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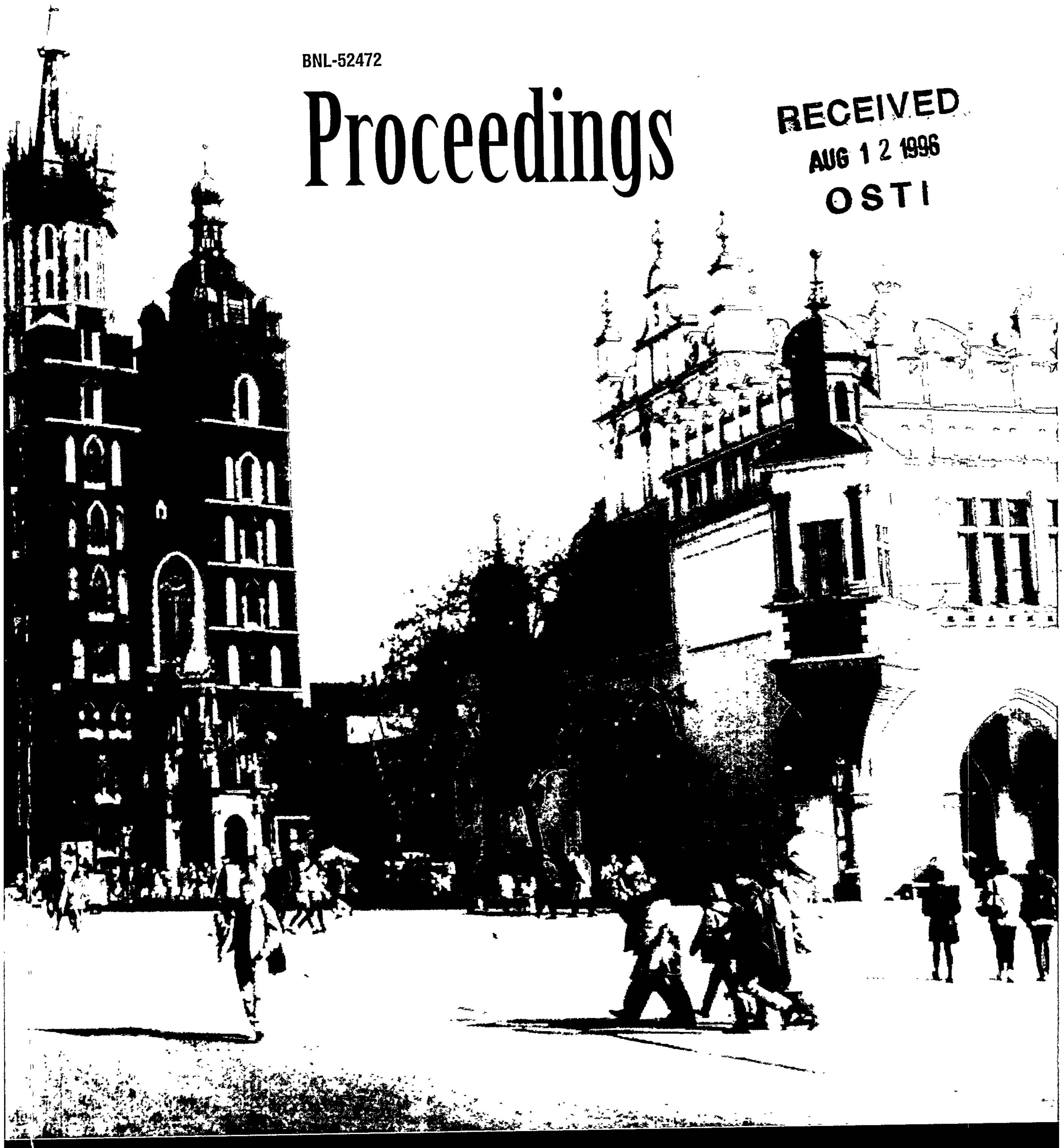

Kraków Conference on Low Emission Sources

October 10-12, 1995 Kraków, Poland

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Proceedings

Kraków Conference on Low Emission Sources

October 10 - 12, 1995
Kraków, Poland

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FOREWORD

The Krakow Conference on Low Emission Sources presented the information produced and analytical tools developed in the first phase of the Krakow Clean Fossil Fuels and Energy Efficiency Program. This phase included:

- Field testing to provide quantitative data on missions and efficiencies as well as on opportunities for building energy conservation,
- Engineering analysis to determine the costs of implementing pollution control, and
- Incentives analysis to identify actions required to create a market for equipment, fuels, and services needed to reduce pollution.

Collectively, these Proceedings contain reports that summarize the above phase one information, present the status of energy system management in Krakow, provide information on financing pollution control projects in Krakow and elsewhere, and highlight the capabilities and technologies of Polish and American companies that are working to reduce pollution from low emission sources.

It is intended that the U.S. reader will find in these Proceedings useful results and plans for control of pollution from low emission sources that are representative of heating systems in central and Eastern Europe.

The Conference was sponsored by the Bilateral Steering Committee for the Krakow Clean Fossil Fuels and Energy Efficiency Program. This Steering Committee includes representatives of:

- Office of the President of the City of Krakow
- Department of Environmental Protection, Krakow Province
- Polish Ministry of Environmental Protection
- U.S. Agency for International Development, and
- U.S. Department of Energy

Jan Friedberg
Co-Chairman
Vice President of Krakow

Howard Feibus
Co-Chairman
U.S. Department of Energy

Proceedings

Kraków Conference on Low Emission Sources

Table of Contents

Session I: Keynote Presentations

Co-Chairmen: Howard Feibus, U.S. DOE and Jan Friedberg, Deputy Mayor of Kraków

Session II: Kraków Program Phase I Results - Energy Conservation

Co-Chairmen: Adam Guła, FEWE and Joanna Markussen, U.S. Department of Energy

Table of Contents (cont.)

Session III: Kraków Program Phase I Results - Economic Approaches for Control of Emission Sources and Improvement of Air Quality

Co-Chairmen: Jan Bieda, Kraków Development Office and Thomas Butcher, Brookhaven National Laboratory

Table of Contents (cont.)

Session IV: Use of the Results of the Low Emission Sources Project in the Development of a Model Energy System Management in Kraków

Co-Chairmen: Jan Friedberg, Deputy Mayor of Kraków and Joseph Strakey, U.S. Department of Energy

Table of Contents (cont.)

Session V: Financing Projects

Co-Chairmen: Jerzy Wertz, Voivodeship of Kraków and Robert Ichord, U.S. Agency for International Development

Commercial Presentations

Session I

Keynote Presentations

Co-Chairmen: Howard Feibus, U.S. DOE and Jan Friedberg, Deputy Mayor of Kraków

AIR PROTECTION STRATEGY IN POLAND

Bernard Błaszczyk
The Ministry of Environmental Protection, Natural Resources and Forestry

Air quality is one of the basic factors determining the environmental quality and influencing the life conditions of people. We do not speak about air shortages at all, like for instance in the case of water, yet there has been already a shortage of proper quality air in many regions of Poland. In consequence, and due to unhindered transport, air pollution is the direct cause of losses in the national economy (reduction of crops, losses in forestry, corrosion of buildings and constructions, worsening of people's health).

Poland is believed to be one of the most contaminated European countries. The reason for this, primarily, is the pollution concomitant with energy-generating fuel combustion; in our case it means the use of solid fuels: hard coal and lignite. This mono-cultural economy of energy generation is accompanied by low efficiency of energy use (high rates of energy loss from buildings, heat transmission pipelines, energy-consuming industrial processes). This inefficiency results in the unnecessary production of energy and pollution.

Among other reasons, this results from the fact that in the past Poland did not sign any international agreements concerning the reduction of the emission of pollution.

The activities aimed at air protection in Poland are conducted based on the „Environmental Formation and Protection Act" in effect since 1980 (with many further amendments) and the „The Ecological Policy of the State" (1991).

In 1994 the Ministry of Environmental Protection, Natural Resources and Forestry completed a study assessing the performance of both the „Environmental Protection and Formation Act" and „The Ecological Policy of the State". Both the chambers of our Parliament - the Diet and the Senate - passed those bills and made proper resolutions. Therefore, they became the base for the realization of the ecological policy until 2000 and at the same time confirmed that the accepted guide-lines for changes and new solutions comply with the policy of a balanced development, thus of the arrangements approved of the Earth's Summit in Rio de Janeiro.

The tasks regarding the air protection and given in the documents mentioned above are very extensive and comprise in the years 1994 - 2000:

- a fall in the emission of sulfur dioxide by 1 million t/year;
- a fall in the emission of nitrogen oxides by 130.000 t/year;
- a fall in the emission of dusts coming from stationary emission sources by 700.000 t/year;
- having the emission of carbon dioxide stabilized at a level of 480 million t/year;
- having the emission of methane stabilized at a level of 15 million t/year, a reduction in the emission of carbon monoxide, hydrocarbons, nitrogen oxides, asbestos and lead dusts from the transportation vehicles.

After 2010 the activities under realization should cause:

- total elimination of private, hard coal-fired stoves in urban centers and protected areas;
- introduction of catalysts in all cars under construction and operation;
- elimination of the use of Freons and Halons;
- reduction in the emission of compounds of sulfur, nitrogen, heavy metals, organic substances down to the levels arising from international agreements.

In the first half of 1995 the First Conference of the Parties of the General Convention of the United Nations on Climatic Changes was held. The course of the sessions, the documents accepted and the arrangements indicate that till 2010 Poland will have not only to stabilize but also to reduce the emission of greenhouse gases, including carbon dioxide - the most essential from the viewpoint of fuel combustion.

On one hand, such an outlined operational scheme entails some amendments in the Polish statutes regarding the environmental protection and on the other - financial aid and implementation of modern technologies, foreign techniques and stimulation of domestic companies to operate in the field of environmental protection.

In the case of Cracow such a collaboration has been, among others, struck up with the United States of America due to US President George Bush's personal engagement in the regional environmental protection problems.

The very poor level of the ecological knowledge exhibited by the Polish society would say that big industrial works were chiefly to blame. The best example may be "Sendzimir" Steelworks. For years this plant had been believed to be the main destroyer of Cracow's monuments. This industrial structure must have had a big share in this process, yet those assessments did not consider noxious low emissions from private stoves and small municipal boiler houses. The simplest way was to shift the obligations on one subject, not on many small structures working directly in favor of the town's inhabitants.

Presently, the changes postulated in the legal regulations on air protection are focused chiefly upon re-ordering the existing principles and rules so as to maintain and make new ones, better adjusted to the present situation of Poland in the period of very intensive economic transformations.

In relation to the permissible values of air polluting agents:

- Standardized values for a dozen or so common pollutants affecting the global environment, to be subject to the State's Environmental Monitoring;
- the concentration values for the remaining pollutants to be considered standardized, but serving mainly for the assessment of the local risks;
- the desired values for those pollutants whose effect on forest areas or monumental landmarks has been documented,

are planned to be introduced.

A verification of the standardized values for the pollutants produced in energy-generating fuel combustion and the introduction of such standards for other industrial processes are scheduled as far as the permissible levels of the pollution emission are concerned; in the case of new industrial structures they will be identical with the corresponding standards of the European Union - either in effect or to be introduced. Instead, for the existing structures, those will be standards containing detailed terms of coming into effect and of having them gradually more and more restricted.

In our practical approach to air protection, the essential role is played by the modeling of pollution dispersion. In 1981 in Poland there have been in effect some uniform evaluation methods for determining the air pollution state based upon Pasquille's model of pollution dispersion. Progress achieved in this field entails also some changes in the approach to the assessment of potential menaces generated by sources that exist or are under design in order to have the inaccuracies already known and resulting from the assumed model guidelines eliminated.

So as to re-arrange and simplify the formal procedure on the part of ecological services, the requirements for the organizational units shall be determined in an unequivocal way:

- each organizational unit emitting pollution in air will have to obtain a decision determining the kinds and volumes of the substances that may be discharged as well as other requirements regarding, e.g., the use of certain technological solutions;
- for small energy generating fuel combustion structures, it is intended to relinquish the necessity of issuing the decisions said, yet the Voivode (head of the province) shall retain his right to lay obligations resulting from the necessity of protecting air from pollution;
- in order to simplify the fee computation procedures - a tax-like procedure is set forth - the units will by themselves fix and settle payments on the accounts of ecological funds.

In urban and industrial agglomerations the arrangement of automatic control and measurement systems as well as alarm systems are foreseen.

In new legal solutions the voivodes shall be provided with a possibility of introducing alarm levels of the air pollution concentrations; then, there shall be also a procedure for having such alarms raised.

Due to the aid of the US Administration, Cracow is proud of possessing an automatic system and being able to avail itself of the possibilities it offers.

The experience gained in a few countries has encouraged Poland to start the feasibility studies in order to have the system of alienable rights implemented.

The design solutions should enable an economic, technical and organizational optimization so as to achieve maximum ecological effects. Nowadays, making use of PHARE financial resources some pilot activities on introducing such mechanisms in the territory of Province of Opole have been underway.

As aforementioned, a considerable problem is the elimination of the low emission sources of the urban and private sectors. It constitutes one of the priority operational purposes recommended in the „The Ecological Policy of the State".

This target has been under realization through:

- extending and improving the operation of heat distribution networks;
- energy saving in buildings;
- introducing more ecologically-friendly energy carriers;
- improving the operation of boilers and protective devices;
- improving the quality of both private stoves and combustion fuels used;
- eliminating local boiler houses.

The collaboration with abroad and due to the financial aid of the USA, a low emission elimination project has been implemented in Cracow; finally, about 90% of the emitted particulates will be eliminated.

The low emission problem is to be analyzed in the context of the present Polish system of generation, distribution and use of energy. Such a system does not arise only out of the fact that the basic energy carrier in Poland is coal, but also that the obtained energy is not used effectively. One of the ways of reducing the volume of pollution emitted while producing enough energy to satisfy the basic needs is changing its carriers. Another way is the modernization of the existing systems of generation, distribution and receiving of heat, so as to have losses diminished.

The American aid adjudicated to get the pollution in Cracow reduced assumes the use of all possible options:

- a development of the heat distribution network;
- a change in the energy carrier - from coal into gas;
- the application of electricity for heating;
- an improvement in the efficiency of coal-fired boiler houses;
- an improvement of the operation of private coal-fired stoves.

It does not arise out of the performed bids, collected offers and numerous analyses that it is profitable in Cracow to have gas and electricity introduced as basic energy carriers.

To begin with, there are no sources for covering the increase in the cost of heat energy generated with gas and electricity being carriers, against the costs while using coal.

An essential role in creating and promoting the activities in favor of saving energy, thus in order to reduce the burden laid on the environment, is to be played by the Home Agency for Energy Saving established at the initiative of the Ministries of Industry and Trade, of Land Management and Building Industry, and of Environmental Protection, Natural Resources and Forestry. Both organizationally and financially the tasks regarding the limitation of low emission are supported from the central administration level. However, it is hard to say anything about universal solutions adjusted to each problem. Those are problems so strictly related to local circumstances that a separate organizational, financial and technical approach is demanded in each case.

The hitherto experience, gained due to the collaboration performed under the US aid program, allows a determination of the main problems and the ways to have them solved. This collaboration has prepared proper foundations and circumstances for new ideas and conception.

Cracow - the old cradle of Polish tradition - is worthy of particular care on the part of all, including the US society.

Therefore, the ecological future of this town can be seen optimistically.

NEEDS AND PERSPECTIVES OF AIR QUALITY IMPROVEMENT IN CRACOW

Jerzy Wertz
Environmental Protection Department, Provincial Office, Cracow

In 1970s and 80s the Cracow province area belonged to the regions of highest concentration of air pollutants throughout the Europe. The majority of inhabitants, terrified of continuously worsening condition of the environment, were of the opinion that this situation was caused by the industrial plants located within Cracow area (town and/or province) as well as by the advection of pollutants from the neighboring Katowice province - the most industrialized region of Poland.
The results of two large measurement series carried out in Cracow in 1984 and 1986 were surprising for the majority of the people. It appeared that ca. 40% of pollution charge comes from local coal-fired boiler houses and household coal-fired stoves. These emission sources, situated at relatively low altitude above the ground level, were called „low emission sources". Then the quantity of such sources has been estimated. It was evaluated that the number of local boiler houses was close to 1 600 while the total number of household tile stoves reached ca. 200 000. A full inventory of these sources drawn up in 1989-90 confirmed the quantity of existing boiler houses and the verified total number of tile stoves was ca. 130 000.
In 1986 the elimination of low emission sources was admitted to be one of the strategic directions of actions in the field of air quality protection. Following two solutions of this problem were accepted for implementation:

1) extortion of boiler house elimination by means of an administrative, compulsory decision;
2) co-financing or even complete financing from the environmental protection fund, of the capital investment related to the elimination of a boiler house or its conversion to another mode of heating (gas, fuel-oil or connection to the municipal district heating loop).

The obligatory conversion and elimination of an existing coal-fired boiler house was frequently combined with the issue of the administrative decision on permissible pollutant emission into air. The Provincial Office estimated a feasible time-frame for such conversion and after this period (e.g. after two years), the Office defined the permissible emission level equal to zero - for connections with municipal loop or an emission level corresponding with the assumed new energy source.
The second way of administrative extortion of elimination of coal-fired boiler houses was the finding of excess emission (above the permissible level) as a result of inspection. Depending on the magnitude of excess, an administrative penalty (in the case of small excess) was inflicted or a decision extorting the complete elimination of the boiler house (as a rule within a relatively short period) was issued.
In the case of high costs of this task or a difficult economical condition of the source owner, a financial support from the environmental protection fund was suggested in a form of a grant covering partly the investment costs.
In the case of budgetary units, the main incentive extorting the conversion was the financial help. Numerous schools, créches, hospitals, scientific institutes, orders, etc. have got financial support in a form of a grant from the Provincial Fund of Environmental Protection and Water Management, which covered the entire cost of such conversion. In such cases the administrative compulsory decision on the elimination of a boiler house within the limited time-frame played only a disciplining role.
It should be underlined, that the effectiveness of administrative actions towards the industrial plants was supported to great extent with the central government decision dated 1989, when Cracow was acknowledged to be the particularly protected area with sharpened air quality standards. Therefore the Provincial Office was authorized to issue very rigorous administrative decisions, to oblige the boiler house owners to keep the defined level of emission. This special status of Cracow, well founded by exceptional monumental character of the City was in force for three years till the amending legal regulation has deleted this category of protected areas.
When evaluating the efficiency of actions in the field of elimination of low emission sources, following should be stated:

- the strictly administrative decisions appeared to be efficient in the case of large, noxious, industrial and communal boiler houses,
- the financial support was very effective in the case of small facilities.

The above described actions resulted in elimination of over 500 local boiler houses in the period 1989-94. The amount equivalent to $ 4 millions was spent annually by the Provincial Fund of Environmental Protection and Water Management, and 70-100 boiler houses were eliminated every year.

In spite of the significant change of legal regulations concerning the operation of the Provincial Fund of Environmental Protection and Water Management issued in 1993, there is still a real chance to keep the present rate of works and the level of annual effects because the elimination of low emission sources can be supported also from other funds.

The effects of actions mentioned above are visible and sensible in Cracow. It can be proved basing upon the results of air quality monitoring measurements carried out in Cracow since 1991 thanks to the help organized by Mr. George Bush, US President. The arduousness of industrial sources was reduced effectively and 30% most noxious boiler houses were eliminated. It resulted in significant improvement of air quality. The average annual level of air pollution with SO_2 dropped from ca. 100 $\mu g/m^3$/year (1987/88) to ca. 40 $\mu g/m^3$ /year (1993), i.e. by ca. 60%. The scale of reduction of other pollutants is similar. Also the smog menace in winter is continuously reduced.

The policy towards local boiler houses seems to be effective. On the other hand, the creation of an effective system for initialization and supporting actions aimed at the elimination of coal-fired stoves, was not successful. An administrative action cannot be implemented for this case. The Environmental Protection Law in force makes possible implementation of actions towards the companies and not towards the private owners of residential houses. Elimination of ca. 30 000 coal-fired stoves in 1989-94 results only in a small portion from the programmed actions aimed at the elimination of low emission sources. Since the limitations in gas or electricity supplies for heating purposes have been reduced and then eliminated completely, the apartment owners waiting for the permission for years, used the new circumstances and converted their heating systems from coal. The further development of the project of elimination of coal-based heating depends now on the implementation of system solutions to support this program.

THE KRAKÓW CLEAN FOSSIL FUELS AND ENERGY EFFICIENCY PROGRAM

Howard Feibus
U.S. Department of Energy

On behalf of the U.S. Department of Energy, I would like to welcome everyone to this conference.

The joint effort by Polish and American organizations in Kraków has accomplished a great deal in just a few years. In particular, the low emission sources program has had major successes, and I would like to congratulate those who have been participating in the program. Our three-day conference will give us all a chance to learn what has been happening. To those of you from other areas of Poland, who are here to learn about what has been accomplished, I think you will find that there is much that can be applied to achieve cost effective solutions to your pollution problems.

Poland and America have a lot to learn from each other in the clean and economical use of coal. Both our countries are major producers and users of coal. We have both had to deal with the emissions of particulate and organics from coal combustion. We were fortunate, since our free market economy and democratic government helped us deal with a lot of these problems in the 1950s. In Poland, the freedom to solve these problems has evolved only in the last few years, but you have made progress fast. You have allowed energy prices to rise toward market levels, reduced shortages and promoted more efficient use of fuels. We went through a similar thing in deregulating oil and gas prices in the 1970s and 1980s.

On the other hand, you have been charging the polluter for emissions from large stationary sources by the ton as part of a national program. We have developed similar mechanisms based on the recently passed Clean Air Act Amendments of 1990, which provided for marketable sulfur dioxide allowances.

You have been deregulating and privatizing various functions associated with the generation of electric power. Moves to deregulate various elements of our generation and electricity sales have been initiated. Recently, the California Public Utility Commission has taken initiatives in deregulating the sale of electric power. Some deregulation has already occurred nationally for wholesale power sales. We both seem to be approaching our problems in similar ways. That is why it was natural for us to work together in the Kraków low emission sources program.

As many of you know, this cooperation started back in 1990. The U.S. Congress had just passed the SEED Act (Support for Eastern European Democracy). A U.S. delegation came here and was briefed by the leaders of Kraków about the low emission sources problem. It was clear that the main problem was particulates, and it was causing health problems for people and soiling the historic buildings.

During the first visit, the leaders of Kraków presented our delegation with a preliminary plan to reduce emissions from the low emission sources. That plan emphasized the proposed conversion of coal boiler houses to natural gas. This original plan would have led to very clean air in Kraków, but it would have entailed a very high cost to accomplish the conversion. The ultimate goal may be to convert to gas and reserve the use of coal for electricity production and combined heat and power plants. However, Kraków officials agreed that a free market approach would be needed to actually accomplish an interim reduction of pollution.

After reviewing the data with the Kraków officials, DOE developed a simple spreadsheet model to estimate the capital costs, annual costs, and emissions of various scenarios for heating Kraków. The Kraków officials conducted a detailed survey of the fuel usage and boiler capacity of the 1300 boiler houses in Kraków. This enabled us to refine the model and provide good estimates for the present situation. The model started with the present situation and calculated the incremental costs of various pollution control approaches. Working together with the model, we did a scoping analysis of Kraków's alternatives.

The model confirmed that the 1990 plan proposed by the Kraków officials would remove over 99 percent of the particulate from the boiler houses and home stoves, but the conversion cost would be high. The annual cost for heating would be more than double that of the present situation.

The model also showed that there are other options that are much less expensive that would remove about 90 percent of the particulates while raising costs only 11%. These technologies, which you will hear about at this conference, burn coal more efficiently and cleanly. After reviewing the scoping analysis with the Polish participants, we formed a U.S.-Polish bilateral steering committee (BSC) to oversee the project. The BSC established a three-phase program:

1. Engineering Studies and Testing
2. Public Meetings in the U.S. and Poland
3. Competitively Selected Commercial Ventures

In the first phase of the program, Polish and American engineers ran combustion tests on boilers and stoves in Kraków. They also performed analyses on the cost and feasibility of various equipment changes. The results of the first phase were used in refining the spreadsheet model to give better estimates of costs and emissions.

The first phase also included analyses of incentives for proceeding with needed changes. These analyses identified actions needed to create a market for the goods and services which control pollution. Such actions could include privatization, regulation, or financial incentives.

A survey of public opinion was also part of the first phase. It was not surprising that when people were asked who should pay for pollution control, most people replied that it should be somebody else, like the landlord or the government. When asked about eliminating pollution from coal-burning home stoves by converting them to gas or electric and paying market prices for fuels, less than a quarter of the people wanted to do it. Thus, people want clean air, but they are unwilling to pay a lot for it. The public's response means that proposed solutions must be economical.

The second phase of the program consisted of public meetings in Chicago, Washington, and Kraków. The purpose of the meetings was to inform U.S. and Polish firms about the results of phase 1 and to encourage them to compete to take part in phase 3. At the meetings we described the approach and presented the results from phase 1. We also discussed the plans for phase 3, so that the interested firms could begin preparing for the development of project proposals. We structured the program to require at least 50 percent cost sharing, to give everyone an incentive to stay in their ventures for the long run, and continue to commercialization. We asked for proposals from teams comprised of Polish and American firms. We selected the winners from among the competitive proposals.

The third phase currently underway consists of the commercial ventures that were competitively selected. These ventures were consistent with recommendations unanimously made by the BSC. We will be hearing about these ventures at this conference.

The Polish organization selected to coordinate the program was BRK. They are here at the conference to provide details of the program. The results of the phase 1 effort have been published. Under the continuing program, BRK is providing support to the eight selected commercial ventures to help assure their success. BRK also provides information to other cities, such as at this conference, to help others in using the approach we used in Kraków.

We believe that the patterns we observed in Kraków's low emissions sources are common throughout Poland and much of Eastern Europe.

1. The overall costs and emissions need to be analyzed.

   This requires a detailed survey of the boiler houses and good estimates of home heating. The survey data should then be used in a spreadsheet model like the Kraków model, with free market fuel prices. Without this objective analysis, investors will not be able to tell which improvements will provide the best return, and they will not be willing to invest in improvement projects.

2. The problem is typically particulates.

   In much of Eastern Europe, coal is burned in boiler houses, inefficiently and without adequate particulate controls. The resulting heavy emissions of particulates cause health problems and the appearance of buildings deteriorates. Huge reductions in particulates can be achieved at low cost by using better coal and burning it more efficiently. Several of the Kraków projects use these approaches.

3. A cost effective investment is needed.

   You have to structure your program with proper incentives for investors and local participants. This means choosing projects where you get the greatest return for the investment. Only projects like these will attract investors as Eastern Europe moves toward a market economy.

As we all know the process used in Kraków works. It can also be used to advantage in Cesky Krumlov and Plzen in the Czech Republic. We believe that it can be applied throughout Eastern Europe. We have structured this conference to share with everyone the Kraków success. As the conference proceeds, the exchange of ideas and values will be invaluable as we all move ahead to address our mutual interests.

Thank you. Enjoy the program.

Session II

Kraków Program Phase I Results - Energy Conservation

Co-Chairmen: Adam Guła, FEWE and Joanna Markussen, U.S. Department of Energy

ENERGY SAVINGS IN POLISH BUILDINGS

Lawrence C. Markel, Electrotek Concepts, Inc.
Adam Guła, Fundacja na Rzecz Efektywnego Wykorzystania Energii
George Reeves, Lakeland Utility Conservation, Inc.

Abstract - A demonstration of low-cost insulation and weatherization techniques was a part of phase 1 of the Kraków Clean Fossil Fuels and Energy Efficiency Project. The objectives were to identify a cost-effective set of measures to reduce energy used for space heating, determine how much energy could be saved, and foster widespread implementation of those measures. The demonstration project focussed on 4 11-story buildings in a Kraków housing cooperative. Energy savings of over 20% were obtained. Most important, the procedures and materials implemented in the demonstration project have been adapted to Polish conditions and applied to other housing cooperatives, schools, and hospitals. Additional projects are being planned, in Kraków and other cities, under the direction of FEWE-Kraków, the Polish Energié Cities Network, and Biuro Rozwoju Krakowa.

BACKGROUND

The City of Kraków, in the Vistula River basin, has been plagued with serious air pollution for decades. Significant sources of pollution include industry (both in Kraków and in upper Silesia, which is upwind from Kraków), automobiles, and solid-fuel boilers and stoves used for space heating. Air quality monitoring systems (those installed by Poland as well as seven monitoring stations installed by the U.S. Environmental Protection Agency) have shown elevated levels of particulates, SO_2, NO_x, CO, and volatile organic compounds. These air pollutants have taken their toll on Kraków's historic buildings and monuments and, more importantly, on its citizens. Kraków residents have significantly higher levels of respiratory disease, as well as other illnesses which have been associated with this type of pollution.

For years, the local and regional governments, as well as non-governmental organizations such as the Polish Ecological Club, have sought to improve the air quality in Kraków. These efforts have resulted in limited automobile access to the central city and installation of emission control equipment or closure of some of the most toxic of the area's industries. Since the solid-fueled boiler houses, furnaces and stoves, used mainly for space heating, contribute about 35-40% of Kraków's air pollution, the City has concentrated on reducing these emissions. These efforts have resulted in elimination of over two-thirds of the solid-fuel boilers and coal stoves. (These low smokestack sources are referred to as "low emissions" sources.) The Kraków Clean Fossil Fuels and Energy Efficiency Program, begun in 1991, is a U.S. assistance program designed to help Kraków formulate and implement its low emissions reduction efforts. The objective of the U.S. assistance is to provide data to evaluate the emission reduction alternatives. Where reliable data were not readily available, demonstration programs and monitoring/testing projects were used to obtain necessary emissions, efficiency, energy use, and economic information.

The Kraków building stock, typical of most of Poland's cities, includes about 1000 buildings made of prefabricated concrete panels, with little or no insulation. These buildings are usually heated by the municipal (pressurized hot water) district heat system or by local coal- or coke-fired boilers. Conservation can be a force for pollution reduction according to the following scenarios:

- Less fuel can be burned by the coal- or coke-fired heating systems.
- By reducing building heat requirements, it is less costly for the residents to burn alternate fuels, which are less polluting but more expensive than coal. Thus, conservation can encourage conversion to non-coal fuels.
- Reducing the heating requirements for district heat-supplied buildings will enable the existing district heat system both to serve additional customers without constructing new central heat sources and to eliminate local boiler houses on the district heat system.

In all cases, effective use of energy can improve the economics of the pollution reduction options Kraków is evaluating.

OBJECTIVES

The objectives of the conservation demonstration were to:

- Identify affordable, cost-effective residential energy efficiency measures applicable to Polish conditions.
- Evaluate the costs and benefits (energy reductions) due to selected measures.
- Identify institutional and infrastructure impediments to the adoption of economically attractive energy efficiency measures and the means to overcome those obstacles.
- Foster the implementation of suitable energy efficiency programs.

DESIGN OF THE CONSERVATION DEMONSTRATION

The demonstration is described in detail in [Markel *et al,* 1995] and in the final report of the Kraków project, phase I [Butcher *et al,* 1995]. It consisted of three major aspects, implemented in 4 buildings of the Spółdzielnia Mieszkaniowa "Krowodrza" housing cooperative:

- Building envelope improvements, to reduce the requirement for heat and improve comfort.
- Building-level control, to reduce the amount of heat delivered to the building during mild weather.
- Thermostatic valves on individual radiators, and incentives for the residents to use them.

The 4 buildings are identical, 11 stories tall, with 66 apartments each. Different combinations of energy efficiency measures were tried in each building over 2 heating seasons:

- Baseline building (no improvements)
- Regulated hydroelevator
- Regulated heat exchanger
- Thermostatic valves on radiators and chemical cleaning of pipes in the building
- Fiberglass insulation of air space under the roof
- Fiberglass insulation of air channels in the concrete slab of the basement ceiling
- Weatherization package consisting of
    - Caulking interior cracks and around door and window frames
    - Weatherstripping all doors and windows
    - Installing door sweeps and thresholds on all entry and balcony doors
    - Installing insulated reflective foil behind radiators
    - Sealing infiltration bypasses around electrical and pipe openings in the basement
    - Suggesting to residents that they not block radiators with furniture or curtains
- External polystyrene insulation applied either to all walls or to flat (no windows or balconies) walls only

Because the heat delivered to the building is directly dependent on the temperature of the water delivered by the district heat utility (MPEC) and not what the building actually needs, it was necessary to both improve the buildings' thermal characteristics to reduce the heat requirements and to install controls to reduce the amount of heat delivered.

RESULTS OF THE DEMONSTRATION

The demonstration showed that the weatherization package (cost $45 US per apartment) and roof insulation (cost $37 US per apartment) were cost-effective, with simple paybacks of less than four years at current energy prices.

Some form of control was needed to reduce the amount of heat delivered to the building; otherwise the weatherization will just make it overheat. The demonstration used thermostatic valves on radiators, as well as temperature reset controls on building hydroelevators or heat exchangers. The district heat utility, MPEC, feels that comparable savings can be obtained by installing heat exchangers and air temperature-based controls in the network substation nodes, each of which serves from

5 to 25 buildings. This would lower the cost of controls to about $80 per apartment. Our experience suggests that a strategy of rebalancing the building heating system after weatherization, reducing the size of the orifice at the district heat connection (to reduce heat deliveries and lower the fixed capacity charge), and relying on MPEC's current control of the water temperature in the network may also accomplish most of what the more sophisticated controls do, but at a much lower cost.

For buildings heated with gas or electricity, where thermostats are already installed, or buildings heated with coal stoves (where the temperature depends upon how much fuel the resident burns), it is not necessary to add additional controls. Tests by FEWE-Kraków in gas-heated apartments in the Old City showed energy reductions comparable to those observed in the primary demonstration.

The building receiving the control, weatherization, and attic insulation measures reduced its seasonal heat energy consumption by over 21% (640 GJ, or almost 10 GJ per apartment). The other measures tested, external insulation and basement insulation, did reduce energy consumption, but were not cost-effective and, in the case of external insulation, were prohibitively expensive for widespread implementation.

The weatherization/insulation measures also improved thermal comfort, and reduced some of the internal moisture and condensation problems many apartments had before the demonstration. The ability to control one's heat usage, with the thermostatic valves, was very popular with the residents.

If the Kraków district heating system were to eliminate all local boilers, and connect the buildings they serve to the MPEC network, it would need 330 MW of additional heat capacity [Bieda *et al*, 1995]. Conservation projects, such as this demonstration, could easily reduce the city's heat demand to enable all buildings to be served by MPEC's existing central heat sources. For basic business reasons, MPEC and its primary heat supplier (EC-Łęg) are also interested in energy efficiency technologies as a means of encouraging people to connect to the central heat system, adding to the MPEC/Łęg customer base.

In summary, the demonstration project identified affordable weatherization measures which could reduce heating energy by over 20% in all types of Kraków's older, un- or under-insulated buildings. The measures improved comfort, reduced energy bills, and were well received by the housing cooperative residents, cooperative management, and MPEC. FEWE-Kraków has gone on to implement similar measures in other housing cooperatives, hospitals, schools, heat pipelines, industrial enterprises, and private homes and offices [Warsaw *Voice* 1995]. These projects have resulted in significant energy and cost savings [Piotrowski 1995] as well as pollution reduction.

PROMOTING ENERGY EFFICIENCY

There remain two primary impediments to widespread implementation of conservation technologies. The first is the shortage of money to pay for the improvements. Even with fast payback, some initial investment is needed.

The second impediment is the heat tariff and payment system, where:

- Most buildings do not have heat meters, so they are charged for calculated energy use, which may not give sufficient credit for energy efficiency measures and activities.
- Residents pay a government-set uniform price for district heat, based upon floor area of their apartment. Their heat bill does not decrease if they use less energy. (Note that for gas- and electric-heated residences, where the consumer pays for actual energy use, this is not a factor.)
- A large part of a building's district heat bill is a fixed capacity charge which, also, is calculated. There are no practical heat demand meters. Reducing this charge requires negotiating with the district heat utility.
- Lack of controls, on buildings or on radiators, limits the ability of building owners and residents to actually reduce their consumption of district heat.

This section suggests ways to overcome the obstacles mentioned above. The overriding constraint is lack of money for the initial investment. The financing for an energy efficiency project is not large; a housing cooperative may need $25,000-$100,000 for all of its buildings. Many sources of funding, such as the World Bank, EBRD, or the Polish Eco-Fund (BÓS) are geared to lend money to large projects. An energy service company (ESCO) may be willing to do the work at no up-front

ECONOMIC ASPECTS OF POSSIBLE RESIDENTIAL HEATING CONSERVATION

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SUMMARY

The paper presents methods of evaluation of energy and economy related effects of different actions aimed at conservation in residential buildings. It identifies also the method of selecting the most effective way of distribution funds assigned to weatherization as well as necessary improvements to be implemented within the heating node and the internal heating system of the building. The analysis of data gathered for four 11-stories high residential buildings of „Żerań" type being subject of the Conservation Demonstrative Project, included a differentiated scope of weatherization efforts and various actions aimed at system upgrading. Basing upon the discussion of the split of heat losses in a building as well as the established energy savings for numerous options of upgrading works, the main problem has been defined. It consists in optimal distribution of financial means for the discussed measures if the total amount of funds assigned for modifications is defined. The method based upon the principle of relative increments has been suggested. The economical and energy specifications of the building and its components, required for this method have also been elaborated. The application of this method allowed to define the suggested optimal scope of actions within the entire fund assigned for the comprehensive weatherization.

INTRODUCTION

According to the statistic data reported for 1990, in total 74% of the apartments situated in towns are equipped with central heating systems while 40% are heated from the district heating systems. The report elaborated in 1994 by the Polish Academy of Sciences (a team of the Committee of Power Engineering Problems) entitled „Development Policy of Complex Power Engineering in Poland Till 2010" shows, that **in average unitary heat consumption in domestic housing is two times greater than this assumed in standards presently valid in developed countries.** The report underlines also negative economical and ecological consequences related to this fact. This enormous consumption results from bad technical condition of the district heating systems (sources, network) caused by improper technical solutions of energy generation, transfer and supply control in large district heating systems. Another reasons, which influence significantly the level of energy consumption for heating purposes are as follows: bad thermal insulation and improper tightness of external barriers of the buildings as well as bad technical condition and poor quality of internal heating installation. It has been estimated that the potential savings within this group of parameters is very high and reaches about 30% of current energy consumption for residential heating. In order to reach this level of conservation, number of effective measures - so called weatherization - should be undertaken.

