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Urban Waste

Turning Problems into Energy Opportunities

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F E A T U R E

Poland:

Energy and Environmental Improvement Through Technical Exchange

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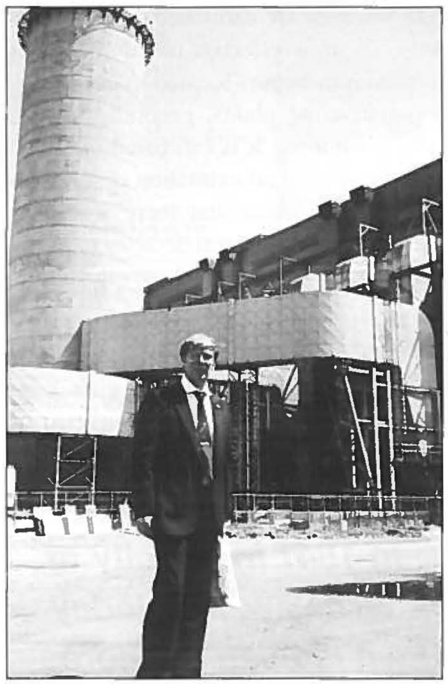
Editor's Note: *Henry Manczyk is administrator of building operations for the Monroe County Government (Rochester, New York) and on the board of directors of the Rochester District Heating Cooperative (RDH). Recently he had the opportunity to exchange his knowledge and experience in energy management and municipal facilities administration with his professional colleagues in Krakow, Poland, and assist them in their efforts to improve the environment and economic health of their community.*

Tadeus Salwa, president of the city and county of Krakow, invited Mr. Manczyk and Professor Ronald Amberger, chairman of Energy Engineering at the Rochester Institute of Technology (RIT), to spend a week with the Polish officials and work with officials of the Krakow, Poland, municipal government and utilities to evaluate plans to improve regional energy management and pollution control. They (1) visited power plants, hot-water and steam-heating distribution facilities, the Lenin Steel Works and the Jagielonian University; (2) reviewed needs assessments and improvement plans developed by local experts; and (3) reported their observa-tions and recommendations to President Salwa. Following is an excerpt from Mr. Manczyk's final report.

Our 1989 visit to Poland resulted from my prior meetings with Krakow officials in connection with sister city activities between Krakow and the city of Rochester, New York. It began in 1985 when I



Henry Manczyk at Poland's Wang Cogeneration Plant. Courtesy Henry Manczyk

was Rochester's manager of heating, ventilating and air-conditioning (HVAC) and energy, and was a member of Rochester Mayor Thomas P. Ryan's delegation that visited Rochester's sister city, Krakow, Poland. As a native speaker of Polish, I was able to meet with Zygmunt Dulbas, director of the power utility serving the southern region of Poland, to discuss energy management analysis techniques and improvement planning. I met with President Salwa when he visited Rochester in 1988 and gave him a tour of several County buildings for which I am currently responsible. Salwa invited me to visit Krakow to meet with local energy management officials for an exchange of technical information and experience.

Energy, The Environment and Economics: An International Impact

At almost the same time that plans for our July 1989 visit were being finalized, Poland's stunning elections occurred and, subsequently, international economic assistance was made available to the country. In March 1989, the Krakow City Council declared the city a "special economic area."

World Bank experts studying pollution-control in Poland recommended that improvements be made in the Krakow district heating system because it represented the greatest return on investment for modernization of Poland's metropolitan areas.

Goals were established to reduce energy consumption and raise emissions standards to reduce the notorious pollution levels in the region. In July, U.S. President George Bush visited Poland and designated $15 million of a $120 million aid-package to be used for air- and water-pollution reduction and other environmental improvements for the city of Krakow. Recently, even more U.S. and international aid has been made available to Poland.

World Bank experts studying pollution-control improvement possibilities in Poland recommended that improvement investments be made in the Krakow system because it represented the greatest return on investment for modernization efforts among Poland's metropolitan areas. Their study recommended that sulfur dioxide, dust and other pollutant levels be reduced. It observed that improved energy management at the main city power plant and reduced consumption throughout the distribution system could result in a savings in coal consumption and savings which could be used to finance the cost of pollution-control devices.

The coincidence of these events added a new dimension to the technical exchange. Both the Krakow-region energy officials and President Salwa had the opportunity for our review of the proposed improvement plans and our support in the competition among the City agencies for the assistance funds.

Yet it is important to note that this was truly a technical *exchange*. Krakow offers useful knowledge and experience to us, too. Poland's primary energy source for electricity and steam production, industrial and residential heating, etc., is bituminous coal and lignite. Natural gas must be imported. Krakow produces electricity, steam and hot water for industrial and residential use at a central cogeneration plant. Although Krakow has a central distribution system, 230,000 households also maintain coal-fired heating systems.

