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TECHNICAL REPORT

Summary Report

Task 5: Industrial Environmental Audits

by Tom Higgins - July 1997

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A USAID Project Consortium Led by CH2M HILL

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**Environmental Policy and Technology
Project Regional Field Office / Moscow**

(Managed by CH2M HILL)

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EPT Regional Director



Date

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Section 1 Introduction

1.1 Background

Novokuznetsk (NVK) is a large industrial city in Western Siberia with significant air pollution, primarily caused by burning locally abundant coal. The EPT Project's Air Pollution Task identified the city's approximately 160 small boiler houses as the main source of particulate air pollution in the city, based on the fact that these boiler houses have low efficiency air emission control equipment (usually cyclones) and discharge their emissions from low stacks located near residential areas. The EPT Project Audit Task targeted these boiler houses as the key to reducing particulate emissions and improving air quality.

To reduce air emissions from these boiler houses would require an approach different than just designing and installing high efficiency air emission control equipment. This would improve the air quality, but would require large capital expenditures (something in short supply in Russia) and increase operating costs. An approach was needed that would provide economic as well as environmental improvements to boiler house operations.

Energy efficiency considerations also had to be considered. Because of a variety of poor energy utilization practices and the improper maintenance of energy systems, it was necessary to introduce rapid improvements in industrial energy efficiency in Novokuznetsk. In fact, the low energy efficiency of the facilities was related to the high emission of particulates into the atmosphere from the coal-fired boilers. Higher-than-designed coal burning rates overloaded the flue gas clean-up equipment, which worsened the emissions problem. Emissions penalties alone were not providing sufficient economic incentive to proceed with projects to reduce emissions.

Energy efficiency improvements are cost-effective within the current energy economy and can provide economic incentives that support the concern to clean up the environment. These energy efficiency improvements will also result in an improvement in air quality by reducing emissions at the source. Increases in energy prices to equivalent world prices have put additional pressures on industrial firms to conserve energy. Changes within the economic system (energy prices, privatization, etc.) will create a new emphasis on the necessity to increase energy efficiency and reduce energy intensity of production.

The industrial audit program demonstrated the effectiveness of energy efficiency improvements as part of an overall low-cost effort to reduce particulate emissions. Towards that end, the Project provided training on energy efficiency audit practices, use of energy performance measurement equipment, and evaluation of energy conservation opportunities.

1.2 Strategy

The Audit Project took a four-step approach to improve coal combustion and thereby reduce particulate emissions. These steps included:

- 1 Performing energy audits and boiler tune-ups to identify the best methods for improving the efficiencies of typical boilers.
- 2 Installing fixed combustion control equipment to maintain effective combustion and serve as a demonstration of the equipment's potential. Installation of improved end-use controls in a small district heating system also will reduce coal consumption.
- 3 Providing better quality coal by sorting and/or cleaning the coal prior to combustion (reported separately)
- 4 Providing training and establishing companies to carry on and replicate the results of the task throughout the city and region.

Section 2 Results

2.1 Energy Audits and Boiler Tune-ups

Energy audits were conducted at the following six facilities within Novokuznetsk to identify opportunities for installing improved control and heat utilization systems:

- 1 Abashevskaya Communal Boiler
- 2 Ziryanskaya Communal Boiler
- 3 ZapSib Combined Heat and Power Plant
- 4 The Novokuznetsk Refrigeration Plant
- 5 The Novokuznetsk Poultry Processing Plant
- 6 The Novokuznetsk Cement Plant

The boiler houses chosen for the EPT Industrial Audit project are representative of many companies or similar facilities within the city, making them ideal targets for the industrial energy audit work since potential for replication is very high. The cement plant audit was included due to its significant emission of particulates and use of energy in the production of Portland cement. Many of these medium-sized plants are viable, but have not yet implemented energy conservation activities. Changes within the system (increased energy prices, full collection of tariffs, privatization, etc.) will create a new emphasis on the necessity to increase energy efficiency and reduce energy intensity of production. Parallel emission reductions can be expected with increases in energy efficiency.