In the past, and even at present, the scope of this term was limited - as a rule - to the weatherization of external walls only. It was based upon the current legal status and the need to eliminate first of all the existing technological defects. As a result, the improvement of operating conditions was rather more significant than conservation effects.

At present - due to the higher and higher costs of residential heating - another weatherization solutions are developed, which are more efficient in reducing energy consumption and relatively low expensive. The efficiency of these efforts depends to the great extent on the comprehensive character of implemented actions and on the selection of proper set and range of weatherization works. In order to elaborate appropriate solutions, numerous actions are undertaken aimed at the evaluation of the technical condition of both the building and the heating network. These efforts are followed with the elaboration of several options of upgrading works (related to the weatherization and the improvement of heating system) in order to select the best solution in an economical analysis based upon the results of calculations of savings and capital costs required for different options. Application of such a procedure in the determination of **the scope of comprehensive weatherization measures** after numerous power engineering audits of residential buildings [Domińczyk *et al.*, 1994; Gintowt, 1994], has shown that in spite of optimistic results in conservation there appear frequently problems in transferring them to economic effects. And therefore the development of economic analysis procedures is so important to help in the determination of the most efficient methods and scope of weatherization programs for residential housing.

WEATHERIZATION OF RESIDENTIAL HOUSING. REMARKS ON THE SCOPE OF ACTIONS

Basic and the most effective way to reduce energy consumption in a building consists in the improvement of its thermal insulation as a result of weatherization. The buildings could be weatherized as follows:

- additional insulation of external walls, basement ceiling and the space between the top apartment's ceiling and the building's roof (with mineral wool or foamed polystyrene);
- weather-stripping of windows and external doors to prevent excessive, non-controlled air infiltration from outside;
- replacement of existing windows with new ones glazed with special glass (with a low-emission cover) or triple glass with perimeter sealing and with special controlled ventilation gaps;
- reduction of the influence of wind on the building by means of anti-wind screens or protective plants.

In order to achieve the desired conservation efficiency, the building weatherization works must be executed carefully. The above mentioned measures related to the construction frame should be accompanied with upgrading works to adapt the central heating system for the operation in terms of reduced energy demand. This is a *sine qua non* condition of reaching a significant result in conservation.

The majority of occupied multi-family buildings were erected before eighties. In the case of these objects, the weatherization of external walls with a 5 cm thick layer of effective thermal insulating material (foamed polystyrene or similar material) allows to reach the level of heat-transfer coefficient required according to the heat protection regulations (PN-91/B-02020). The attics insulation requires at least 10 cm thick additional thermal insulation to fulfill the regulation. In the case of basement ceiling a 5 cm thick additional insulation is needed.

Although the insulating materials used for weatherization of the above mentioned types of barriers are rather similar, the capital cost of these works depends significantly on the type of barrier and ranges between PLZ 100 000 and PLZ 700 000 per square meter of the surface. The highest unitary cost of external wall insulation appears if the insulating layer should be mounted outside the building. The external walls could also be weatherized from inside, however this solution - feasible in the new buildings prior to the first occupation - is accompanied with understandable protest of the residents in the case of older buildings. Much simpler - from technical point of view - and less expensive is the weatherization of the attics (the space between the top apartment's ceiling and the building's roof) and the basement ceiling. In the case of ventilated attics, the insulation layer (predominantly made of plates or mats) could be simply laid in the ventilation space. In the basement ceilings, the air channels can be filled following a special technology or the insulating plates made of foamed polystyrene can be mounted to cover the basement ceiling.

As the external walls of the multi-stories residential buildings constitute a significant portion of the total surface of the building barriers, their weatherization requires very high capital costs. From the economical point of view, much more effective is the weatherization of the attics and the basement ceiling. Basing upon the evaluation carried out for selected types of system buildings, it follows that the weatherization of the basement and attics could result in 6-8% total conservation, compared with less than 20% savings related to the insulation of external walls. However when comparing the capital costs of these options, it appears, that full weatherization of external walls - depending on the applied technology - is 15-30 times more expensive than the thermal insulation of basement ceiling and attics.

DESCRIPTION OF THE ACCEPTED METHOD OF SELECTION OF THE OPTIMAL UPGRADE SOLUTION

Because of the complicated character of the comprehensive weatherization project, including a long list of available options and limited fund, assigned for all the discussed measures, an important question raises: **„How to split the available fund among the optional solutions related to the improvement of thermal insulation condition and upgrading the heating system of the building in order to maximize the economical effect reached?"**

In order to determine the optimal scope of weatherization measures, the economic comparative analysis of different options should be elaborated. Such an analysis could apply the so-called economic specifications determined separately for each discussed upgrade option. The above mentioned question has been answered using the „method of analyzing the relative increments of economic efforts", well known and widely applied in heating management, e.g. when determining the principles of load distribution of parallel operated devices if their operating costs are different [Szargut, 1983]. The only difference consists in the fact that in our analysis the relative increments of operating costs have been replaced with relative decrements (i.e. negative increments) of the heating costs. They represent the values of relative reduction of operating costs as a function of related capital costs for each discussed weatherization measure (barrier weatherization, modernization of the heating installation). Since the weatherization measures should be analyzed separately for different types of barriers, a characteristic curve of reduction of the operating cost as a function of total weatherized surface has been elaborated for each type of improved barrier (for a chosen technology). The analysis is based upon the relative degree of barrier weatherization because of significant differences in surfaces. Following formula has been used to determine the changes in operating costs:

$$\Delta K_{oper} = \Delta Q_{calc} * \frac{86\,400 * S_d}{(t_{wm} - t_e)} * k_{uc} \qquad (1)$$

This dependence expresses the difference in heating costs of a building for base case and after upgrade implementation. This is a slightly simplified, modified version of Hottinger's formula used for determination of fuel amount consumed for heating purposes. Assuming minor effect of caulking of window and door frames and excluding these measures from the discussed methods, the difference in heating costs related to the weatherization of barriers could be written as follows:

$$\Delta K_{oper} = (k_{B,base} - k_{B,wth}) * F_{fr} * 86\,400 * S_d * k_{uc} \qquad (2)$$

Following symbols are used in this formula:

$k_{B,base}$ - averaged heat-transfer coefficient for all the external barriers of the base case building [W/(m^2*K)];

$k_{B,wth}$ - averaged heat-transfer coefficient of the weatherized building [W/(m^2*K)];

S_d - number of „degree-days" for a given town [K*day];

K_{uc} - unit cost of heating energy supplied from the district heating network, according to the current price list;

F_{fr} - total surface of the external „frame" of the building (including all types of its external barriers).

It follows from the formula (2) that the averaged heat-transfer coefficient was used in calculations of the changes in heating costs. This coefficient could be expressed for the base case building as follows

$$k_{B,base} = \frac{\sum_{i-1}^{n} k_i * F_i}{F_{fr}} \qquad (3)$$

Since the external walls, the space between the top apartment's ceiling and the building's roof (or ceilings under the roof) and basement ceilings are predominantly weatherized while weather-stripping of windows is not so common, the averaged heat-transfer coefficient for the base case building could be defined with following expression:

$$k_{B,base} = \alpha * k_{EW} + \beta * k_{At} + \gamma * k_{bsm} + \delta * k_{wnd} + k_o \qquad (4)$$

The indices in this formula mean: EW - external wall, At - attics; bsm - basement ceiling; wnd - window, respectively. The symbol k_o means the average heat-transfer coefficient for another external barriers of the building multiplied by the weighing factor which determines the share of these barriers in the entire surface of the external „frame" of a given building (including e.g.: walls of the basement, walls of the elevator engine room etc.) The Greek letters $\alpha, \beta, \gamma, \delta$ denote the shares of dominating external barriers in the entire surface of the „frame".

The average heat-transfer coefficient of the entire building for separate options of weatherization measures could be determined using following scheme:

- in the case of weatherization of external walls:

$$k_{B,wth}^{EW} = \alpha * k_{EW} * (1 - x) + \alpha * k_{EW,wth} * x + \beta * k_{At} + \gamma * k_{bsm} + \delta * k_{wnd} + k_o \qquad (5)$$

where: x - portion of the surface of weatherized part of external walls in the total surface of this barrier in the discussed building.

- the calculations for remaining barriers of the building are similar.

The another economical characteristic curve of the modernization undertaking presents the relation between required capital investment costs and the degree of weatherization of the discussed building. The amount of capital costs related to the weatherization measures could be expressed as follows:

$$\Delta I_{wth} = x*F_{ext}*k_j^{ext} + y*F_{At}*k_j^{At} + z*F_{bsm}*k_j^{bsm} \quad (6)$$

The components of the sum in formula above denote capital costs related to the weatherization of external walls, attics and basement ceiling, respectively. These costs result from the surface of weatherized barriers as well as the unit costs of weatherization of a given barriers following accepted technical solution.

DESCRIPTION OF THE OBJECT USED FOR TESTING AND THE SCOPE OF ANALYSIS

The detailed analysis following the suggested procedure has been carried on in multi-stories buildings of „Żerań" type erected commonly in Cracow area during seventies. Such buildings, situated in Cracow, Batalionu-Skała-St. (former Wolasa-St.) #4, #6, #8 and #10 were the subjects of the Conservation Demonstrative Project included in the American-Polish Program of Elimination of Low Emission Sources in Cracow, Poland sponsored by the US Department of Energy. Taking into consideration the scope of measurement data suitable for analysis, provided by the Cracow Development Office and the Polish Foundation for Energy Efficiency, detailed calculations and experiments were feasible. The subject of the experiments was a „Żerań" type, 11-stories high building consisting of two parallel staircases and made of prefabricated large concrete panels. The total heated volume exceeds 10 000 m^3. The building includes two different types of external walls. The first one - hereinafter called A-type wall - is a supporting wall made of 24-cm thick panels with circular air channels. The wall is made of reinforced concrete, with channels situated vertically, along the height. The wall is weatherized from outside with a 12 cm thick gas concrete, PGS blocks, type 500, and covered with plaster on both sides. The heat-transfer coefficient of this wall is $k = 1.154$ [W/m^2*K)]. The second type of external walls in this building (the B-type wall) is a filling wall with windows. This wall is made of large blocks of cellular concrete PGS, type 500, 24-cm thick, integrated with cement-lime mortar and plastered on both sides. The heat-transfer coefficient of this barrier was $k = 0.865$ [W/m^2*K)]. The basement ceiling (signed *bsm*) is also made of panels with circular air channels. This ceiling was originally weatherized with 40-mm thick mineral wool layer, and its heat-transfer coefficient reached 0.933 [W/m^2*K)]. In the case of ventilated attics, the heat-transfer coefficient is $k = 0.821$ [W/m^2*K)]. The windows and balcony doors are typical: wood-framed with two glasses - their heat-transfer coefficient is $k = 2.60$ [W/m^2*K)].

The Conservation Demonstrative Program included following measures of weatherization in 4 examined buildings:

1. External walls type A and B were weatherized in the building #10 with 50-mm thick foamed polystyrene layer following the light wet procedure called DRIVIT SYSTEM.
2. In the building #8 the space between the top apartment's ceiling and the building's roof (attics) and basement ceiling was weatherized with an insulation (mixture of mineral wool and latex binder) blown into the air channels. The ceiling under the roof was covered with 35-cm thick insulation layer. Furthermore the gable walls were weatherized following the light wet procedure called TERRANOVA.
3. In the building #6 the space between the top apartment's ceiling and the building's roof (attics) and basement ceiling was weatherized and the window and door frames were caulked.
4. In the building #4 the only weatherization measure applied was caulking of window and door frames.

The measurement results were stored for all the examined buildings. The authors have carried on analyses and calculations of heat-transfer coefficients for base case barriers and for weatherized barriers after implementation of measures defined by the coordinators of the Demonstrative Project.

The Table 1 presents determined values of heat-transfer coefficients k of the barriers for the base case and after weatherization together with the surfaces of these barriers and the k-coefficient limit required in the Polish Standard PN-91/B-02020 „Heat protection of buildings". It follows from these data that the implemented methods of building weatherization allowed to reduce significantly the heat-transfer coefficient k with regard to all its external barriers. These values were reduced circa two times for external walls and basement ceiling and ca. 6.5-times in the case of the attics.

Table 1. Calculation results for the barriers of the discussed building

Barrier	Surface [m^2]	Heat-transfer coefficient k [W/(m^2*K)]	k_{max} limit acc. to PN-91/B-02020 [W/(m^2*K)]
EW A-type EW A-type wth	1811 1811	1.154 0.535	0.55
EW B-type EW B-type wth	1147 1147	0.865 0.440	0.55
At At wth	360 360	0.821 0.126	0.30
bsm bsm wth	340 340	0.933 0.511	0.60

Also the comparison of the **k** coefficients of weatherized walls with the k_{max} values (required according to the heat protection regulations) allow to draw the conclusion that the implemented weatherization meets the requirements. Only in the case of the A-type wall after weatherization, the **k** coefficient is close to the standard requirement - it results from the bad primary insulating condition of this type of walls.

Heating energy (150/70 °C) is supplied to the discussed buildings from the district heating network. Initially the central heating system of the buildings was connected through a hydroelevator; designed parameters of water in the internal installation were 95/70 °C. The undertakings planned within the Conservation Demonstrative Program included also several actions aimed at modernization of the installation and the heat node. Following modernization procedures - hereinafter called variants - have been implemented in individual buildings:

Variant I - buildings #8 and #10

The hydroelevator was replaced with a compact heat exchange system including an LP M-type panel heat exchanger and an in-building circulating pump Grundfos with continuous automatic regulation of rotational speed (Varitrol system). This variant included implementation of the Aquatrol temperature-based regulation device and a heat meter. The internal installation has been closed and protected with a membrane-type cumulation tank. Furthermore the Honeywell thermostats were added to the radiators.

Variant II - building #6

The only difference between this option and the first Variant consists in the fact, that in this case the circulating pump has not been equipped with the automatic regulation of rotational speed because the implementation of thermostat valves was not foreseen in this building.

Variant III - building #4

In this option the standard hydroelevator has been replaced with a controlled jet pump manufactured by ERST company. This variant included also implementation of the temperature-based regulation device in the hydroelevator as well as the heat meter.

The capital costs of weatherization of separate barriers of the building as well as the cost of modernization of the central heating system according to the above mentioned variants have been determined in beginning-1994 prices. Also the unit cost of heating energy has been taken according to the price list of the municipal district heating authority (MPEC SA - Municipal Power Engineering Enterprise - Stock Company) of April 1994. Measurement results from two heating seasons: 1992/93 and 1993/94 were used in calculations. These measurements have been carried out using the EXCEL 100 systems which allowed to determine the instantaneous values of 18 measured quantities in each building, e.g. temperature inside chosen rooms in the building; temperature, flow rate and pressure of heating water circulating in the network as well as in the building installation as well as heat meter readouts. During the heating season 1993/94 the heat exchanger and hydroelevator were switched (alternating) every two weeks (buildings #4 and #6). Also the operation of thermostat heads (in buildings #8 and #10) was switched every two weeks (alternating thermostat heads assembled and disassembled). The experimental results (provided by the Cracow Development Office and the Polish Foundation for Energy Efficiency) have been validated at the Cracow Technical University, Institute of Heat Engineering and Air Protection. The most important results are presented in Table below.

Table 2. Economic indices of accepted modernization solutions

Variant	ΔI [million PLZ]	ΔE [GJ/year]	ΔK_{oper} [million PLZ/year]
weatherized EW	2 331.00	495.20	77.80
weatherized At	36.00	71.00	11.30
weatherized bsm	27.20	43.30	6.80
Wolasa #4	115.00	532.60	83.67
Wolasa #6	260.00	533.50	83.82
Wolasa #10	353.10	782.30	122.90

The symbols used in this table denote:

ΔI - capital investment costs;

ΔE - obtained heat conservation;

ΔK_{oper} - savings in district heating operating costs in a building.

The three first rows concern the capital costs and effects related to the weatherization measures only; next rows concern the total value of capital costs and effects of modernization of the installation in individual buildings according to the scope of works defined above. The effects given in rows 4-6 refer both to the weatherization of barriers and the implemented measures of system modernization. Thus, in order to obtain the total capital costs related to the modernization of a building, the values of costs given in the second column should be added up in consistency to the scope of works implemented in each building. When comparing the total capital costs and effects determined in such a way allows to find out the **direct** pay-back of these costs for each set of upgrade actions implemented in the buildings.

VALIDATION OF OBTAINED RESULTS

The final effect of the analysis discussed in this work is a graph, which presents the optimal distribution of funds assigned for the investment aimed at the reduction of energy demand for heating the multi-stories residential building. This graph has been drawn basing upon economic characteristic curves of individual upgrading measures, discussed above. The structure of this graph is consistent with the method of optimal distribution of the funds among different measures. There are three such measures of „Żerań"-type building improvement: external walls, attics and basement ceiling weatherization. The relative increments of the characteristic curve of operating costs are different for these three options. Therefore they are arranged on the graph to reach the highest savings in operating costs for the defined total amount of capital investment costs. It should be noticed that first of all the measures presented with an abrupt section of the curves should be undertaken. Thus the order of „switching on" discussed weatherization measures should be as follows:

1. attics weatherization;
2. basement ceiling weatherization;
3. external walls weatherization.

The presented method of arranging the order of weatherization works influencing the heat demand of the building should be combined with economic indices dealing with profitability of different options of upgrading the in-building heating installation. These indices have been determined in measurements. Finally the graph consists of three broken lines for each of the three discussed options of upgrading the heating installation. For economical reasons these actions should precede all the weatherization measures.

The obtained graph enables optimal distribution of funds assigned to the building weatherization and modernization of the in-building heating installation for any amount ranging between 0 and 1 750 million PLZ. Basing upon the attached graph it is possible to choose the most profitable option of modernization. Thus in the case of discussed multi-stories „Żerań"-type residential building - first of all - the modernization of the heating node is recommended. The Variant III of the modernization of heating node and in-building heating installation should be accepted as it is well-founded both technically and economically.

On the other hand, the weatherization of external barriers of the discussed building should be implemented as follows: full weatherization of the attics and the basement ceiling and partial weatherization of the external walls. The reasonable scope of these works ranges from 25 to 30% of the total surface of external walls. In the case of defined scope of upgrading works the capital costs could be paid back after 7-11 years (interest rate $p = 0.10$ - preferential credit line). This is an acceptable pay-back period of undertakings in the field of weatherization.

The pay-back period for complete weatherization of external walls for above mentioned conditions exceeds 17 years. The present conditions of credits assigned for weatherization works, even for different calculation method (including the changes of costs and potential savings during project implementation) do not motivate the decision on comprehensive weatherization. This conclusion is consistent with the results presented by other authors [e.g. Gintowt, 1994; Ickiewicz, 1994] evaluating the pay-back of the weatherization of the walls of residential buildings.

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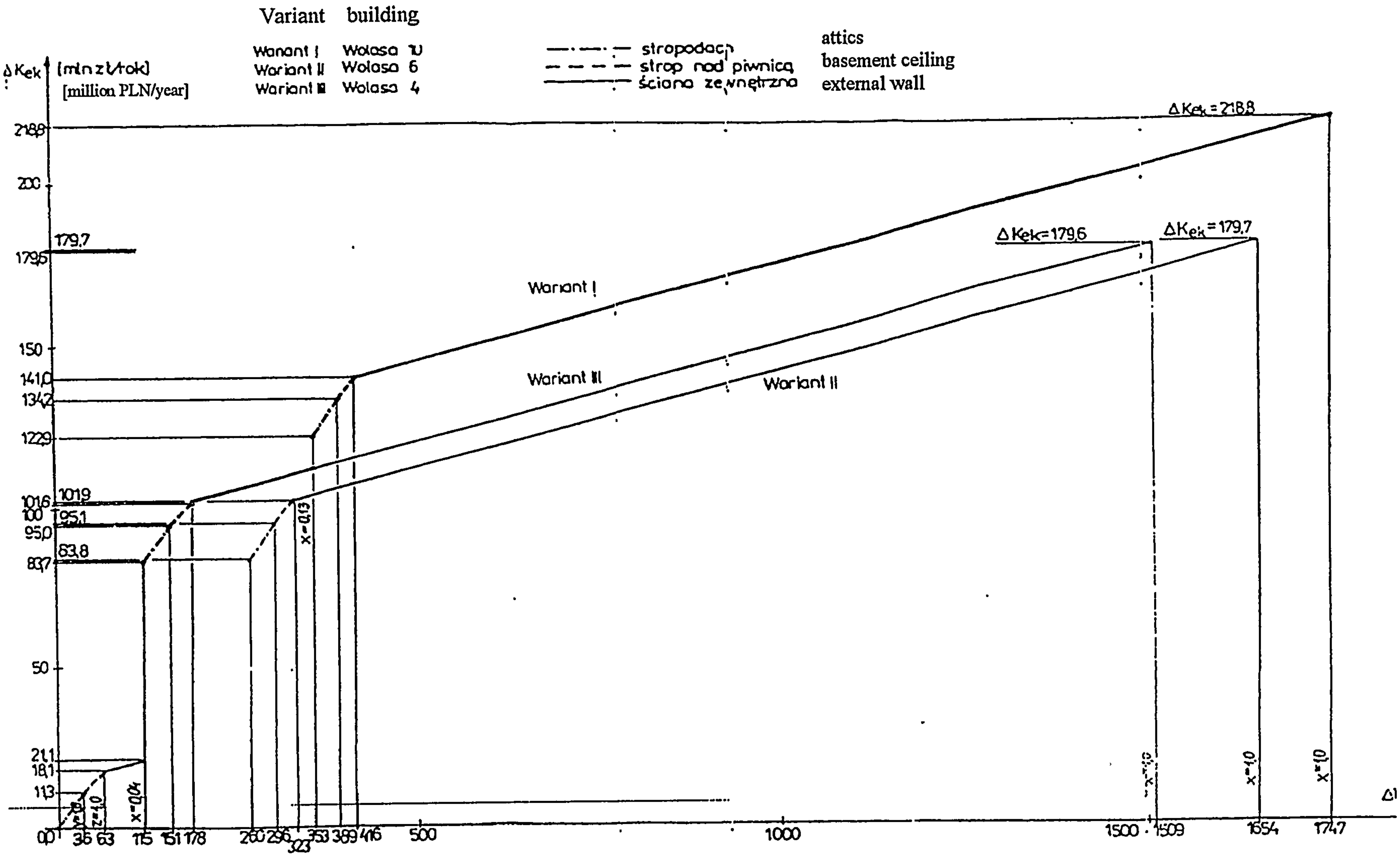

Fig. 1. Graph of optimal distribution of funds as a function of total capital investment cost.

PRACTICAL RESULTS OF HEAT CONSERVATION IN A HOUSING ESTATE SCALE - - ACTIONS IMPLEMENTED BY THE „PRĄDNIK-BIAŁY-ZACHÓD" HOUSING COOPERATIVE IN CRACOW

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In total there are 11 600 000 apartments occupied in Poland. More than 7 700 000 of these apartments are located in towns. Energy consumption for heating, ventilation and district hot water in residential housing reaches 40% of the national power balance.

High portion of district heat distribution and relatively low energy efficiency is characteristic for Polish residential housing. Ca. 75% of apartments in towns are provided with central heating installation and ca. 55% of the entire heat demand in Polish buildings is covered by the district heating systems. The total installed heat power of these systems reaches ca. 46 000 MW.

The situation with regard to conservation in Polish residential housing is directly related to the legacy of central planning of national economy and to the current phase of its re-organization to the market-oriented system.

The standard value of the overall heat-transfer coefficient for external walls in Poland until 1980 was 1.16 W/m^2K; at present it is reduced to 0.55 W/m^2K.

There are numerous reasons of low energy efficiency in residential housing, e.g.:

- poor heat insulation properties of building barriers; there exist many defects of the structure of apartment buildings erected in seventies and eighties following the industrialized technologies, especially large-panel system, e.g. frost and water penetration through external walls;
- the coal-oriented structure of the national primary balance of energy extorts erection of large heat engineering systems; because of rather low level of automation of such systems, they are hardly controllable;
- the hydraulic network, heating nodes and in-building installation is put out of adjustment (to a significant extent), because of the process of pipe encrustation;
- the lack of heat meters installed in heating nodes as well as the lack of thermostat valves at the radiators in the apartments;
- no possibility to clear accounts individually with the consumers of heat energy.

The generating companies and distributors of heat energy clear their accounts with the administrators of residential buildings using the so-called negotiated prices. The tenants are charged official prices announced by the Minister of Finance. The difference between the payments remitted by the tenants to the housing cooperative and the purchase cost of heat energy is made up by the national budget as a subsidy paid for the benefit of the cooperative.

The system mentioned above does not motivate neither the suppliers (generating companies and distributors) - to reduce the heat production costs, nor the heat consumers - to save heating energy. It follows from the data gathered by the Ministry of Site Planning and Construction in early 1991, that the total estimated cost of upgrading works implemented in the housing cooperative buildings reached ca. PLZ 9 000 000 000 000 ($ 374 688 000[1]) after 10 years of repair works executed by the housing cooperatives.

The circumstances related to the options of financing such upgrade and repair works have been changed significantly in 1990, i.e. when the Law on Setting Loan Conditions in Order dated December 28, 1989 has come into force. The cancelable credits aimed at the weatherization of apartments belonging to the housing cooperative have been withdrawn.

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[1] All the values given in US dollars have been converted basing upon the average currency rate announced by the National Bank of Poland (NBP) on March 31, 1995: $ 1 = PLN 2.4020
(Note: PLN 2.4020 = PLZ 24 020; PLZ - so called „old" Polish Zloty valid till December 31, 1994; PLN - new currency called Polish Zloty and valid since January 1, 1995.)

Weatherization efforts have been based upon the complete or partial recovering the cost borne through the state subsidization of housing cooperatives. Apart from the works which result in the improvement of thermal insulation of the buildings (weatherization) - the additional action is aimed at supporting the implementation of measurement devices in apartment or building level. Assembling thermostat valves, water flow meters and heat meters has created proper circumstances to motivate reduction of water and heat consumption. (Problemy energii cieplnej - *Heat energy problems* - information delivered by the Ministry of Site Planning and Construction in „Administrator" No. 10/94).

This option is used by the „Prądnik-Biały-Zachód" Housing Cooperative in Cracow since 1992.

The „Prądnik-Biały-Zachód" Housing Cooperative manages 1 552 apartments in 19 buildings, including:

- 8 buildings 11-stories high
- 11 buildings 5-stories high

The buildings listed above contain 80 300 m^2 of apartments and premises occupied by 4 674 inhabitants..

- In 12 buildings the central heating system is supplied from the heat exchanger owned by the municipal district heating utility (MPEC SA - Municipal Heat Power Engineering Enterprise in Cracow); the heat exchanger has been upgraded and the temperature-based regulating devices has been installed. The heat exchanger supplies 30 substations of heat exchangers which serve in total 1 005 apartments.
- There are 14 hydroelevators in 7 buildings, which need to be replaced with heat exchangers with temperature-based regulation system. These hydroelevators supply heat for 548 apartments. If the installation is operated efficiently, the apartments are overheated.

Since October 1, 1992 the gable walls and offsets in walls have been weatherized in 13 buildings and the weatherization of wall offsets in another 5 buildings has been completed. Total surface of these walls is 8 453 m^2. The capital cost of these works amounted to PLZ 3 478 000 000 ($ 144 796) - the major portion (80%) of this cost has been made up by state subsidy.

The base case average heat-transfer coefficient was 0.869 W/m^{2}K, while after weatherization it has been reduced to 0.417 W/m^{2}K.

The average cost of the weatherization works following the TERRANOVA light wet procedure amounted to PLZ 411 400 per m^2 ($ 17.13 per m^2). The first stage of the project has been completed (1992 - first half 1994).

The second stage f the project includes weatherization of window walls where frost and water penetration has been observed. The ultimate surface of these works is 27 683 m^2.

In second half of 1994 ca. 4 530 m^2 of window walls have been weatherized (buildings: Szopkarzy #2 and Pachońskiego #18). The state subsidy made up 55% of the total costs of these works. Furthermore the amount of PLZ 872 000 000 ($ 36 303) has been spent by the Housing Cooperative to weatherize the top apartment's ceilings in 11 buildings 5-stories high using a US device INSUL-8-2000. The surface of weatherized ceilings constitutes 9 011 m^2. These works have been executed in 1993-1994 by the Cracow Branch of the Polish Foundation for Energy Efficiency (FEWE), managed by Prof. Adam Gu³a. Apart from these works, FEWE Foundation weatherized 278 m^2 of the top apartment's ceilings in one 11-stories high building and furthermore - as agreed with Mr. Lawrence C. Markel (USA) - FEWE caulked window and door frames and installed insulated reflective barriers made of aluminum foil in 30 apartments. The total value of these works executed free of charge for the benefit of the cooperative amounted to ca. PLZ 57 000 000 ($ 2 373) in 1993 prices.

As a result of the weatherization works in ceilings, the heat-transfer coefficient „K" has been reduced from 1.04 W/m^{2}K to 0.29 W/m^{2}K.

As a consequence of the executed weatherization, the Housing Cooperative applied to MPEC Cracow for the reduction of the ordered amount of heat. For 1994 the Housing Cooperative has got the reduction of district heating power from 8.448 MW to 7.269 MW, i.e. decrease by 1.179 MW, and for 1995 the ordered power has been reduced again - now by 0.741 MW - from 7.269 MW to 6.528 MW.

In total the Housing Cooperative will reduce the ordered amount of power by 1.920 MW since January 1, 1995.

The apartments have been equipped with 1 189 individual water flow meters and it results in reduction of water consumption by 1/3.

The weatherization works are accompanied with the installation of measuring devices at the heating nodes and with assembling thermostat valves in the apartments. The thermostat valves manufactured by TUR ANDERSON and by HERZ have been installed in the „Prądnik-Biały-Zachód" apartments. In total ca. 7 000 such valves have been installed.

The heating nodes were equipped with Swedish ACM heat meters and water flow meters manufactured by MEINEKER Co. In total the housing cooperative has 45 heating nodes. Till now the total value of works related to the installation of measuring devices and thermostat valves amounts to ca. PLZ 4 600 000 000 ($ 191 507).

In 1994 the heating nodes have been modernized in 4 buildings: Nad-Sudołem #10, Nad-Sudołem #24, Danka #4 and Danka #5. The ineffective hydroelevators have been replaced with modern heat exchangers (meeting the European standards), fully automated and provided with temperature-based regulation of Swedish and Swiss production (TUR ANDERSON and LANDIS). The total cost of these works reached ca. PLZ 1 050 000 000 ($ 43 714).

The cooperative has got a state subsidy which made up 50% of these costs. The total amount of subsidies making up a part of works executed in 1992-1994 is ca. PLZ 8 500 000 000 ($ 353 872).

The combined efforts related to the installation of measuring devices and weatherization allowed the cooperative to save ca. PLZ 2 445 000 000 ($ 101 790) in 1994. At the same time till the end of 1994 the tenants were charged PLZ 12 570 per m^2 ($ 0.52 per m^2) i.e. the price paid was lower than the official price of district heating: PLZ 14 700 per m^2 ($ 0.61 per m^2). Following information should be added to explain the situation:

- In 1992 „Prądnik-Biały-Zachód" Housing Cooperative has got from the Provincial Office the due amount of PLZ 2 478 000 000 ($ 103 164) as a state subsidy related to the costs of district heating spent by the cooperative. The official price of district heating was ranging from PLZ 3 600 to PLZ 4 880 per m^2 ($ 0.15 to $ 0.20 per m^2), the annual heat consumption was 64 489 GJ and the monthly power ordered was 8.441 MW.

  At this time the MPEC Cracow prices ranged from PLZ 27 117 to PLZ 35 660 per GJ ($ 1.13 to $ 1.48 per GJ), and from PLZ 35 566 590 to PLZ 44 981 850 per MW ($ 1 481 to $ 1 873 per MW).

- In 1993 „Prądnik-Biały-Zachód" Housing Cooperative has got the due amount of PLZ 1 278 000 000 ($ 53 506) as a state subsidy related to the costs of district heating. The official price of district heating was ranging from PLZ 6 150 to PLZ 9 110 per m^2 ($ 0.26 to $ 0.38 per m^2).

  Monthly power ordered was 8.441 MW and the annual heat consumption determined by MPEC (without measurements) was 59 174.5007 GJ.

  At this time the district heat prices determined by MPEC Cracow ranged from PLZ 35 660 to PLZ 45 350 per GJ ($ 1.48 to $ 1.89 per GJ), and from PLZ 44 981 850 to PLZ 52 531 500 per MW ($ 1 873 to $ 2 187 per MW).

  During the period 1992-1993, when the view point on heat conservation has been changed and the program of implementation of measurement devices and weatherization of residential buildings has been started, the state treasury paid PLZ 3 756 000 000 ($ 156 370) for heat energy consumed in „Prądnik-Biały-Zachód" Housing Cooperative to make up the difference in prices.

- In 1994 the official price of district heating was ranging from PLZ 9 110 to PLZ 14 700 per m^2 ($ 0.38 to $ 0.61 per m^2) and the district heat prices determined by MPEC Cracow ranged from PLZ 45 360 540 to PLZ 59 738 650 per MW ($ 1 888 to $2 487 per MW) and from PLZ 57 420 to PLZ 75 615 per GJ ($ 2.39 to $ 3.15 per GJ).

  The annual heat consumption in 1994 was 47 193.4 GJ.

- In 1995 the official price of district heating amounts to PLN 1.47 per m^2 ($ 0.61 per m^2) and the district heat prices determined by MPEC Cracow ranged from PLN 5 973.87 to PLN 6 368.12 (this price is valid since April 28, 1995) per MW ($ 2 487 to $ 2 651 per MW) and from PLN 7.56 to PLN 8.13 (also this price is valid since April 28, 1995) per GJ ($ 3.15 to $ 3.385 per GJ).

The proportion between district heat power ordered and consumed in „Prądnik-Biały-Zachód" Housing Cooperative since the start of implementation of the measures of weatherization and assembling measurement devices, is given below:

1993	69% : 31%	PLZ 5 203 794 000 ($ 216 644) PLZ 7 549 908 000 ($ 314 318)	:	PLZ 2 326 114 000 ($ 96 841) PLZ 7 549 908 000 ($ 314 318)
1994	59% : 41%	PLZ 4 813 247 000 ($ 200 385) PLZ 8 118 706 000 ($ 337 998)	:	PLZ 3 300 459 000 ($ 137 405) PLZ 8 118 706 000 ($ 337 998)
1995	56% : 44%	PLN 544 980.64 ($ 226 886) PLN 977 885.46 ($ 407 113)	:	PLN 430 904.82 ($ 180 227) PLN 977 885.46 ($ 407 113)

The heat demand per 1 m² in 2.5-m high (average) apartments administered by the Housing Cooperative is as follows:

1993	105.2 W/m²
1994	90.2 W/m²
1995	81.4 W/m²
average in Poland	150.0 W/m²

The past conservation activities of the housing cooperative resulted in 25% savings of heat energy.
Furthermore in the I quarter 1994 the housing cooperative has got from the Cracow Provincial Office PLZ 335 000 000 ($ 13 947) state subsidy making up the costs of heating energy. Since the total cost of district heating in the Housing Cooperative has been reduced below the official price - in July 1994 the Cooperative returned the entire amount of subsidy back to the Provincial Office and no more state subsidy will be required to make up the costs of district heating in the „Prądnik-Biały-Zachód" Housing Cooperative. As a result of the implemented conservation and weatherization measures, in future the price of district heating in this cooperative will be lower than the official prices valid in Poland.
The difference between the residents' payments related to the district heating and the total amount of invoices paid to MPEC has been assigned to remunerate in part the works executed by MPEC Cracow and MarCo company and financed by them as well as to assembly modernized heat exchangers equipped with automatic temperature-based regulation devices, meeting the European standards and to finance the implementation of the remaining thermostat valves and building weatherization.
In I quarter 1995 the housing cooperative has re-entered in books the costs and the difference between incomes and costs related to district heating in total amount of PLN 3.20 per m² ($ 1.33 per m²) and the difference will be returned to the residents in 10 equal installments PLN 0.32 per m² ($ 0.13 per m²). Thus since March 1995 the district heating rate in „Prądnik-Biały-Zachód" Housing Cooperative is PLN 1.10 per m² ($ 0.46 per m²). Since May 1, 1995 the next reduction of the rate is planned - down to PLZ 0.85 per m² ($ 0.35 per m²).
The installation of heating cost allocators in separate apartments is being prepared in order to implement the individualized system of clearing accounts for district heating in residential housing, because the residents use heat more rationally if they have installed cost allocators. If the consumers would save heat, they will be able to reduce the temperature in non-occupied rooms or at nights which allows to save even 15% heat and this saving will be assigned to the individual apartment. The system of individual accounts motivates the users to the conservation and gives them real profits in reduced invoices. Such a statement summarizes the conclusions drawn by the Chief Board of Supervision in II quarter 1994 of the 1993 state budget supervision (Administrator No. 2/95).
This problem has been analyzed within the cooperative in a form of questionnaire. Ca. 1 000 residents took part in this inquiry action and 80.4% of them were for the implementation of cost allocators. However the Meeting of Partners' Representatives decided that the question of installing cost allocators in the housing cooperative buildings will be analyzed after 1995, when building weatherization will be completed.
Since 1992 the total cost of conservation measures implemented in the „Prądnik-Biały-Zachód" Housing Cooperative amounts to ca. ZLP 13 300 000 000 ($ 553 705), including the state subsidy got from the Ministry of Site Planning and Construction and the Cracow Provincial Office - ca. ZLP 8 500 000 000 ($ 353 872). The Housing Cooperative spent ca PLZ 4 800 000 000 ($ 199 833) their own money on this program.
In 1995 the cooperative is going to weatherize two buildings, including by-works (II-nd stage - window walls), i.e. 3 193 m² for PLZ 2 728 760 000 ($ 113 604) and to replace 4 hydroelevators with modern heat exchangers provided with automatic temperature-based regulation units. These modernization works are partly made up by MPEC Cracow - MPEC has purchased complete compact heat exchangers, while the Housing Cooperative has paid for assembly works and offered to MPEC free of charge appropriate rooms to assembly these exchangers.
In addition the Housing Cooperative takes into account the state subsidy making up the above mentioned works. The total value of weatherization works and assembling automatic regulation of heat exchangers in 1995 will reach ca. PLZ 4 000 000 000 ($ 166 528).
Taking into consideration continuously growing prices of district heat and reduced state subsidies, the capital cost covered by the cooperative will be paid back in three years.
The efforts and accomplishments of „Prądnik-Biały-Zachód" Housing Cooperative in the field of conservation through the weatherization of walls and ceilings, assembling the regulation devices at heat exchangers, implementation of heat meters

and thermostat valves were the reason why the cooperative has got a grant from the Global Environment Facility to carry on a pilot project aimed at the demonstration of potential savings from non-investment measures in individual apartments. These action, started in early 1995 include cleaning the coolers of refrigerators and freezers (15-20% electric energy savings), flame adjustment in gas-fired cooking stoves and instantaneous water heaters mounted in bathrooms, etc.