Krakow lies in a valley in southern Poland along the Vistula River. Prevailing southeasterly winds carry pollutants from the East German and Czechoslovakian industrial regions and the nearby Lenin Steel Works. Cars use leaded gasoline, coal-fired steam engines run on local rail lines, and residential coal furnaces are substandard. The Vistula is dreadfully polluted and the ravages of acid rain threaten the historic buildings which passed unscathed through the destruction of two world wars. There are no nuclear power plants in Poland and plans to develop a 108-megawatt plant in Krakow have been suspended as a result of the Chernobyl incident and other considerations. Municipal planning for energy management and air-pollution control improvements have necessarily turned toward the coal-fired central cogeneration plant, the central distribution system and household heating systems.

Poland's Native Energy—Coal as a Primary Resource

Coal is one of the most important raw materials of modern industry and the basic source of energy in Poland. The most common types of coal found in Poland are bituminous coal and lignite.

Poland's bituminous coal, the most widely used, comes from mines which extend as much as 2,000 meters below the surface. According to 1980 estimates, 150 billion tons are expected to be found; lignite reserves are estimated at 40 billion tons. The most effective use of this coal is to burn it in boilers located in large electric-generating plants, generally located near the mines. It is estimated that with these reserves and extraction of 120 million tons per year that there would be enough coal for several decades to a century, depending on annual growth rate and future discoveries.

Coal gasification started in Poland in 1847 in the city of Wroclaw, and today it is used by more than 400 cities and towns.

Bituminous, or "soft," coal is used in large quantities for power generation and steel making. It is also widely used for home heating and occasionally for gasification. Its physical characteristics vary widely—from a highly volatile moist coal to a less volatile dry coal. It can have from 0.5 percent to over 8 percent sulfur content and is pulverized for usage at Krakow's central electric-generating and district heating plant.

Lignite coal has a low heat value, a very high moisture content and has limited use as a home heating fuel. In Poland it is widely used by electric power plants specifically designed to burn it; they are commonly located near coal mines.

Coal gas is also widely used in Poland. It is produced from bituminous coal which has been heated in an oxygen-free oven to over 1,000 degrees Celsius for 10 hours or more. The volatiles are driven off and captured. The coal gas is often employed for heating when mixed with other gases and is distributed for residential use. The heat output is between 400 and 600 Btus per cubic foot. Coal gasification started in Poland in 1847 in the city of Wroclaw, and today it is used by more than 400 cities and towns. At first, coal gas was mainly used for lighting streets. Later it was used residentially for cooking, hot water and home heating. Development of coal gas distribution systems in Poland continues at an estimated rate of 1,000 km per year.

The coke remaining from the coal gasification process is also used as a fuel. It burns with little or no smoke and is important for heating in metallurgical work. Its heat value is about the same as bituminous coal, but only 1,200 to 1,400 pounds of coke can be obtained from a ton of coal. The conversion from coal to coke and coal gas yields about 90 percent of the original heating value of the coal.

Natural gas production is on the rise and is largely being used in central heating systems. Because the major quantity must be imported, continued increase in its usage depends on future discoveries and its availability from neighboring countries. Areas of Poland, including the Krakow region, are nonetheless abandoning coal gas and using more and more natural gas, both from domestic and foreign sources.

As part of its environmental improvement plan, Krakow plans to convert the majority of its coal-fired systems to natural gas, including those in downtown Krakow and its "mini" heating plants, and to distribute gas to and convert the 230,000 residential heating systems. Distribution lines are already installed and the equipment will soon be converted.

