the money necessary for large-scale energy-efficiency improvements. Therefore, one of the main goals of this DOE-funded program is to help the most promising enterprises obtain financing for energy efficiency projects from a variety of financial institutions, or through new, creative financing mechanisms.

The program has involved several site visits to different industrial plants in Ukraine to gather preliminary data on the facilities. Most of these plants are in the process of being privatized or have been recently privatized and are financially sound. Among the plants visited have been a glass manufacturing plant, a coke-chemical plant, a tire factory, a food processing plant, a paper mill, an alumina plant, an iron mine, a metallurgical firm, and a steel cable factory. Following a preliminary analysis of the site-specific data obtained during the first visit to the plants, a limited number of plants were chosen for a more detailed energy audit and financial assessment. Results of a detailed engineering analysis and a financial assessment of each plant led to a prioritized list of recommended energy efficiency measures. The measures recommended thus far include replacing an existing steam plant with a base-load gas turbine cogeneration plant, replacing an existing compressed-air system with high-efficiency equipment, upgrading the glass process furnaces, upgrading the lighting system, and installation of heat recovery systems. Some specific technologies recommended have included installing a new Western furnace, which not only saves energy but also increases the volume and quality of glass production. The gas turbine cogeneration plant proposed for the coke-chemical plant will

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1 Operated for the U.S. Department of Energy by Battelle Memorial Institute under contract DE-AC06-76RLO 1830.
use coke-oven gas, a by-product of the coking process, as the primary fuel. This paper describes the process of identifying opportunities and discusses the recommendations made to plant managers at two of these facilities. The paper also provides an update on the implementation plans for some of the recommended energy efficiency measures at these industrial enterprises.

**BACKGROUND**

Ukraine is a large, new market for energy efficiency. The country has a population of 51 million and imports about $12 billion worth of goods and services every year. The market for energy efficiency equipment and services is substantial. Ukrainians can no longer afford to use energy inefficiently because energy prices in Ukraine are now close to world prices and are no longer subsidized, as they used to be under the old Soviet system.

The bulk of the energy efficiency market is in the industrial sector. Industry accounts for 60% of the total energy use in Ukraine. In recent years, industrial enterprises have felt increasing pressure to reduce their energy use; energy subsidies are disappearing and many enterprises are privatized or on the path to privatization, which means they can no longer rely on the state for general subsidies. One might ask why these enterprises have ignored cost-effective energy efficiency opportunities, given the rising energy costs. Part of the reason is that there are several barriers to energy efficiency and business overall in Ukraine, including high risk, the non-payments problem\(^2\), lack of financing, and lack of infrastructure.

While doing business in Ukraine may at first seem a daunting undertaking, companies can take several steps to minimize the risks and difficulties. A reliable local partner is crucial, particularly when a company is first starting to work in Ukraine. One such partner that PNNL staff chose to work with is the Ukrainian Agency for Rational Energy Use and Ecology (ARENA-ECO) which can provide basic market data and can help companies with more specific needs through individual contracts. For example, within the industrial sector, there are a few basic characteristics to look for in an enterprise, which will make structuring and financing deals easier:

- Hard currency earnings
- Proportionally large energy costs
- Market-oriented management team
- Financial viability.

Metallurgical, paper and pulp, chemical and oil refining enterprises are likely to export their products and have hard currency earnings. Enterprises in these industries also consume large quantities of energy because of the nature of their businesses. However, the management style of these enterprises in these sectors varies significantly. As a rule, an enterprise that is slated for privatization or is currently privatized is more likely to

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\(^2\) Non-payments or arrears problem is one when a plant does not pay in full for the goods and services it consumes. For example, industrial plants often have debts for the natural gas they use.
have a market-oriented management team than one that is protected from privatization and market forces.