This project started in „Prądnik-Biały-Zachód" Housing Cooperative will be implemented for the residents at own charge of SGP Global Environment Facility by trained staff owing to the efforts of the Cracow Branch of the Polish Foundation for Energy Efficiency and the Foundation of Environmental Protection Assistance, Cracow, Poland.

Session III

Kraków Program Phase I Results - Economic Approaches for Control of Emission Sources and Improvement of Air Quality

Co-Chairmen: Jan Bieda, Kraków Development Office and Thomas Butcher, Brookhaven National Laboratory

COAL-FIRED BOILER HOUSES IN CRACOW
PRESENT STATE AND POSSIBILITIES TO IMPROVE THEIR EFFICIENCY

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SUMMARY

A significant amount of heat energy both for heating and process purposes is generated in Cracow, Poland in small- and medium size local boiler houses. The operating procedure of these boiler houses is most often economically and ecologically ineffective because of the bad condition of boilers and lack of funds to install automation, control and measurement equipment.

Within the Polish-American Program of Elimination of Low Emission Sources financed by the US Department of Energy, the „ENERGOEKSPERT" Co. Ltd. investigated chosen boiler houses in Cracow, commissioned by the Cracow Development Office. The results of these investigations were subject of engineering analysis carried out at the Institute of Industrial Equipment and Power Engineering, Technical University, Cracow. The analysis proved that the low-cost improvement of economic efficiency and reduction of air pollutant emission is feasible for combustion of coal fuels.

The results of analysis allow to draw following conclusions:

- in the case of mechanical stoker boiler, simultaneous economical and ecological advantages can be reached by proper selection of fuel and operating procedure;
- in the case of fixed grate, the pure coal is - from the ecological point of view - the worse sort of fuel, however the costs of heat generation from coal are the lowest;
- the contribution of pollutant emission fees in the entire production cost is small and it does not exceed 1-2%.

INTRODUCTION

A significant portion of hot water used both for communal heating purposes and for industrial processes as well as portion of process steam is generated in Cracow (likewise in many other Polish towns) in small- and medium-size local boiler houses. At present ca. 200 mechanical stoker and ca. 2 000 fixed grate boiler are operated in Cracow. This amount is permanently being reduced because the users are partly connected to the district heating network or the boilers are switched over to gas fuel. However, a significant portion of these boiler houses will be still operated considering relatively low cost of heat production and the large capital investment cost necessary for eventual switching over to another fuel type. Furthermore the district heating network cannot be connected everywhere. The average condition of the boiler house is mediocre or even bad, and the boiler devices do not reach their nominal parameters. It is caused by the deficiency in the equipment for continuous monitoring of boiler operation and the lack of automation.

As a rule, the boiler house user does not try to change this situation because of the reluctance to bear additional investment costs. In addition the user often purchases cheap sorts of coal, with high sulfur and ash content. It results from the common opinion, that this is the less expensive method of boiler operation.

The problem is especially important in the case of large urban agglomerations and within protected areas (e.g. in Cracow) because the boiler houses of this type constitute a significant „low emission" source.

The present state of natural environment and „low emission" sources has been evaluated within the First Stage of the Polish-American Program of Elimination of Low Emission Sources in Cracow. One of the tasks of this program was to analyze the operation of an average boiler house, in order to answer following two questions:

- what are the real operating parameters for an average boiler operation, an average staff, without the interference of a measurement group nor special preparation of the boiler;

- what are the attainable effects in the case of optimization of boiler operation, switching over to another type of fuel and what will be the change in heat production cost, accompanying these efforts.

These investigation have been financed thanks to the help of the US government, who awarded a grant through the US Department of Energy and the Brookhaven National Laboratory. On the Polish side, the investigations were coordinated by the Cracow Development Office. The program of tests has been agreed with the representatives of these two institutions. The investigations were executed by „Energoekspert" Co. Ltd. A comprehensive analysis of test results has been carried out in the Institute of Industrial Equipment and Power Engineering, Technical University, Cracow.

The American partners provided the entire equipment for the investigations.

SCOPE OF INVESTIGATIONS

The investigations were carried out in three boiler houses owned and operated by the Municipal Heat Power Engineering Enterprise (MPEC) in Cracow and one boiler house owned and operated by the Military Unit at Ułanów-St. [1], [2], [5].

Following boilers have been tested:

WR-10 mechanical stoker heating boiler, nominal output ca. 11.6 MW, operated seasonally in „Balicka" boiler house;

PLM-2.5 mechanical stoker steam boiler, output ca. 2.9 MW, operated all year round in „Krzesławice" boiler house;

Eca-IV cast iron heating boiler, output ca. 0.35 MW, operated seasonally in Rydla-St. boiler house;

Es-Żet steel boiler house, output ca. 0.24 MW, operated seasonally in Ułanów-St. boiler house.

In general four types of fuel have been tested for mechanical stoker boilers:

- base case - coal from „Ziemowit" Coal Mine;
- coal from „Staszic" Coal Mine - hereinafter marked „Staszic I";
- washed and sieved fine coal from „Staszic" Coal Mine - hereinafter marked „Staszic II" (additionally sieved fine coal is marked „Staszic III");
- coal from „Bolesław Śmiały" Coal Mine, marked „Pea" - the largest coal.

The grain size of „Ziemowit" and „Staszic" coals is equal to the IIa fine coal, however the „Staszic II" and „Staszic III" sorts were respectively improved. The „Bolesław Śmiały" coal is larger - pea grains. Furthermore the semi-coke was tested, but the results were not encouraging.

In the case of fixed grate boiler, three types of fuel were used: coke, a coke-coal mixture and briquettes manufactured by the Chemical Coal Processing Plant at Zabrze.

In the cast iron Eca-IV-type boilers a 1/1 coke-coal mixture, and in the steel boilers - the 7/3 coke-coal mixture (used as a standard by the operators) were used.

The properties of all applied fuel sorts are listed in Table 1.

Table 1. Properties of fuel sorts used in investigated boilers

Parameter	Units	Mechanical stoker boilers				Fixed grate boilers		
		Ziemowit	Staszic I	Staszic III	Pea	Coke	Coal	Briquettes
Total moisture	%	17.39	17.44	7.58	10.9	3.13	2.2	3.34
Ash	%	22.91	23.10	6.05	4.6	11.10	9.2	11.20
Volatile particles	%	27.21	26.91	30.89	33.7	2.0	31.5	8.80
Heating value	J/g	19 014	21 918	26 840	28 823	27 490	28 993	27 498
Total coal content	%	53.12	61.33	72.70	75.1	81.20	76	79.9
Total sulfur content	%	1.50	0.73	0.72	0.52	0.91	0.93	0.55
Combustible sulfur content	%	0.79	0.47	0.30	0.36	0.82	0.8	0.52

The boiler investigations were carried out according to the US Standards, i.e. consistent to the requirements of EPA (Environmental Protection Agency) and ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers). [3], [4]. Simultaneously the requirements given in Polish Standards PN-72/M-34128 and BN-86/1317-02 and the draft of PN-92/204030 were observed.

Boiler efficiency was calculated indirectly.

The computer controlled measurement paths of flue gas analyzers were used in the tests; measured pressure and temperature values were registered automatically by means of a Datalogger.

Separately, out of the computer system, concentration of particulates was measured with APEX analyzers, before and after the dedusting devices. Concentration of organic and inorganic compounds in the sucked samples was determined. Fuel, slag and ash composition was analyzed.

All the boilers were tested for different loads. In the case of fixed grate boilers the set of boilers was treated as a whole and afterwards the results were re-calculated for an individual boiler, because the samples for measurements of particle concentration had to be taken from a common stack. During the investigations, operating procedures were optimized for each type of fuel.

This optimization of the operating procedure for a given fuel type and a chosen boiler load consisted in suitable adjustment of the quantity of air used in combustion process.

SYNTHETIC DISCUSSION OF THE RESULTS OF INVESTIGATIONS

Two points of view: the economical and the ecological, are the most significant for the comparative analysis of obtained results. Therefore these two aspects were precisely discussed when comparing the results of these experiments. Costs of energy generation and harmful effect to the natural environment were compared.

Table 2 presents the recommended indices of pollutant emission resulting from these measurements, as well as those, found for another boiler houses tested by the author earlier (1991-1995).

It can be stated that, except for the emission determined for coal fired fixed grate boilers, the emission of particulates is much lower than this suggested in the Instruction of the Ministry of Environmental Protection, Natural Resources and Forestry. In general emission of CO and NO_x is equal or higher than the values given in the Instruction. The measured SO_2 emission is significantly lower; it might be caused by a high value of excess air ratio in these boilers, reduction of temperature at the grate and incomplete combustion of the elementary sulfur. However, since such situations should be eliminated, it is suggested to approve the indices given in the Ministry Instruction, and therefore the SO_2 emission values are marked with an asterisk (*).

The comparison of emission of various pollutants is based upon the notion called Equivalent Emission, E_r. This notion does not include the boiler efficiency and the emission is ascribed to the quantity of fuel. Furthermore the user is interested in the costs of emission fees, arising from the Ordinance issued by the Cabinet. Therefore the so-called Cost-oriented Criterion of Harmful Effect based upon the emission fees has been derived. This criterion is defined with the following formula [5].

$$KK = \frac{K_p \cdot E_p + K_{CH} \cdot \left(E_{CO} + E_{CH_H}\right) + K_{NS} \cdot \left(E_{NO_x} + E_{SO_2}\right)}{\eta} \qquad \text{[PLN/GJ]}$$

(related to the net energy taken out from the boiler)

where:

η	boiler efficiency
$E_p, E_{CO}, E_{CH_4}, E_{NO_x}, E_{SO_2}$	emission of pollution components [g/GJ] related to the energy in fuel
K_p	particulates emission fee, K_p = PLN 0.00008 per gram
K_{CH}	carbon monoxide and methane emission fee, K_{CH} = PLN 0.00004/g
K_{NS}	nitrogen oxides and sulfur dioxide emission fee, K_{NS} = PLN 0.00015/g

As already mentioned, all the tests were carried out for three levels of boiler load, according to the Polish Standards. Following comparisons will be given for ca. 75% load of the boilers in order to synthesize the obtained results. It follows - first of all - from the fact that 75% efficiency is the most frequent load of these boiler during their normal operation for average weather conditions. The comparisons presented for the medium load are also qualitatively valid both for 50% and 100% efficiency of the boiler. The quantitative relations vary.

Table 2. List of recommended pollutant emission indices [g/kg] obtained from the executed investigations, US EPA standards and the instruction issued on January 1, 1991 by the Polish Ministry of Environmental Protection, Natural Resources and Forestry

Specification	Recommended basing upon:		
	Results of boiler tests	US EPA standards	Instruction issued by the Polish Ministry
MECHANICAL STOKER BOILERS			
Particulates (before the de-dusting device)	15.4	8	57
CO	5.0	3	2.5
Organic compounds	0.03	-	-
C_xH_x	0	-	-
NO_x	3.2	3.8	3.0
$SO_2$2	12(*)	19.5(*)[S]	16(*)[S]
COAL FIRED FIXED GRATE BOILERS			
Particulates	20	7.5	14
CO	45	45	45
Organic compounds	1.6	-	-
C_xH_x	2.9	-	-
NO_x	2.3	1.5	1.5
SO_2	6(*)	19.5(*)[S]	16(*)[S]
COKE FIRED FIXED GRATE BOILERS			
Particulates	2.1	5	16.6
CO	46	45	25
Organic compounds	0.2	-	-
C_xH_x	0.5	-	-
NO_x	1.4	1.5	1.5
SO_2	12(*)	19.5(*)[S]	16(*)[S]
FIXED GRATE BOILERS FIRED WITH A COKE/COAL MIXTURE			
Particulates	5.4	6.25	14.6
CO	74	45	35
Organic compounds	1.1	-	-
C_xH_x	6.3	-	-
NO_x	1.2	1.5	1.7
SO_2	11.6(*)	19.5(*)[S]	16(*)[S]

OPTIMIZATION OF THE OPERATING PROCEDURES

The operating procedures were optimized for almost all investigated boilers and almost all fuel types, in order to reach maximum boiler efficiency, i.e. to minimize the heat generation cost as the test result of highest importance for the user. As an example, results obtained for „Staszic III" fuel burnt in a PLM-2.5 boiler are given in Table 3. The costs of heat generation were compared with the base case results determined for standard fuel - „Ziemowit" coal and for the most frequent load - 75% efficiency of the boiler.

Table 3. Results of investigations and ecological analyses carried out for a PLM-2.5 boiler

Type of fuel used	Emission of:					Equivalent emission	Costs of emission fees (so-called Cost-oriented Criterion)	Relative cost of heat generation compared with „Ziemowit" fuel
	Boiler load	parti-culates	CO	NO_x	SO_2			
	%	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	PLN/GJ	PLN/GJ
„Ziemowit" standard procedure	75	111	1 065	186	667	2 061	0.3366	0
„Staszic III"	100	215	913	141	171	1 660	0.1360	-1.70
„Staszic III"	100	50	673	155	176	1 107	0.1217	-1.04
„Staszic III"	100	144	591	156	191	1 357	0.1432	-0.45
„Staszic III"	75	57	642	125	160	1 009	0.0995	-1.69
„Staszic III"	75	80	1 339	166	176	1 559	0.1741	-0.75
„Staszic III"	75	148	428	169	179	1 312	0.1317	-0.54
„Staszic III"	50	52	280	161	170	928	0.0950	-1.28
„Staszic III"	50	135	386	183	185	1 300	0.1401	-0.12
„Staszic III"	50	201	393	192	181	1 517	0.1526	-0.03

Following components were taken into consideration when calculating the heat generation costs: boiler price, depreciation, fuel price including transportation and slag removal, boiler repair costs, emission fees. It has been assumed that the personnel costs and boiler house location will be fixed for all the cases. The calculations bear in mind boiler efficiency for each examined fuel and mode of operation.

Simultaneously the results of the Cost-oriented Criterion of Harmful Effect (KK) are shown. In the majority of cases, the results lead to two significant conclusions:

the operating procedure which is found to be optimal for a given fuel type with respect to the economy - gives also the best results from the ecological point of view;

the optimal operating conditions of each boiler slightly differ depending on the type of fuel burnt, and the determination of the optimum would be impossible without flue gas analysis and observation of the combustion chamber (e.g. temperature distribution). It concerns both the stoker speed (as a function of fuel layer for a given load), and adjustment of fans (blast air fan, suction fan and secondary air fan).

It results from the observations, that fuel grain size and content of volatiles is of highest importance for the run of combustion process.

The results of these investigations can be used in two ways. At first a detailed instruction of boiler adjustment can be elaborated. Consequently reliable measuring devices should be installed and a system of personnel motivation must be implemented. However, in author's opinion it is a difficult task, because it requires changes in the habit of the personnel.

The second possibility is to implement the automatic control devices. Basing upon the prices of automation equipment presented by an American company involved in the Program of Elimination of Low Emission Sources and demonstrated calculations, the author finds that the savings resulting from the optimal operation of the boiler allow to pay back the investment costs in 3-4 years and simultaneously emission of pollutants will be reduced significantly.

In the case of fixed grate boilers the differences in the mode of operation were of much smaller importance with respect to economy. However, application of adjusted secondary air stream at the beginning of combustion process allowed to reduce methane and carbon monoxide emission by ca. 35%, unfortunately - accompanied with an increase in emission of particulates.

The operating procedure was very important for combustion of briquettes, however only in the case of Es-Żet-type steel boiler, the attempts to optimize the procedure were successful.

EFFECT OF FUEL TYPE ON BOILER OPERATION

As already mentioned the results obtained for various fuels burnt in various boilers have been compared for the load, which constitutes ca. 75% of the nominal boiler output.

Results of investigations carried out for four boilers and tested types of fuel for 75% load are given in Table 4 and presented graphically in Fig. 1.

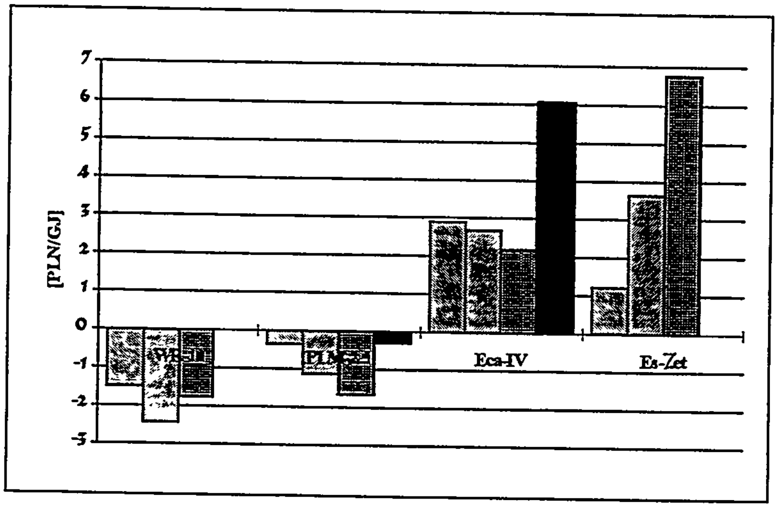

Fig. 1. Relative costs of heat generation at 75% load in WR-10, PLM-2.5, Eca-IV and Es-Żet boilers for various fuel sorts

0 level - base case
„Ziemowit" - standard procedure

WR-10
„Ziemowit" - standard procedure
„Staszic I"
„Staszic III"

PLM-2.5
„Ziemowit" - improved procedure
„Staszic I"
„Staszic III"
„Pea"

Eca-IV
coke - standard procedure
coke - improved procedure
1/1 coal/coke
briquettes

Es-Żet
coal
7/3 coke/coal - standard
briquettes

In fig. 1 the costs of heat generation are compared with the cost of heat generated in a PLM-2.5 boiler unit at medium load, for standard „Ziemowit" coal and following a standard operating procedure.

It is distinctly visible that the lowest energy generation costs are related to the largest investigated boiler type: WR-10. Furthermore it is clear that application of an improved sort of „Staszic" coal results in over 50% reduction in emission of pollutants combined with reduced heat generation costs for correct operation procedure. Taking into consideration that annual heat output of a PLM-2.5 boiler reaches ca. 20 000 GJ per year and unit (as reported by MPEC - Municipal Heat Power Engineering Enterprise), application of „Staszic III" fuel results in round PLN 34 000 annual savings per unit, i.e. ca. $ 14 000 (annually per unit). Since the current costs of combustion process automatic control and supervision equipment amounts to ca. $ 45 000 per unit, the installation can be paid back in 3-4 years. In fact much better results may be expected if the boilers will be run at near 100% load. Similar conclusions can be drawn also for WR-10 boiler which generates ca. 43 000 GJ per year and unit. (The heat generation in these boilers was estimated basing upon the data reported by MPEC Cracow.)

In the case of fixed grate boilers, the worse ecological results were found for pure coal and fuel mixtures. Unfortunately, this is also the less expensive mode of operation of these boilers, because the costs of emission fees contribute only 1-2% of the total cost of energy generation. Therefore application of coal fuel in these boilers should be burdened with additional restrictions.

Good ecological results were obtained for firing steel boilers with coal briquettes. In this case 40% reduction of the summarized emission has been reached - comparing with a coke/coal mixture applied as a standard fuel. However, high price of briquettes causes, that heat generation cost increase by PLN 5.60 per GJ comparing with coal fuel, and by PLN 3.20 per GJ in relation to the mixture used as a standard fuel.

Table 4. Results of investigations and ecological analyses carried out for 75% load of WR-10, PLM-2.5m Eca-IV and Es-Żet boiler units

Boiler house	Boiler type	Fuel sort used	Emission of: particulates	CO	NO_x	SO_2	CH_4	Equivalent emission	Costs of emission fees (so-called Cost-oriented Criterion)	Relative cost of heat generation compared with „Ziemowit"-fired PLM-2.5 boiler
Units			g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	PLN/GJ	PLN/GJ
„Balicka"	WR-10	„Ziemowit" - standard procedure	328	260	146	586	0	2 091	0.23	-1.50
	WR-10	„Staszic I"	129	89	115	340	0	1 092	0.11	-2.44
	WR-10	„Staszic II"	107	53	160	180	0	981	0.08	-1.76
base case	PLM-2.5	„Ziemowit" - standard procedure	111	1 065	186	667	0	2 061	0.34	0.00
Krzesławice	PLM-2.5	„Ziemowit" - improved procedure	131	385	128	608	0	1 552	0.25	-0.36
	PLM-2.5	„Staszic I"	126	373	138	275	0	1 227	0.14	-1.13
	PLM-2.5	„Staszic III"	57	642	125	160	0	1 009	0.10	-1.68
	PLM-2.5	„Powstańców Śląskich"	43	234	114	212	0	784	0.10	-0.31
Rydla-St.	Eca-IV	coke - standard procedure	55	2 546	52	437	20	2 030	0.25	2.90
	Eca-IV	coke - improved procedure	75	1 684	50	448	20	1 663	0.20	2.68
	Eca-IV	1/1 coal/coke	214	2 950	47	413	248	2 769	0.30	2.17
	Eca-IV	briquettes	636	1 573	39	288	34	3 049	0.24	6.07
Ułanów-St.	Es-Żet	coal	650	1 804	76	195	141	3 273	0.28	1.21
	Es-Żet	7/3 coke/coal standard	242	2 097	61	197	31	2 140	0.22	3.65
	Es-Żet	briquettes	69	1 553	37	95	71	1 214	0.13	6.77

CONCLUSIONS

The presented results of investigations allowed to draw following conclusions:

(1) A significant reduction in „low emission" and improvement of boiler efficiency in terms of an average condition of the equipment installed in Cracow boiler houses by implementing the automatic control devices. The capital cost of this solution is relatively law, and it can be paid back in 3-4 years.

(2) Implementation of better sorts of fuel in fixed grate boiler units is advantageous both from ecological and economical point of view provided that the boiler is operated properly.

(3) In the case of fixed grate boilers the worse ecological results are related to the combustion of pure coal and its mixtures. Unfortunately these sorts of fuel are also the less expensive ones in operating procedure.

(4) From the ecological point of view briquettes appear to be a good alternative for steel boilers. This option is, however the most expensive one in operating procedure.

(5) Basing upon the carried out investigations, the optimal operating procedures should be selected and kept for each boiler and each type of fuel. It allows to reach significant economical and ecological profits.

(6) In has been found out in the investigations, that the Ordinance of the Polish Ministry of Environmental Protection, Natural Resources and Forestry dated February 12, 1990 which defines the level of 600 g/GJ as a limit of particles emitted to the atmosphere from mechanical stoker boiler units, is very tolerant, because notwithstanding an average condition of boilers, this value has never been reached nor approached during the investigations. In fact in the case of better sorts of fuel, the measurements proved that the content of particles even before the dedusting equipment did not reach 600 g/GJ.

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ON THE POSSIBILITIES OF REDUCTION IN EMISSION CAUSED BY HOME TILE STOVES IN CRACOW

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SUMMARY

The coal-fired tile stoves are still very popular in Poland. The estimated total number of such home stoves operated in Cracow reaches ca. 100 000. Operation of these stoves during the heating season belongs to the most significant sources of air pollution. Type and scale of emission of the most important pollutants, caused by coal combustion in home stoves in Cracow has been determined basing upon the investigations carried out at the laboratory of the Department of Power Engineering Machines and Devices, Academy of Mining and Metallurgy, Cracow, Poland within the American-Polish Program of Elimination of Low Emission Sources in Cracow. Further experiments included in this Program allowed to estimate the attainable efficiency of home tile stoves and possible reduction in pollutant emission resulting from their operation. A short discussion of these data and capacities is presented in this lecture.

INTRODUCTION

A major part of buildings in Cracow area is heated from the district heating network operated by MPEC (Municipal Heat Power Engineering Enterprise in Cracow) or from local sources, e.g. housing estate boiler houses or built-in boilers. However, a significant number of apartments, especially in older buildings, is heated by ceramic, accumulation-type stoves. These units, called often tile stoves are erected since many years predominantly in one, common structural option of red bricks, chamotte bricks and ceramic tiles; they differ in their size and external decorations. As estimated by the Cracow Development Office, during the heating season there are still ca. 100 000 such stoves operated in Cracow and ca. 100 000 tons of hard coal (of very differentiated quality) is burnt. As a rule such a stove is got going once a day. Its current maintenance includes preparation of the combustion chamber for putting in kindling material and a portion of fuel, loading the stove with kindling material and a whole amount (or a part) of fuel assigned for a given day, kindling it, addition of the rest of fuel (if case of need) and an occasional supervision until the door is closed. Every now and again (frequency depending on coal quality, and especially ash content), ash and remaining (not burnt) pieces of coal should be removed from the ash box.

During heating season the substances emitted during hard coal combustion in tile stoves are a source of very important air pollution in Cracow, caused by the so-called „low emission". The main components of these pollution are: particulates and soot together with organic and inorganic substances adsorbed on their surface, as well as gaseous pollutants: carbon dioxide, carbon monoxide, sulfur dioxide, nitrogen oxides and volatile hydrocarbons. Since the contribution of tile stoves in the pollution of Cracow natural environment is significant, they were included in an experimental schedule constituting one task of the American-Polish Program of Actions for Elimination of Low Emission Sources in Cracow, financed by the US government through the US Agency of International Development (USAid) and the US Department of Energy. Within this Program, in a laboratory of the Department of Power Engineering Machines and Devices, Academy of Mining and Metallurgy, Cracow, Poland - in cooperation with the Brookhaven National Laboratory and the Cracow Development Office - a test position, provided with American measurement equipment, has been organized to investigate the pollutant emission and efficiency of a typical tile stove for various types of fuel used. A detailed description of the measurement system and the method of data collection and processing has been presented in numerous papers [2, 3, 4]. There were two basic purposes of the investigations carried out using the above mentioned test device. At first, the authors were going to gather information on real efficiency of these tiles and on real emission of pollutants. These data were used then for the estimations of costs and possible advantages attainable if the tile stove heating are replaced with another systems of residential building heating. The second purpose was to investigate possible reduction in pollutant emission from the tile stoves if the tile stove operation procedure and applied fuel would be changed. This second scope of investigations arose bearing in mind the fact that, although the total elimination of tile stoves is the best way to reduce the emission of pollutants, but - beyond all doubts - the tile stoves will be operated for many years for economical reasons. Thus if the necessity of their operation must be accepted - it seems to be reasonable to look for a feasible method of reducing the basic troubles caused by tile stoves.

INVESTIGATIONS

As already mentioned above, the tile stove is got going - as a rule - once a day. The combustion process (called „active period" of tile operation cycle) lasts in average 60-90 minutes for correct run. During this period, heat is accumulated in the stove lining. This heat will be given up into the apartment interior by convection and radiation during the remaining part of the cycle (the rest of the 24-hour period). Thus, all the operations, significant from the point of view of pollutant emission and stove efficiency, related to the servicing and measurements, must take place in this short period. The measurement procedure followed at the above mentioned test position, has been based upon the EPA recommendations and requirements [1] and has been described in details in the first report on these tests [5]. The procedure is based upon an indirect measurement of the flue gas flow leaving the stove and included gaseous pollutants and particulates. The measurements were carried out in a dilution channel. It allows to measure precisely the flue gas flow and to avoid exceeding the ranges of measurement devices. The measured amounts of particulates convected as well as the fractions of individual gaseous pollutants in flue gases allow to determine directly the emission of various substances. On the other hand, from the known coefficient of flue gas dilution it is possible to determine chemical composition of flue gases and flow rate at the stove outlet and thus - latent chimney loss as well as distinct loss (if flue gas temperature is known). In addition, after the determination of the mass and composition of combustibles in ash and coke remaining on the grate - the uncomplete combustion loss has been determined. Consequently the tile stove efficiency can be calculated.

The combustion process run, and - in this connection - stove efficiency and emission of pollutants - depend significantly on the method of stove servicing (stove operation procedure). The primary procedure of stove operation has been arranged in such a way, as to make the test stove working very similar to the natural procedure (the chimney draught and its variation in time as well as typical customs procedures followed by the user have been taken into consideration). The procedure planned in such a way was called „average user's procedure" and the tests carried out following this procedure were used as „base case" investigations. The tests took in mind also the fact that the stoves may by operated improperly. Series of appropriate tests were carried out to simulate the errors which might be committed by the user and to check the results of these errors.

When measuring pollutant emission from the stove and when looking for the methods how to reduce emission and improve the efficiency, several various types of fuel were tested. There are the sorts of fuel which are or can be used in tile stoves. Basic properties of investigated fuel lots are given in Table 1.

Table 1. Specification of fuel types

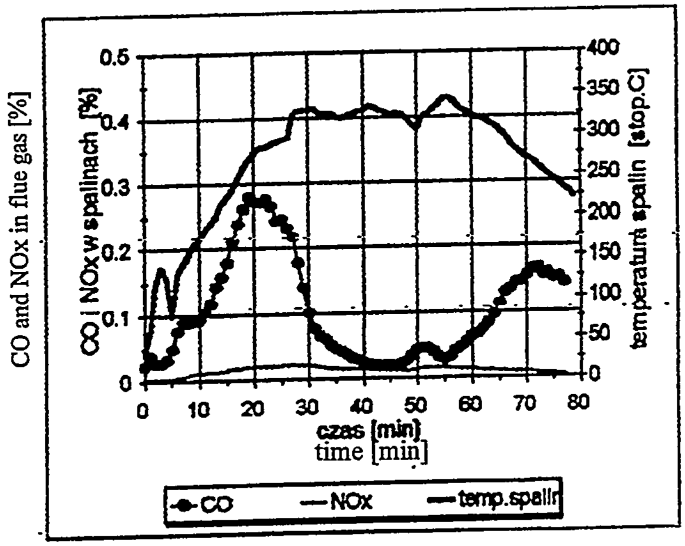
Fuel	Heating value [kJ/kg]	Mass portion of the substance [%]			
		Volatiles	Combust. sulfur	Total moisture	Ash
BS	24 605	30.3	0.29	2.5	21.6
BR '92	27 619	8.1	0.22	3.3	10.9
BR '93	27 611	10.3	0.34	3.7	11.3
WU '92	31 324	32.1	0.28	2.7	3.3
WU '93	27 226	30.9	0.59	4.4	7.3
Coke	30 280	1.0	0.50	0.1	8.7
BR TR	17 916	71.6	0.00	5.6	1.8
SIERSZA(*)	23 918	32.3	1.04	12.4	12.3

Following symbols are used in this Table: BS - coal from „Bolesław Śmiały" Coal Mine; BR '92 and BR '93 - briquettes manufactured in 1992 and 1993, respectively, by the Institute of Chemical Coal Processing in Zabrze; WU '92 and WU '93 - coal from „Wujek" Coal Mine exploited in 1992 and 1993, respectively; Coke - dry quenched coke from „Przyjaźń" coking plant; BR TR - briquettes made of waste sawdust; SIERSZA(*) coal from „Siersza"

Coal Mine - the analyzed sample of this coal has been used to estimate the emission level, however this coal was not used directly in tests.

The run of all the parameters required for calculations of pollutant emission and stove efficiency has been registered during the entire testing procedure. As an example, the function of temperature and content of carbon monoxide and nitrogen oxides in flue gases leaving the stove (before dilution) are presented in Fig. 1.

The functions presented on this graph have been obtained during tests in which the so-called „average user's procedure" was followed. The tests were carried out keeping this procedure (signed hereinafter with TZ letters) for three first investigated fuel sorts, i.e. coal from „Wujek" and „Bolesław Śmiały" Coal Mines and briquettes produced by the Institute of Chemical Coal Processing in Zabrze. Afterwards, a series of experiments have been executed using the stove operating procedures which simulate improper user's operation and stove leakage. In this time „Wujek" coal and Zabrze briquettes were used. The „Bolesław Śmiały" coal was left out in these experiments because of high ash content (over 20%). Only the worse results (with respect to the emission and stove efficiency) obtained in these „improper procedure" experiments are presented in this paper. These results are signed with TP symbol. Emission of various pollutants and stove efficiency obtained in the TZ and TP tests are treated as those determining the range of emission. They were used as a base in evaluating the present condition of tile stoves in Cracow.



CO NO$_x$ flue gas temp.

Fig. 1. Temperature of flue gas as well as CO and NO$_x$ content in flues gases at the stove outlet connection. Combustion of coal from „Wujek" Coal Mine.

The next step in the investigations was to carry out a series of tests keeping certain modifications of the „average user's procedure" of stove operation. The purpose of these experiments, in which two above mentioned sorts of fuel (WU '93 and BR '93) were used, was to discover the method of improvement of the combustion process run. Such an „improved procedures" (which differ in some details for various fuels) have been developed for „Wujek" coal and for Zabrze smokeless briquettes and then tested also for two completely different sorts of fuel - not used till now in Cracow: dry quenched coke and briquettes made of waste sawdust. The tests carried out keeping these modified (improved) procedures are signed with TU symbol.

RESULTS OF INVESTIGATIONS

The run of individual parameters registered during the active period of stove operation (since kindling till closing the door) allowed to calculate the absolute values of emission of individual pollutants (in grams per test or in grams per test series). Among those determined in these experiments, only the emission of the most important substances, i.e. carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxides (NO_x), volatile hydrocarbons (expressed by means of methane equivalent - CH_4) and particulates (M_s), is presented in this paper. The determined values of absolute emission of each substance can be converted into different units, i.e. in relation to the fuel mass unit or the energy unit. In order to provide compatibility of the emission data with the information from other sources and to check the observance of the requirements defined in the Ordinance of the Minister of Environmental Protection [6], the emission of all the substances is given in this paper in relation to the unit of energy supplied in fuel (GJ).

Without a single, common criterion, it is very difficult to compare pollutant emission from a tile stove for combustion of various fuel sorts and for various stove operation procedures kept. Without such a criterion comparison of emission from the stoves with the emission from other pollution sources would be completely impossible. Therefore a so-called „equivalent emission" has been calculated using a formula applied in another reports elaborated within the discussed Program [7]:

$$E_r = 2.9 * M_s \div 0.5\,(CO \div CH_4) \div 2.9 * NO_x \div SO_2 \qquad [g/GJ]$$

in which CO, CH_4, NO_x SO_2 and M_s denote emissions of the substances mentioned above, converted into g/GJ of energy supplied in fuel.

The emission of individual substances used as a base for the calculation, determined values of equivalent emission as well as stove efficiency values obtained in each discussed series of tests (for a given fuel sort and stove operation procedure), are given in Table 2. The presented results of efficiency are the average values calculated for the entire series of each test.

Table 2. Emission of pollutants in relation to the unit of energy supplied in fuel and stove efficiency for each series of tests. Fuel sort abbreviations - see Table 1.

Fuel	Series of tests	CO [g/GJ]	CH_4 [g/GJ]	SO_2 [g/GJ]	NO_x [g/GJ]	M_s [g/GJ]	E_r [g/GJ]	η [%]
BS	TZ	813	136	228	135	559	2 7	61.8
BR '92	TZ	1 7	88	121	87	29	1 3	56.9
BR '92	TP	2 9	124	97	98	43	2 0	49.1
BR '93	TU	752	50	149	65	43	863.2	73.6
WU '92	TZ	865	57	163	219	531	2 7	68.5
WU '92	TP	782	100	176	132	638	2 8	47.2
WU '93	TU	1 1	137	97	98	530	2 5	75.1
COKE	TU	929	58	93	52	58	905.5	73.1
BR TR	TU	2 7	337	0	28	359	2 6	74.0

Efficiency values given in this table are presented graphically in two groups in figures below. Fig. 2 presents the results for the stove operation procedures which seem to be commonly kept in Cracow (TZ and TP test series); fig. 3 presents separately the results achievable for improved procedures (TU test series).

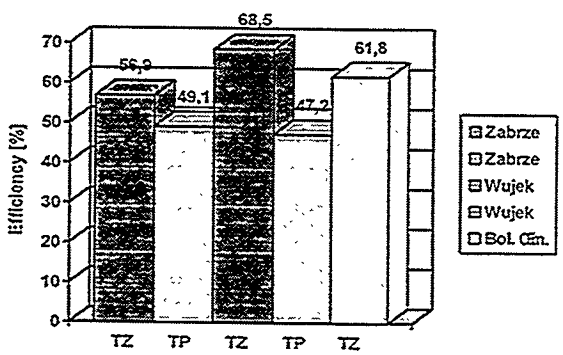


Fig. 2. Stove efficiency in TZ and TP test series. Present range.

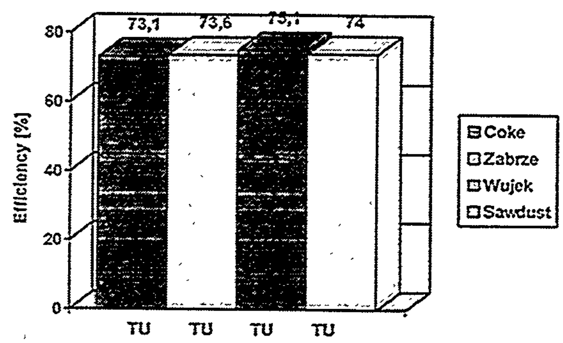


Fig. 3. Stove efficiency in TU test series. Expected values.

In the graphs above, the efficiency obtained during the base case tests (TZ series) and those simulating an improper user's procedure (TP series) are treated as the „Present range" of stove efficiency, because it can be assumed that this procedure of stove operation by the majority of the users is a medium level between the procedures represented in

TZ and TP test series. The efficiency achieved for improved procedure test series (TU) are called „expected values" because these values are attainable provided that the combustion process is run correctly with regard to the fuel sort used.

It follows from the data presented above, that the common opinion on a very low efficiency of the tile stoves (ranging at a rumored level of 25 to 30%) is false. It has been proved that even in the case of an incorrect procedure of stove operation, the stove efficiency reaches almost 50%. Thus, assuming that the average efficiency of stoves operated without special care are ranging between 45 and 65% (in average ca. 55%), it is clear how different are these values from these commonly expected. By the way, the obtained results confirm also the experimental data reported still in 1993 by the Technical Institute of Commissariat, Warsaw, Poland, in which 62% efficiency of such stoves has been proved. The author of a paper [8], referring to this report recommends 60% as a reliable value of tile stove efficiency and it is in accordance with the results obtained in this work.