Growth Led to Consolidated Heating Systems & Cogeneration

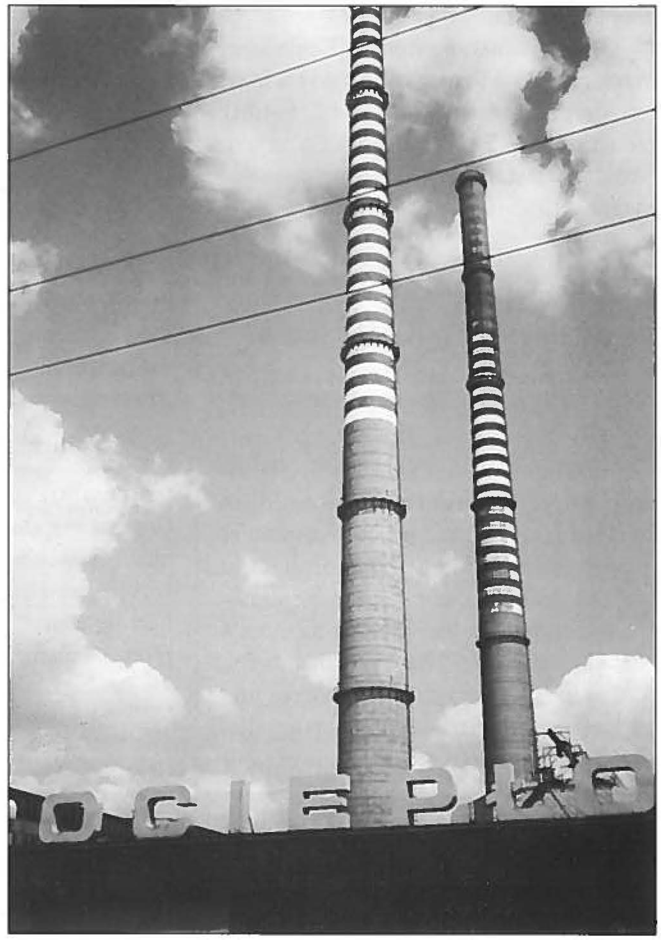
Electrical power in the Krakow region originated in 1905 at Dajwor, starting with two 4.5 MW generators, with 3 MW capacity added in 1921. These plants supplied the first of the many small power and heating districts that were formed in the region. In 1953 they were consolidated into the heating district which now serves the Krakow region and initially supplied primarily from the Lenin Steel Works.

The Krakow region has a peak electrical demand of 1,100 MW which is supplied by local plants and from the national grid. The largest electric-generating and heat-distribution plant in the district is the Wang Plant. It has a combined electrical generation capacity of 561 MW. It supplies Krakow with and average of 540 MW. The Wang Power Plant opened in 1970, and until 1977 it produced high-temperature water for the district heating system, replacing the Lenin Steel Works Plant as the main supplier to the district. Since then the Wang Plant has continued to expand.

> ***The cogeneration system allows the [Wang] plant to operate around the clock at optimum efficiency because surplus production is diverted into an international distribution net and sold to other regions of Poland, Czechoslovakia and Austria.***

In 1977 the current cogeneration process was added to produce electrical power for use in the heating district; a 70 MW cogeneration plant was built nearby in Skawina in 1976, also to supply the district. The Wang Plant was built in five stages and completed in 1985. Both the Wang and Skawina plants became the main electricity and high-temperature hot-water suppliers for the Krakow-Skawina-Wieliczka areas; the 1905 Dajwor Plant has therefore been taken out of operation. Two other plants in the system supply thermal energy; one at the Lenin Steel Works (33 MW) and one at Solway (19 MW).

Forty-three percent of the total thermal energy for the district heating system is produced at the Wang Plant by cogeneration. The cogeneration system allows the plant to operate around the clock at optimum efficiency because surplus production is diverted into an international distribution net and sold to other regions of Poland, Czechoslovakia and Austria.



The Wang Plant's 256- and 234- meter smokestacks.
Courtesy Henry Manczyk

Cogeneration in Krakow

Cogeneration is beneficial from an energy resource viewpoint only if it saves primary energy when compared to separate generation of electricity and steam or hot water.

A cogeneration plant normally has an overall energy efficiency of 70 to 80 percent. The conventional method of producing heat and electricity separately loses more than 50 percent of the energy content of the fuel. With cogeneration it is possible to reduce the loss to an average of 20 percent.

There are two general techniques of energy conversion in cogeneration: the "topping" cycle and the "bottoming" cycle. The topping cycle, which is used by the Wang Plant, first generates electricity and then waste heat in the form of exhausted steam is used for thermal needs, either directly or for hot-water production.The high-temperature hot water for the Krakow central heating district system is heated by the exhaust steam from the turbines and heating from the supplemental boilers.

Environmental Concerns

Sulfur occurs in coals as iron sulfide (pyrite), organic sulfur and sulfates. Upon burning, most of this is changed to sulfur dioxide, SO_2. Sulfur dioxide is an acid gas emission caused by the oxidation of sulfur in the fuel during combustion. Sulfur dioxide in the atmosphere combines with water vapor or rain to form sulfuric acid, resulting in the acid rain which is linked to adverse affects on forests and lakes.

Pre-combustion and post-combustion controls are the two classifications of technologies available to control SO_2 emissions. Pre-combustion control methods are generally limited to the use of low-sulfur fuel sources. Post-combustion techniques involve the removal of SO_2 from flue gas by desulfurization and particulate removal.