An energy audit report dated September 1995 was prepared for each of the six facilities audited and a seventh report summarized the results of the stack particulate sampling done at each of the five facilities, excluding the cement plant. These seven reports provide complete coverage of the energy/environmental audit activities conducted in Novokuznetsk, Russia during the period of 25 April-26 May 1995.

Energy audits included the tune-up of boilers to improve energy efficiency. These boiler tune-ups focused on reducing flue gas excess air and reducing CO. These audits also identified opportunities for reducing energy losses in the end-use of energy, such as better control of temperatures at the apartment houses at the Poultry Plant. In addition, better process control of cement production improves product quality and reduces product loss, related energy loss, and associated emissions.

Energy savings as a result of boiler tune-ups were found to result in an approximately 6 to 10 percent savings in energy and rapidly pay back the cost of the tune-up. However, it is not possible to maintain the total effectiveness of the tune-up without improvements in monitoring and control and a frequent tuning of boilers would be necessary to maintain results. On an annual basis it may be expected that boiler tune-ups would result in a 3 percent energy savings.

2.2 Installation of Combustion Control Equipment

Recommendations from these audits were used as the basis for the purchase and installation of approximately \$500,000 of equipment at the facilities to implement recommendations from the audits and demonstrate the effectiveness of these improvements

As a result of the energy audits, fixed equipment was installed to better control boiler operations and provide data technicians could use to improve boiler operations. Tests of boiler energy efficiency and particulate emissions were conducted before and after installation of this equipment with the following results

- Digital controls for boiler operation provided the boiler operators with the ability to set operating regimes more precisely in order to optimize boiler performance and to repeat operational settings more easily
- Test results from control systems demonstrations show a potential for reducing flue gas combustion losses by up to 12 percent
- Providing better control of the boiler combustion air by controlling air flow rate and distribution demonstrated the possibility of reducing particulate loadings to the gas cleaning equipment by up to 25 percent on average at the Abashevskaya Communal Boiler House
- At Abashevskaya Communal Boiler House there was an average 8 percent improvement in overall boiler efficiency due to the installation of controls. With a value for the coal of \$27 per ton, the annual savings is estimated at \$52,000, which repays the cost of equipment and installation in approximately 16 months

Details describing tests on the effectiveness of the automated control equipment are provided in a separate report (see B. Erickson's report "Equipment for Environmental Pollution Reduction," August 1997).

2.3 Clean Coal Demonstration Project

The proper combustion of coal also requires control over the quality of coal provided to the boilers. Local coal available in Novokuznetsk tends to have a large percentage of "fines" i.e., particles of coal of a size less than 6mm. Therefore a series of tests were conducted to determine the effectiveness of sorted coal to reduce particulate emissions and improve energy efficiency. Clean coal test results are summarized as follows and are reported in more detail elsewhere.

The clean coal demonstration project indicated that boiler operating costs can be significantly reduced by the use of coal properly prepared for the boiler in which it is used. These cost

savings are sufficient to justify the building of a local coal sorting facility. Substantial human health benefits would also ensue due to improved air quality, based on 30-90 percent particulate emission reductions achieved during the demonstrations by the use of properly prepared coal

It was estimated that coal preparation would add about \$4 per ton to the cost of coal delivered to the boiler. This is compensated by savings of approximately \$5 per ton resulting from the need to buy and ship less coal and an additional \$1 per ton due to reduced maintenance and ash disposal costs. The net benefit is a \$2 per ton, or 10 percent, reduction in fuel costs attributable to switching to prepared coal, which is sufficient to justify the construction of a coal sorting facility

2.4 Training Activities

A study tour in the US was organized to reinforce local specialists' understanding of the on-site energy/environmental audit work done in Novokuznetsk and to exhibit the applications in a setting where more modern technologies are applied. In addition, one additional energy/environmental audit was conducted to give the local engineers the experience of completing an audit basically on their own.