As it follows from the efficiency values given in Fig. 3, in the case of stove operation keeping the improved procedure (in which fuel properties are taken into the consideration), the efficiency ranging between 73 and 75% is attainable; in average 74%. It is a very significant increase in relation to the efficiency obtained for an average operating procedure and - in addition - this increase can be reached without any capital cost, changing only the stove operation procedure. There appears also another interesting conclusion: in follows from fig. 3 that in the case of correct operation of the stove, its efficiency is practically independent of the type of fuel burnt.

The data presented in Table 2 prove that differences in emission of individual substances for different procedures of combustion of the same fuel sort are significant (up to one order of magnitude) and sometimes the opposite tendency for different pollutants is observed. It is also visible, that an improvement in stove operation procedure causes reduction in emission of certain pollutants accompanied with an increase in the emission of other compounds. These effect make difficult the comparison of fuel types and the quality of combustion procedures. Therefore the following graphs (Figs. 4 and 5) present in a similar manner the values of equivalent emission taken from Table 2.

Fig. 4. Equivalent emission in TZ and TP test series. Present range.

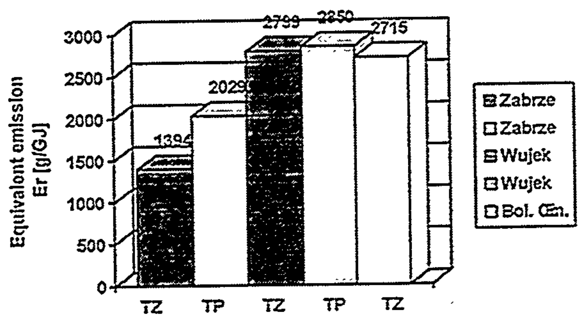
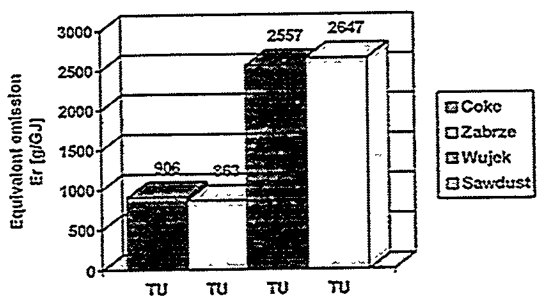


Fig. 5. Equivalent emission in TU test series. Expected values.



Comparison of the values presented in these graphs proves that - from the point of view of pollutant emission, the smokeless briquettes from Zabrze are definitively the best investigated fuel. Especially for the improved procedure of stove operation (TU test series), the equivalent emission for briquettes becomes 3 times lower than in the case of coal or sawdust briquettes. It is a characteristic feature of the Zabrze briquettes, that they are really smokeless - their combustion results in 10-times reduction of the emission of particulates in comparison with hard coal combustion. The emission caused by combustion of dry quenched coke is comparable with briquettes. However this sort of coke requires greater amount of kindling material than coal or Zabrze briquettes. Also the application of sawdust briquettes seems to be interesting. Although the value of equivalent emission obtained for these briquettes is almost equal to the emission caused by coal combustion, it follows from Table 2 data that the sawdust briquettes do not emit sulfur dioxide at all and the emission of nitrogen oxides is very small - thus the reduction in emission of the most harmful compounds is excellent. Furthermore sawdust briquettes are almost ashless and less expensive kind of fuel, and their combustion - in itself - consists in waste utilization.

POSSIBLE REDUCTION OF EMISSION

The emission values presented above are not so convincing. Therefore this chapter presents possible reduction of emission attainable for the entire heating season, after improving the stove operation (i.e. increasing combustion efficiency) and changing fuel sorts for the entire amount (assumed 100 000) of tile stoves operated in Cracow. For this purpose it has been assumed that at present all the stoves are operated at an average 55% efficiency, and the improved procedure of stove operation allows to reach 74% efficiency. Furthermore, basing upon the information obtained from the fuel yards in Cracow, the evaluation of the present state of emission is based upon a hypothetical „analytical" coal, understood as a mixture of 25% coal form „Siersza" Coal Mine and 75% coal from „Wujek" Coal Mine. Basing upon the estimated fuel consumption per one stove unit per heating season [9] and using the known heating value of fuel, the total amount of each sort of fuel required for all the stoves operated in Cracow. Consequently, it was possible to determine the total comprehensive emission both for the present conditions (i.e. for the „analytical" coal signed OWK and 55% efficiency of combustion) and for the „expected" case - at 74% efficiency. The values of this emission split up into the separate pollutants, as well as the equivalent emission (E_r) are given in Table 3 below.

Table 3. Emission of pollutants for the entire amount of stoves in Cracow (100 000 units) for the present ($\eta = 55\%$) and expected ($\eta = 74\%$) conditions, in tons of substance per year

Fuel	Efficiency [%]	Emission of pollutants					
		CO ton/year]	CH_4 [ton/year]	SO_2 ton/year]	NO_x [ton/year]	M_s ton/year]	E_r [ton/year]
„Analytical" coal OWK	55	2 202	221.0	782.0	467.5	1 530	7 78
„Analytical" coal OWK	74	1 636	164.3	581.2	347.5	1 137	5 78
„Wujek" coal WU '93		2 123	255.5	180.8	183.5	987.3	4 76
Zabrze briquettes BR '93		1 401	92.5	278.0	120.8	80.3	1 60
Coke from „Przyjaźń" cokery		1 730	107.7	174.1	96.6	107.7	1 68
Sawdust briquettes		5 037	627.0	0.0	53.0	668.6	4 93

Basing upon the data given in Table 3, relative emission values have been determined for given fuel sort and at improved procedure of stove operation ($\eta = 74\%$) compared with the present conditions („analytical" coal and efficiency $\eta = 55\%$). The results of these calculations are presented in Table 4.

Table 4. Relative emission of pollutants for various fuel sorts and at the improved procedure of stove operation ($\eta = 74\%$) compared with the present conditions („analytical" coal and efficiency $\eta = 55\%$)

Fuel	Relative emission of pollutants [%] compared with the present condtions					
	CO	CH_4	SO_2	NO_x	M_s	E_r
„Analytical" coal OWK	74.3					
„Wujek" coal WU '93	96.4	115.6	23.1	39.3	64.5	61.2
Zabrze briquettes BR '93	63.6	41.9	35.5	25.8	5.2	20.7
Coke from „Przyjaźń" cokery	78.6	48.7	22.3	20.7	7.0	21.6
Sawdust briquettes	228.9	283.7	0.0	11.3	43.7	63.3

The relative values of emission, in [%], given in the above Table 4 have been obtained keeping the improved procedure of stove operation for given sorts of fuel. In practice, the combustion process can be adjusted in following ways only:

- selection of a proper duration of the active period of stove operation cycle (since kindling till door closing);
- appropriate controlling the stove doors, which determines the place and amount of air supplied for the combustion;
- duration of combustion and number of subsequent fuel layers on the grate.

The improved procedure of stove operation has been determined by adequate selection of the above mentioned parameters for each fuel sort. These procedure are, to some extent, differentiated for various fuel sorts, however generally speaking, there are at least two characteristic common features of the „good method" of combustion regardless the fuel sort used:

1. The major part (or even a total amount) of air for combustion should by supplied to the fuel layer from underneath (from under the grate); thus the ash box door should be opened whereas the upper door should be closed (except the moment when fuel is loaded into the stove).
2. On contrary to the common opinion, the period of fuel combustion process should be as short as possible. The investigation have proved that the stove should be closed at the moment when the outlet gas temperature starts decreasing from its highest value.

A detailed analysis of obtained results of test measurements has shown that the latter condition is very important. The average duration (t_m) of the active part of stove operation cycle (since kindling till door closing) was analyzed with respect to its usability as a criterion of combustion process quality assurance. In figs 6 and 7, the combustion efficiency and equivalent emission (E_r) as a function of the average test duration.

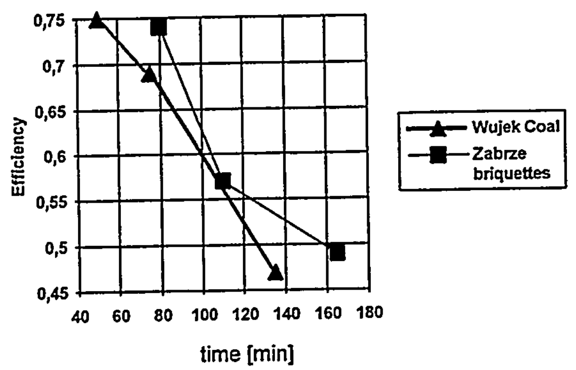


Fig. 6. Efficiency of combustion as a function of the average duration of the combustion process

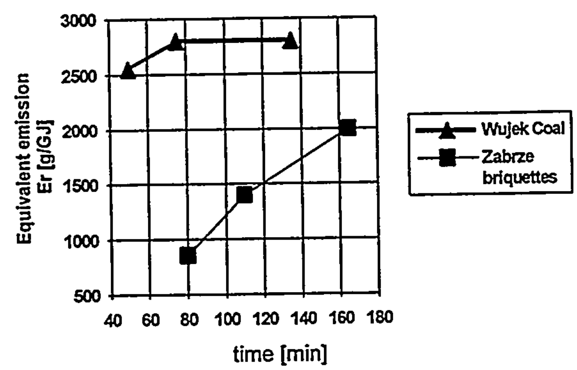


Fig. 7 Equivalent emission as a function of the average duration of the combustion process

It follows from the above presented graphs, that the combustion efficiency and emission parameters are distinctly dependent on the duration of the cycle. Duration of this period differs, obviously, for various fuel sorts, however, generally speaking, in can be stated that the greater is volatile content in fuel, the shorter should be the period of combustion. In the case of fuel sorts, for which the highest efficiency level has been obtained for the improved procedure of stove operation, the optimal duration of the combustion process was:

- for briquettes from Zabrze and for coke (content of volatiles: 8-10% for briquettes and 1% for coke) t_m = ca. 80 minutes
- for coal from „Wujek" Coal Mine (content of volatiles: 31-32%) t_m = ca. 50 minutes
- for sawdust briquettes (content of volatiles: ca. 72%) t_m = ca. 35 minutes.

Thus the duration of the active period of stove operation constitutes an excellent and distinct criterion for maximization of stove efficiency. In addition, this criterion is easy applicable provided that an appropriate information on combustion optimization is delivered to the user together with fuel. It appears also, that prolongation of the combustion process by the additional (not necessary) time, is a significant mistake. Prolongation by 1 hour causes decrease in stove efficiency by 30-40% depending on fuel type.

RESUME

Evaluated emission of pollutants from all the tile stove operated at present in Cracow, given in Table 3, proves that during heating season the tile stoves become a very significant component of environmental pollution in Cracow. Of course the most radical and effective method of elimination of this source would be total elimination of tile stoves and replacing them with alternative systems of residential heating. However, for economical reasons, a significant portion of these stoves (in fact - majority of existing stoves) will still remain operated for a couple of years. Therefore the emission values given in Table 3, evaluated for the improved procedure of stove operation (i.e. for increased efficiency) and for various types of fuel, seem to be interesting. The relative emission, compared with the present state, is given in Table 4. It follows from these data that even within the period when the operation of tile stoves in Cracow must be considered as necessary evil, a significant reduction of pollutant emission from the tile stoves is attainable. The major condition is to elaborate a leaflet with information on the optimal procedure of stove operation for a given type of fuel and to distribute it among the users. Even without any change in the sort of fuel used, 26% reduction of the emission can be reached. Furthermore the improved fuel sorts should be introduced into the Cracow market. Basing upon the available data, the best solution would be application of the improved procedure of stove operation combined with implementation of smokeless briquettes produced by the Institute of Chemical Coal Processing in Zabrze. Such an option allows to reduce the overall emission even by ca. 80% (converted into the equivalent emission), and to reduce ca. 19 times emission of particulates.

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MEASUREMENT RESULTS
OBTAINED FROM AIR QUALITY MONITORING SYSTEM

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INTRODUCTION

An automatic system of air pollution monitoring operates in Cracow since 1991. The organization, assembling and start-up of the network is a result of joint efforts of the US Environmental Protection Agency and the Cracow environmental protection service. At present the automatic monitoring network is operated by the Provincial Inspection of Environmental Protection.

There are in total seven stationary stations situated in Cracow to measure air pollution (Table 1). These stations are supported continuously by one semi-mobile (transportable) station. It allows to modify periodically the area under investigation and therefore the 3-dimensional picture of creation and distribution of air pollutants within Cracow area could be more intelligible.

Table 1. Location and measurement range of air quality monitoring stations

			Scope of measurements										
No.	City quarter	Location	1	2	3	4	5	6	7	8	9	10	11
1	City Centre	Main Square	☐	☐	☐	☐	☐	☐	☐				
2	Krowodrza	„John Paul II" Hosp.	☐	☐	☐	☐			☐	☐	☐	☐	☐
3	Podgórze	Rynek Podgórski	☐	☐	☐	☐	☐		☐	☐			
4	Prokocim	ul. Kurczaba	☐	☐	☐	☐			☐		☐	☐	☐
5	City Centre	Avenue	☐	☐	☐	☐	☐		☐	☐			
6	Nowa Huta	„Żeromski" Hospital	☐	☐	☐	☐	☐		☐	☐	☐	☐	☐
7	Krowodrza	ul. Balicka	☐	☐	☐	☐		☐			☐	☐	☐
8	Semi-mobile	transportable	☐	☐	☐	☐	☐	☐	☐	☐			

Scope of measurements:

1 - measurement of sulfur dioxide
2 - measurement of nitrogen monoxide
3 - measurement of nitrogen dioxide
4 - measurement of nitrogen oxides
5 - measurement of carbon monoxide
6 - measurement of ozone
7 - measurement of suspended particulates
8 - chemical composition of particulates
9 - wind velocity measurement
10 - wind direction measurement
11 - air temperature measurement

The "Main Square" station is situated within the area of significant communal emission from individual stoves and small local boiler houses, i.e. low emission sources and without any industrial nor traffic emission

The "Krowodrza" station is situated within the area of medium industrial, communal and traffic emission.

The "Rynek Podgórski" station is situated within the area of significant industrial, communal and traffic emission.

The "Prokocim Nowy" station is situated within the area of low traffic, industrial and communal emission.

The "Avenue" station is a traffic-oriented station situated in a heavy traffic street canyon (ca. 30 000 vehicles daily). It measures first of all the traffic related pollution.

The "Nowa Huta" station is situated in the southern part of the Nowa Huta housing estate close to the T. Sendzimir Steel Works, i.e. within the area of high industrial emission combined with small communal and traffic emission.

The "Balicka" station is situated in western Cracow outskirts of low industrial, traffic and communal emission. The station is situated in a valley of air pollutants advection from the West (Silesia, Czech Republic).

Measurement results

Air pollution in Cracow 1994

The discussion of air pollution in Cracow requires presentation of thousands of values for different pollutants, analyzed periods and locations. Annual publication entitled "Report on Cracow air pollution" contains few hundreds pages and this constitutes already a shortened information on air quality.

Certain data have been selected for this presentation.

Sulfur dioxide pollution

The Table 2 presents the results of measurements of sulfur dioxide pollution of Cracow air. The table includes measured values. The permissible limits of concentration of pollutants in atmospheric air are defined in the valid Ordinance of the Minister of Environmental Protection, Natural Resources and Forestry issued February 12, 1990. In the case of sulfur dioxide these limits are as follows:

permissible annual average concentration D_a	32 µg/m^3
permissible 24-hour average concentration D_{24}	200 mg/m^3
permissible instantaneous (30-minute) average concentration D_{30}	600 mg/m^3
maximum 24-hour average concentration 2 * D_{24}	400 mg/m^3
maximum instantaneous (30-minute) concentration 2 * D_{30}	1200 mg/m^3
frequency of exceeding the D_{24} limit	2.0%
frequency of exceeding the D_{30} limit	0.2%

The last row includes the information whether air quality met the standards in force or not.

Table 2. Sulfur dioxide concentration in Cracow air - 1994

Station No.	1	2	3	4	5	6	7
Location	**Main Square**	**John Paul II Hospital**	**Rynek Podgórski**	**Prokocim Nowy**	**Avenue**	**Żeromski Hospital**	**Balicka**
City quarter	City Centre	Krowodrza	Podgórze	Podgórze	City Centre	Nowa Huta	Krowodrza
Average annual concentration [µg/m^3]	**50.5**	**29.9**	**29.3**	**23.4**	**55.6**	**28.4**	**29.6**
Average concentration in winter [µg/m^3]	**74.3**	**48.0**	**44.7**	**26.5**	**75.2**	**37.6**	**42.1**
Average concentration in summer [µg/m^3]	**26.8**	**21.3**	**17.7**	**19.6**	**36.0**	**13.0**	**17.1**
Maximum instantaneous (30-min.) value [µg/m^3]	**301**	**235**	**390**	**249**	**281**	**186**	**229**
Maximum 24-hours average value [µg/m^3]	**178**	**136**	**104**	**98**	**179**	**93**	**113**
Frequency of exceeding the D_{30} level [%]	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Frequency of exceeding the D_{24} level [%]	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Air condition with regard to the standards in force	**inconsistent**	**consistent**	**consistent**	**consistent**	**inconsistent**	**consistent**	**consistent**

Basing upon the gathered results following can be stated:

1. The air quality does not meet the legal regulations in force within the area monitored by following stations:
   - No. 1 Main Square City Centre
   - No. 5 Avenue City Centre
2. The permissible average annual values have been exceeded in "Main Square" and "Avenue" stations as follows:
   - in the case of "Main Square" station the permissible level has been exceeded 1.58 times
   - in the case of "Avenue" station the permissible level has been exceeded 1.73 times
3. The excess of the D_{30} permissible level has not been reported in any station.
4. The excess of the D_{24} permissible level has not been reported in any station.
5. In all the stations the average concentration in winter was much higher than in summer season. Following values of summer/winter increase coefficient which evidences the effect of low emission sources on sulfur dioxide concentration in air were calculated:

Station No.	Location	Town Quarter	Value
No. 1	Main Square	City Centre	3.00
No. 6	"Żeromski" Hospital"	Nowa Huta	2.89
No. 3	Rynek Podgórski	Podgórze	2.52
No. 7	Balicka	Krowodrza	2.46
No. 2	"John Paul II" Hospital	Krowodrza	2.25
No. 5	Avenue	City Centre	2.0
No. 4	Prokocim Nowy	Podgórze	1.35

Air pollution with suspended particulates

The Table 3 presents the results of measurements of Cracow air pollution with suspended particulates. The table includes measured values. The permissible limits of concentration of pollutants in atmospheric air are defined in the valid Ordinance of the Minister of Environmental Protection, Natural Resources and Forestry issued February 12, 1990. In the case of suspended particulates these limits are as follows:

permissible annual average concentration D_a	50 μg/m³
permissible 24-hour average concentration D_{24}	120 μg/m³
permissible instantaneous (30-minute) average concentration D_{30}	250 μg/m³
maximum 24-hour average concentration 2 * D_{24}	240 μg/m³
maximum instantaneous (30-minute) concentration 2 * D_{30}	500 μg/m³
frequency of exceeding the D_{24} limit	2.0%
frequency of exceeding the D_{30} limit	0.2%

The last row includes the information whether air quality met the standards in force or not.

Basing upon the gathered results following can be stated:

1. The air quality does not meet the legal regulations in force within the area monitored by following stations:
   - No. 1 Main Square City Centre
   - No. 2 "John Paul II" Hospital Krowodrza
   - No. 3 Rynek Podgórski Podgórze
   - No. 5 Avenue City Centre
   - No. 6 "Żeromski" Hospital Nowa Huta
2. The permissible average annual values have been exceeded in "Rynek Podgórski", "Avenue" and "Żeromski Hospital" stations as follows:

   in the case of "Avenue" station the permissible level has been exceeded 1.57 times

   in the case of "Rynek Podgórski" station the permissible level has been exceeded 1.15 times

   in the case of "Żeromski Hospital" station the permissible level has been exceeded 1.09 times

Table 3. Concentration of suspended particulates in Cracow air - 1994

Station No.	1	2	3	4	5	6
Location	**Main Square**	**John Paul II Hospital**	**Rynek Podgórski**	**Prokocim Nowy**	**Avenue**	**Żeromski Hospital**
City quarter	City Centre	Krowodrza	Podgórze	Podgórze	City Centre	Nowa Huta
Average annual concentration [μg/m³]	**42.4**	**48.2**	**57.8**	**44.1**	**78.8**	**54.5**
Average concentration in winter [μg/m³]	**52.3**	**63.1**	**74.7**	**48.6**	**91.0**	**67.5**
Average concentration in summer [μg/m³]	**32.6**	**40.9**	**45.2**	**38.1**	**64.0**	**41.5**
Maximum instantaneous (30-min.) value [μg/m³]	**315**	**421**	**515**	**226**	**460**	**360**
Maximum 24-hours average value [μg/m³]	**188**	**246**	**161**	**134**	**295**	**222**
Frequency of exceeding the D_{30} level [%]	**0.9**	**0.6**	**0.2**	**0.0**	**1.2**	**0.6**
Frequency of exceeding the D_{24} level [%]	**1.6**	**2.8**	**3.6**	**0.3**	**16.4**	**3.5**
Air condition with regard to the standards in force	**inconsistent**	**inconsistent**	**inconsistent**	**consistent**	**inconsistent**	**inconsistent**

3. The excess of the D_{30} permissible level has been reported at the Station No. 3 "Rynek Podgórski". Maximum instantaneous (30-minute) value reached 515 μg/m³
4. The frequency of exceeding the D_{30} value was higher than the permissible frequency at following stations: "Main Square", "John Paul II Hospital", "Żeromski Hospital" and "Avenue" and reached following values:

in the case of "Avenue" station	City Centre	1.2%
in the case of "Main Square" station	City Centre	0.9%
in the case of "Żeromski Hospital" station	Nowa Huta	0.6%
in the case of "John Paul II Hospital" station	Krowodrza	0.6%

5. The excess of the D_{24} permissible level has been reported at the Station No. 5 "Avenue" (295 μg/m³) and "John Paul II Hospital" (246 μg/m³).
6. The frequency of exceeding the D_{24} value was higher than the permissible frequency at following stations: "John Paul II Hospital", "Rynek Podgórski", "Avenue" and "Żeromski Hospital" and reached following values:

in the case of "Avenue" station	City Centre	16.4%
in the case of "Rynek Podgórski" station	Podgórze	3.6%
in the case of "Żeromski Hospital" station	Nowa Huta	3.5%
in the case of "John Paul II Hospital" station	Krowodrza	2.8%

7. In all the stations the average concentration in winter was higher than in summer season. Following values of summer/winter increase coefficient which evidences the effect of low emission sources on the concentration of suspended particulates in air were calculated:

Station No.	Location	Town Quarter	Value
No. 3	Rynek Podgórski	Podgórze	1.65
No. 6	"Żeromski" Hospital"	Nowa Huta	1.62
No. 1	Main Square	City Centre	1.60
No. 2	"John Paul II" Hospital	Krowodrza	1.54
No. 5	Avenue	City Centre	1.42
No. 4	Prokocim Nowy	Podgórze	1.27

Summary of measurement results - 1994

The Table 4 summarized data related to the Cracow air pollution in 1994.

Table 4. Evaluation of air pollution in Cracow - 1994

Monitoring station	POLLUTANTS				
	SO_2	NO_2	CO	Ozone	PM 10
Station No. 1 Main Square	Da (1.58)	conform able	Da (16.4) 2D30 2D24 CZ D30 CZ D24	2D30 2D24 CZ D30 CZ D24	CZ D30
Station No. 2 John Paul II Hospital	conform able	conform able			2D24 CZ D30 CZ D24
Station No. 3 Rynek Podgórski	conform able	conform able	Da (14.8) 2D30 2D24 CZ D30 CZ D24		Da (1.15) 2D30 CZ D24
Station No. 4 Prokocim Nowy	conform able	conform able			conform-able
Station No. 5 Avenue	Da (1.73)	Da (1.21)	Da (23.3) 2D30 2D24 CZ D30 CZ D24		Da (1.57) 2D24 CZ D30 CZ D24
Station No. 6 Żeromski Hospital	conform able	conform able	Da (8.7) 2D30 2D24 CZ D20 CZ D24		Da (1.09) CZ D30 CZ D24
Station No. 7 Balicka	conform able	conform able		2D30 2D24 CZ D20 CZ D24	

In the cases when air quality did not meet the standards, the exceeded parameters were marked with grey background.

The symbol **Da** means that the permissible annual average value exceeded the limit - the values given in brackets present how many times the limit has been exceeded.

The symbol **2 D30** means that the instantaneous (30-minute) concentration of a given pollutant exceeded the permissible 2 D_{30} limit.

The symbol **2 D24** means that the 24-hours concentration of a given pollutant exceeded the permissible 2 D_{24} limit.

The symbol **CZ D 30** means that the frequency of appearance of results ranging between D30 and 2 D30 has been exceeded.

The symbol **CZ Ď 24** means that the frequency of appearance of results ranging between D24 and 2 D24 has been exceeded.

Summarizing the obtained results following should be stated:

1. Only in the case of the area monitored by the Station No. 4 "Prokocim Nowy" the measured concentration of air pollutants met the permissible limits defined by legal regulations in force in Poland.
2. In the case of the Station No. 7 "Balicka" the permissible limits have been exceeded for ozone only.
3. Within the scope of investigations carried out at the Station No. 2 "John Paul II Hospital", the permissible limit of particulates pollution has been exceeded.
4. In the case of the stations "Żeromski Hospital" (Nowa Huta) and "Rynek Podgórski" (Podgórze) the permissible limits of concentrations of carbon monoxide and suspended particulates have been exceeded.
5. In the case of the Station No. 1 "Main Square" following permissible limits have been exceeded:
   - sulfur dioxide (permissible average annual concentration has been exceeded by 58%);
   - carbon monoxide (permissible average annual concentration has been exceeded by 1540%);
   - suspended particulates (frequency of exceeding the D30 concentration limit was 4.5 times greater that permitted);
   - ozone (all the parameters determining the conditions of air pollution with ozone have been exceeded).
6. The worse air quality has been determined within the area monitored by the Station No. 5 "Avenue". Within this area following permissible limits have been exceeded:
   - carbon monoxide (permissible average annual concentration has been exceeded by 2230%); frequency of exceeding the instantaneous (30-minute) concentrations is 14.4% while 0.2% frequency is permissible; frequency of exceeding the average 24-hours concentrations is 89% while 2.0% frequency is permissible; both 2 D30 and 2 D24 limits have also been exceeded).
   - suspended particulates (the permissible average annual concentration has been exceeded by 57%).
   - lead in suspended particulates (the permissible average annual concentration has been exceeded by 55%).
   - nitrogen dioxide (the permissible average annual concentration has been exceeded by 21%).
   - sulfur dioxide (the permissible average annual concentration has been exceeded by 73%).

Trends in air pollution during the period 1992-1994

Sulfur dioxide

Following Cracow areas have been taken into consideration in the evaluation of trends in air pollution with sulfur dioxide in Cracow during the period 1992-1994

Monitored area	City quarter	
Station No. 1	Main Square	City Centre
Station No. 4	Prokocim Nowy	Podgórze
Station No. 5	Avenue	City Centre
Station No. 6	"Żeromski" Hospital	Nowa Huta
Station No. 7	Balicka	Krowodrza

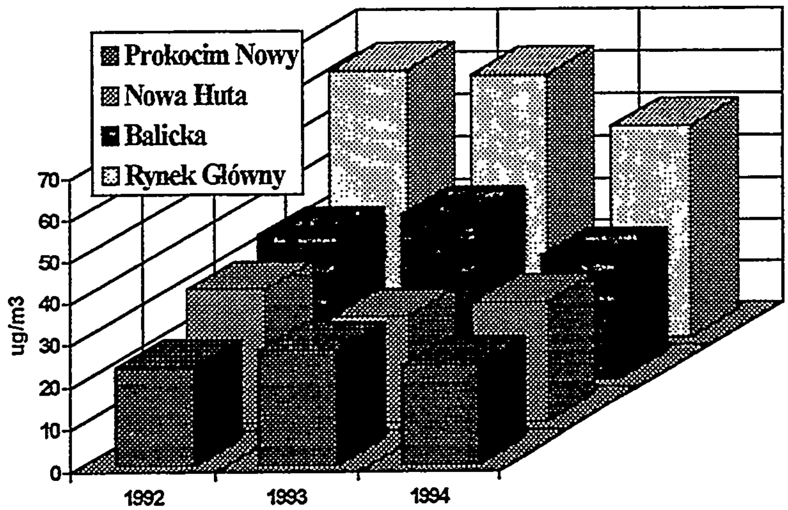
The selection of these areas was based first of all on following circumstances:

- continuity of measurements at a given location in 1992-1994
- reception of complete and reliable results

The trends in sulfur dioxide concentration in 1992-1994 is presented in Fig. 1.

When summarizing the changes in concentrations of sulfur dioxide in Cracow air during the period 1992-1994, following can be stated:

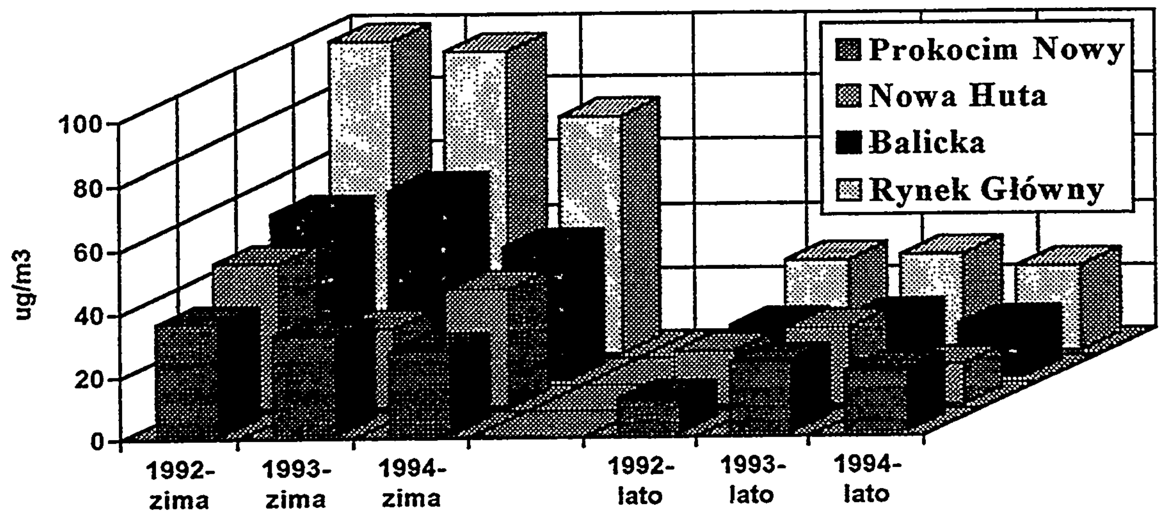
1. The average annual concentration exceeds the permissible limit at many locations in Cracow
2. Reduction of average annual concentration is visible



Rynek Główny - Main Square

Fig. 1. Trends in annual concentration of sulfur dioxide at selected locations in Cracow

3. In winter a reduction of sulfur dioxide concentration is observed while in summer season random changes in concentrations have been found. This trend has been illustrated in Fig. 2.
4. Continuous reduction of maximum instantaneous (30-minute) and 24-hour concentrations as well as reduction of the frequency of exceeding the permissible limits has been observed.
5. The highest reduction of average annual côncentration has been measured at Main Square, while the highest increase has been stated in the Avenue.



zima - winter　　　lato - summer

Fig. 2. Trends in sulfur dioxide concentrations for selected Cracow areas in winter and in summer

Suspended particulates

Following Cracow areas have been taken into consideration in the evaluation of trends in air pollution with suspended particulates in Cracow during the period 1992-1994

Monitored area	City quarter	
Station No. 1	Main Square	City Centre
Station No. 3	Rynek Podgórski	Podgórze
Station No. 4	Prokocim Nowy	Podgórze
Station No. 5	Avenue	City Centre
Station No. 6	"Żeromski" Hospital	Nowa Huta

The trends in concentration of suspended particulates in 1992-1994 are presented in Fig. 3.

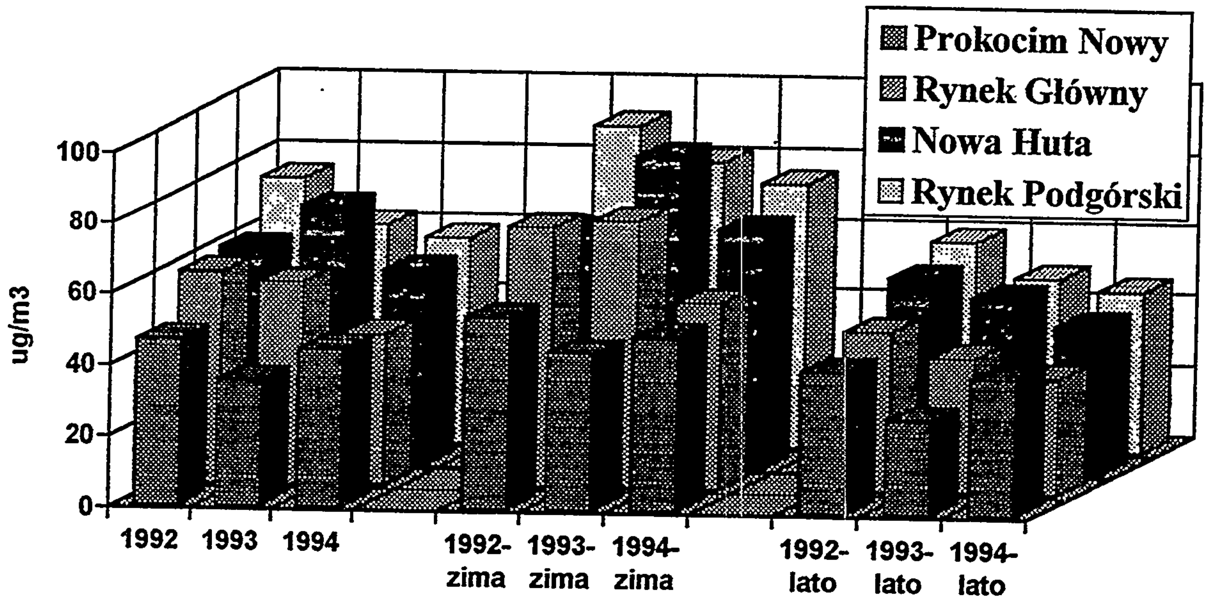


Fig. 3. Trends in annual concentration of suspended particulates at selected locations in Cracow within the period 1992-1994

When summarizing the changes in concentrations of suspended particulates in Cracow air during the period 1992-1994, following can be stated:

1. The average annual concentration of suspended particulates in Cracow tends to be slightly reduced, however the measured values exceed continuously the permissible limit.
2. The reduction of both maximum 30-minute and 24-hour concentrations is observed, e.g. at the Main Square in 1992 both maximum 30-minute and 24-hour concentrations exceeded the permissible limits, in 1993 only the maximum 24-hour concentration was too high, while in 1994 both these parameters met the standard requirements.
3. Frequency of exceeding the 30-minute and 24-hour concentration has been reduced within the discussed period.
4. The highest concentrations of suspended particulates were found at the Station No. 5 - Avenue (City Centre). After a reduction by 17.5% in 1993, the increase by 10.8% has been stated in 1994. It might result from the reduction of the concentration of suspended particulates due to the reduction of emission from the low emission sources followed by an increase caused by the increasing traffic-related emission within this area.

SUMMARY

The selection of sulfur dioxide and suspended particulates as the main components of air pollution during the winter season results from the existence of these pollutants as main air deteriorating components of flue gas emission in Cracow. The concentration of these two pollutants is also the basic criterion for smog alarms in winter. Detailed information on these and other monitored pollutants can be found in the "Reports on Cracow air pollution" issued on annual base by the Cracow Voivode Office.

These pollutants were dominating in Cracow during last three years although their level is being systematically reduced and therefore in last two years the "winter smog" criteria were not exceeded.

The high average annual concentrations of sulfur dioxide and suspended particulates at the selected locations, exceeding the permissible standards, are caused by low emission and traffic-related pollution. The monitoring stations in Main Square, Rynek Podgórski and Avenue registered the highest level of air pollution. It means that low emission sources is still a significant problem of the town although the intensity of air pollution is much lower than in seventies and eighties.

The local professional power sources, advection of pollutants from outside as well as low emission sources and traffic-related pollution remain still the main sources of air pollution in Cracow.

EFFECT OF LOW EMISSION SOURCES ON AIR QUALITY IN CRACOW

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SUMMARY

The paper presents calculation of „power engineering low emission" and results of simulation of the effect of this emission on air quality in Cracow, Poland. It has been stated that the segment of „low emission" in central areas of the town makes up ca. 40% of the observed concentration of sulfur dioxide. Furthermore it has been stated that the capital investment must be concentrated in the central part of the town in order to reach noticeable improvement of air quality in Cracow. Neither the output of a separate power source nor the emission level and its individual harmful effect, but the location of the source and especially „packing density" of the sources must decide the priority of upgrading actions.

INTRODUCTION

The state of atmospheric air pollution in Cracow, as a large residential and industrial center, is influenced by a combination of overlapping independent factors. In spite of the pollutant advection from outside, there exists a significant effect of the sources situated within the town area. Following basic groups of these sources can be listed: industry and professional power engineering (so called „high emission"), traffic and low power engineering sources (local boiler houses; in-house, apartment stoves). The last group is frequently called „low emission".

The purpose of the American-Polish Program of Actions for Elimination of Low Emission Sources in Cracow was to initiate the technical actions with regard to the „low emission power engineering sources" aimed at sensible improvement of air quality in the town. Of course it is expensive, and it costs a lot of money. Therefore following questions must be answered: What is the present state and what are the reasons? What are the expected results of implementation of a given action? and finally: Do the engaged financial means result in adequate effects?

Following parameters have been used as a base of the evaluation: emission and imission of two basic „power engineering pollutants" - particulates and sulfur dioxide. These two pollutants have been chosen first of all because of the fact, that the emission of these pollutants is relatively best known theoretically and therefore the correctness of simulation technique is hopeful. Furthermore emission of sulfur dioxide is the most harmful element of synergetic effect of the products of solid fuel combustion. (The coefficient of pollutant harmful effect is defined as emission (*E*) vs. instantaneous permissible concentration (D_{30}) ratio; in the case of solid fuel combustion, the highest ratio is found for sulfur dioxide.) Last but not least - imission measurement devices are relatively less expensive and the simplest. Thus it was possible to use the results of measurements of these two pollutants, gathered by the Provincial Sanitary and Epidemiology Station and the National Inspection of Environmental Protection. Because of a small quantity of measurement stations in which concentration of other pollutants was measured - the set of available data (on the imission of e.g. NO_2 or hydrocarbons) was inadequate.