**MOTIVATION**

In the fall of 1994, the U.S. Department of Energy (DOE) asked the Pacific Northwest National Laboratory (PNNL) to identify energy efficiency opportunities in Ukraine that could help offset the loss of power from Chernobyl when the damaged reactor and the rest of the plant is closed. To this end, staff from the Advanced International Studies Unit (AISU) of PNNL organized a mission to Ukraine with ARENA-ECO staff. The mission team reviewed information on a large number of Ukrainian industrial enterprises based on their size, energy use and the particular sectors they represented. Later, PNNL also sought the services of a Ukrainian financial appraisal firm called Industrial Real Estate (IRE). Based on the information gathered and discussions with Ukrainian government officials, the team decided to visit several enterprises to meet with the management teams and get some first-hand but preliminary information on the enterprise’s status and philosophy with respect to energy efficiency improvements. Most of these plants are financially sound and have either been recently privatized, or are in the process of being privatized. They can afford to spend their own money or obtain financial loans to fund the energy efficiency opportunities identified during this project. Among the various plants visited by the team have been a glass manufacturing plant, a coke-chemical plant, a tire factory, a food processing plant, a paper mill, an alumina plant, an iron mine facility, a metallurgical firm, and a steel cable factory. Following a preliminary analysis of the site-specific data obtained during the first visit to the plants, a limited number of plants were chosen for a more detailed energy audit and financial assessment. Results of a detailed engineering analysis and a financial assessment of the plant led to a prioritized list of recommended energy efficiency measures. The rest of this paper describes the process of identifying opportunities and discusses the recommendations made to the plant management at two of these enterprises. An update of the implementation plans for some of the recommended energy efficiency measures at these industrial enterprises is also provided at the end of this paper.

**ENERGY EFFICIENCY AT THE GOSTOMEL GLASS PLANT**

The Gostomel Glass Plant produces bottles for beverages, perfumes and pharmaceuticals. Its customers include Coca-Cola, Pepsi-Cola, Obolon (a large Ukrainian brewery) and several Ukrainian cosmetic and pharmaceutical companies. Gostomel’s plant is located in the Kiev region, 16 miles from the city of Kiev. The plant has run continuously at full capacity in recent years. Much of this successful operation can be attributed to Gostomel’s creative market-oriented management style, in place since the company was privatized in 1993. Gostomel’s management and board of directors realize that the plant uses energy very inefficiently in comparison to similar plants in the West. This high energy use has created high costs. Gostomel management also knows that it could expand its market and sales if it could increase production capacity. PNNL and ARENA-ECO staff conducted a detailed energy audit of the Gostomel plant, the findings of which are described below.
The most significant energy efficiency measure considered was replacing glass furnace number 3 with a new, Western-design furnace. This measure will produce large energy savings and will also allow Gostomel to increase the volume and quality of its production. The energy savings alone will not pay for the furnace, as indicated in the table below. Nonetheless, the total benefits of the new furnace will likely make it a very appealing investment. In addition to the new furnace, the following measures were recommended:

- installing a high-efficiency compressed air system, including several new compressors, an automatic control system and a refrigerated air dryer system
- installing heat recovery hot water boilers in the glass furnace exhaust system and a new hot water boiler
- upgrading heat insulation on the hot water distribution system
- relocating the air intake for screw-type air compressors to outside the compressor building.

Table 1 summarizes the results of the energy audit and lists the proposed energy-efficiency measures (along with the internal rates of return (IRR) on the investments) identified to be potentially cost-effective for the Gostomel Glass Plant.

**Table 1. Summary of Proposed Energy-Efficiency Measures**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Cost (US $)</th>
<th>Annual Savings (US $)</th>
<th>Simple Payback (years)</th>
<th>Internal Rate of Return (IRR) (%/yr.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-efficiency compressed-air system and controls</td>
<td>967,754</td>
<td>193,862</td>
<td>5.0</td>
<td>19.5</td>
</tr>
<tr>
<td>Heat recovery hot water boilers in glass furnace exhaust systems</td>
<td>530,900</td>
<td>156,395</td>
<td>3.4</td>
<td>29.3</td>
</tr>
<tr>
<td>Relocate compressor air-intake outside the compressor building</td>
<td>4,000</td>
<td>2,130</td>
<td>1.9</td>
<td>53.2</td>
</tr>
<tr>
<td>Piping insulation upgrade</td>
<td>39,070</td>
<td>14,550</td>
<td>2.7</td>
<td>25.1</td>
</tr>
<tr>
<td>Upgrade glass furnace*</td>
<td>18,190,000</td>
<td>592,900</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

* This measure was recommended as a modernization project. It cannot be economically justified based on energy savings alone. As a result, the simple payback and IRR based on energy savings are not meaningful, so these calculations have been omitted.