2.4.1 Study Tour

A study tour to Pittsburgh, PA was organized for a group of six engineers and two translators during July 1995. Site visits were scheduled at district heating stations, power plants, and a coal cleaning facility, and a meeting was arranged with an energy service company representative. These visits were structured to demonstrate applications that were parallel to those being experienced in Novokuznetsk and included:

- Two district heating systems were visited with boiler sizes approximately the size of the facilities being audited in Novokuznetsk. One was a gas-fired facility and the second was coal-fired. Boiler operations and maintenance were reviewed, heat supply metering and system monitoring systems were demonstrated, and environmental controls discussed. As the coal-fired facility was located in the center of the city, it demonstrated that it was possible to operate on coal cleanly.
- Two power plants were visited, one being the approximate size and age of the ZapSib combined heat and power plant. The site plant engineers presented the overall plant control systems, their approach to preventive maintenance, and a review of the environmental control system for flue gas clean-up. The second power plant was a co-generation facility that was smaller and older than ZapSib. Combined heat and power operations were addressed, as well as the approach to meeting emission requirements by purchasing high quality coal.

- A third power plant was visited that was meeting its environmental requirements with a major coal-cleaning facility on-site. This site, in combination with the previous two power plants, gave the study tour group the opportunity to see three different approaches to meeting environmental standards, including coal cleaning, flue gas clean-up, and the purchase of high quality coal.
- One full day was spent with a representative of a US energy service company (ESCO) doing business in Russia. The ESCO approach to doing business was presented along with sample contracts, in Russian, of projects being developed in Russia.
- During the last half of the trip two of the engineers traveled to San Francisco to work with the US EPT coordinator of particulate sampling activities to observe stack testing projects similar to those conducted in Novokuznetsk.

2.4.2 Training Audit

An energy/environmental audit was conducted at the Kedrovsky Mine near Kemerovo, the Oblast capital, utilizing locally trained engineers and audit equipment. The purpose of this audit was to provide local engineers with the experience of conducting an audit with the staff and the equipment that would continue to be available in Novokuznetsk after the completion of the EPT Project. The Kemerovo region was selected to give wider exposure to EPT activities. The industrial sector of Kedrovka township consists of only one enterprise, the "Kedrovsky Open-pit Mine" joint-stock company, which, in its turn, is comprised of five separate divisions. The heating plant that was selected for the audit will serve as a model, since that boiler house is most typical of a large number of those located in Kemerovo and areas adjacent to it. Additionally, it is situated in close vicinity to the city. The "Kedrovsky" company also possesses sufficient financial resources to undertake at its own expense the activities outlined in the course of the audit. Parallel to the increased energy efficiency, emission reduction is also expected.

Results of the audit conducted in the Kedrovsky Communal Boiler House were presented in a report giving an overview of the facility, energy audit results, recommendations for low cost energy conservation opportunities, and specification of equipment to implement the recommendations of the audit.

2.5 Establishing a Capacity to Carry On

It was recognized from the beginning of this project that in order to have a significant effect on the environment of Novokuznetsk it would be necessary to replicate audits and equipment installations in a significant number of boilers in the city. This would be accomplished only if there were a local capability to sustain the work initiated under this project.

The thrust of the program under the audit task has been to develop local capability to implement projects. We have accomplished this through two general approaches:

- Training of local environmental managers in auditing techniques
- Helping local companies to establish themselves to replicate the activities that we were providing

The EPT project has trained over 50 Russian technical staff in the process of performing environmental and process efficiency audits. This has included hands-on training in the performance of multi-media environmental audits at large industrial complexes and the specific air emissions and energy efficiency audits at boiler houses and a power plant. Additional training was carried out in a study tour of boiler houses and other industries in the Pittsburgh area. These trained individuals form the principal vehicle for replicating the successes of the project.

The project has demonstrated that a savings in coal can be accomplished through boiler tune-ups, using the equipment supplied by USAID through the EPT project, by the staff that has been trained under the project. Tune-ups have the advantage of not requiring capital investment to implement. They involve an investment of operating costs (hiring the team to perform the tune-ups), which is paid back rapidly in reduced operating costs for coal purchase.