PRESENT STATE OF AIR POLLUTION IN CRACOW

Routine measurements of air pollution are carried out continuously in Cracow. There exist two independent monitoring networks: a manual network operated by the Provincial Sanitary and Epidemiology Station and the automatic one, owned by the National Inspection of Environmental Protection. The data gathered by these two institutions allowed to elaborate the maps of concentration of both discussed pollutants.

The average seasonal concentration of sulfur dioxide exceeds the permissible value of 32 $\mu g/m^3$ on the entire territory of the town, within its administrative boundaries. The isoline of double excess of the permissible value (i.e. 64 $\mu g/m^3$) includes the entire town settlement with its southern outskirts and Nowa Huta (on the east). The closer to the town center - the higher is the concentration. Within the area of old residential housing - which corresponds approximately with the boundaries of early 20. century Cracow - and in addition within the industrial district of Rybitwy-Łęg-Bieżanów, the permissible level is exceeded three times. Within the close center of the town - slightly north-east of the Main Market Square (Rynek Główny), in Olsza, old Prądnik and in Grzegórzki the permissible limit is exceeded four times (128 μg/m³).

The course of isolines presenting average concentration of particulates is similar. In winter season the permissible concentration amounting 50 μg/m³ is exceeded in the entire territory of the town within its administrative boundaries. Distinct peaks, reaching 100 μg/m³ (and even more) have been stated in the old residential areas of Grzegórzki, Kazimierz and Podgórze (Market Square).

The results of similar measurement carried out in summer season can be used as a preliminary comparative material related to the contribution of power engineering sources in the creation of the entire condition of air pollution in Cracow.

In summer three isolated enclaves of excessive sulfur dioxide concentration (marked with 32 μg/m³ isoline) are visible in the town. There are: the area of compact residential housing in the center of Cracow, including Kazimierz and „old" Podgórze, the Nowa Huta territory - close to the „Tadeusz Sendzimir" Steel Works and the industrial area of Bieżanów. Within the strict center of the town, the concentration reaches twofold permissible level with local maximum in Grzegórzki area - up to 96 μg/m³ (and more).

The concentration of suspended particulates in summer are distinctly below the permissible level. The central part of the residential district (the second ring - Trzech-Wieszczów-Ave.) lies within the area delimited by the 25 μg/m³ isoline (50% of the permissible limit). A local maximum of the concentration exceeding 50 μg/m³ is found on a small area in the old part of Kazimierz.

The presented comparative material confirms high contribution of power engineering sources in the entire picture of town pollution. The summer season background is related first of all to the sources operated all year round (in the first approximation - the process boiler houses), industry and traffic. The beginning of the heating season causes an immediate - almost jumping increase in the concentration of pollutants. It seems interesting to compare the average seasonal concentrations within the strict center of the town. The arithmetic mean of the results measured in three monitoring stations located in this area, has been calculated:

Table 1

Comparison of average seasonal concentrations of main pollutants within the strict center of Cracow [μg/m³]

Pollutant	Permissible value	Winter season	Summer season	Difference
Suspended particulates	50	71.8	26.8	45.2
Sulfur dioxide	32	106.2	39.4	66.9

It follows from the comparison above presented that an increase in the concentration of suspended particulates by a value almost equal to the permissible level is observed for the heating season. The concentration of sulfur dioxide increases by more than a twofold permissible level. Obviously, this increase is related not only to the „low emission". The beginning of the heating seasons causes also an increase in power demand in the central heat sources and in the boiler houses operated all the year round. An increase in the advection of external pollution is also observed. However the role of „low emission" sources is dominating.

THEORETICAL BASE FOR THE EVALUATION METHODOLOGY OF THE INFLUENCE OF A GROUP OF LOW EMISSION SOURCES

Two criteria can be used to determine the influence of emission sources:

(1) criterion of total emission of pollutants from a given source (group of sources);

(2) criterion of imission, i.e. influence of the discussed group of sources on air quality, expressed in pollutant concentration units [mg/m³].

From the point of view of an „average inhabitant of a town", the second criterion is, obviously, much more significant. The emission parameter and statements related to its possible reduction, expressed in tons per year, is a factor available for a narrow circle of specialists. The average resident is interested in quality of air he uses for respiration.

The available mathematical instruments allow to combine the emission value with expected imission level. Among numerous available models of pollutant distribution in atmospheric air, the Gauss-type model by Pasquille is the most accurate. Its classic (simplified) solution is the value of concentration, S at a given point in space (coordinates x, y, z) caused by the emission from a H-meter high (effective height) source.

$$S_{xyz} = \frac{E}{2\pi \cdot u \cdot \sigma_x \cdot \sigma_z} \exp\left[-\frac{y^2}{2 \cdot \sigma_y^2}\right] \cdot \left\{\exp\left[-\frac{(H-z)^2}{2 \cdot \sigma_z^2}\right] + \exp\left[-\frac{(H+z)^2}{2 \cdot \sigma_z^2}\right]\right\}$$

where:

E pollutant emission;

u average wind velocity;

σ_y, σ_z atmospheric diffusion coefficients.

Of course some sophisticated versions of this model take into consideration several corrections, related to the transformation of pollutants, their erosion, absorption by the ground, etc.

The simulation of the field of pollutant concentration, caused by simultaneous influence of many emission sources, is based upon the additivity of concentration field components related to the individual emitters of a given group. The average annual concentration at a given point (x, y) is an arithmetic sum of component concentrations caused by the individual influence of discussed sources. This property implies technically and substantially the evaluation methodology because:

(1) analysis of the effect of practically unlimited number of emitters appears feasible;

(2) determination of the component field of concentrations related to the influence of a given group of emitters allows to calculate the contribution of this group in creation of the comprehensive field of concentrations.

This second conclusion could be formulated even more precisely: elimination of a given group of emitters will cause reduction in concentration by the value assigned to this component group of emitters. Thus the obtained result will be a measure of expected improvement of air quality in relation to the present state.

Consequently the applied procedure of evaluation of the influence caused by a given group of sources on air quality, within a defined reception territory, is equivalent to the implementation of the following tasks:

(1) to take stock of the parameters of existing emitters (chimneys), including determination of their location in an accepted local system of coordinates;

(2) determination of the existing emission of pollutants from the discussed group of sources;

(3) model calculation of the field of pollutant concentrations, related to the given group of emitters.

If the elimination of the group of emitters is not foreseen and only their upgrading is suggested, the described procedure should be repeated for the designed conditions. The ecological effect of the upgrade works will be determined as a balance of profits (elimination of the „old" field of concentrations) and costs (introduction of the „new" field of concentrations).

The elaboration of such a model for the entire town must be burdened with a certain error. Data processing for each single object (boiler, stove) individually, exceeds the capability of the available computer hardware. Anyway the expected advantage over the simplified version is rather doubtful. The emission level depends first of all on fuel quality and this information - for such a large scope of elaboration - must be approximate.

MODEL ASSUMPTIONS FOR EVALUATING THE EFFECT OF „LOW EMISSION" SOURCES

An evaluation of the present state was based upon the inventory of the „low emission" sources elaborated in 1991 by the Cracow Development Office. The Low Emission Data Bank contains an information on 1 322 objects (boiler houses) in which 2 927 boilers are operated (2 254 of them fired with solid-fuel). In addition the data base includes 25 759 records on buildings (tenement houses) heated from the individual heating sources (apartment stoves, room heaters). This part of the data bank contains information about round 100 000 individual tile stoves existing and operated in Cracow.

The estimation of the present state of „low emission" effect allows to evaluate the expected advantages. Of course, complete elimination of power sources is not feasible - because of defined power demand in the town. Therefore a program of substitution to define the ecological „cost" of the program should be formulated.

The American-Polish Program of Actions included an analysis of various option of technical solutions aimed at gradual elimination or reduction of the negative effect of low emission power sources. Following variants have been taken into consideration: development of the district heating network to connect additional users to the municipal system, usage of the so-called „pure" heat carriers and finally usage of improved (purified) solid fuel. Each discussed version has been evaluated from the point of view of the „ecological advantage", achievable at simulated circumstances of full implementation of the task. Basing upon the obtained results, a scenario being a compilation of the separate solutions, has been formulated.

The historical development of the town has generated certain distinctly separated zones. They differ in the type of characteristic building and in the function. Therefore the town has been subdivided into three zones with different suggested scenarios of heating system modernization. For self-evident reasons the best solution (with regard to the environmental protection) is suggested for the central area of the town - the closer to the center, the „cleaner" is the solution. The assumptions used in the simulation are presented in Table 2 below.

Table 2

Assumptions used in the simulation of upgrading the heating system in Cracow

ZONE	GROUP OF SOURCES	SUGGESTED TECHNICAL UNDERTAKINGS
I OLD TOWN	coal-fired boiler houses	switching over to gas
	individual tile stoves	switching over to gas or electricity - proportion equivalent to the present contributions of individual „pure" installations
II SECOND CIRCLE	small boiler houses	if feasible - connection with the district heating network; remaining - switching over to gas
	large (process) boiler houses	upgrading - combustion of fuel together with alkali's addition in a fluidized bed combustion chamber, high-efficient separation of particulates
	individual tile stoves	within the Łobzów area - switching over to electricity, in the remaining part of this zone - switching over to gas and/or electricity (proportion as in the first Zone)
III REMAINING PART OF THE TOWN	small boiler houses	if feasible - connection with the district heating network; remaining - coke-fired devices
	large (process) boiler houses	upgrading - combustion of fuel together with alkali's addition in a fluidized bed combustion chamber, high-efficient separation of particulates
	individual tile stoves	switching over to gas and/or electricity (proportion as in the first Zone)

EVALUATION OF THE INFLUENCE OF „LOW EMISSION" EMITORS

The emission of pollutants has been calculated both for the present state and designed conditions. The calculations were based upon the known output of boilers or the total volume heated by tile stoves. Synthetic indices, determining the level of pollutant emission, have been derived for the above mentioned data. Calculation results are given in Table 3 below.

Table 3

„Low emission" balance for the discussed scenario of modernization of the heating system in Cracow [Mg/season]

Zone of the town	Suspended particulates			Sulfur dioxide		
	Present state	Designed conditions	Balance	Present state	Designed conditions	Balance
I Zone - OLD TOWN	266	2	264	119	1	118
II Zone - SECOND RING	2 0	9	2 0	866	0	866
III Zone - OUTSKIRTS	5 8	740	5 0	5 0	866	4 1
TOTAL - CRACOW	8 1	751	7 3	6 0	867	5 1

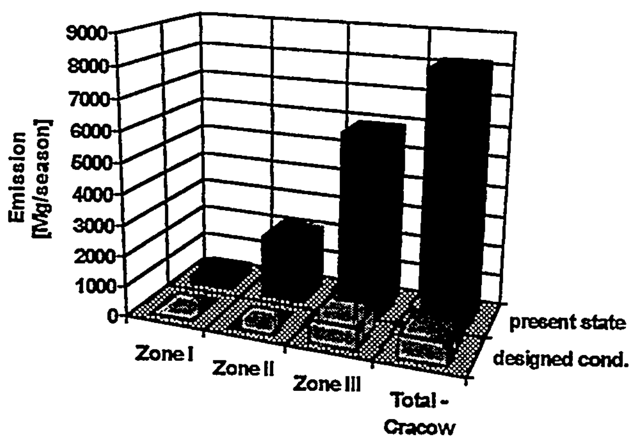

Fig. 1. „Low emission" balance of suspended particulates

The highest quantitative effect of elimination of suspended particulates emission is foreseen within the III Zone - i.e. in the town area out of the second ring. It results first of all from the fact that the majority of low emission sources are situated in this Zone. At the same time, this is the lowest effect in aspect of the volume of present emission (reduction of emission by 87% of the present state is expected). It follows from the significant limitations of the programmed technical actions assumed for the discussed zone - solely connection to the district heating network and replacement of fuel fired in the boiler houses has been planned.

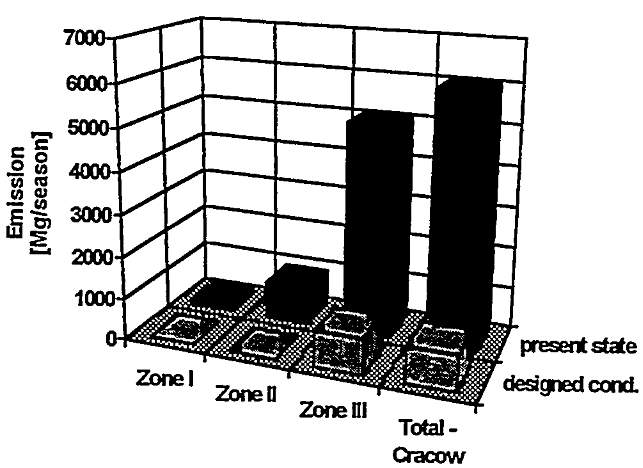

Fig. 2. „Low emission" balance of sulfur dioxide

The problem of sulfur dioxide emission is very similar. Only in the central part of the town a complete elimination of the pollutant is expected. It is much more interesting to evaluate the effect of elimination of pollutant emission on air quality in the town. Therefore calculations have been carried out to simulate the concentrations of particulates and sulfur dioxide caused by the influence of the discussed group of sources for the present state and for the designed conditions.

The results of calculations allow to formulate a following statement concerning the present contribution of the „low emission" component into the concentration of pollutants in the central part of the town (within the Second ring - Zones I and II):

- suspended particulates: ranging between 15 and 30 μg/m³, locally 42-60 μg/m³, in average during the heating season. This value constitutes 30-60% (locally 84-120%) of the standard permissible value D_a = 50 μg/m³. The observed concentration of suspended particulates within the central part of the town ranges between 110 and 180% of the permissible value. It means that the „low emission" component contributes 30-60% (depending on the area) of the existing state of air pollution with suspended particulates.
- sulfur dioxide: ranging between 10 and 33 μg/m³ locally 43-56 μg/m³, in average during the heating season. This value constitutes 31-103% (locally 134-175%) of the standard permissible value D_a = 32 μg/m³. The observed concentration of sulfur dioxide within the central part of the town ranges between 320 and 372% of the permissible value. It means that the „low emission" component contributes 10-50% (depending on the area) of the existing state of air pollution with sulfur dioxide.

With regard to sulfur dioxide, the value of average concentration of the pollutant contributed by the „low emission" sources is close to the difference between the pollution measured in winter and in summer seasons (see Table 1). This fact confirms directly the significance of the „low emission" component as a parameter creating local aero-sanitary conditions within the intensively urbanized areas. As concerns the „cost" of the discussed scenario of modernization, following average concentrations will be contributed in winter by the „low emission" component:

- suspended particulates: ranging between 1 and 4 μg/m³, locally 6 μg/m³, i.e. between 2 and 8% (locally 12%) of the standard permissible value;
- sulfur dioxide: ranging between decimals and 2 μg/m³, locally 4 μg/m³, i.e. up to 12% of the standard permissible value;

Thus it should be stated that the „ecological cost" of the suggested scenario of modernization is relatively low. Elimination of the existing low emission sources can bring real, sensible improvement in air quality within the center of the town. In the case of the most intensive pollution in the city center, the concentration of pollutants can drop by 100-150% of the standard permissible value, i.e. improvement of air quality by ca. 40% in relation to the present state is expected.

An interesting result has been obtained in calculations carried out for the outskirts. The existing low emission sources situated in this Zone cause at most few μg/m³ air pollution. The „low emission" component, important for creating the background for this Zone, does not play significant role unlike the situation observed in the central part of the town. Taking into consideration lower air pollution in the outskirts it should be estimated that - from the point of view of the entire town, focusing the investment costs to modernize the heating sources in the center of Cracow is more effective. An opinion can be ventured that the technical actions undertaken in the outskirts of the III Zone, will result in a very limited ecological effect, which could be neglected in comparison with the general problem.

It follows from the simulation, that the pollution background contributed by the „low emission" sources is higher if the density of sources increases. On contrary, the influence of a single, isolated emitter - even a relatively harmful one - is of local importance, only.

The effect of the significant influence of „low emission" emitters appears only in the case of overlapping the contributions of hundreds chimneys situated close to each other. The individual harmful effect of such sources - treated as isolated objects - is small or even very small. Therefore the basic pro-ecological criterion of assignment of available funds to the determined upgrade undertakings should be the density of residential housing within a given area. The program of differentiated actions (in which the scale of actions decreases with increasing distance from the center of the town), discussed in this paper is consistent with the requirements of reasonable assignment of financial means.

The carried out calculations prove, that the possible solution of the „low emission" problem will not result in absolutely satisfactory improvement of air quality. Even in the case of complete elimination of this group of sources the decrease in pollutant concentration below the permissible values cannot be expected. However, it must be taken in mind that only the „low emission power sources" and road traffic are in fact „controllable" sorts of emission. Under the existing, imperfect legal conditions of environmental protection, the town and its authorities have practically no influence on the operation of emission sources situated outside the town boundaries. To some extent the city has an influence - when combining actions with the state administration - on the operation of the „high emission" sources. Still, urgent solution of the problem discussed in this paper is so necessary.

CONCLUSIONS

(1) Cracow belongs to the ecologically menaced areas. In winter the permissible level of pollutant concentration is exceeded on the entire territory of Cracow; in the central part of the town the limits are exceeded several times.

(2) The component of „low emission" contributes ca. 40% of the existing pollution in the central part of Cracow.

(3) It is feasible to formulate an investment-upgrade program to reduce the ecological cost of energy demand of the town, met at present by the low emission sources.

(4) The density of residential housing and not the individual output nor the harmful effect of a separate local source should be used as a basic criterion for assignment funds available for the actions in the field of environmental protection.

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CONCLUSIONS DRAWN FROM ACTIONS IMPLEMENTED WITHIN THE FIRST STAGE OF THE CRACOW PROGRAM OF ENERGY CONSERVATION AND CLEAN FOSSIL FUELS

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I. INTRODUCTION

Since 1992 Brookhaven National Laboratory (BNL) and Pacific Northwest Laboratory (PNL), acting on behalf of the U.S. Department of Energy, executed the first stage of the Cracow Program of Energy Conservation and Clean Fossil Fuels, called also American-Polish Program of Actions for Elimination of Low Emission Sources in Cracow. The main contractor for BNL and PNL was the Cracow Development Office (BRK).

The interest in improving the condition of Cracow air results from the fact that the standard for permissible air pollution was exceeded several times in Cracow and especially within the central part of the town. Therefore air pollution appeared one of the most important problems that faced the municipal authorities.

It followed from monitoring investigations that the high level of air pollutant concentration is caused by in-home coal-fired tile stoves operated in winter seasons and by coal- and coke-fired boiler houses situated mainly in the central part of the town. These stoves and boiler houses are called low emission sources.

According to the detailed inventory carried out in Cracow by a questionnaire completed in 1991, there were over 1 300 boiler houses, out of them 1 100 were fired with solid fuel, with total output of almost 1 000 MW. Furthermore the inventory list includes almost 100 000 coal-fired tile stoves and 17 000 rooms heated by small coal-fired boilers. These boiler houses consumed ca. 350 000 Mg of solid fuel while stoves and small apartment boilers used over 100 000 Mg. In total ca. 500 000 Mg of coal and coke was burnt in low emission sources.

This was the starting point for the implementation of the first stage of the Program. Main components of this stage were completed in 1994. The results obtained in first stage have been presented several times. This paper is an attempt to formulate conclusions drawn from these works and recommendations with regard to the future policy of the town authorities; selected results are presented to clarify or illustrate the conclusions.

II. CONCLUSIONS AND RECOMMENDATIONS

1. The calculations carried out have proved the significant contribution of low emission sources in emissions of air pollutants in Cracow. These sources generate tens of thousands of tons of particulates and gaseous pollutants annually. As an example, emissions calculated using emission coefficients obtained in tests of heating devices and the inventory data on the quantity and quality of fuel sorts used was:
   - sulfur dioxide (SO_2) — 10 508 Mg per season
   - particulates — 3 541 Mg per season
   - carbon monoxide (CO) — 14 868 Mg per season
   - methane (CH_4) — 741 Mg per season
   - nitrogen oxides (NO_x) — 1 635 Mg per season

   Equivalent emissions calculated for these data amounts to 32 952 Mg per season.

Low emission sources contribute only a part of the existing air pollution in Cracow. The remaining pollution is caused by:

- transportation (communication) means;
- high emission sources; and
- advection from adjacent regions.

Estimations are confirmed that the low emission sources contribute ca. 35-40% of pollutant concentration measured by the monitoring stations situated in downtown Cracow.

2. The coal-fired tile stoves in residential buildings constitute the most noxious component of low emission sources. They generate over 1 000 Mg of particulates per season (over 43% of total emissions) and their contribution to total equivalent emissions exceeds 23%.

   Since the stacks are the lowest, the contribution of tile stoves in pollutant concentration is even more significant. The noxious effect of tile stove operation has recently intensified because some users started purchasing and burning the cheapest, i.e. also the worst, sorts of coal. In addition different sorts of wastes and rubbish is burnt in such stoves.

3. Elimination of coal-based stove heating situated almost completely within the older, central part of the town is therefore a significant element of actions aimed at the reduction of low emission.

   Technically there are two ways to eliminate coal-fired tile stoves:
   - installing electric heaters (or accumulation radiators) in the existing stoves combined with modification of a part of internal electric installation and assembling a two-tariff counter;
   - assembling a gas-fired central heating furnace in the apartments (sometimes used also for production of hot water) combined with assembling the central heating installation in the apartment and often accompanied also by the erection of a new stack and ventilation system.

   The electric heating installation in an apartment requires capital investment up to US$ 1 000, while the cost of gas heating systems ranges from ca. US$ 3 000 to US$ 4 000. Ca. 500 apartments annually are converted from coal fuel to gas and an additional ca. 1 500 are converted to electric heating. Ca. 5 000 to 6 000 stoves are eliminated every year. At present the municipal gas distribution system is able to provide gas for all buildings heated with tile stoves. The electricity distribution system is able to meet only a part of the potential demand.

   It has been estimated that the capital costs to be covered by the Power Distribution Plant in Cracow to enable complete conversion of all coal-fired apartment stoves to electric heating amount to ca. US$ 10 000 000. Therefore the Power Distribution Plant requires support in order to avoid the situation that the limitations in the power distribution network stop the individual initiative of residents wanting to convert heating systems from coal to electricity.

4. The results of questionnaire investigations proved that many residents living in apartments heated with coal-fired stoves intend to convert their heating system to gas or electric heating. Electric heating is preferred.

   The town authorities are going to support these initiatives, e.g. by partial reimbursement of expenses related to the conversion of heating systems; however, the regulations still in force do not offer such a possibility. Regulations on subsidies granted from the Communal Fund of Environmental Protection should be changed, so that this Fund is able to assign a part of its funds to support private residents of apartments.

5. The entire elimination of tile stove heating based on coal combustion is not possible in the near term. Taking into consideration that every year only few thousand stoves are eliminated, the full elimination of 100 000 tiles stoves will last many years. During this transition period certain temporary solutions should be implemented in order to significantly reduce emissions without investment.

The Program has proved that this can be achieved by changing the fuel used in tile stoves: replacing coal with smokeless briquettes. The tests carried out during this Program have shown that the smokeless briquettes produced, e.g. following the technology elaborated in the Institute of Chemical Coal Processing in Zabrze, will reduce emission of particulates from the stoves 12-15 times in comparison with the emissions reported even for the best sorts of coal.

Combustion of briquettes also causes reduction of sulfur dioxide which is two times smaller than in the case of a good sort of coal. The following results have been obtained from calculations carried out with a spreadsheet:

- conversion of coal-fired stoves to electric heating causes reduction in annual emissions of particulates by 1 530 Mg, sulfur dioxide by 782 Mg, and equivalent emissions by 7 674 Mg;
- the change of tile stove fuel i.e. replacement of coal with briquettes causes reduction in annual emission of particulates by 1 422 Mg, sulfur dioxide by 409 Mg, and equivalent emissions by 5 576 Mg.

The numbers presented above show that the emission of particulates from tile stoves can be significantly reduced when switching over to smokeless fuel.

Use of another type of briquette appearing in the domestic market and called even sometimes „ecological", which are produced using washed coal with binding agent and sorbents, also causes reduction in emissions, however this reduction is smaller than in the case of smokeless fuel produced with degasified coal.

Another way of reducing emission from tile stoves is to change the combustion procedure followed by the users. It has been proved in tests that implementation of another procedure of fuel combustion in tile stoves can increase the stove efficiency by almost 20%, and reduce fuel consumption and - consequently - emission of pollutants.

6. Quantitatively, the greatest part of pollutant emission is related to the combustion of solid fuel in boilers. With respect to the protection of atmospheric air and the sort of fuel, these boilers can be divided into two basic groups:
   - fixed grate boilers made of steel (adapted to the combustion of coal) or of cast iron (adapted the combustion of coke), which are not equipped with any device protecting atmospheric air;
   - mechanical stoker boilers adapted for combustion of coal fines; for the most part they are equipped with dedusting devices (cyclones, multicyclones).

   Boiler houses situated in Cracow Centre are equipped as a rule with fixed grate boilers. Apart from coal and coke they can also be fired with a coal-coke mixture of various proportions. Their output - as a rule - does not exceed 1 MW.

   Stoker boilers are fired with raw, ungraded coal fines, grain size 0-20% with a large content of the finest fractions. The mechanical stoker boiler houses are situated outside the central part of the town and they supply heat to a larger group of buildings. Their output ranges between ca. 2 and 35 MW.

   These boiler houses operate as space-heat suppliers, space-heat and process steam suppliers or process-steam suppliers. It follows from the inventory list of 1991 that there were in Cracow 2 033 fixed grate boilers of 452.02 MW total output and 229 mechanical stoker boilers of 510.65 MW total output. Emission of pollutants from these boilers calculated with a spreadsheet is given in the table below.

Annual Emissions from Boilers

Specification	SO_2		Particulates		CO	
	Mg	%	Mg	%	Mg	%
Emission from all boilers	9 489	100	1 754	100	12 308	100
from fixed grate boilers	2 537	26.74	671	38.26	9 176	74.55
from mechanic stoker boilers	6 952	73.26	1 083	61.74	3 132	25.45

Table (cont.)

Specification	CH_4		NO_x		Equivalent emission	
	Mg	%	Mg	%	Mg	%
Emission from all boilers	485	100	963	100	23 522	100
from fixed grate boilers	485	100	205	21.29	9 665	41.09
from mechanic stoker boilers	0	0	758	78.71	1 385	58.91

Emission of pollutants from Cracow boilers can be reduced or eliminated in the following ways:

- connection of boiler houses to the municipal district heating network system (elimination of boiler houses);
- conversion of coal- or coke-fired boilers to natural gas;
- upgrade of the boiler houses including improvement of the combustion process;
- change in fuel used - switching to the improved (upgraded) fuel sorts.

7. The group of fixed grate boilers is dominated by cast iron boilers adapted for coke combustion. Use of a coke-coal mixture reduces boiler efficiency and increases emission parameters (e.g. the equivalent emission increases by 36%). The cast iron boilers should be fired with coke only. Combustion of smokeless briquettes in cast iron boilers results in reduction of their efficiency and in increased emissions when compared with coke combustion; therefore in such a case the briquettes should not replace coke.

8. The fixed grate boilers made of steel are adapted for combustion of coal; in this case pollutant emission is high (equivalent emission is ca. 60% higher than in the case of coke-fired units). Emission reduction from these boilers can be achieved by replacing coal with smokeless briquettes. The equivalent emission drops by ca. 63%, and emission of particulates is even 10 times smaller.

9. The actual efficiency of stoker boilers (of the order of 50-60%) is much lower than the design values. It has been proved in tests that improvement of the operating procedure and replacement of fuel allows the boilers to reach ca. 75% efficiency and the equivalent emission can be reduced by 50%. Additional increase in efficiency and decrease in pollutant emission from these boilers can be achieved by implementing automatic control of the combustion process.

10. Heat energy conservation is possible in all parts of heat distribution systems and at the end consumers. The highest and most distinct energy savings can be achieved at the heat consumers by means of weatherization of the buildings, assembling the measurement equipment and devices which make possible controlling temperature in rooms, and as a consequence, billing for actual heat consumption.

    The results of the demonstration program of energy conservation proved that the attainable savings may exceed even 30%. This means that 400-500 MW output can be conserved in the municipal heating system supplied from the Cogeneration plants.

11. Heat capacity surplus in the central heat sources permits more than half of the existing boiler houses to be eliminated by connecting them to the municipal district heating network. The analysis of the problem showed that 635 boiler houses with total output of ca. 450 MW situated throughout the territory of Cracow can be eliminated in this way.

12. The gas supply system existing in the Old Town has a sufficient capacity to allow the elimination of coal- and coke-fired boiler houses by replacing them with gas-fired units. The gas distribution system in the remaining part of the city centre - between the first and the second ring - requires modification in order to supply sufficient gas for existing coal- and coke-fired boiler houses. However the capital costs required are within the financial capacity of the Gas Distribution Plant in Cracow. The necessary upgrading works can be implemented within a few years.

13. In order to eliminate or to significantly reduce low emissions in Cracow, it is possible to undertake various actions, for example:

- application of improved operating procedures for tile stoves and boilers;
- use of improved fuel in tile stoves and boilers;
- connection of boiler houses fired with coke and coal to the municipal district heating network;
- replacement of coke- and coal-fired boiler houses with gas-fired units;
- modernization of boiler houses, especially the mechanical stoker boiler houses, using various technically feasible methods in order to increase efficiency of the units and to reduce emission;
- elimination of coal-fired tile stove heating by replacement with electric or gas heating.

In various parts of the town, various solutions can be implemented; their economic efficiency is different depending on many circumstances.

14. The unit capital cost (per 1 KW output) required for the implementation of various options of conversion of low emission sources, averaged for the entire territory of the town is as follows:

• connection to the municipal district heating network	ca. $ 90/KW
• conversion of coal-fired home boilers to gas-fired units	ca. $ 120/KW
• conversion of coal- or coke-fired district heating boilers to gas-fired units	ca. $ 125/KW
• conversion of coal-fired home stoves to electric heating	ca. $ 150/KW
• complete modernization of mechanical stoker boilers	ca. $ 245/KW
• conversion of coal-fired home stoves to gas heating units	ca. $ 320/KW

15. As a part of the Program, a spreadsheet model has been developed for quick analysis of economical and ecological efficiency of numerous possible optional solutions. In spite of simplifying assumptions made in preparing the data for the spreadsheet model, as well as in the structure of the spreadsheet itself, the results of analyses carried out using this model can be useful in contributing to decisions with respect to the energy policy at the town level.

BNL has introduced into the model a quantity called „user combined annual cost" (UCAC). It is defined as the annualized capital cost of a given conversion option over the project life time, including the interest rate of the investment loan and the annual user's cost after and before (base case) conversion (the difference in fuel, operating, and maintenance costs). The UCAC value is normalized to a unit decrease in equivalent emissions due to the chosen conversion option. It is an attempt to use a criterion that takes into account the total capital costs required for implementing the option, the difference in operating and maintenance costs borne by the user before and after the conversion, and the environmental efficiency of the measures undertaken.

Using this criterion, calculated with the spreadsheet, the following list ranking measures aimed at eliminating or reducing low emissions has been derived (starting from the most effective option):

- usage of improved fuel (the best UCAC index);
- connection to the municipal district heating network;
- conversion of coal-fired tile stoves to electric heating;
- conversion of solid-fuel fired boilers to gas-fired units;
- conversion of coal-fired stoves to gas-fired heating units;
- comprehensive modernization of mechanical stoker boilers (the highest UCAC index).

16. A general long-term concept of activities for reducing low emissions was studied with the spreadsheet:

- Coal-fired home stoves will be replaced with electric and gas heating units;
- Small solid-fuel fired boilers in individual apartments (also in single family houses) will be replaced with gas-fired heating units;
- All the solid-fuel fired boiler houses situated in the Old Town will be replaced with gas-fired boiler houses. Consequently all the solid-fuel fired units will be eliminated from this part of Cracow;
- Solid-fuel fired boiler houses situated in the remaining part of the Cracow centre (between the first and the second ring) will be replaced with gas-fired units or - in part - eliminated by connecting them to the municipal

district heating network. Consequently all the solid-fuel fired boiler houses will be eliminated also from that part of Cracow;

- Outside the city centre but within the area covered by the municipal district heating network, the space heat suppliers as well as the heating part of the combined space heat and process steam suppliers will be connected to the municipal district heating network. The process steam suppliers will be modernized and continue solid-fuel combustion.
- Boiler houses situated at the town outskirts, beyond the range of the municipal district heating network, are considered to be a lesser nuisance for the natural environment and their emissions can be reduced by using improved sorts of fuel.

It is obvious that it will take many years to reach this model; during the transition period options to reduce emissions should be chosen which involve no capital cost, e.g. implementation of smokeless briquettes in tile stoves and fixed grate steel boilers, using coke in fixed grate cast iron boilers, and combustion of washed and sorted coal in mechanical stoker boilers.

17. The above mentioned example of elimination of low emission sources has been analyzed using the spreadsheet software. The most important results of these calculations can be summarized as follows:
    - The capital cost of investments aimed at the implementation of the options presented in this concept amounts to ca. US $ 190 000 000;
    - Equivalent emissions will be reduced by ca. 90%; particulates by ca. 97%; and sulfur dioxide by ca. 93%.
    - Elimination of stoves and coal-fired boilers in the apartments will reduce the equivalent emissions by ca. 26%, and emissions of particulates by ca. 50%.

The comprehensive results of these calculations are given in Table enclosed (below).

Other, low-cost, concepts were also evaluated using the spreadsheet and were shown to be very attractive. These examples showed that with low or no capital investment, emissions can be significantly reduced. Simply by using better fuels, for example, SO_2 emissions could be reduced by 62% and particulate emissions by 80%.

18. Events in the recent few months may have an effect on small modifications of the general concept of the elimination of low emission sources.
    - An important element is a decision of the Municipal District Heating Utility (Municipal Heat Power Engineering Enterprise - MPEC) to operate the district heating network round the year beginning from the 1995/96 heating season, instead of the seasonal operation in practice so far.
    - This decision could mean elimination of those boiler houses which produce district hot water for household use, by connecting them to the municipal network.
    - The part of the central area of the town accessible to the district heating network is increasing. The use of channel-less district heating network is gaining popularity and permits penetration of the central part of the town with dense residential housing and underground infrastructure.
    - Common availability of natural gas also outside the city centre could result in converting some solid-fuel fired boiler houses to gas, instead of modernizing them.
    - An expensive, comprehensive modernization of big coal-fired boiler houses could be replaced with effective technologies offered by American companies operating in Cracow. Instead of implementation of fluidized bed boilers, these companies are offering a complete control and automation system of the combustion process, heat recovery from flue gas, and application of efficient air protection equipment, which can give similar results at lower capital costs.

A detailed concept will be developed in the Master Plan for elimination of low emissions. The elaboration of this plan has just been initiated by the Cracow Development Office.

Results of calculations for model option of elimination of low emission sources in Cracow

Specification	Cost of option	Reduction in annual emission [tons and percent]											
		SO_2		Particulates		CO		Hydrocarbons		NO_x		Equivalent emission	
	[$]	t	%	t	%	t	%	t	%	t	%	t	%
Elimination of coal-based residential heating	52 695 995	903	8.59	1 759	49.67	2 535	17.05	255	34.41	449	27.46	8 574	26.02
Conversion to gas-fired boilers	14 285 415	634	6.03	160	4.52	2 292	15.41	121	16.39	-6	-0.37	2 226	6.76
Connection to the municipal district heating network	41 233 061	3 600	34.26	695	19.63	7 783	52.35	353	47.62	351	21.47	10 525	31.94
Modernization of boiler houses	79 161 899	4 046	38.5	718	20.28	1 648	11.08	-	-	105	6.42	7 257	22.02
Fuel change	-	592	5.63	108	3.05	270	1.81	6	0.86	38	2.32	1 150	3.49
Combination of all above mentioned conversions	187 385 454	9 775	93.02	3 441	97.18	14 527	97.71	736	99.33	938	57.37	29 732	90.23

19. Under current prices of energy carriers as well as operating and capital costs, conversion of heating systems imposes severe cost burdens on users, and may require financial assistance for those who intend to change their heating system.

The provincial and municipal authorities, distributors of fuels and energy, and heat suppliers are in the position to provide such assistance. It is estimated that the total fund required for assistance in the elimination of noxious heat sources may exceed US $ 10 000 000 annually. Currently, prices of gas and electric heat are considered low in Poland. If conversions are delayed and future prices come in line with Western European prices, possible subsidy levels will increase significantly. It will be necessary to change certain legal regulations so that such assistance can be provided to individuals.

20. It follows from the monitoring measurements carried out in Cracow, that the air pollution is continuously reduced. The table below presents the situation in Cracow centre air pollution in the recent few years.

Years	Particulates [μg/m³] Standard 50 [μg/m³]	SO_2 [μg/m³] Standard 32 [μg/m³]
1987	110	119
1988	81	91
1989	74	84
1990	64	75
1991	57	85
1992	52	75
1993	45	57
1994	41	42

The improvement in air quality in Cracow results from the interaction of many different factors. The most important one is probably reduction in industrial production in Cracow, however - for sure - the improvement results also from actions undertaken in order to eliminate low emission sources.

In less than twenty years the issue of low emissions from energy sources should be reduced to such an extent that is will no longer be one of the most serious environmental menaces to the residents and the town.

LEGAL AND FINANCIAL METHODS FOR REDUCING LOW EMISSION SOURCES: OPTIONS FOR INCENTIVES

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1. ABSTRACT

There are two types of the so-called low emission sources in Cracow: over 1 000 local boiler houses and several dozen thousand solid fuel-fired stoves. The accomplishment of each of 5 sub-projects offered under the American-Polish program entails solving the technical, financial, legal and public relations-related problems. The elimination of the low emission source requires therefore a joint effort of the following parties:

a) local authorities
b) investors
c) owners and users of low emission sources
d) inhabitants involved in particular projects.

The results of the studies developed by POLINVEST indicate that the accomplishment of the projects serving for the elimination of low emission will require financial incentives. Bearing in mind the today's resources available from the community budget this process may last as along as a dozen or so years. The task of the authorities of Cracow City is making a long-range operational strategy enabling reduction of low emission in Cracow.