**ENERGY EFFICIENCY AT THE AVDEEVKA COKE-CHEMICAL PLANT**

Several recommendations for increasing energy efficiency at the Avdeevka Coke-Chemical Plant were made based on a site visit and energy audit of the plant. Avdeevka is located in Donetsk Oblast, just outside the city of Donetsk. It is one of the largest
coke-chemical plants in Europe and has a strong market position in Ukraine. In recent years, the plant has sold coke to almost every Ukrainian steel mill. Its primary customer is currently Ilich Steel Plant in Mariupol, a plant with a strong export base. Avdeevka also sells over 20 types of chemicals derived from coal including low-octane gasoline, paint additives, and sulfuric acid, and exports 10% of its products. Avdeevka has financed significant modernization, renovation, and other plant upgrades with its net profits. The company was privatized in 1992 – one of the first Ukrainian enterprises to do so.

Combustion of the coke-oven gas (essentially a free by-product of the coking process) and electricity purchases cover most of Avdeevka’s energy demand. However, Avdeevka’s combined heat and power station is very outdated; as a result, it produces less electricity and steam than a more modern facility could with the available coke-oven gas. Plant management recognized this problem and commissioned a study by Mashproekt staff to assess the feasibility of installing locally designed and manufactured gas turbines with waste heat recovery boilers for meeting Avdeevka’s energy needs. The feasibility study by PNNL and ARENA-ECO staff further reinforced the feasibility of installing a gas turbine cogeneration system and made additional recommendations for improving the energy efficiency of the plant as listed below:

- install a new gas turbine cogeneration system
- install efficient outdoor lighting
- replace insulation on steam and hot water piping
- modify the compressed-air system
- identify and repair leaks in the compressed-air system
- install steam traps

The most significant measure considered by PNNL and ARENA-ECO for the Avdeevka plant was installation of a new gas turbine cogeneration system. The preliminary analysis of the electrical and steam demands at the plant confirmed that a new 15 MW gas turbine cogeneration system would be a cost-effective investment. An economic analysis was conducted for three different options involving one, two or three equally-sized gas turbine cogeneration systems. The final recommendation was that two gas turbine cogeneration systems be installed in two phases so the savings from the first phase can help pay for the second phase. However, in the short-term, the plant is only considering the first phase, installation of one gas turbine unit. The economic feasibility of the second turbine will significantly improve if selling excess electricity to the local utility in the summer becomes an option for the plant. The second turbine will also enable a more complete utilization of the excess coke-oven gas in the plant. It was estimated that the cogeneration system installation would take about 27 months after the project financing has been approved. A small initial investment of about $12,000 in coke-oven gas flow measuring equipment was also recommended to improve the ability to assess the quantities of the production and consumption of the gas within the plant. The PNNL analysis was based on the products of two potential vendors - Asea Brown Boveri (ABB) of Sweden and the Mashproekt Turbine Plant in Nikolayev, Ukraine. Both vendors had similar performance and cost data for their products, which were used as sample data in
the analysis. It was assumed that Avdeevka would go through a competitive bid process and seek full engineering and cost proposals to be able to compare product reliability and the gas turbine vendor’s experience with coke-oven gas-fired systems prior to the final selection of a vendor.

Based on the end-use energy-efficiency potential at Avdeevka, the audit revealed that the plant has several additional cost-effective opportunities to save energy through such measures as installing efficient outdoor lighting and replacing insulation on steam and hot water piping. The former measure recommends replacing existing low-efficiency incandescent lights with new high-efficiency lamps and lighting fixtures while maintaining a similar level of illumination at the facility. Two high-efficiency lamp (high-pressure sodium and low-pressure sodium) options were considered for the outdoor lighting retrofits. Although not as energy efficient as low-pressure sodium, high-pressure sodium lighting is still about 300% to 600% more energy efficient than the existing incandescent lighting and offers a lamp life 24 times as long. Other recommended measures include modifying the compressed-air system by either replacing the existing unit with a high-efficiency unit equipped with a load control system or installing a series of smaller compressors and automatic load management controls.

Electricity efficiency measures will reduce electricity purchases so the economic analysis of these measures is fairly straightforward. However, thermal energy (steam and/or hot water) is produced on site with coke-oven gas, a by-product of the coking process, so the economic analysis of thermal energy saving measures is slightly more complicated. With the cogeneration system, thermal energy efficiency measures will allow the plant to produce more electricity, which in turn will reduce electricity purchases. In some cases, thermal energy savings will reduce expenses involved in generating the steam (such as costs for maintenance and the water supply). Thermal energy savings will also prolong the life of the heat-generating equipment, thereby reducing capital expenditures. In addition, thermal energy efficiency measures like steam traps will help reduce the steam demand on the new cogeneration system, particularly in the winter months when steam demand is expected to slightly outpace coke-oven gas availability. These expected thermal energy and electricity savings were included in the analysis when the proposed cogeneration system was sized. The end-use energy efficiency measures are thus an integral part of the proposed strategy for improving the energy efficiency at the plant.