One demonstration project was directed at improving the efficiency of the end-use of energy supplied from the factory boiler house at a poultry processing factory. Installation of temperature controls at the entrance to the apartment blocks allowed the temperature of the water supply for heating to be controlled as a function of outdoor temperature and to be decoupled from the higher process water temperatures needed in the factory. Reduction in use will be reflected in a reduction of coal consumption.

The equipment that has been installed at the boiler houses and large power station demonstrates the savings that can be achieved by providing for automated control of combustion. This equipment is generating a savings of about \$400,000 per year, paying for its installation in about one year.

The equipment was purchased under a contract with Control Techtronics International (CTI). CTI was selected partly because they have successfully set up a long-term delivery system in Poland and other former soviet block countries to provide similar equipment installations. They bid the project at or below costs in order to establish a similar "beachhead" in Russia.

CTI supplied the equipment, but installation design and some installation was handled by NECCO, a company that Ludmila Kazakova and Boris Sidorenko established to install this equipment and sell similar installations at other boiler houses. They have a representation agreement with CTI, as well as access to other suppliers to replicate the successful installations performed under the EPT project. They have already combined with CTI to provide similar equipment at one other boiler house.

Capital investment is a potential barrier to expanding the automated equipment to the remaining boiler houses in Novokuznetsk. Fortunately, the investment requirement is not

large (on the order of \$50,000 per boiler) and the payback is rapid. This amount of money has been shown to be available, as evidenced by the investments in upgrades to the boilers to Chinese-type grates

As the main mechanism of carrying on these improvements, we have helped set up companies (NECCO and EcoUgol) that will provide full energy services to the Novokuznetsk region. The Business Center provided assistance to these individuals in preparing business plans and establishing themselves as independent companies. The portable equipment brought to Novokuznetsk for the audits was left in Novokuznetsk as seed equipment for providing continued audit services. These companies have performed projects under our direction, including audits, boiler house tune-ups, and equipment design and installation. They have gone on to do these activities on their own.

The city has taken over ownership of most of the communal heating boilers in the city. The results of our project were presented to the new City Administrator responsible for boiler house operations. He expressed strong interest in setting up a regular tune-up program, utilizing the staff that EPT has trained.

Section 3

Conclusions

The Audit Task has demonstrated that a significant improvement in air quality in Novokuznetsk (and other cities of the former Soviet Union) is possible and cost effective. The project demonstrated that audits at boiler houses lead to improvements that both reduce air emissions and increase energy efficiency. In the short term, tuning up boilers reduces emissions and provides about a 3 percent improvement in efficiency, paying for the effort almost immediately. In the longer term, installing automated controls on the boilers results in an approximate 10 percent improvement in efficiency, paying for the investment in about a year and reducing emissions by about 30 percent. Providing facilities for sorting coal to reduce the fractions of fines was shown to produce similar cost savings and air emissions reduction.

The Audit Task started the process of replicating the results of this project at other boiler houses by developing an experienced local testing and boiler performance assessment capability, providing reports on the work that has been done, and helping establish local representation for equipment supply. As a result of these efforts, the information and personnel necessary to support the evaluation of equipment requirements, select control equipment, provide support in purchasing that equipment, and identify options for financing equipment were made available in Novokuznetsk. Before the project was completed, the individuals trained in the project had already started to sell their services at other boiler houses and industries in the Kemerovo region.

The lessons learned by EcoUgol will serve other cities in Russia well, since the types of boiler houses found in Novokuznetsk are representative of those used throughout the former Soviet Union for communal and industrial heating. The significant results achieved by local experts in Novokuznetsk using the audit techniques described above are, therefore, replicable in communities across Russia. EPT has recommended strongly that EcoUgol staff apply for funding under USAID's Replication of Lessons Learned (ROLL) program to perform training audits and demonstrations in other cities in the greater Kemerovo region and across Russia in order to begin to realize the full potential of those technologies that USAID has introduced into the Russian Federation.