POLINVEST finds it possible to accept the following general conditions:

a) the task of the Community is to pass proper resolutions so as to create a convenient system of incentives for reducing low emission sources.
b) The Community's operational strategy can be based upon an assumption that the assessment of the profitability of the investments is the investor's task. The task of the City Authorities is to support respective projects and to organize the conditions for their accomplishment.
c) The Community can influence the profitability of the investments as well as the period of their accomplishment by making proper legal conditions and the co-participation in financing the investments, acting in its own interest, as supporting the investors shall protect the Community from future expenses.

2. INTRODUCTION

The range of works performed by POLINVEST from January 1992 to November 1994 included:

a) the elaboration of forecasts of price rises of natural gas, electricity, coal, coke, briquettes, fuel oil and of heat energy from the municipal heat distribution network in Poland till 2020;

b) a feasibility analysis of the investments serving for the elimination of low emission sources consisting in:
- connecting the heat distribution network MPEC SA in lieu of the local boiler houses under elimination;
- converting the solid fuel-fired local boiler houses into gas-fired ones;
- in the region of the "Łobzów" station - conversion of the coal-fired stoves to electric heating installations;
- using briquettes for firing stoves;

c) comparative analyses on the present and forecast operational costs of various systems and heating devices applying different kinds of fuels,

d) legal analyses regarding the performance of the program, among others:
- the methods used for forming prices of energy carriers;
- the methods used for controlling prices and payments regarding different heating systems, paying particular attention at subsidies;
- property owning relations;
- environmental protection statutes;
- financial and tax regulations;
- regulations on renting premises and civil service;
- statutes on local self-government;

e) a analysis on the stimuli and recommended tasks that may be started by the municipal authorities so as to encourage the users of today's heating systems and devices to perform the projects under programs.

The tasks performed by POLINVEST were aimed at:

a) determination of the feasibility of investment projects aimed at the elimination of low emission sources in different regions of Cracow using various fuels and technologies,
b) determination of the means that should be apportioned as incentives (subsidies) by the City authorities for the accomplishment of the projects under analysis,
c) determination in what ways the City authorities ought to have the accomplishment of the program performed

3. RESULTS OF THE STUDIES ON THE INVESTMENT PROJECTS

3.1. Extension of the MPEC SA heat distribution network in lieu of the eliminated local boiler houses

3.1.1. Possible solutions for extending the MPEC SA's network.

The accomplishment of the project requires cooperation between the Office of Cracow Community, Voivodship and the Municipal District Heating Company, Co. (MPEC SA) and the Cracow Heat & Power Plant, Co. (EC Kraków SA).

Below are listed possible actions aiming at providing conditions for a successful program accomplishment:

a) intensifying by the Office of Voivodship Administration steps leading to charging the owners of local boiler houses with the costs of using the natural environment by means of payments and fines administered in relation thereto and by issuing the writs of closing down the particularly harmful installations.
b) rigorous application by the Community Authorities the provisions resulting from the Environmental Protection Act in order to arrange such plans related with air protection; those plans shall actually improve the local air quality. However, in the case when, despite applying penalties and other administrative means provided, either an

owner or user of boilers causing degradation of the natural environment does not comply with the environmental protection act, he shall be made to have the noxious boiler replaced and the operation of the boiler shall be prohibited[1].

c) Rendering the lands belonging to either the Community or the Treasury available for extending the MPEC SA network.

d) The Office of Voivodship Administration shall help the individual investors eliminating local boiler houses by extinguishing penalties and payments for the use of the natural environment (the means gained this way must be apportioned for the participation in the program) and the Community shall assist the investors through tax exemptions in their favor.

3.1.2. Conclusions regarding the profitability of connecting the MPEC SA's heat distribution network in lieu of the boiler houses under elimination.

POLINVEST has performed a preliminary profitability analysis for the conversion of 70 solid fuel-fired boiler houses in 4 regions of Cracow. Below are listed general conclusions regarding the feasibility analysis of the investments consisting in converting the solid fuel-fired boiler houses into the MPEC SA central heating network supply:

a) An impediment in the accomplishment of the investments can be the today's unified rates of the MPEC SA; this tariff causes that the owners of the local boiler houses under elimination shall have to bear nominally high participation payments in order that the investment being discussed on may be profitable for the MPEC SA. According to POLINVEST even in the case of the conversion being profitable for the owners of a local boiler house, the owners may be unable to settle the whole payments for having no proper financial resources at their disposal;

b) seeing the situation described in a), the MPEC SA shall be obliged to take over some investment outlays on themselves and try to get them gradually refunded by collecting an extra investment fee;

c) one should aim at a connecting boiler houses in groups making a joint use of some installations (e.g. local centers and main lines);

d) it arises out of the analyses presented that the current costs of heat production in local boiler houses are in most of cases ranging between US $5 and US $6. 5 per 1 GJ. Provided that MPEC had offered in 1992 the price of $4.64/GJ being the sum of (B) and (C) components of a three-segment tariff, the value of (A) component securing the refund of the outlays borne[2] would have been comprised in 1992 in the interval $0.36 - 1.84/GJ. Should instead the MPEC collect a higher investment fee, the conversion would become unprofitable for the owners of local boiler houses.

e) The conversion profitability is dependent most on average outlays per kW of power ordered by prospective recipients of heat from local boiler houses after having them converted into the central heating network. It should be the preliminary parameter at the pre-selection of the examined boiler house groups.

f) For 70 boiler houses tested and of a total output of 17 919 [kW][3], the conversion of only 26 (i.e. 37.1%), of a total output of 4 561 [kW] (i.e. 25.5%) did not require any incentives.

g) Should each boiler house be examined separately, the conversion of the remaining 44 local boiler houses (62.9%) of a total output 13,358 [kW] that is 74.6% would require providing incentives of a value updated as for 1992 and equal to approx. $2 210 000 (constituting a sum of only negative NPV).

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1 Art. 76, points 1 and 2 of the Environment Protection and Formation Act dated January 31st 1980 (final text of the Act with successive amendments dated March 21st 1994, Official Gazette of Law no. 49, dated 15-04-1994).

2 i.e. an extra investment fee according to b)

3 Demand for power means such a power value that would be ordered by the recipients after having the boiler house converted into the MPEC SA central heating supply.

h) Should each boiler house be examined separately in the 4 regions under investigation, the connection of 1 MW of boiler house power per network would require providing incentives of a value updated as for 1992 and equal to approx. $123 333.

i) From the viewpoint of the policy conducted by the City, it is profitable to provide incentives and stimuli for connecting to the MPEC SA central heating network those local boiler houses which belong to the groups with the majority of profitable conversions (e.g. for 8 local boiler houses in the region of 7, Podwale-St. can be converted without incentives and stimuli; the connection of the 8th facility would entail incentives whose value would total approx. $11. 000).

j) In case the conversion of the said 70 boiler houses was implemented by the MPEC SA as one investment project, NPV for this project shall amount to approx. US$(198) 000[4]. The project accomplishment would therefore require incentives of a value updated as for 1992 of US$198 005 (that is approx. US$11 050 per 1 MW of power of a boiler house connected to the network).

k) The City Authorities can create non-financial incentives for the owners of boiler houses to encourage them to join the municipal network. In addition, the Community should support those prospective customers of the MPEC SA who from their own means must bear a part of outlays indispensable for the conversion (e.g. the modernization of internal networks). The level of those outlays has not been analyzed yet.

3.2. Conversion of solid fuel-fired local boiler houses into gas-fired ones in the Old City region.

3.2.1. The objective of the analysis

The analysis was aimed at determining the following data:

a) economic and legal circumstances securing the feasibility of an investment project consisting in converting the solid fuel-fired boiler houses into gas-fired ones in the Old City region,

b) the volume of means as incentives that seems necessary for the accomplishment of the projects

c) the sequence of the elimination of the boiler houses from the viewpoint of using the provided means by the City Authorities in order to eliminate low emission.

3.2.2. Conclusions on the investment profitability

Results of calculations of the pay back period of investment outlays without applying incentives indicate that the conversion into gas is economically not profitable from the investor's viewpoint.

The level of the necessary incentives for each of the three possible cases:

a) subsidies for heat energy prices;
b) subsidies for investment outlays;
c) subsidies as reduction in the tax on real estate.

It was calculated at what percentage level of subsidies on prices (Base version 1) and subsidies on outlays (Base version 2) the pay back period of investment outlays will be 10 and 20 years. At the same time it was found that even if a subsidy on investment outlays should reach 100% of their pre-set level , the NPV for 10 and 20 years is negative. Hence, the statement "the level of subsidies on investment outlays at which the pay back period is 10 and 20 years"

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[4] NPV for the whole project has been calculated as a sum of respective (positive and negative) NPVs found for each of the boiler houses under investigation.

hereinafter referred to, will also comprise such cases in which for the subsidies of 100% of the planned outlays, NPV in the 10th and 20th year is negative (the investment is not profitable). The subsidy on prices means that such a constant percent share of subsidies against the (increasing) production costs during the outlay pay back period so as to secure a positive NPV in the periods 10 or 20 years, respectively.

The calculation results related with the boiler house conversion indicate that:

a) potential subsidies on heat energy prices are of progressive course in successive years. It arises out of the fact that the base price related with increasing operational costs of the boiler houses in successive years also comes up.
b) giving up complex computations for the sake of simplicity it may be appraised that the amount of subsidies on prices (for a 10 years refund period) will be higher than the 10-fold subsidy amount given for 1994, and the amount of subsidies on prices (for a 20 years refund period) will be higher than the 20-fold subsidy on prices for the Base version 1 given for 1994;
c) the amount of subsidies on prices, computed as above for Base version 1, will be:
US$ 2 058 900 (for a 10 years refund period)
US$ 3 005 180 (for a 20 years refund period)
d) the amount of subsidies on prices, computed for Base version 2, will be:
US$ 3 928 540 (for a 10 years refund period)
US$ 6 606 820 (for a 20 years refund period).

The calculation results of subsidies on prices of energy and on outlays indicate that:

a) the subsidy on outlays is more efficient than on heat energy prices as less financial means are required;
b) should the City discontinue its support for the conversion of boiler houses in successive years, the subsidy amounts necessary afterwards will be appreciably higher than nowadays.

From the viewpoint of the owner of a boiler house who has no means for a conversion, a subsidy as a reduction of the tax on real estate is clearly less profitable than other possible options of financial assistance. In addition, such an incentive regards only some boiler house owners in Old City as not everybody pays this tax.

3.2.3. Results of the profitability analysis on the project from the viewpoint of the City Authorities

a) The performed analysis showed that in order to eliminate completely the coke and coal-fired boiler houses in the Old City region the Community of the City of Cracow will have to resort to incentives for potential investors.

b) In most of cases, the bearing of investment outlays for converting the coke and coal-fired boiler houses is not profitable from the viewpoint of the owners. Such investments would, however, bring considerable financial profits for the Community of the City of Cracow for the premises and plots situated in the center of Cracow being more attractive after having eliminated the low emission sources.
c) It is required that the Council of the City of Cracow passed a resolution on apportioning in 1996 and following years a part of money from the Community Fund for the Environmental Protection for subsidies on the outlays supporting the conversion of boiler houses in Old City. The amount of subsidies for about 30 boiler houses will be approx. ZLP 23 000 000 000 (US$1 064 554). The suggested sequence of converting the boiler houses and a detailed list of subsidies for respective boiler houses comprises an elaboration of POLINVEST entitled: "A Analysis on Stimuli and Recommendation of the Actions that might be acceptable for the Municipal Authorities so as to encourage the Owners of Solid Fuel-Fired Boiler Houses to have them converted into Gas Fuel ones".

d) For a part of boiler houses, even granting the subsidies as high as 100% of the investment outlays will not secure a positive NPV during the project life. Postponing the investment in time will make it necessary to grant subsidies on outlays in 100% for each boiler house. A subsidy on outlays should turn out to be simpler in the performance and cheaper than other subsidy forms and more desirable from the investors' viewpoint.

e) In consequence of having the solid fuel-fired boiler houses converted into gas fuel in the Old City region there will be a reduction in the equivalent emission as high as 225 400 [kg/season] against the period from before the conversion. Data lists regarding a reduction in the equivalent emission in boiler houses after the conversion performed are comprised in the said elaboration of POLINVEST.

3.3. Extending the "£obzów" energy distribution system

3.3.1. Conclusions resulting from the analysis

Basing upon the assumptions resulting from the BRK's engineering studies and the information received from the Power Distribution Plant, two values of the Project PV have been computed. The first one has been found basing upon the forecast prices of electricity determined by POLINVEST; the other one has been determined by applying the DOE's forecast of energy price. The following results have been obtained:

a) in the case of using the POLINVEST's energy price forecast, the Project PV is negative and amounts to ZLP 23 465 000 000, that is US$ 1 011 728,

b) should the DOE's forecast be used, the Project PV is negative and amounts to ZLP 20 041 000 000, that is $864 097.

From the viewpoint of the Power Distribution Plant, the project of extending the "£obzów" energy distribution system is not profitable and the today's value of the necessary incentives is equal to the Project PV one.

PV of the Project without incentives would thus reach zero in the case if the volume of the energy sold should reach approx. 208% of the level assumed in the forecast.

3.4. Application of smokeless briquettes in lieu of coal for stove heating.

No briquettes are offered on the Cracow fuel market. As yet, no appreciable volumes of briquettes have been sold; it causes there is no fixed price for them. A comparative analysis by POLINVEST on the stove operational costs and regarding either coal or briquette firing, has been performed assuming that introducing briquettes on the Cracow fuel market is possible provided that the briquette price is fixed at a level close to the price of good quality coal, e.g. from WUJEK Coal Mine. The price relation does not concern those of one ton of coal and briquettes but those per 1 GJ of the energy contained in coal and per 1 GJ of the energy contained in briquettes. The price per 1 GJ from the coal from WUJEK Coal Mine amounted to $3.07 /GJ in 1994. The proposed briquette sales price in Cracow in 1995 and computed this way could be as high as $82.86 /t.

Instead of apportioning means directly of subsidies, the Municipal Authorities may influence a rise in demand for briquettes via economical actions. One of the possibilities is establishing a Budgetary Institution for briquette trading. The Budgetary Institution, pursuant to the Statutes in effect, avails itself of tax exemption and in grounded cases it may conduct its activity on prime costs, i.e. without generating profits. In addition, the Budgetary Institution can avoid the yard rental payments constituting a considerable cost component - if the yard area should be the Community property. All those components may cause that the Budgetary Institution - if established - might offer briquettes in Cracow at prices lower than in other fuel storage yards. A solution consisting in establishing the Budgetary Institution will, however, not diminish the costs borne by the Community, yet the financing procedure may be easier for the Municipal Authorities for being performed.

The City Authorities may also influence indirectly the project financing from the Treasury. It is possible that the Municipal Authorities will apply to the Minister of Finance for a temporary VAT exemption for briquettes. It is also assumed the manufacturer will sell a part of the output for Cracow without charging the profit margin. It might happen if he, supported by the Cracow Municipal Authorities, could obtain tax or customs tax reductions for exporting a part of the output.

3.4.1. Project profitability from the viewpoint of the municipal authorities

A stove user may use briquettes without any modifications in the stove itself. **The total costs related to the project accomplishment will be the sum of the costs related with the introduction of briquettes on the market at a price competitive to that of coal and the promotion-related advertisement campaign.** Those costs may be borne either by the municipal authorities interested in the elimination of low emission or by the investors and tradesmen bearing only the risk of starting a briquette market in Cracow or by a briquette manufacturer who will consider the current investing for the sake of future profits to be gained profitable.

From the City's viewpoint, the project under discussion constitutes a part of a larger strategy. The project profitability should be assessed from the viewpoint of a rise in profits on tourism and savings in the National Health Service expenses arising out of a diminution of emission. But such questions exceed the range of this paper aimed at determining only the efficiency of the financial means engaged.

Possible subsidies to briquette prices will not be necessary as long as briquettes are more expensive than coal by only 5%.

3.5. Operational strategy of the municipal authorities and procedures necessary for the elimination of low emission

3.5.1. Preliminary comments

The task of the Cracow authorities is elaborating a long range operational strategy enabling the elimination of low emission in Cracow. The results of POLINVEST analysis indicate that the accomplishment of projects serving for the elimination of low emission will entail financial incentives. With the present resources which may be used in this purpose and coming from the Community budget, this process will be lasting for a dozen or so years. The process of elimination of low emission entails a joint involvement of the following parties:

a) local authorities
b) investors
c) owners and users of low emission sources
d) inhabitants referred to in respective projects.

3.5.2. Tasks of the municipal authorities.

The Community authorities may start the following actions for creating proper conditions for the operation of investors in the field of elimination of low emission sources :

a) passing local statutes with incentives,
b) apportioning means from the Community budget and the Community Environmental Protection Fund for supporting investors (participation in the financial montage of respective projects),
c) bidding for the accomplishment of the investments supported by the Community in order to eliminate the low emission sources,
d) financial and organizational support for social initiatives related with the elimination of low emission sources by establishing, among others, the Office for Program Promotion and Services .

3.5.3. Financial assembling

The basic instrument necessary for the accomplishment of investments can be the **financial assembling.** In the case of the projects under investigation it may turn essential to obtain a few financing sources for each investment. The means for the accomplishment of investments with the application of the financial montage will be, for example, obtained from the following sources:

a) from investors (enterprise);
b) from the Community budget;
c) from the environmental protection funds;
d) from the credits to be used for the investments related with the environmental protection;
e) from the private shares of the owners or users of low emission sources and of the inhabitants involved in the given project.

It is the task for the municipal authorities to gain over the following firms and enterprises to accomplish the low emission sources reduction program:

- units generating and delivering heat energy
- distributing fuels and energy
- rendering different services e. g. sales, installations, maintenance and operating the heating systems.

With the present the legal circumstances it is possible that the Community may grant subsidies for the investments related with the reduction of low emission from the means apportioned for supporting social initiatives. Whether those initiatives are successful or not depends on the volume of the means provided in this purpose in the budget and on the activity of the inhabitants.

3. 6. Incentives for respective subprojects of the Program of the low emission reduction.

3.6.1 ***Subproject no 1 -*** *connecting of the existing boiler house to the MPEC SA's network*

For the performance of Subproject no 1 the proper incentives are:
a) issuance of writs prohibiting further use of solid fuel-fired boiler houses;
b) financial support from the Community fund for environmental protection and other environmental protection funds;
c) financial support from the foundation.

3.6.2. ***Subproject no 2 -*** *a conversion of solid fuel-fired boiler houses into gas ones in the very centre of Cracow*

The proper incentives for the performance of Subproject no 2 are:
a) issuance of writs prohibiting further operation of solid fuel-fired boiler houses;
b) reduction in the tax on real property;
c) issuance of permits for major repairs of tenant houses provided that the hitherto heating process is changed;
d) financial support from the Community fund for environmental protection and other funds;
e) financial protection with the means from the foundation.

3.6.3. *Subproject no 3* - *exchange of coal-fired stoves for electric heating*

The proper incentives for the performance of Subproject no 3 are:

a) establishing and supporting social committees for building and extending power distribution and supply installations;

b) reduction in the tax on real estate;

c) issuance of permits for major repairs of tenant houses on condition of changing the hitherto heating process;

d) financial support from the Community fund for environmental protection and other funds;

e) financial aid with the means from the foundation.

3.6.4. *Subproject no 4* - *a modernization of combustion processes of solid fuel in borough and technological boiler houses not subject to conversion into gas nor connecting to the MPEC SA.*

In order to have Subproject no 4 realized the proper incentives will be:

a) issuance of writs ordering the limitation of emission from the solid fuel-fired boiler houses under operation;

b) financial aid with the means from the Community fund for environmental protection and other funds;

c) financial aid with the means from the foundation.

3. 6. 5. *Subproject no 5.* - *a conversion of the fuel currently used in coal-fired stoves into a fuel of lower noxiousness to the environment.*

The proper incentives for the accomplishment of Subproject no 5 are:

a) issuance of a writ prohibiting the sale of coal of a worse quality;

b) supporting the production and sale of dressed (washed) coal in Cracow;

c) supporting of the production and sale of smokeless briquettes in Cracow.

THE SELECTION OF THE AMERICAN-POLISH JOINT VENTURE PROJECTS FOR THE KRAKOW PROGRAM AND RESULTS OF THE EFFORTS TO DATE

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ABSTRACT

To implement the Krakow Clean Fossil Fuels and Energy Efficiency Program, eight U.S. firms were selected by the U.S. Department of Energy to market their technologies to reduce pollution from low emission sources in Krakow. The eight U.S. firms were selected by a competitive solicitation that required the proposing firms to themselves provide funding to match or exceed the funding provided by the Program. These U.S. firms and their Polish partner companies have begun sales and cooperative work efforts in Krakow, and some have already made initial equipment installations with measurable performance improvements. Following their efforts as part of the Program, these U.S.-Polish joint ventures will market their technologies and achieve the associated environmental benefits elsewhere in Poland and Eastern and Central Europe.

As part of the Krakow Program a spreadsheet model was developed to compare technological options for supplying heat to the city by calculation and comparing the heating costs and associated emissions reduction for each option. Comparison of options is made on the basis of the user cost-per-metric ton of equivalent emissions reduction. For all options considered in the Krakow Program, this cost parameter has ranged from -$1469 (best) to $2650 (worst). The costs for technologies associated with the eight projects in the Krakow Program are at the lower end of this range placing these technologies among the most cost effective solutions to the pollution problems from the low emission sources.

INTRODUCTION

The Krakow Clean Fossil Fuels and Energy Efficiency Program (or Krakow Program) was initiated to reduce pollution from coal- and coke-fired low emissions sources (i.e., small-scale boilers and home stoves) in Krakow, Poland. The Krakow Program was designed to be a model for reducing pollution from low emissions sources elsewhere in Eastern and Central Europe by obtaining information about representative equipment and fuels and by the application of U.S. technologies.

The United States Department of Energy (USDOE) is administering the Krakow Program with funds provided by the United States Agency for International Development (USAID). In October 1991, U.S. and Polish officials signed a Memorandum of Understanding formally initiating the Krakow Program and establishing a Bilateral Steering Committee (BSC) to provide direction and oversight for the Program. The BSC is composed of representatives of USDOE, USAID, the City of Krakow, and the Ministry of Environmental Protection, Natural Resources and Forestry of the Republic of Poland.

The possible technical approaches for emissions reduction in Krakow were organized into five areas of interest (sometimes called "subprojects" or "pilot projects"):

1) Energy Conservation and Extension of Central Station District Heating. Energy conservation and the installation of energy efficiency measures reduce the load and emissions from boiler houses or make more heat available for expansion of the district heating system. Extension of the central station district heating system results in the elimination of local boiler houses in favor of heat supplied by more efficient, less-polluting cogeneration plants.

2) Replacement of Coal- and Coke-Fired Boilers with Natural Gas-Fired Boilers. The feasibility of such replacements is limited to areas of the city, such as Old Town, where natural gas is available and the infrastructure is sufficient to handle the additional load.

3) Replacement of Coal-Fired Home Stoves with Electric Heating Appliances. This involves the installation of electric thermal storage heaters or the refit of heating coils to home stoves. Such conversions are feasible in areas of the city where excess electrical capacity is available, but requires extensive rewiring of apartments and the use of day/night electric rates.

4) Reduction of Emissions from Boiler Houses Firing Coal and Coke. Many local boilers are relatively new or are far from existing district heating lines. These boilers will not be replaced or eliminated, but there are numerous alternatives to increase their efficiency and reduce their emissions. These boilers can be modernized by the addition of economizers or pulverized coal firing systems. Their efficiency can be improved by the installation of automatic combustion controls or by the use of coal that is cleaned and properly sized for stoker firing. Emissions from these boilers can be reduced by the upgrade of existing cyclones, the installation of other particulate control devices, or the incorporation of other flue gas cleanup techniques.

5) Reduction of Emissions from Coal-Fired Home Heating Stoves. Due to the historical significance and esthetics of the tile home stoves, it is doubtful that these stoves will be replaced by other stoves or significantly modified, while still firing coal. Emissions reductions from home stoves are possible through proper operation of these stoves and the use of smokeless fuels, such as certain briquettes.

The BSC structured the Program in three phases. Phase 1 consisted of information gathering and data analysis. In this phase, various technological alternatives for pollution reduction were identified. Combustion tests were performed to measure the emissions reduction performance of each technology, and economic analyses were performed to determine the cost of implementing these alternatives. Regulatory and financial incentives were identified to encourage the implementation of these technological alternatives.

Phase 1 was conducted by Biuro Rozwoju Krakowa (BRK) and its subcontractors through contracts with the Brookhaven National Laboratory (BNL) and the Pacific Northwest Laboratory. The Final Report on the Phase 1 activities is to be available from BNL and BRK in October 1995.

Phase 2 of the Krakow Program consisted of three public meetings designed to inform U.S. and Polish businesses about the Program and its opportunities. The meetings were held in Chicago, Illinois and Washington, D.C. in June 1992 and in Krakow in November 1992. At these meetings, the initial results of Phase 1 were presented and the opportunities of Phase 3 were announced.

Phase 3 of the Krakow Program consists of projects conducted by joint ventures of U.S. and Polish companies to introduce U.S. technologies and services to reduce emissions in Krakow. The process by which these companies were selected and the results of their efforts is the primary subject of this paper.

THE SELECTION OF PROJECTS AND PARTICIPANTS FOR PHASE 3

Based upon the public input from the meetings in Phase 2, USDOE authored and in September 1992 issued a solicitation to support projects to reduce emissions from small-scale coal-and coke-fired boilers and coal-fired home stoves (the low emissions sources) in Krakow, Poland. The solicitation requested proposals from U.S. firms for cost shared Cooperative Agreements. U.S. firms that proposed were strongly encouraged to include Polish firms as team members. The minimum cost sharing was 50 percent to be provided by the U.S. firm, its Polish team members, or third party investors.

All proposals to the solicitation were required to describe a project to provide equipment, fuels, or services to reduce emissions in the city of Krakow within the scope of one of the five areas of interest. The equipment, fuels, or services proposed were to be associated with a U.S. technology that was either commercially available or ready for commercialization. The proposed projects were to be of two to four years in duration and were to establish businesses in Poland to market and utilize the proposed technologies for the immediate benefit of Krakow. Once established by the projects, these businesses were to remain and to service the larger markets in Poland and elsewhere in Eastern and Central Europe.

Proposals were received by USDOE in February 1993. No acceptable proposals were received that addressed the second and third areas of interest, conversions to gas or electricity. The proposals were evaluated by a USDOE board according to predetermined criteria that were published along with the original solicitation document. These criteria were used to score each proposal according to the performance and advantages of the proposed technology, the size of the market and the proposer's approach to it, projected pollution reductions and associated costs, and the capabilities and experience of the proposed U.S.-Polish teams. The USDOE evaluation board was advised by a group of Polish engineers and by the BSC.

Following the evaluation process, proposals submitted from the following nine firms were selected for award of Cooperative Agreements in the Krakow Program:

Addressing energy efficiency or the district heating system:

- o Shooshanian Engineering Associates of Boston, Massachusetts,
- o Hart Associates, Inc. of Washington, D.C.,
- o Honeywell, Inc. of Minneapolis, Minnesota,

Addressing the reduction of emissions from boilers:

- o Control Techtronics of Harrisburg, Pennsylvania,
- o Tecogen, Inc. of Waltham, Massachusetts,
- o LSR Technologies of Acton, Massachusetts,
- o TCS, Inc. of Annapolis, Maryland,
- o EFH Coal Company of Wilkes Barre, Pennsylvania, and

Addressing the reduction of emissions from home stoves:

- o Acurex Environmental Corporation of Mountain View, California.

After selection, the proposal from Hart Associates was withdrawn. USDOE conducted negotiations with the remaining eight firms such that Cooperative Agreements were awarded to these firms between February 1994 and August 1994.

DESCRIPTION AND STATUS OF THE PHASE 3 PROJECTS

Shooshanian Engineering Associates has teamed with Miejskie Przedsiebiorstwo Energetyki Cieplnej (MPEC), which is the Krakow municipal district heating utility, and Polinvest, a Krakow economic and legal consulting firm, to plan, design, and implement extensions of the central station district heating system. These extensions will supply district heating as hot water provided primarily from Elektrocieplownia Krakow (ECKSA), the Krakow combined heat and power plant, which fires low-sulfur coal and is equipped with efficient electrostatic precipitators for control of particulates. Local coal- or coke-fired district heating boilers within range of the pipeline extension and their pollutant emissions could be eliminated. The new sections of the district heating system are being designed incorporating state-of-the-art conservation features.

In the project, Shooshanian and MPEC have extended the district heating line and connected the main PKP railway terminal, eliminating 3 MW of local boilers. Agreements have been signed with other boiler house owners in the area to connect to the MPEC system and retire 2.7 MW of coal-fired capacity. The pipeline extension to the PKP terminal has created the potential for over 20 MW of new district heating customers who previously did not have the option to connect to the system. This pipeline extension also facilitates the future connection of MPEC pipelines in the northern and western portions of the MPEC system, which will act to balance system pressures in the area and permit improved supply of heat to some present MPEC customers and provide district heat as a new option for other potential MPEC customers.

Shooshanian has developed a manual for marketing and customer service training and has conducted training sessions for MPEC both in Boston and Krakow. This training will help MPEC to educate its customers in the advantages of district heating and to provide new and beneficial customer services that will enhance the appeal of district heating. With this training and assistance from Shooshanian, MPEC plans to begin a customer service department.

Honeywell has teamed with MPEC to utilize controls and automatic supervision of the district heating system to improve its efficiency. Honeywell and MPEC will upgrade the controls in the district heating system from the Balicka boiler house. The Balicka boiler house and the Widok housing community which it serves are not connected to the central station district heating system of MPEC. Honeywell will supply the Balicka boiler house with a Supervisory Control and Data Acquisition system for its local network, will replace existing hydroelevators in Widok buildings with heat exchangers and control equipment, and will install thermostatic radiator valves (TRV's) in all apartments of the Widok community. These improvements will allow MPEC to perform demand side management in the Balicka network, will permit more efficient operation of the heating system, and will reduce emissions from the Balicka boiler house.

Honeywell will also assist ECKSA in its efforts to connect new customers to the district heating system. In this cooperation Honeywell will supply controls for these new district heating connections.

To date in this project, the Balicka supervisory system has been installed, and system startup is planned for the beginning of the 1995-96 heating season. Fourteen building heat exchangers (in nine buildings) and one group heat exchanger have been installed in the Widok housing community, and the building heat exchangers have already been put into use. The software for control of the group heat exchanger has been prepared for startup. TRV's have been installed in all apartments in six buildings and three pavilions in the Widok housing community.

Four group heat exchangers have been installed for district heat connections in cooperation with ECKSA eliminating over 11.5 MW of coal-fired boiler capacity. Startup and operations training for these installations has been completed.

Control Techtronics is working with the Pennsylvania State University, MPEC, Naftokrak-Naftobudowa, Polytechnika Krakowska and Energoaparatura to increase boiler efficiency and reduce emissions from local boiler houses by the installation of automatic combustion controls. The project includes training in combustion techniques and automatic controls, and the combustion controls installations will utilize clean, graded coal to further reduce emissions. A total of five installations are planned in this project.

Training material written and used at the Pennsylvania State University has been translated into the Polish language and transferred to the Polytechnika Krakowska to offer future training courses in Krakow. The first automatic combustion control system has been engineered for the Balicka boiler house by Control Techtronics. Control panels for Balicka have been fabricated and the control system assembled by Energoaparatura. The combustion control system was installed by Naftokrak-Naftobudowa, and the system will communicate with the supervisory district heating system installed at Balicka in the Honeywell project.

Performance testing of the automatic controls system at Balicka in April 1995 showed an energy savings of 25 percent and a particulate emissions reduction of 85 percent for the projected boiler usage loads compared to the results of baseline tests. The performance tests also showed that the controls system and graded coal permitted boiler operation at a much lower boiler load than previously. The system at Balicka is also projected to have a two-year payback on the investment based primarily on the increased efficiency of operation.

In its project, Tecogen is forming a joint venture with MPEC, Naftokrak-Naftobudowa, and the Japan International Development Organization (JAIDO). The joint venture, named Ecogy, will design and install various boiler system modifications to improve system performance and reduce emissions. Tecogen proposed to install an economizer, automatic combustion controls, and a flue gas recirculation system, improve existing cyclones, and utilize cleaned and graded coal at MPEC's Krzeslawice boiler house. Equipment installation will be performed by Naftokrak-Naftobudowa, and cost sharing for the project is being provided by JAIDO. The unique aspect of the Ecogy approach to boiler modernization is that the customer pays for the new equipment and other modernization costs through a shared savings plan agreement.

The Tecogen project has been delayed because of drastically reduced heat demand from the Krzeslawice boiler house. Whereas significant engineering efforts have been completed for the Krzeslawice installation, the Ecogy joint venture has been negotiating with the owner of another very similar boiler house with a higher boiler heat load. Ecogy's negotiations are being conducted to improve both the emissions reductions and economic performance for its first installation.

LSR Technologies is teaming with EcoInstal and the Polish Foundation for Energy Efficiency (FEWE) in Katowice to utilize LSR's novel particulate collector called a "core separator." The core separator is more efficient than a cyclone, and its low cost, simplicity, reliability, and ease of maintenance make it ideal for the small boiler market. The LSR project includes exchange of information and equipment with its fabrication partner, EcoInstal, for modern, automated fabrication of core separator components. The team plans seven core separator installations in Krakow in the project.

Marketing efforts by FEWE and EcoInstal have resulted in several installations of core separators in Poland but none yet in Krakow. Testing of the first core separator installation at a boiler in Oborniki have shown particulate reductions greater than required by performance guarantees. The Oborniki site is now available for potential customers to observe the core separator in operation. The first installation of a core separator in Krakow as part of the LSR project in scheduled for fall of 1995.

TCS proposed to work with OPAM and Polish Military Unit No. 1616 to install a combustion system firing micronized coal at the boiler house operated by the Polish military at the Balice Airport. The combustion system would be composed of a coal micronization mill and combustor together with a baghouse produced by the U.S. firm Amerex, Inc. of Woodstock, Georgia. The mill is designed to co-micronize limestone for reduction of sulfur dioxide emissions, and the baghouse captures both flyash and spent limestone sorbent. The micronized-coal combustion system equipped with a baghouse promises more complete combustion, lower emissions of nitrogen oxides, reduced boiler fouling, and lower sulfur dioxide and particulate emissions.

In the first year of its project, TCS conducted a significant amount of design work to prepare its proposal to the Polish Military. TCS also conducted combustion tests of Polish coals and characterization tests of Polish limestones to select an active sorbent for sulfur removal and to provide basic information necessary to prepare the system design. However, after considering the TCS proposal, the Polish Military has decided to install a gas-fired boiler at its base at the Balice Airport. As a result, TCS with help from Elektrim and other Polish and U.S. firms has been looking for another site for the installation of the TCS combustion system. Funding for the TCS project is still available if TCS and its team members find a new host site.

EFH Coal Company has teamed with MPEC and Naftokrak-Naftobudowa to build a coal preparation plant to provide cleaned and graded coals for stoker fired boilers in Krakow. As part of the project, the Pennsylvania State University will conduct laboratory-scale combustion tests to ensure proper preparation plant design and boiler combustion tests to confirm improved boiler operating performance and reduced emissions.

EFH Coal Company, MPEC, and Naftokrak-Naftobudowa have negotiated and signed agreements forming a joint venture company named Ecocoal. The joint venture has secured an abandoned dolomite mine in the Katowice Voivodeship as the site for its coal preparation plant. While the joint venture is obtaining permits for construction and operation of the plant, EFH and its partners are negotiating with coal mines for coal supply and with boiler owners for sales of cleaned stoker-grade coal and other coal fuels from the preparation plant.

Acurex Environmental Corporation has teamed with Planmar Consulting of Research Triangle Park, North Carolina, the district heating company of Chrzanow, Eurominíng, and the Academy of Mining and Metallurgy (AGH) of Krakow to introduce coal briquettes to the Krakow market. Compared to coal firing, the coal briquettes with a proprietary binder promise to reduce emissions of particulates and carcinogenic hydrocarbons from home stoves and small boilers.

AGH's briquetting laboratory prepared numerous laboratory-scale batches of briquettes for tests of the briquettes' physical properties and for combustion testing in the instrumented home stove facility at AGH. The tests were conducted to determine the best Polish coal and binder ingredients and proper proportions to obtain the necessary physical integrity, combustion performance, and emissions reductions. Larger batches of the briquette showing the best overall performance were produced by Euromining at its pilot-scale facilities in Lublin. Combustion tests of these briquettes were conducted at the AGH home stove facility and in boilers in Chrzanow and Krakow.

Test results showed that the Acurex fuel demonstrated 55 percent reduction of particulates, 35 percent reduction of total hydrocarbons, and 29 percent reduction of carbon monoxide on a heat basis when compared with the combustion of good quality chunk coal. It was also found that a larger briquette was stronger and that emissions were lower from briquettes made from more finely ground coal. The Acurex fuel had no effect on emissions of sulfur or nitrogen oxides. As such, the environmental qualities of the fuel will be enhanced by the use of washed coal fines for fuel preparation. Furthermore, the reduction in total hydrocarbon emissions corresponded to similar reductions in non-volatile and semi-volatile organics.

Acurex also conducted a marketing study in Krakow by supplying over 200 home stove users who volunteered to receive free fuel in exchange for the completion of a survey related to the users' impressions of the performance of the fuel. In general, these potential customers were pleased with the performance of the Acurex fuel. While they indicated a concern for the quality of the air in Krakow, these potential customers indicated that fuel price in comparison to chunk coal would be the determining factor in their future decision to purchase the fuel.

Acurex has identified a site for the manufacture of a full-scale plant to manufacture its fuel for use in Krakow and neighboring communities. Acurex is currently securing access to the site and obtaining the cost sharing necessary to match Program funds for the construction of the plant.

COST EFFECTIVENESS OF THE TECHNOLOGIES SUPPLIED BY THE AMERICAN-POLISH PROJECTS IN THE KRAKOW PROGRAM

Fully eliminating the pollution problems caused by the low emission sources will present a cost burden which can be met in a variety of ways including higher energy costs, direct capital subsidies, increased rents, directed tax reliefs, low interest loans from environmental funds etc. Regardless of how the costs are absorbed it is clearly in the best interest of the city to promote the most cost-effective options. Some options which have been considered by the City, for example gas conversion or connection of all local boilers to the district heating system, would present more of a cost burden than the City could absorb in the near term and lower cost, intermediate solutions should be considered. There are many different ways in which options can be compared. One approach being used in this program is based on a spreadsheet program written under DOE sponsorship specifically for making simple comparisons between such options.