Table 2 lists the proposed energy-efficiency measures recommended for implementation at the Avdeevka coke-chemical plant. These measures are all cost-effective, with the returns on investment ranging from 15% to over 1000%.
Table 2. Summary of Proposed Energy-Efficiency Measures  
(Avdeevka Coke-Chemical Plant)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Cost (US $)</th>
<th>Annual Savings (US $)</th>
<th>Simple Payback (years)</th>
<th>Internal Rate of Return (IRR) (%/yr.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cogeneration System</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-- ABB, one unit</td>
<td>13,000,000</td>
<td>5,400,000</td>
<td>2.4</td>
<td>40</td>
</tr>
<tr>
<td>-- Mashproekt, one unit</td>
<td>10,000,000</td>
<td>4,700,000</td>
<td>2.1</td>
<td>43</td>
</tr>
<tr>
<td>-- ABB, two units</td>
<td>26,000,000</td>
<td>10,900,000</td>
<td>2.4</td>
<td>40</td>
</tr>
<tr>
<td>-- Mashproekt, two units</td>
<td>20,000,000</td>
<td>9,400,000</td>
<td>2.1</td>
<td>43</td>
</tr>
<tr>
<td>Efficient Outdoor Lighting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-- High-pressure Sodium</td>
<td>305,868</td>
<td>78,381</td>
<td>3.9</td>
<td>24.7</td>
</tr>
<tr>
<td>Piping Insulation</td>
<td>95,000</td>
<td>1,681,000</td>
<td>0.06</td>
<td>1,772</td>
</tr>
<tr>
<td>Compressed-Air System</td>
<td>139,000</td>
<td>47,000</td>
<td>3.0</td>
<td>36</td>
</tr>
</tbody>
</table>

IMPLEMENTATION PLANS

Gostomel Glass Plant

Gostomel has implemented several of the recommendations described in this paper, and the plant is actively seeking financing for the rest. Specifically, Gostomel has installed a waste heat recovery boiler in glass furnace 3. The measure was so effective that Gostomel is now planning to install a second heat recovery boiler at glass furnace 1. The plant has also relocated the air intake for its compressors, and plans to use internal funding to finance the insulation of steam piping. The plant is looking for external financing for the largest cost measures: the furnace upgrade and the new air compressors and controls.

The furnace upgrade is part of a larger modernization plan for which Gostomel is seeking financing. Gostomel would like to set up a joint venture with a strategic investor to realize this modernization plan. This type of joint venture takes time to establish. In the interim, Gostomel is considering other alternatives such as a loan from the European Bank for Reconstruction and Development (EBRD), vendor financing, and leasing for both the compressor and furnace upgrades. PNNL and IRE are working with Gostomel to structure the different financing options.

Avdeevka Coke-Chemical Plant

Avdeevka’s board of directors and senior management have made a formal decision to implement PNNL’s recommendations. The company plans to implement most measures with internal financing; these include efficient outdoor lighting, piping insulation and compressed-air system modifications. Avdeevka is preparing procurement documents to competitively select a vendor for the cogeneration equipment. The cogeneration project is too large for the plant to finance internally, so PNNL and IRE have developed a
preliminary financing plan with Avdeevka. The financing package will only be finalized after the vendor is selected, but it will almost certainly include a significant down payment and collateral from Avdeevka. The structure and sources of financing are currently under discussion, but leasing and vendor financing are two likely options.

CONCLUSIONS

The Ukrainian industry is coming to the realization that it must increase its energy-efficiency to cut costs, remain competitive, and at the same time, expand its export markets. This realization provides an opportunity for foreign suppliers of energy efficient equipment and services to help implement energy-efficiency measures. Given the constantly changing economic climate and its inherent uncertainties, it is extremely important to carefully review any business opportunities before getting involved. In all likelihood, however, the Ukrainian market for implementing energy-efficiency measures within its industries will only grow, as formerly state-run firms become privatized.

Based on these audit experiences and studies of the different industrial sector companies in Ukraine, PNNL staff are preparing a guide for Ukrainian industrial managers on identifying and financing energy-efficiency improvements. The guide is expected to be available in 1999.

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BIBLIOGRAPHY