The electrostatic precipitators, a post-combustion technology, are used in Krakow at the Wang electric-generating and district heating plant and at the Lenin Steel Works and have a theoretical efficiency of 95 to 99.8 percent. Because of inadequate maintenance and prohibitive repair costs, however, the best performance Wang engineers report they achieve is about 60 percent.

Present emissions from the Lenin Steel Works are 25.5 tons per year, down from prior years' averages of 67 tons. Further reductions to 9.5 tons per year are planned, based on installation of modern equipment by 1995 to decrease emissions.

Evaluation of Energy and Environmental Improvements in Krakow

At a meeting with the local unit of Heating and Energy for the city of Krakow and vicinity, plans were discussed regarding how the $15 million of the $120 million pledged to Poland by President Bush could be used to improve the environment in and around Krakow. One of the best ways to do that is to decrease the atmospheric emissions by reducing the area's coal consumption. The recommendation was to install energy-saving devices and temperature controls into the central district heating system distribution network for an estimated 10 percent coal-use reduction. This would save 90,000 tons of coal per year, reducing not only pollution but also saving $4 million in purchase costs (summer '89 prices). The money saved could be invested annually for pollution controls. The coal not used locally would be available to export and bring in foreign exchange for the nation.

We also discussed economic analysis of these devices and gave examples of the methodology. Our hosts customarily calculate only simple payback periods and do not consider internal rates of return, present worth or the discounted rate of money. (Regulated prices, instability of foreign exchange rates and inflation that recently varies from 500 percent to 700 percent per year combine to make such long-term calculations unreliable for comparing alternative investments.) Furthermore, the artificially low price of fuel sources (compared to other commodities) results in long payback periods which discourage investments in and installation of energy-saving devices.

We recommended that fuel prices should be raised nationally to reflect the real cost of production or purchase. We have noted recent announcements from Poland of a 250 percent increase in electricity rates, a 100 percent increase in gas prices and a 50 percent increase in district heating charges. We expect that this will greatly improve the ability of Polish energy officials to justify investments in badly needed energy consumption and pollution-control improvements.

We discussed installing controls on the distribution system which have proved highly dependable and cost-effective in the Rochester, New York, system. We also discussed ways of saving power consumed by eight pumps used in distributing hot water from the Wang Plant. One option for reducing electrical and thermal costs is variable volume pumping. Another is an energy management system temperature and demand monitoring sensor points scattered throughout the high-temperature water distribution loop. Current response time to major demand changes is six hours, resulting in poor service and unnecessary post-demand heating costs. This could be avoided by remote sensing and control devices.

The primary impediment to our colleagues' application of their knowledge has been the lack of financial and equipment resources to accomplish their very well-considered plans.

We also talked about the concept of "co-firing," burning coal and gas simultaneously in large systems, and the planned conversion of 230,000 residential coal-fired systems in the city of Krakow from coal to gas.

We were impressed by the knowledge and training of the engineers we met. Jerzy Socha, chief application engineer to the Krakow Central Heating District, who assembled the data for the World Bank study and served as our major technical informant and guide during our visit, was particularly perceptive and well-informed. With the foreign assistance being offered and improvement programs already developed in Krakow, we are sure that our Polish counterparts can make significant advances in bringing their country's energy usage to optimal efficiency.

On Reflection

I had been looking forward to an opportunity to visit Krakow again following my initial meeting in 1985 with Director Dulbas. I have corresponded with him and other energy professionals of the region over the years. Despite the difficulties that beset them—economics, equipment and repair parts availability, etc.—I have been impressed by the thorough training of our Polish counterparts and their eagerness to tackle the technical challenges posed by the facilities they manage. It has been a delight to learn about their systems and how they plan to improve them, and to have an opportunity to make a contribution to their effect.

And despite the different political and business structures, the Krakow situation has parallels here in North America. Many small communities and industries—and even some large ones—face similar difficulties in solving pollution and economic problems. Particularly in the industrial northeastern United States, the electrical generation and industrial process heating facilities have aging, inefficient polluting equipment which must be replaced—but at a price which the owners cannot or can only with difficulty afford.

The strategies of cogeneration and the adoption or renovation of central heating distribution systems could produce savings to finance subsequent system improvements. The improvement plans were being developed in Krakow long before current events brought foreign assistance to finance them, but they needed far-sighted financial and political support to move off the drawing boards. This has come to Krakow through commitments of aid such as that of President Bush, but also—and no less importantly—through the political courage of Polish authorities in such acts as to begin to allow prices to reflect the true production costs. I think these aspects of what Professor Amberger and I learned in our exchange with our colleagues in Krakow bear the greatest significance to us in our professional pursuits.