The spreadsheet program was written as a screening tool, providing a rapid method of analysis of many options primarily to aid policy decisions on a city-wide scale. Two important simplifying assumptions are used in the model including: 1) constant fuel and electric energy prices over the project life, and 2) the use of averaged capital costs for conversions between options and other costs averaged for large categories of emission sources. Even with these simplifications the spreadsheet program is a very effective and efficient tool for rapid comparisons of options.

In the spreadsheet program all of the low emission sources in the city are placed into categories based on physical characteristics and type of fuel used. This spreadsheet has been developed as a general tool and has been applied to several Central European cities. In the application to Krakow the low emission sources have been divided into 25 categories. For example, one defined category is hand-fired boilers which burn coke and do not have cyclone particulate collectors. For each such category, information is entered on total current (baseline) fuel use, efficiency, fuel type and cost, air pollutant emission factors, operating costs, and maintenance costs. In Krakow this information was derived from surveys made of the boiler and stove populations and also from the engineering cost studies and the source testing program conduced as part of this work.

Some of the categories defined in the spreadsheet are only possible, future options and, in these cases, baseline fuel use is zero. Using the spreadsheet, heating options available to the city can be compared by varying the fuel use assigned to each defined category and tallying the resultant costs and emissions. In this way, future options can be factored into the city's heating mix and compared to current heating methods. For example, one category consists of coal-fired tile stoves with a very substantial current fuel use, and another category consists of the same stoves firing smokeless briquettes which are not yet available in Krakow. Using the spreadsheet, the impacts of using such a candidate alternative fuel in some or all of the home stoves can be evaluated by moving capacity from the coal-fired stove category into the briquette-fired stove category.

In evaluating options using the spreadsheet there are several choices:

1. heating capacity can be changed from one category to another (for example from hand-fired boilers to gas-fired boilers);
2. the efficiency of boilers or stoves in a category can be increased (by adding economizers to boilers for example);
3. heat demand and fuel use in a specific category can be reduced through building energy conservation measures;
4. pollution controls can be added or upgraded in a specific source category.

For each of these choices capital costs of the modifications must be input as well as operating, fuel, and maintenance costs. Output from a spreadsheet run includes total emissions for each pollutant before and after the option is implemented, and total annual "user" costs before and after. The user costs include energy costs, operating costs, and maintenance costs.

The spreadsheet program provides details of costs and emissions of specific pollutants before and after conversion in tabular and graphical form. It is useful, also, to have a single number which indicates the cost effectiveness of each case being evaluated. To do this emissions of specific pollutants are first combined into a single "Equivalent Emission" defined as:

$$\mathbf{Ee = 2.9\ (Ep + ENO_x) + 0.5\ ECO + ESO_2}$$

where:
Ee = Equivalent Emissions, metric tons per year
Ep = particulate emissions, metric tons per year
ENO_X = nitrogen oxide emissions, metric tons per year
ECO = carbon monoxide emissions, metric tons per year
ESO_2 = sulfur dioxide emissions, metric tons per year

Conversion or upgrade capital costs are then annualized assuming a project life of 20 years and an interest rate of 15 percent. This annualized capital cost is then added to the annual user cost and the result is termed the "user combined cost". Finally, for any specific option implemented the change in user combined cost is calculated per-ton of reduction of equivalent emissions. This user combined cost-per-ton of Ee reduction is then taken as a primary basis for comparing options.

As a part of Phase 1 of this program a wide range of options for the low emission sources were evaluated [1]. For these the user combined cost-per-ton of Ee reduction ranged from a low of -1469 (best) to a high of 2650 (worst). If an option has a negative number for this parameter, the user will ideally save money by taking this approach. This program has sought to identify options of this type wherever possible.

The most cost effective options were those which involved improved coal-based fuels, operations improvements, and minimal capital investments. This includes using better coal at stoker fired boiler houses in combination with efficiency improvements, and switching home stoves and hand-fired boilers to better briquettes. The highest cost options included major reconstruction of the stoker-fired boiler houses including the installation of new boilers, conversion to gas, and conversion to electric heating. Elimination of local boiler houses by connection to the district heating system is somewhat difficult to evaluate generally using this spreadsheet because connection costs are very site-specific. On average, however, district heating connection is relatively attractive.

All of the projects in Phase 3 of this program are in areas which the spreadsheet analysis shows to be attractive. The projects with LSR, TCS, Tecogen, Control Techtronics, and EFH Coal Company in different ways will take advantage of the cost effective opportunities for emissions reductions which exist at the stoker-fired boiler houses while retaining the existing boilers. The projects involving Shooshanian Engineering and Honeywell address the most economical opportunities for expansion of the district heating system. The Acurex project addresses fuel switching and the spreadsheet analysis has shown this generally be a very attractive area.

The spreadsheet analysis has been used to address options in a general sense. In their current activities the Phase 3 companies are developing cost and performance data which will allow their project to be compared specifically using the spreadsheet. Currently data is available which will allow some of these project to be compared in this manner.

As a first example the Acurex briquettes are expected to be sold at a price similar to the coal currently used in home stoves. As previously discussed, extensive combustion testing of Acurex briquettes at AGH in Krakow gave a reduction in particulate emission of 55% and a reduction in CO emissions of 29% relative to fuels currently used. In addition, new stove operating procedures have been developed at AGH which will allow stoves to be operated with higher efficiency, further reducing emissions. While these procedures can be used to increase efficiency even with current fuels it is expected that the introduction of the Acurex briquettes would be done along with an information campaign instructing residents of the best procedure to use with this specific fuel. An analysis of the relative attractiveness of the Acurex briquettes has been done using the spreadsheet with several different sets of assumptions. While Acurex is projecting this fuel will cost about the same as current fuels this analysis has also evaluated cases in which the briquettes may cost more. Results are shown in Table 1 below.

Table 1. Analysis of Cost of Pollution Reduction with Acurex Briquettes

Case Assumptions	User Combined Cost per Ton of Equivalent Emission Reduction
Acurex fuel cost same as current coal. Efficiency with current coal 60% and with Acurex fuel 72%	-146
Acurex fuel cost $10 more per ton than current coal. Efficiency with current coal 60% and with Acurex fuel 72%	-36
Acurex fuel cost $20 more per ton than current coal. Efficiency with current coal 60% and with Acurex fuel 72%	+74
Acurex fuel cost $10 more per ton than current coal. Efficiency with both current coal and Acurex fuel 60%.	+129

The results of the analysis done with all of the above assumptions are relatively good. In comparison the spreadsheet analysis has shown that conversion of the home stoves to electric heating has a user combined cost per ton of equivalent emission reduction of $930. Conversion to gas heating with a small boiler in each apartment has a user combined cost per ton of equivalent emission reduction of $1720.

Another example case for which there is currently sufficient performance data and cost information available is the Control Techtronics project. Based upon the results obtained at the Balicka boiler house and assuming that the boilers would switch to improved coal with a price of $43.00/ton vs. the current $31/ton the user combined cost per ton of equivalent emission reduction is -400.

Other Phase 3 projects have not yet been analyzed using the spreadsheet primarily because of insufficient site specific data. In some cases the above results can be extended to show that these have the potential to be as attractive. The projects involving Tecogen, Inc. for example are expected to yield very similar performance results to the Control Techtronics projects. EFH Coal Co. is developing a source for the improved coals which can also allow substantial performance improvements to be realized at the stoker-fired boiler houses.

CONCLUSION

Phase 3 of the Krakow Program was designed to implement pollution reduction from the low emission sources in Krakow through the introduction of U.S. technologies and services. Using a competitive solicitation, eight U.S. firms were selected to participate in Phase 3. These eight projects offer some of the most cost-effective solutions to control pollution from low emission sources. These projects are presently underway in Krakow, and the eight U.S. firms together with their Polish partners have already completed the initial installation and operation of equipment. This is just the beginning of Phase 3, as the bulk of the implementation efforts and the resulting reduction in pollutant emissions are yet to be achieved over the next several years.

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Session IV

Use of the Results of the Low Emission Sources Project in the Development of a Model Energy System Management in Kraków

Co-Chairmen: Jan Friedberg, Deputy Mayor of Kraków and Joseph Strakey, U.S. Department of Energy

EFFECT OF CRACOW PROGRAM OF ELIMINATION OF LOW EMISSION SOURCES UPON THE ENERGY MANAGEMENT SYSTEM IN CRACOW

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ABSTRACT

At the end of the 1980s, the energy management at the local level - like the whole set of such utility services - was based upon respective enterprises subject to a certain supervision of the establishing body and to a control of the District Inspectorate of Energy Management. Those enterprises that deal with generation and supply of heat energy to the local market, with distribution of heat, natural gas and electricity, operated as state companies; the last two branches made a part of either regional or national companies. Irrespective of the aforesaid, the co-generation power plants existed usually outside the heat generation and supply system. The business economics of these enterprises was not subject to any market rules whatsoever, the prices were controlled and the customers had no right of choice of the energy supplier.

From the very beginning the low emission elimination program assumed to have commercial rules introduced in the energy management. Thus, it turned out necessary to prepare the market - to draw up inventory of the conditions and needs related with heat supply and to take up market solutions as well. The management system, and in particular the items specified below, has been adjusted to those assumptions:

1. A general plan of the town development has been worked out with an assumption that there exist some zones of domination of respective energy media (based upon the existing systems), yet there are no administrative control methods as far as the access thereto is concerned.
2. The respective enterprises operate as self-dependent; they are to be transformed into commercial business units (although subject to certain regulations).
3. According to the Polish law, the ecological permits concerning permissible emissions are issued, yet regarding the principle of „trade with emissions"', viz. it is possible to exceed the permissible levels at some points on condition of their drastic diminution at other ones, where it can be done easier and less expensive.
4. The heat generation and distribution branch introduces the requirement of having the prices based upon a long-term investment and tariff making schedule. Furthermore a demand of an active role of the enterprise in actions in favor of energy conservation in the building sector, is implemented..
5. A system of incentives has been started in order to convert the traditional solid fuel-based heating systems into different, more efficient ones. In particular, the environmental protection funds (at the provincial and community level) support the conversion of coal- and coke-fired boiler houses into gas- or oil-fired ones and the connection of the solid-fuel-fired facilities to the municipal heating loop. In addition, the community has inaugurated a system of subventions for eliminating the household stoves; it prepares certain regulations in the field of licensing the fuel trade (in order to eliminate the solid fuels of the lowest quality).

The co-operation of energy distribution enterprises has been based upon a voluntary agreement (The Team for Energy Suppliers) so as to agree upon the basic actions of the respective partners; joint actions have been taken up more and more willingly.

PROGRAM OF „LOW EMISSIONS" ELIMINATION AND POWER RECOVERY BY THE KRAKÓW HEAT AND POWER PLANT FOR THE CITY OF KRAKÓW AND ITS RESIDENTS

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1. DESCRIPTION OF HEAT DEMAND IN 1990-1995

For over three years the Kraków Heat and Power Plant S.A. (ECK SA) has been implementing its strategy of adapting to operation and growth in the market economy. The accomplishments and results of these efforts are presented in the enclosed *Annual Report 1994.*

The social and economic conditions prevailing during the transformation from a centrally controlled economy to a market economy have changed the realities and regulations that restricted the availability of energy carriers. The continual shortages and restrictions on supplies of gas, electricity, heat and even solid fuels (coke) that occurred in previous years have been replaced by a surplus. That is why many investment planning decisions have had to be revised. A sharp increase in energy carrier prices has required detailed analyses and viability studies to be made before final investment decisions are made. The choice of fuel and heating methods has begun to be dictated by the market and the economy, and not by rationing and administrative decisions. Clearly, a free market in energy generation and distribution has come into existence in the Kraków urban area.

In 1990 the structure of the Kraków heating system was as follows:

Kraków Heat and Power Plant	1422 MW -	50.86%
industrial generators (soda factory and steel plant)	43 MW -	1.54%
Skawina Power Plant	13 MW -	0.4 %
local boiler houses	998 MW -	35.7 %
coal-fired stoves	240 MW -	8.6 %
natural gas	44 MW -	1.6 %
electricity	36 MW -	1.3 %

A drop in heat demand, brought on by energy price increases, deeper appreciation of the need to conserve energy, recession in housing construction, and other factors, have steadily reduced the thermal power ordered by MPEC S.A. (district heating utility) from ECK SA in recent years, amounting to:

1422 MW_t in 1990
1397 MW_t in 1991
1357 MW_t in 1992
1299 MW_t in 1993
1199 MW_t in 1994.

The lower demand for heat from ECK SA in 1991-93 was the result of the construction of the Zakrzówek pumping station, which permitted the area supplied by the Skawina Power Plant to be connected to the area supplied by the Kraków Heat and Power Plant; the connection reduced the thermal power taken from ECK SA by 100 MW.

The Plant began to have a surplus of about 250 MW_t of the installed capacity over actual power demand. There was also a surplus of the district heating network's transmission capacity , though not as large as the power surplus (additional power from the Skawina Power Plant).

The energy conservation drive is irreversible and should be estimated to result in a 25-40% drop in heat consumption on a macro scale.

In general, the trends outlined above will produce a situation in which the fixed costs (depreciation, repairs, payroll) incurred by manufacturers and distributors will be apportioned among a smaller number of power units (MW_t), thus increasing the capacity price (fixed payment). The fixed payment lowers with decreasing fixed costs (which depend on the power plant and the distributor) and with increasing power demand (which depends on the consumers). The customers who have bought heat up to the present, having no means of converting to other heating system, will be forced to pay increasingly higher prices only because of the decreasing heat demand. As this phenomenon will occur both at the generator and the distributor, the customers will suffer the combined effect of the price rise.

To counteract these phenomena the Plant has begun to restructure itself and is taking an active part in the program for elimination of „low emissions." The results and experiences gained during restructuring were presented at a conference held in October 1994. The restructuring consisted in reducing the Plant's activity exclusively to its basic activity, i.e. generation of heat and electricity. The extensive auxiliary activities, i.e. repairs, transport, social benefit services and other services, were separated and passed to newly formed limited liability companies; ECK SA's former employees who joined the new companies became also their shareholders. The restructuring improved the Plant's labor organization, the looks of the premises, and brought tangible financial advantages. The creation of these companies resulted also in higher productivity along with higher quality and a wider range of services to the Heat and Power Plant.

Our efforts to eliminate atmospheric pollution caused by local coal-fired boiler houses (supplying individual housing estates) was inspired by the financial assistance program of USD 20 M) granted by President George Bush. As part of the program a thorough survey of all local sources of air pollution was carried out. The survey showed that there are about 1100 local boiler houses in Kraków which contribute 35% of the sulfur dioxide concentration. In the area supplied by ECK SA there are 560 such boiler houses with a combined capacity of 357 MW_t. Their elimination, accomplished by connecting their clients' buildings to the district heating network supplied by ECK SA, will permit an 8-20% reduction of sulfur dioxide in Kraków.

As results clearly from the reports of the American-Polish Program, a solution to the problems of „low emissions" and the recovery of power by ECK SA is in the common interest of ECK SA, MPEC SA, district heat customers and all residents of Kraków.

This thesis has found confirmation in the Master Plan for the Kraków district heating network, developed by SWECO, a Swedish consulting company. The most important statements indicated in the Plan are:

a) it is necessary to introduce quantitative-qualitative control of district heat water and to prepare the Plant both technically and organizationally for that change; the necessary technical steps have been taken this year.

b) the elimination „low emissions" by connecting local boiler houses to the municipal district heating network will increase the demand for heat by 300 MW_t; it is a long-time process which, depending on the scenario adopted, would be completed in 2005 or 2010.

c) after modernizing the exchangers or installing new ones along with automation and central control permitting the reading of the power taken, the savings coefficient will be 26%, on the average.

2. DEMAND-SIDE MANAGEMENT BY ECK SA

Using the results of the analyses and studies done in the preliminary phase of the American-Polish Program, which confirmed the need to fully use the transmission capacity of the district heat network and the generation capacity of the heat source, ECK SA initiated a demand-side investment policy, allocating about USD 2.5 M in 1994 for elimination of „low emissions" by connecting the local boiler houses to the municipal network. These actions were forced by both the steadily declining power ordered by MPEC, and the decision of August 14, 1992 by the Department of Environmental Protection of the Provincial Office, which made it obligatory for the Heat and Power Plant to participate in the program for elimination of „low emissions". To undertake these innovative activity, the Plant's investment team had to familiarize themselves with the layout of the municipal district heating network, to develop a general concept of co-financing these projects, and to establish the appropriate organizational framework.

The Plant launched a demand-side policy of investment in projects in the areas where the Distributor took no interest and where the heat users repeatedly contemplated connection to the gas network. These actions were chiefly directed at the customers listed in the survey made as part of the American-Polish program for elimination of „low emissions" in Kraków. The negotiations included the owners or users of heat, or heat and process boiler houses within the area covered by ECK SA. The proposed projects call for substantial financial resources needed to:

a) construct pipeline connections between the existing mains and the heat exchangers

b) construct heat exchangers and, in some cases, low parameter network for distributing heat from heat exchangers to individual buildings.

Using its own funds, the Plant is financing the construction of the pipeline connections between the district heating mains and the heat exchangers. The heat exchanger that is to replace a local boiler house, remains the property of the customer;

however, in most cases the customers are not able to bear the costs of the heat exchanger construction. That is why ECK SA is offering to arrange financing for these projects from various sources. Such a division of tasks permits the best use of the subsidies while retaining the user's ownership of the heat exchanger. Formally, ECK SA offers to the prospective heat customers a contract which authorizes ECK SA to act as a proxy-investor. ECK SA is also providing a professional supervision over the entire investment process.

The prospect of financing the project is a very attractive aspect of the ECK SA's offer as most customers do not have sufficient resources to finance elimination of their local boiler houses which pollute the atmosphere. The customers lack also the experience, necessary to prepare formal and legal aspects of the project (in accordance with the Act *The Building Law)*; this makes the ECK SA's offer particularly advantageous.

ECK SA's effective efforts towards elimination of „low emissions", and the environmental benefits produced, attracted interest and gained confidence of the organizations which have funds that could be allocated for that purpose. The fact that ECK SA complies with all bidding procedures (defined by the Act on Orders in the Public Sector) increases reliability of the actions undertaken by ECK SA. Thus, for the purpose of financing the construction of heat exchangers, ECK SA gained access to such sources of financing as:

a) the Provincial Environmental Protection Fund; the Plant has been co-operating with the Fund in the elimination of „low emissions" since 1994. The Fund subsidizes organization paid from the Budget (schools, army, police) and grants preferential credits, with an interest ranging from 0.2 to 0.8 of the National Bank of Poland's so-called „refinance credit" rate, to other firms and organizations, for covering in part their investment costs.

b) the Eko-Fund Foundation, an international foundation involved in converting the Polish debt to pro-environmental investment. The Plant has co-operated with the foundation since 1995; the foundation can cover 30% of the total cost of the project in the form of a subsidy for the heat exchanger owner

c) the fund of the US Department of Energy, the purpose of which is elimination of „low emissions" in Kraków; based on the agreement between Honeywell and ECK SA, which was concluded in November 1994, the fund subsidizes the heat exchangers constructed by ECK SA.

The unit cost of constructing a section of district heating network and a heat exchanger supplying heat and hot domestic water is estimated at 83.0 USD/kW (this was the unit cost in the first year, when the project dealt with boiler houses with a relatively easy access). The unit cost of converting a solid-fuel fired local boiler house to gas, is 151.0 USD/kW (see materials of the conference „Gas in Kraków", held on April 7, 1995). The users/owners of the boiler houses, for which ECK SA acts as a proxy investor, will cover only a part of the heat exchanger cost, this share is estimated at 35 USD/kW; after taking into account subsidies granted for this purpose by the environmental funds, this share would not exceed 20.0 USD/kW.

The Plant's efforts in 1994 towards increasing the demand for power and eliminating the emissions of pollutants (particulates, SO_2, NO_x, CO, CO_2) are illustrated in Table 1. The environmental benefits resulted from a lower fuel consumption per unit heat. This was possible owing to our high efficiency boilers and the installation of the systems for air protection (the electrostatic precipitators have an efficiency of over 99%, while local boiler houses capture „casually" in the boiler flue gas ducts only about 10% of the dust. The flue gas, previously released by low chimneys, is now released in smaller quantities by high stacks equipped with modern systems for full monitoring and control of emissions of pollutants. In 1995 the program included 32 local boiler houses with a total installed capacity of 44 MW_t (according to Table 2, below). Taking into account the actual heat demand, the fact of installing automatic heat exchanger controls, and other energy conservation measures, the energy consumption has been reduced by about 35%, that is to a level of 27 MW_t. The automation of heat exchangers was done using Honeywell's expertise and control systems. The use of programmable controllers of space temperature, water temperature, and heat meters, produces tangible savings in energy management and water consumption.

Assuming that 30 boiler houses with a total capacity of 44 MW_t will be replaced by heat exchangers supplied from the municipal district heating network, the following unit factors (per 1 MW_t of the eliminated power of „low emissions" sources) have been obtained:

power reduction factor (actual demand/power eliminated)	0.64 MW_t / 1 Mw_t
sulfur dioxide reduction	1.16 $Mg/MW_t/year$
particulates reduction	4.60 $Mg/MW_t/year$
carbon dioxide reduction	268.0 $Mg/MW_t/year$

Table 1. Results of the program for elimination of „low emissions" in 1994

No	Location	Power ordered in years [MW_t]				Emissions [Mg/a]				
		1994/95	1995/96	1996/97	1997/98	Particulates	SO_2	NO_2	CO	CO_2
1.	MPK, W. Sławka 3		5.8			26.98	23.6	12.65	1.69	647.55
2.	Obszar Płaszów		11.9			196.17	83.78	25.64	88.9	0
3.	Zakład Poszukiwań Nafty i Gazu - ul. M. Wiślanej		2.92			10.6	4.4	0.9	36	1988.1
4.	Nadbrzeżna - Grochowska	2.71				13.87	15.36	2.74	45.3	622.3
5.	PKP, ul. Rogatka	1.53				15.1	19.3	2.5	4	1670
6.	Miraculum ul. Zabłocie 23	1.22				7	5.6	0.8	21.5	1332.4
7.	JW ul. Rydla		0.5			4.5	2.5	0.254	8.75	695.4
8.	JW ul. Rakowicka		0.8	0.8	1.4	8.6	35.8	1.21	67.07	3108
9.	Schools:									0
	No. 57 (ul. Cechowa 57)	0.33				12.43	8.44	0.67	19.98	
	Music (ul. Józefińska 10)	0.065				0.7	0.44	0.034	1.13	
10.	WDDM ul. Głowackiego 56	0.95				4.95	2.4	0.18	3.36	443
11.	Woj. Bud. Mieszk. ul. Pijarów 1,2	0.38				4.5	2.9	0.15	6.9	399
12.	SM „Lipska" ul. Lipska 51	0.7	0.2	0.4	0.8					0
	Total	7.885	22.12	1.2	2.2	305.4	204.52	47.728	304.58	10905.75

The Plant is planning to invest regularly in the program for elimination of „low emissions" some USD 2-3 M annually for the next ten years.

Another action which is important to future sales of heat is a **promotional program for supply of district heat and hot domestic water** from our source to newly built housing estates and to old building stock of the Kraków housing co-operatives, to eliminate health and life hazards arising from the use of unreliable and dangerous gas-fired water heaters. Due to their faulty operation and a specific microclimate of Kraków, dozens of people are deadly poisoned by carbon monoxide each year. The hot water promotional program, developed jointly with MPEC, eliminates this hazard effectively. To make the program more attractive to customers, the price of hot domestic water was set 10% lower than the cost of gas-heated water.

3. CO-OPERATION WITH THE US DEPARTMENT OF ENERGY AND HONEYWELL,USA

In order to implement the program for elimination of „low emissions" in Kraków, Honeywell, an American company, has concluded an agreement with US DOE, and a contract in November 1994 with the Kraków Heat and Power Plant S.A.

In 1994 four local boiler houses were eliminated by replacing them with heat exchangers equipped with Honeywell automation systems. These 4 sites were:

1. Szkoła Mistrzostwa Sportowego in Grochowska Street
2. Kolejowe Zakłady Nawierzchniowe (Railroad Track Works) Kraków P³aszów

3. Prokocim Locomotive Shed
4. PKP's (State Railroad's) residential houses in Grochowska Street

Further local boiler houses are planned to be eliminated in 1995, and Honeywell automation systems will be installed at 28 heat exchangers, using US DOE financing.

It should be pointed up that in implementing these tasks Honeywell closely cooperates with MEGAREM, a company formed as a result of the ECK SA restructuring.

Forty further exchangers are projected for 1996, which will be equipped with Honeywell-USA installations; these projects will also be financially supported by the US Department of Energy.

In view of the large number of Kraków local boiler houses to be eliminated, the Kraków Heat and Power Plant expects a long-term co-operation with Honeywell within the program for elimination of „low emissions", and a further support of the US DOE.

Table 2. Program for elimination of „low emissions". Plans for 1995.

Specification	Address	Design [MW_t]	Scope	Emission of: Particlt [Mg/a]	SO_2 [Mg/a]	CO [Mg/a]	NO_x [Mg/a]
Wojsk. Rej. Zarząd Kwaterunk.-Bud.	ul. Głowackiego 95	1,20	dh*	6.40	3.40	6.39	0.40
Wojsk. Rej. Zarząd Kwaterunk.-Bud.	ul. Mogilska 85	0.70	dh	4.10	2.20	6.30	0.26
Wojsk. Rej. Zarząd Kwaterunk.-Bud.	al. B. Prażmowskiego 46a	0.40	dh	18.50	9.80	5.85	1.16
Garnizonowa Administracja Mieszkań	ul. Zabłocie 50	0.20	dh	1.90	1.00	2.88	0.12
ZPO „Vistula"	ul. Cechowa 100a	0.30	dh	1.70	0.90	1.35	0.11
„Techma" Kraków	ul. Walerego Sławka 3	2.00	dh	7.70	4.10	9.00	0.48
Szkoła Odzieżowa	ul. Bulwarowa 33	0.45	dh	2.40	1.30	5.45	0.25
SM „Piast"	ul. Friedleina 18	0.11	dh	0.60	0.30	1.58	0.04
SM „Piast"	ul. Mazowiecka 5	0.11	dh	0.50	0.30	1.35	0.03
SM „Piast"	ul. Friedleina 29	0.11	dh	0.50	0.30	1.35	0.03
Zespół Szkół Ogólnokształcących	ul. Wyrwińskiego 1	0.60	dh	4.70	2.50	13.23	0.29
SM „Piast"	ul. B. Chrobrego 29	0.26	dh	1.90	1.00	4.50	0.12
Lasy Państwowe	al. Słowackiego 17a	0.53	dh	2.80	1.50	3.15	0.17
KW Policji	ul. Mogilska 109	0.65	hdw**	3.70	2.00	5.87	0.23
Komenda Policji	ul. Siemiradzkiego 24	0.86	dh	4.60	2.40	16.20	0.29
Wojskowy Klub Garnizonowy	ul. Zyblikiewicza 1	0.40	dh	1.90	1.00	1.62	0.12
U.J. - Collegium Medicum	ul. Kopernika 7	1.06	dh	4.60	2.60	9.90	0.31
Geofizyka	ul. Łukasiewicza 3	1.50	dh+hdw	10.80	5.80	22.50	0.68
Zakł. Dezynfekcji i Deratyzacji	ul. Chrobrego 51	0.10	dh	1.10	0.60	0.90	0.07
TSP „Autotransport"	ul. Powstańców 1	0.55	dh	5.20	2.80	15.75	0.32
Transportowa Spółdzielnia Pracy	ul. Wodna 2	0.90	dh+hdw	4.90	2.60	15.75	0.31
Centrostal	ul. Kopernika 6	0.26	dh	1.40	0.80	4.95	0.09
Akademia Wychowania Fizycznego	al. Jana Pawła II 62a	0.75	dh+hdw	1.03	0.01	0.03	0.03
„Bipropiec"/"Piecbud"	ul. Bociania 22	5.50	dh	61.40	32.80	11.25	3.84
Sp. Inw. Dembowskiego	ul. Wybickiego 5	0.75	dh	4.10	2.20	5.63	0.26
Uniwersytet Jagielloński	Al. Słowackiego 15	0.46	dh	2.20	1.20	1.94	0.14
Naftobudowa	ul. Powstańców 66	3.00	dh	33.40	17.80	48.26	2.09
TS „Wisła"	ul. Reymonta 22	0.64	dh+hdw	4.80	2.60	7.02	0.30
Instytut Technologii Nafty	ul. Łukasiewicza 1	2.00	dh	18.40	9.90	24.75	1.15
Urząd Ochrony Państwa	ul. Mogilska 109	0.42	dh+hdw				
Sanepid, Geodezja	ul. Gazowa 15	0.44	dh	1.68	0.71	2.7	0.09
TOTAL	**The capacity installed currently in these boiler houses =44 MW_t**	27.21		231.41	123.12	275.40	14.56

* dh - district heat

** hdw - hot domestic water

EXTENSION AND MODERNISATION OF THE SYSTEM OF MUNICIPAL HEAT DISTRIBUTION NETWORKS AND ELIMINATION OF EMISSION IN THE REMAINING SOURCES

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1. INTRODUCTION. A short description of assumptions for 5 programs with participation of the MPEC SA, Cracow.

After a preliminary conference held in November 1992, the MPEC SA struck up contacts with 6 US companies so as to prepare offers and the implementation of joint projects. According to their assumptions, those tasks had been picked up and prepared in order to be useful in solving a part of problems related with technology and organization which would be encountered by the MPEC SA that time. Those decisions were then well-aimed, yet a long time that had elapsed till the moment of their implementation did affect them in part. The development of free market economy in Poland was taking place without influencing the program assumptions. The MPEC SA was then interested in the enterprises which presented their activity in the following fields:

- reduction of low emission via extending the operational range and improvement of the municipal heat distribution network - by: Shooshanian Engineering Associates from Boston, Honeywell Corporation and Hart Associates;
- a modernization of solid fuel-fired boiler houses which for their locations or the heating medium supplied cannot be eliminated soon - in order to improve their efficiency and to reduce the emission of pollutions - by: Control Techtronics Co., Tecogen and EFH Coal.

Those tasks comprised the offers prepared and placed at the Department of Power Industry. Those offer concerned in particular the following items.

1.1. Extension and updating of the system based upon heat energy from associated sources

1.1.1. Shooshanian

In the original proposal there was identified the area situated in the potential range of the municipal heat distribution zone, that is in the triangle made by the following streets: Armii Krajowej, Piastowska and Bronowicka. There, the heating process consisted mainly in using solid fuels burnt in small and medium local boiler huoses and stoves. A joint collaboration of Shooshanian Co, Polinvest and MPEC was to create the foundations for a marketing system that from the beginning to the end - i.e. starting from preliminary talks, via elaborating the feasibility studies, arranging and settling land and legal matters and signing proper agreements in the name of the customer would organize the investment process of the elimination of boiler houses and connecting them to the heat distribution network.

1.1.2. Honeywell

This project was aimed at installing the SCADA system for a selected network part, implementing a system of qualitative and quantitative control at the „Balicka" boiler house, updating works in the internal and transmission installations in „Widok" Housing Estate, DSM (Demand Side Management) activities, replacement of the existing hydroelevators with full-automated heat exchangers. In consequence thereof, in this isolated heat distribution and supply enclave an exemplary area of energy production, distribution and reception aimed at energy conservation and diminution in the fuel consumed by the boiler house was to come up.

1.1.3. Hart Associates

The offer submitted by Hart Associates Co. comprised similar items as that from Shooshanian. Its range was, however, not boiled down to one field and was supplemented with some problems regarding a wide range of public relations as far as the questions of environmental protection are concerned.

1.2. Elimination of emission in the remaining sources

1.2.1. Control Techtronics

The automation of the combustion process in the „Balicka" boiler house located in 6, Lindego-St., heating the Widok Housing Estate. Three WR-10 water boilers and two PLM-2.5 steam boilers were subject to a modernization. The modernization said was to supplement the actions of Honeywell. Those operations were aimed at reducing the pollutions emitted by this boiler house down to such a level that might satisfy the requirements of environmental protection which will come into effect in Poland after 1997.
In addition a series of training sessions, creation of some consulting agency dealing with the automatic control of combustion processes in water boilers, as well as establishing a joint venture company for conducting such an activity, were scheduled.

1.2.2. Tecogen

This project was a reply to the current demand for upgrading the boiler house. The demand for steam coming from the „Krzesławice Baza" boiler house exceeded in early 1990ies its contemporary production efficiency. The technical specifications set forth in the offer of Tecogen seemed to be a perfect solution of those problems. The fitting of an economizer, partial air recirculation, automatic control of the combustion process appeared to satisfy the market demand for steam without the necessity of extending the structure and to comply with the environmental protection standards.

1.2.3. EFH Coal

The project related with building a plant dealing with making dressed, purified fuel, having proper granulation and designed for stoker fired boilers deviated from the MPEC SA basic activity; however, it was an excellent investment in future - securing high quality, ecological coal for our own needs in future and guaranteed certain profits on selling this fuel to other customers.

2. DIRECTIONS AND STATE OF PERFORMANCE OF PROGRAMS IN THE FIRST HALF 1995

Since quite a long time elapsed from the moment when the US enterprises placed their offers at the Department of Power Industry till the moment of starting investment actions, some of them had to be verified, updated and slightly altered bearing in mind time and successive changes in Cracow's and Enterprise's needs. In that period some actions connected with a complex rehabilitation of Cracow's heat distribution system to be coordinated with the planned program of the elimination of low emission, were commenced. At the same time, some MPEC SA customers and owners of boiler houses took their own steps so as to improve their own heat management or decided to convert the boiler houses into gas-fired ones. Those were the main reasons for changes against the originally planned operational schedules.

2.1. Shooshanian

2.1.1. Connection of the PKP (Polish railways) zone - new possibilities in the north-western area of Cracow.

For many causes said above, the main investment actions under this program were focused on the elimination and connecting the PKP boiler houses. Connecting the PKP boiler houses (about 3 MW in 1995) is only the beginning of the actions. Due to the erection of a network from Rakowicka-St., via the premises of the Railway Station towards

Świętokrzyska-St. and Wrocławska-Street, there appear clear-cut possibilities for the eradication of low emission sources located actually at Cracow's centre between the first and the second ring-roads. A well-devised construction of this port developed in the junction of the northern and western main lines will allow to gain a series of profits. Of course, the most significant ones is an opportunity of eliminating such boiler houses, like, among others those situated in Montelupich-St. (approx. 6 MW - House of detention, Collegium Medicum of the Jagiellonian University, the School of Military Chemical Detachments). Another zone able to be connected is the region of Warszawska-St., Pawia-St., Basztowa-St. and Matejko-Sq. It is particularly important that this area constitutes the immediate edges of the monumental center. Alas, for a complex character of the problems related with connecting those structures (property questions, possibilities of passing networks, stove heating and no internal installations), the first works cannot be performed before 1996-97.

Yet another region whose connection was not real before making a junction between the northern and western main lines is located among the following streets: Słowackiego-Ave., Grottgera-St., Lenartowicza-St., Kremerowska-St., Batorego-St., Łobzowska-St., Siemiradzkiego-St. and the vicinity. It is estimated that the elimination of boiler houses in this zone should eliminate emission from over 10 MW. In addition, without any necessity of extending the „Wrocalwska" intermediate pumping station , this junction will permit to eliminate low emission and increasing the number of new customers in the north-western part of Cracow. This balance sheet includes the structures contained in the original program - located in the triangle of the streets: Koniewa-St., Bronowicka-St. and Piastowska-St. For some of them (Espefa, Hydrokop) the works have been already commenced and it is provided to connect those structures in the heating season 1995/96. The remaining ones: KFAP, Cooperative of Blind Disabled Persons, an apartment building in 17, Zapolskiej-St. will not be ready for connection before 1996.

2.1.2. *Elimination of local boiler houses in other regions*

Apart from actions in the region directly influenced by the construction of the junction, the Shooshanian program provides those in other town areas. They concern mainly the elimination of the boiler houses in the Secondary School of Communication Engineering in Monte-Cassino-St., Metaloplast Co. and Fur-Makers' Works in Wadowicka-St. or MPEC boiler houses located in Kryniczna-St., Friedleina-St., Odrowąża-St., Łokietka-St., Wrocławska-St. and some others.

It is commonly expected that the full performance of the junction with indispensable ramifications will allow to eliminate in the nearest future over 50 MW of power installed in solid fuel-fired boiler houses. Additionally, it will be possible to connect new customers, and that in turn, will enable to avoid making new gas- and oil-fired emission sources in the nearest future - it will contribute to improve both efficiency and operational economics of the basic heat generating sources of „Cracow" and „Skawina" Cogeneration Plants.

2.1.3. *Training activity and transfer of „know-how" of US marketing*

The program guide-lines allowed to hold a series of training sessions for MPEC's employees so as to place a streamlined and efficiently operating Division of Marketing and Customer's Services Office in the structure of the company. Shooshanian Co. had collected experience gained by US heat distribution companies in this field and transferred it to MPEC's employees. This experience was transferred in a big 14-days training block. The first session was held at Boston. MPEC's employees - the future staff of the Division of Marketing had an opportunity of participating in lectures on the outlines and assumptions of marketing activities in US heat distribution enterprises and of visiting those enterprises. It was possible to be really familiarized with the problems related with marketing operations in specific circumstances in which the heat distribution companies work and to discuss or/and exchange experience gained. Those activities proved to be helpful and nowadays the enterprise's structure comprises the Division of Marketing and the Customer's Services Office based upon US standards that to this extent have been successfully adapted to Polish conditions.

2.2. Honeywell

2.2.1. *Modernization of internal installations of customers living inapartment houses in „Widok" Housing Cooperative*

At the beginning the scheduled joint project of updating the heat enclave supplied from the „Balicka" boiler house was successfully divided into two parts - one realized by Honeywell and the Housing Cooperative - that is the modernization of internal installations of the inhabitants and the other - performed by Honeywell and MPEC - the updating of transmission and generation systems. It permitted to manage the project better; the necessity of negotiating complex trilateral agreements, sometimes with incompatible interests of all parties, was successfully avoided.

2.2.2. *Modernization of networks and centers at „Widok" Housing Estate*

In collaboration with Honeywell the MPEC conducts a modernization of centers by replacing hydroelevators with fully equipped, automiatic time and weather controlled exchangers, automating the group exchanger station and installing a SCADA system on the network which will allow to monitor automatically the operation of the network, according to the instantaneous demand for power, in full collaboration with the source - that is the „Balicka" boiler house.

2.2.3. *Modernization of the hydraulic part of the „Balicka" boiler house supplying the Housing Estate*

So as to make the Demand Side Management complete, the boiler house will be supplemented with some quantitative and qualitative control systems for steering the operation of the pumps and in order to have the boiler house operation completely adapted to the current load. Completed all the tasks resulting from this project, Cracow will have a heat distribution enclave equipped with a control, monitor and operational control system for the thermal installations and management as far as the subject hereof is concerned.

2.3. Control Techtronics

2.3.1. *Automation of the systems for controlling the combustion process in the „Balicka" boiler house.*

In connection with and by supplementing Honeywell's operations, Control Techtronics International has installed a system for automatic control of the combustion process. This system is based upon an M-2000 controller manufactured by this enterprise, allowing to optimize the combustion processes depending on the fuel being burnt and load so as to comply with the environmental protection standards which will come into effect in Poland after 1997.

The preliminary investigations have corroborated an improvement in the characteristic of boiler efficiency as a function of its load and a considerable reduction of dust emission, especially in the range of small and medium loads where the reduction values are a dozen or so times lower.

2.3.2. *Transfer of know-how regarding the operational procedures and automatic control systems used in US coal-fired boiler houses.*

Apart from the tasks physically carried out in the premises of the boiler houses, Control Techtronics Co. listed the problems related with the exchange of experience among Polish and US companies dealing with the operation of boiler houses. Therefore, two training sessions took place: one in the USA, the other in Poland together with a visitation of the structures. The supervision over the training program and in part over its execution was entrusted to Penn State University and the Technical University in Cracow. One of more interesting case of experience was an opportunity of seeing the excellent condition of 50 years old boilers provided that the procedures for water treatment and supervisory schedules are followed. Another question on which a strong emphasis was placed is the selection of coal for the given device.

2.4. Tecogen

2.4.1. *Establishing ECOGY Company*

For appearing as one of more attractive, the program proved to be very difficult in its performance. Some factors caused it - starting from considerable divergence in the interests of all 4 program participants, via differences in their mentality (America, Europe and Japan) as far as the wide range of the program is concerned, the establishment of a partnership and the performance of the boiler house modernization. Some error was here an attempt at a simultaneous negotiating of both the agreements. It appreciably stressed the different interests and hindered a constructive course of talks held. Some turning point occurred when the parties decided that the chief objective would be establishing a company. Long and uphill negotiations were crowned with signing the ECOGY Ltd. Partnership Agreement. Its shareholders are: JAIDO (Japan International Development Organization) from Tokyo, Japan; Tecogen Division of Thermo Power Corporation from the USA and the Polish partners: Naftokrak-Naftobudowa and MPEC. The main objective of the Company activity is modernization of boiler houses basing upon the shared savings agreements. It means that the partnership will modernize boiler houses from its own resources and the customer shall pay this service from a part of the savings gained. The President of the Partnership was elected a representative of Tecogen - Dr. Ronald Breault.

2.4.2. *Negotiation process regarding the Shared Savings Agreement*

The actual process of negotiating the Shared Savings Agreement commenced at the end of September 1994. As the agreement itself, based upon US standards, comprises some controversial items, the talks were quite complicated. The most difficult question was the procedure for computing the savings. It is commonly known that this is a value which cannot be assessed in a simple way. The subject of the negotiations was therefore the determination of the savings components and of the computation principles to what extent they are improved. A disadvantageous situation of the MPEC and of the partnership was yet worsened by the fact of a continuous diminution of reception of the steam generated in the „Baza Krzeslawice" boiler house. Much time was devoted on agreeing upon the number of the employees who would have to be dismissed from the boiler house as the automatic control systems will be to make the management of the boiler house operation more streamlined; the auxiliary systems will have to reduce the direct human labor. Dr. Breault expected that 70% of the old staff would be dismissed - it was out of the question. Finally, in December the basic text of the agreement and those of chief annexes determining, among others, the investigation methods, computation of efficiency, costs calculations and savings determination, were agreed upon. The determination of invoicing principles and transferring the property related with the modernization to the MPEC was not successful. Before the actions said took place, the market condition of the boiler house had been appreciably deteriorated. It was connected with disconnecting successive customers, among others the most important - the dairy. It caused that the sale of the steam generated there fell down to a 20% level as compared with the period when the American-Polish Program for Elimination of Low Emission Sources was started. The implementation of this agreement became thus quite risky and in spring 1995 a new place in Cracow was decided upon. It is also interesting that also some serious companies and institution from outside Cracow took a great interest in ECOGY and only the non-performance of this first step stops the development of the partnership on the external market.

2.5. EFH Coal

2.5.1. *Negotiation process aimed at establishing a partnership and its conclusion.*

Similarly, like in the case of the program performed with Tecogen, the negotiations on the agreement were not easy. It was caused by a wide range of the project to be realized by the partnership, the indispensable high investment outlays and prospective profits. After many rounds of negotiations, in summer 1994 the Agreement of ECOCOAL Partnership Ltd. was signed by three partners: EFH Coal Company from Wikes Barre, USA, Naftokrak - Naftobudowa and MPEC SA. The representatives of each partner formed the managing board of the partnership.

2.5.2. *Activity of ECOCOAL Partnership*

Before starting the actual business activity, the main tasks of the Company managing board focused on a few operational fields. The first one was connected with finding a proper site for building a processing plant. It was related with visitations in many existing plants or those under elimination, as well as in mines. Hundreds meetings, negotiations with the managing board of those plants, land owners and community authorities were held. This assiduity was, to some extent, crowned with winning the bidding for a multiyear lease of the grounds for building the proper installation at the Dolomite Works at Jaworzno-Szczakowa.

Another problem encountered by the young managing board was finding a contracting party who might supply proper fine coal as raw material for processing.

During that almost 10 months period of strenuous activity there were also conducted a preliminary probing of the market of the fuel to be produced by the partnership , as well as the promotion of itself. Preliminary investigations proved that the partnership should have no problems in selling its whole output in Cracow and its neighborhood. Successful results of this activity caused ECOCOAL Ltd. to start its full-range business activity in June 1995 so as to commence the investment process.

3. PROBLEMS THAT APPEARED DURING THE REALIZATION OF THE PROGRAM

3.1. Custom duties and tax problems

One of the most painful problems affecting in particular Polish companies being the final beneficiaries of the DOE grant are tax and customs difficulties. Control Techtronics and Shooshanian - the programs in which the investment process has been already started - have been most affected. Although this process has been also considerably developed in the Honeywell program, yet for being conducted by the Polish branch of Honeywell the accountancy and entry procedures are appreciably simplified.

One of the reasons for such a status quo is having no official documents at the governmental level that might concern the operational ranges in respective subprojects, giving the parties-participants of the program, i.e. the Polish (especially beneficiaries) and US companies. The present form of the „Memorandum of Understanding" does not make those matters precise for coming from the period when none of the companies taking part presently in the program was known.

Nowadays, it is possible to have the imported goods exempted from duties, boundary tax and VAT. This procedure has been applied in a few cases. Such goods must be explicitly described by the supplier on the invoice as a donation from the government of an other country. For a profitable enterprise such a donation is nothing else but income. Therefore, such devices are subject to the income tax for legal persons and this tax reaches 40% (!).

The computation conducted this way gives finally the information that over 80% of pure subvention is led off to the Treasury as customs duties and taxes. The taxation on the import of consulting services is slightly lower - a 22% VAT.

The matter of formal goods registration is hindered by the fact of the leading role played by the US companies. Such a situation took place in the case of Control Techtronics when the devices ordered by an US company in a Polish one and imported from abroad could not have proper documentation necessary for the registration procedures. Another question was engaging Polish sub-contractors. Such a status quo caused a partial double taxation of those services. It was necessary to re-negotiate the agreements and that fact brought about a delay of a few months in the implementation of the project.

So as to avoid this situation caused in part also by changes in the legal and tax regulations during the three years period of the program's operation, MPEC filed a separate motion with the Ministry of Finances for exemption from those taxes.

3.2. Competitiveness of MPEC SA and the system of settling heat distribution and management costs at prospective customers.

Another problem hitting in particular the programs aimed at the elimination of the boiler houses is the system for settling the heat generation costs at prospective customers'. The negotiations and talks held with some big, potential customers proved that the competitiveness of ecological heat produced centrally in the associated economy system is very low as compared with the production taking place in old boiler houses, fired with poor quality coal. In those plants the today's boiler houses are usually equipped with depreciated boilers, in most of cases WLM-2. 5, WLM-5, etc. In addition, the repairs and maintenance activities usually burden the plant overall costs. A similar situation occurs with remuneration and surcharges on salaries of some staff members, especially working in the supervision services. It causes that the calculated cost of heat unit is lower than the actual and in practice only the fuel cost is considered. This fuel, often cheap and of poor quality, also contributes to make the competitiveness advantage yet more distinct.

In general there are no uniform instructions for determining the energy production costs in one's own sources. It caused that the visits paid by the program partakers (mainly in the Shooshanian program) were used to explain and calculate the real costs for those plants. Yet another question is having no legal regulations either obliging or encouraging to use the coal of certain technical specification.

3.3. Possibilities of transmitting process heat via the MPEC to industrial customers

The second and yet more complex problem to be solved is satisfying the customer's technological demand. The MPEC heat distribution network operates today on 150/80 °C during the heating season and 65/40 °C out of this season.

According to the Master Plan guide-lines, those parameters will be soon reduced on an average by 15 °C. It arises out of the investigations performed that the technological demand of most plants oscillate around 100 °C for all the year. In the MPEC network the heat carrier having a temperature of such an order is transmitted through a dozen or so days when external temperature oscillates about -2 °C. Another difficulty is the designed calculation temperature for the ventilation system in the range of high value parameters. Only a direct connection, not recommended for many reasons, can be a solution.

The factors described cause that a connection to the network in a quite atypical configuration is possible - with an exchanger station, high value parameter to high value parameter (and it affects negatively return temperature) or a direct connection can be applied. Both the solutions said must be additionally supported with an extra boiler house to satisfy process demand; this boiler house often generates warm user's water so as to compensate non-uniform loads.

3.4. High activity of the sellers of oil-and gas-fired boilers

Recently, the supply of gas heating and technological devices has come up as compared with the previous period. The boilers have far and away better parameters and arouse quite an appreciable interest among potential customers. In addition, those devices are sold by small, in most of cases by 100% private partnerships offering very flexible assortments. With elapsing of time the development of the market situation caused that the actual competitor for the municipal heat distribution network is not gas - energy carrier, but partnerships offering gas and oil-fired boilers. MPEC's situation is yet hindered by the policy of central price regulation, giving preference to gas. The study carried out under the program prove that should this structure of gas and electricity tariffs be kept up, MPEC's offer will be disadvantageous against heating from one's own gas sources. The worst possible situation occurs in the case of small structures for which the building costs of a high class gas-fired boiler house is lower than that of a compact exchanger station. The limiting value for which a center is cheaper oscillates around 500 kW. There is still, however, a difference in the energy carrier price being the only parameter considered by any prospective heat customer.

3.5. Unclear principles of the program's operation - a big liberty of US companies

According to the MPEC that participates in 5 subprojects, one of the factors that has negatively affected the development of the program was a limited access of the Polish companies to the contracts, materials determining precisely the co-financing principles etc. The US companies which know the DOE procedures better, have taken a privileged position from the very beginning while negotiating agreements. MPEC obtained the agreements officially not before but in August 1994 after having actually concluded all agreements with the US companies. We realize this question was also influenced by the term given for the US companies to sign the agreements, yet it would be considerably easier to hold negotiations knowing the basic structure of typical DOE contracts.

The respective companies interpreted also the program operational principles, the question of bearing pre-awarding costs, settling prime costs or labor time outlays in very different ways. It brought about that almost a year instead of a few months must have passed from the moment when it was to decide upon what proposals were to be given supplementary financing (autumn 1993) till the actual start of the program.

3.6. Barriers caused by legal regulations, financial, technical and language impediments. Differences in the mentality.

In the case of such a large program with participation of foreign partners, some conflicts caused by differences in legal systems, technical standards and normative regulations could not be avoided. According to the MPEC, US companies were not well-prepared for encountering the legal, engineering and technical questions in Poland. This caused the negotiations to be longer, some basic legal obligations of the parties had to be explained many times. Only some companies, e.g. Tecogen, had consulted Trade Counselors and proper ministries in the matters concerning the possibilities and principles of business activity in Poland.

The barrier resulting from the level of preparing the required technical documentation was far and away more difficult to be overcome by the US companies. Some of them were convinced that very simplified flow sheets without any indication of the types of devices, manufacturer, operational parameters and conditions etc., would be sufficient to decide about purchasing a technology. In practice the US partners were not aware of the fact that the technologies to be imported would have to comply with detailed Polish technical standards. They not always appreciated the level of practical knowledge of the MPEC staff who at a certain stage verified very exactly the automatic control diagrams and found a series of inadvertence of the US partners.

Fewest problems were caused by the apparently most imminent barrier - the language one. In general, the problem was only the necessity of having a dozen or several dozen of pages translated from day to day.

3.7. Unexpectedly, it was necessary to involve a large group of MPEC staff in the collaboration

Quite a considerable problem was the necessity of involve a large group of MPEC's staff in the performance of the program tasks. Every year the MPEC carries out from fifty to approx. 200 investment/repair tasks. The expenses coming from both a World Bank credit or our own resources ranges around $15-20 million per year. In most of cases they are carried out in the contracting system; many devices are imported from more than ten manufacturers. The MPEC was much surprised by the necessity of involving a large group of people for dealing with the program. The assumption made that the program will constitute ten or more slightly extended investment tasks proved in practice very difficult for implementation. At a moment it caused a temporary stoppage of a few projects. The solution was employing additional staff members and having some tasks subcontracted.

3.8. The pilot character causes that a part of subventions is absorbed by the organization and management of the projects

The pilot character of the project, a contact with new technologies and operational methods, made it necessary to bear extra time outlays and means in order to carry out the project tasks. In the standard versions, with the application of the known technologies, the necessary outlays might be reduced. This problem can be examined with the idea of the scale economy. If single projects could be realized longer, e.g. for 3 or 4 years, ecological effects would be more measurable. It causes that some programs are burdened with a big surcharge of general costs. In the first budgetary period, depending on the assumptions of respective programs, this index oscillated around 20 to almost 100%. In extreme cases the situation will be radically improved. Instead, this is a factor encouraging to further activity, outside the DOE grant. It must be a great advantage for the Polish an US partnerships already established upon this base; this way they will be well-prepared for conducting their own business activity.

4. CONCLUSIONS

4.1. The preparatory phase of the program should comprise all aspects - also customs, legal matters, taxes and technical standards and patterns

4.2. The US companies participating in the program should be better familiarized with the specific character of the Polish law and technical requirements related with power industry.

4.3. The program frame should be more uniform. In lieu of a big range of free choice, in our opinion there should be prepared optional versions of the documents, settling, employment, purchase, subcontracting etc. procedures (example: World Bank bids).

4.4. For not having started a promotional and explanatory activities on time before, the Program has caused many controversies on the part of experts dealing with the subjects covered in the projects, transferred afterwards via mass media to the public and making the image of the Program quite negative. This situation must be corrected by the MPEC SA as it used to be in the past.

4.5. No proper agreements made at the government level, with indication of the program participators, has caused some hindrances related with obtaining tax reductions for the tasks being performed under the program.

PROBLEMS OF ELIMINATION OF LOW EMISSION

Aleksander Stępniowski

Municipal Gas Distribution Enterprise, Cracow, Poland

The Cracow Municipal Gas Distribution Enterprise is subordinated to the Carpathian Regional Gas Engineering Plant in Tarnów, which - in turn - is a part of Polish Oil Mining and Gas Engineering with its seat in Warsaw. Following Regional Gas Engineering Plants are included in this national organization: Carpathian Plant (Tarnów), Pomeranian Plant (Gdańsk), Great-Polish Plant (Poznań), Mazovian Plant (Warsaw), Upper-Silesian Plant (Zabrze) and Lower-Silesian Plant (Wrocław). Following data characterize the size of the Polish Oil Mining and Gas Engineering:

• employment	43 000 employees
• quantity of gas distributed	9 600 000 000 m^3
• number of end users	6 400 000
• number of areas with installed gas-supply arrangements	3 000 (out of this 510 towns)
• total length of gas distribution network	91 000 km
• total length of gas transmission mains	17 100 km
• number of deposit and industrial pressure stations	27
• documented natural gas reserve	158 000 000 000 m^3.

The required quick development of power engineering in Poland needs harmonized development of all branches of power engineering, including also gas production and distribution industry which constitutes an element of technical infrastructure of Poland influencing the direction of development. After the II World War the gas engineering industry has been transformed from a typical communal service to a big industrial structure which covers the entire territory of the state and has considerable technical and material measures at its disposal. Programming of gas industry development ranges from development of installation of gas-supply arrangements for communal purposes including modification of local gas generators - to the development of gas transportation, storage and purification system.

At present gas is taken from following sources: import, own natural gas deposits (high-methane content gas and high-nitrogen content gas within Polish Lowland); cokeries, local gas generators. Gas sorts obtained in these sources have differentiated physico-chemical properties and they are distributed by three independent transmission systems assigned for: high-methane natural gas, high-nitrogen natural gas and coke-oven gas.

Taking into consideration the forecast demand and potential capacity of natural gas production in Poland, the required import of natural gas will be as follows:

Year	1995	2000	2005	2010
m^3	6 600 000 000	13 500 000 000	24 000 000 000	30 100 000 000

The presented growing quantities of natural gas import for future years are ensured in former agreements and in presently signed Polish-Russian agreement on the erection of a gas transit pipe-line from Russia to the West Europe which includes the condition that the world greatest gas deposits will be accessible also for Poland.

Following data characterize the size of the Cracow Municipal Gas Distribution Enterprise (state for December 31, 1994):

(a)	total length of gas distribution network operated in Cracow		1335.3 km
	• out of this:	main pipelines	596.2 km
		medium pressure network	739.1 km
(b)	number of end users of gas		243 840 consumers
	• out of this:	households	237 238
		households with gas heating	17 648
		production plants	195
		other consumers	6 407
(c)	gas consumption in 1994		402 876 000 Nm^3
	• out of this:	households	219 851 000 Nm^3
		other consumers	183 025 000 Nm^3

The almost 140 year long history of gas distribution system in Cracow began with an agreement concluded by the German Continental Gas Engineering Association in Dessau and the Cracow City Council acting on behalf of the town. According to this agreement, a gas station has been erected in 1855-1857 and its main role was to supply gas for continuously growing town.

Erection of high-pressure gas main distribution pipe from Sub-Carpathian region to Cracow (to convey this energy carrier also for industrial plants situated within the Upper Silesian basin) as well as dynamic development of Cracow after the Second World War caused an increase both in the total number of consumers and in the overall gas demand. It resulted in continuous development of the distribution network: increase in its range and in transmission capacity. This process is implemented according to several preliminary designs of the development of municipal gas distribution network. The program for the years 1956-1960 was limited to the improvement of gas distribution system for households only. It should be noted that till 1964 the Tarnów Natural Gas Distribution Plant was responsible for gas supply for big industrial consumers in Cracow.

The contemporary program of site planning prognozed that in 1980 the total number of Cracow inhabitants will reach 750 000 residents. Therefore the contemporary Cracow Regional Gas Engineering Plant took over the responsibility for gas supply for industrial plants in Cracow and general assumptions for capital investment in the development of Cracow gas distribution network have been elaborated for the period 1965-1980. This capital investment project included the problems of gas transportation, erection of reserve tanks and the issues related to the gas transmission in medium- and low-pressure distribution network. Because of the range of municipal distribution network and - consequently - gas pressure losses related to the long-distance transmission, it appeared necessary to solve the problem of multiple supply of gas network from a series of reduction-measuring stations and reduction points supplied from the high- and medium-pressure networks. At that time the central reduction-measuring stations was designed in Zabierzów, Borek Fałęcki, Mogiła, Bieżanów and Górka Narodowa. Till now these stations erected and modified later constitute the basic natural gas supply source for Cracow. One of these stations - 25 000 Nm^3/h of contemporary flow capacity - has been selected as a basic gas supply source for south-west areas of Cracow as well as for the Old Town via a dia. 400 gas main pipe connecting Borek Fałęcki and Grunwaldzki Bridge. This main line became a source of natural gas supplies for heating purposes in Old Town buildings via a dia. 200 medium-pressure gas network ring and a system of seven underground reduction points situated within this area.

In 1969-1973 ca. 5 km of low-pressure gas network was upgraded and diameters of its connections was fit for future needs of natural gas distribution.

In eighties the existing system of underground reduction points was completed with the eighth - additional - one situated in Poselska-St., required as a result of the correction in balance of gas consumption for heating and residential purposes including future gas demand for ventilation and air conditioning purposes.

In 1975-1990 the district heating of the Old Town residential building took place by erection of so called „block boiler houses". This is related to the „block" - small structural units defined within the Old Town. At present district heating is based upon the individual boiler houses installed by the users of separate tenement houses or even by the users of separate rooms situated in these houses.

Before 1990 there were 89 boiler houses assembled within the Old Town; within the period 1990 - end-1994 next 33 boiler houses were started up.

Table 1. Number of gas-fired boiler houses brought into operation in Old Town

Years	Number of boiler houses brought into operation in a given year	Cumulative number of gas fired boiler houses
before 1990	89	89
1990	4	93
1991	8	101
1992	8	109
1993	6	115
1994	7	122

The status quo is presented graphically in Fig. 1.

In 1985 the Resolution No. 19 of the Government of People's Republic of Poland assigned natural gas for monumental and historically valuable quarters of Kazimierz and Stradom in Cracow to provide the residential buildings with heat, to cover the overall gas demand of the residents for living purposes and to meet the ventilation and air conditioning requirements. The total amount of gas assigned for all these purposes amounted to 7 000 Nm^3/h.

Thus Kazimierz and Stradom were transformed into new residential enclaves in Cracow, in which natural gas as energy carrier serves as a base for solving the power engineering problems. Kazimierz and Stradom are situated in the eastern part of the historical center of Cracow; these districts are adjacent to the Old Center, the Cracow-Tarnów-Przemyśl railway line and Vistula river. They constitute a conglomeration of residential buildings of monumental type and industrial objects (Gas and Electric Energy Distribution Enterprises) together with related apartment buildings erected predominantly at the end of XIX century and the beginning of XX century. These elements are completed with sacral objects belonging both to the Roman-catholic and Judaistic religions.

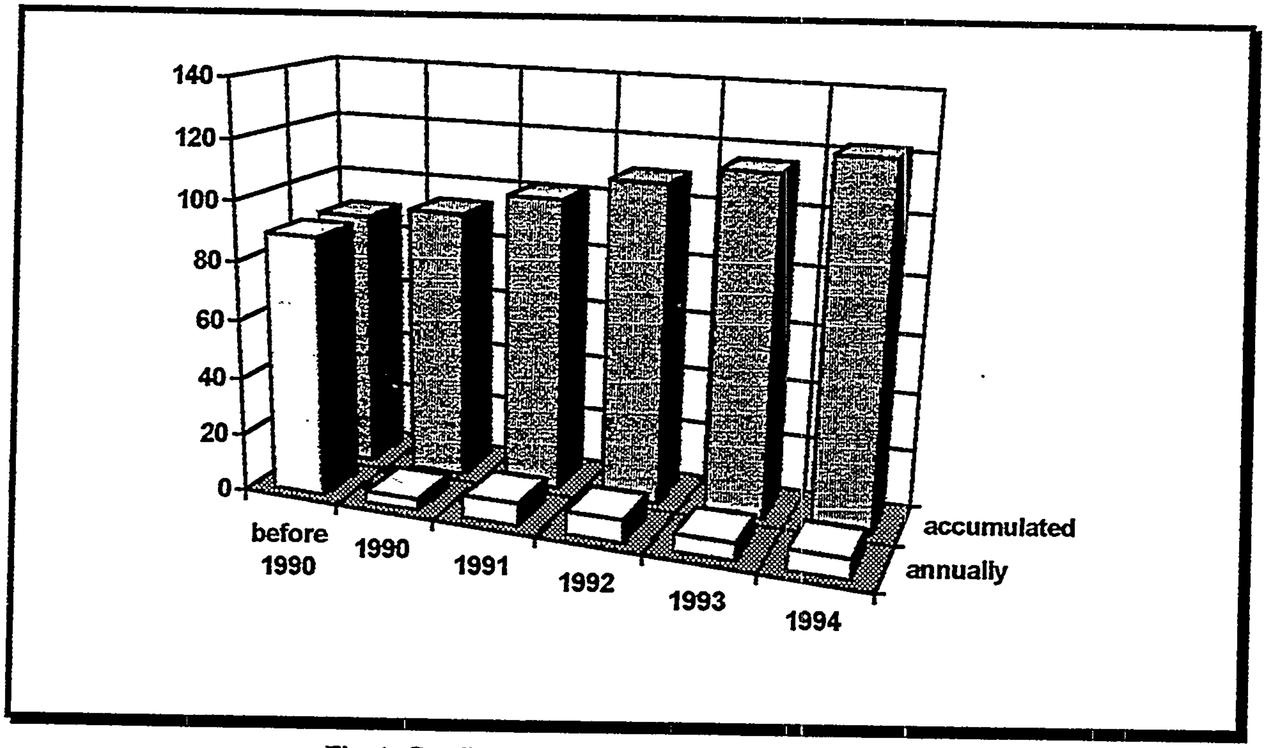

Fig. 1. Gas fired boiler houses within the Old Town

At first the system of gas supply within this area was based upon a local gas station situated in the plot, where later the Gas Distribution has been erected; then the network was supplied with coke-oven gas transmitted from the metallurgical plant situated in north-eastern part of the town. In the period 1975-1982 the entire territory of Cracow (also Stradom and Kazimierz) was switched over from coke-oven gas to natural gas. At present Stradom and Kazimierz areas are supplied from the existing reduction-measuring station situated at the Gas Distribution Enterprise facility and completed with required amounts of gas taken from the points located within the Planty-Ring.

In 1986-1987 the Data Processing Department of the Gas Distribution Enterprise in Cracow elaborated an inventory of buildings situated within the Kazimierz and Stradom areas in order to determine the target gas demand for heating purposes. This inventory has been completed with data related to the 37 690 communal consumers. Based upon this material, the calculation procedures have been formulated together with related data required for calculations. They were entered to the computer and processed in more than ten different versions. Each version took into consideration the optimization of the solution of technical problem in aspect of maximum application of the existing network systems. The best option chosen from the point of view of the network type, its technical condition and location (so important in the case of narrow street in Kazimierz and Stradom with a lot of built-in installations) - is presented in graphic appendices constituting a part of this elaboration. This optimal version includes modification of the existing reduction-measuring station situated at the Gas Distribution Enterprise facility. The upgrading consists in an increase in its flow capacity - up to 10 000 Nm^3/h, erection of a new reduction-measuring station of identical flow capacity, situated close to the Vistula river bank and modification of low-pressure gas pipe-lines in individual streets within Kazimierz and Stradom area. An increased consumption of gas for heating the monumental and historically valuable objects of Kazimierz and Stradom will be combined with necessary modification of the reduction-measuring station in Borek Fałęcki and increase of its flow capacity from 25 000 Nm^3/h (at present) - up to 50 000 Nm^3/h and also modification of the dia. 400 medium pressure gas main supplying natural gas to the Old Town combined with its replacement with a dia. 600 pipe-line. This program is also related to the development in residential housing in the southern part of Cracow which influences also the investment program of the Cracow Municipal Gas Distribution Enterprise.

By the way, it should be underlined that the presently operated cast-iron network together with house terminals (3 000 m of total length) is continuously upgraded and sealed by the service staff of gas supplier and therefore its technical condition must be estimated as satisfactory.

The mode of residential heating implemented in monumental and historically valuable Kazimierz and Stradom areas differs a lot from this existing in Old Town. It results from the fact, that since 1989 (i.e. transformation of the political system in Poland) the owners and users of the buildings apply individual systems of heating. According to the 1990 inventory records kept at the Municipal Gas Distribution Enterprise, in 1990 there were 10 gas-fired boiler houses operated in Kazimierz and Stradom. During the next years, this number increased and in 1994 there were in total 51 such facilities in this area. The successive elimination of cast-iron network as well as modernization and re-construction of gas distribution network within this area foreseen in investment programs and repair schedules should allow transmission of additional gas quantities for heating purposes. The present state of natural gas fired boiler houses and their development is shown in Fig. 2.

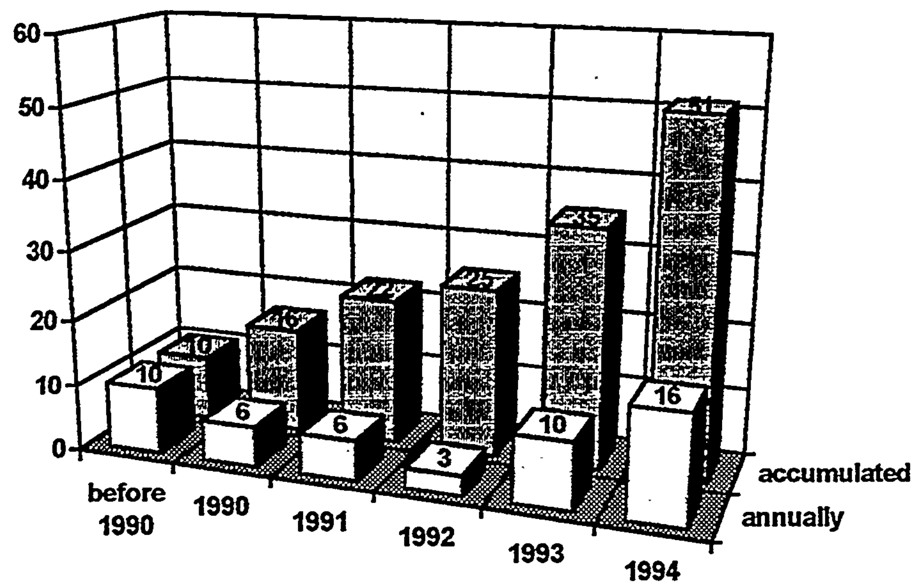

Fig. 2. Gas-fired boiler houses within Kazimierz and Stradom areas

The commencement of the Polish-American Program of Elimination of Low Emission Sources in Cracow has actuated the Gas Distribution Enterprise to start the actions aimed at recognizing the state of district heating within the area situated between the First and the Second Ring. With this regard, in co-operation with Municipal District Heating Enterprise (MPEC SA) an inventory of district heating systems as well as all objects supplied with heat from centralized heat sources, has been elaborated. Furthermore a list of residential buildings provided with central heating systems supplied from solid-fuel-fired boiler houses has been prepared. The comparison of gathered data with the parameters of the existing network system within this area, in particular with flow capacity resulting from earlier distribution of coke-oven gas through the existing gas network, allowed the gas supplier to issue the assertions on gas supplies for the buildings situated in this area, and in particular for those connected at present to the solid-fuel boiler houses.

At present, in total 65 gas-fired boiler houses are operated within the area between the First and the Second Ring and next 30 facilities will be started up in near future (next year). The Fig. 3 presents the number of gas-fired boiler houses started up in last few years (1990-1994) as well as the accumulated number of existing facilities.

Basing upon a feasibility study of conversion of boiler houses and domestic stoves into gas within the Second Ring, elaborated as a part of the American-Polish Program of Elimination of Low Emission Sources in Cracow, several scenarios of conversion to gas in this area have been presented. These options are based upon a new gas supply source, i.e. a reduction-measuring station to be erected at the Cracow Technical University area. This station will be supplied from the system of medium-pressure gas main and it will provide the discussed area with ca. 8 000 Nm^3/h natural gas, out of this ca, 300 Nm^3/h for the boiler house owned by the Technical University, which should be switched over from solid fuel to natural gas. The designed reduction-measuring station will also serve as a natural gas supply source for the objects designed within the western part of the future Cracow Municipal Transport Center. The eastern part of this Center will be supplied with natural gas, also for heating purposes, from the reduction-measuring station to be upgraded at Rakowicka-St. and from another station to be erected close to Kopernika-St. and Śniadeckich-St. Consequently, the future actions of the Gas Distribution Enterprise in the field of designing and investment are aimed at the wide application of natural gas (both for living and heating purposes) within the area situated between the First and the Second Ring.

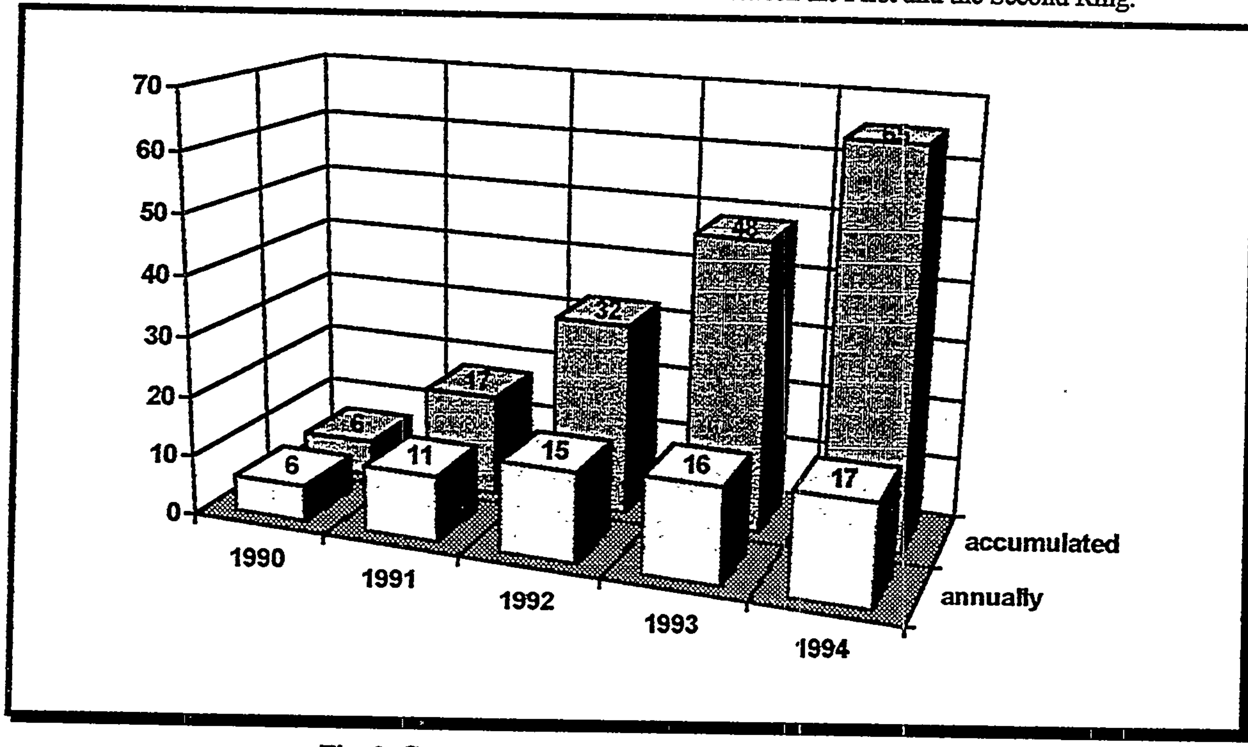

Fig. 3. Gas-fired boiler houses within the Second Ring

At present the basic gas distribution system supplying the entire town is operated basing upon four East-West high pressure gas transmission mains P_{nom} = 4.0 MPa through 6.3 MPa situated along Cracow outskirts and transmitting high methane natural gas originated from domestic deposits and from abroad.

The multiple gas supply in Cracow is based upon five main reduction-measuring stations located in Mogiła, Borek Fałęcki (Zawiła-St.), Węgrzce Wielkie, Zabierzów and Mistrzejowice. The station at Mogiła - apart from providing the medium pressure network with natural gas - supplies also a local high-pressure system P_{nom} = 1.2 MPa of next six reduction-measuring stations.

The described municipal gas distribution system in Cracow transmits gas to 55 second-stage reduction station reducing pressure from medium to low pressure and to 32 reduction stations for industrial and service facilities. At present the interest in natural gas is continuously growing, as it is the less expensive and the most flexible energy carrier. Therefore it is foreseen that natural gas demand for living, heating and industrial purposes will increase continuously.

It is assumed that in 2000 the total demand should reach 200 000 NM^3/h and therefore erection of two new central reduction-measuring stations in Górka Narodowa and in Przewóz is required. Furthermore following actions appear to be necessary: re-construction and upgrading the existing central reduction-measuring stations, re-construction and modernization of the second stage reduction stations, in particular implementation of underground reduction stations, re-construction and modernization of the existing segments of medium- and low-pressure network, in particular erection of the additional gas supplies for the medium-pressure circular pipeline around Planty ring.

With this regard, the Municipal Gas Distribution Enterprise in Cracow, as a supplier of natural gas bears costs related to the investment and overhaul activity. The total costs borne in 1992-1994 are presented in Table 2.

Table 2. Investment costs covered by Cracow Municipal Gas Distribution Enterprise

Years	Construction of network		Repairs of network	
	Cost („old" Zloty)	Scope of works [km]	Cost („old" Zloty)	Scope of works [km]
1992	ZLP 7 300 000 000	5.1	ZLP 11 970 000 000	10.355
1993	ZLP 6 453 000 000	3.0	ZLP 11 300 000 000	15.0
1994	ZLP 6 211 000 000	6.9	ZLP 18 760 000 000	8.56

Table 3. Information of gas sale, number of consumers and the length of municipal gas distribution network in Cracow within the period 1975-1994

Years		1975	1980	1985	1990	1994
Total gas sale [m³]		937 750 000	965 005 000	991 293 000	742 839 000	402 876 000
out of this:	households	136 077 000	182 385 000	180 124 000	219 405 000	219 851 000
	other consumers	801 673 000	782 620 000	811 169 000	523 434 000	183 025 000
Total number of consumer:		163 526	196 337	218 271	233 720	243 840
out of this:	households	158 535	191 157	211 152	226 560	237 238
	production plants	198	207	196	197	195
	other consumers	4 793	4 973	6 923	6 923	6 407
Length of operated distribution network [km]		619.2	784.4	947.8	1 079.9	1 335.3
out of this:	less than 49 hPa	465.6	486.8	497.6	521.6	596.2
	within the range 49 hPa - 0.39 MPa	153.6	297.6	450.2	558.3	739.1
Number of household pressure regulators		3 168	7 594	11 609	15 230	16 896

Table 4. Comparison of prices of energy (fuel) sources for households - state: January 1, 1995

No.	Energy (fuel)	Unit [U]	Heating value [kJ/U]	Heating value [kW/U]	Unit price [PLN/U]	Energy price [PLN/kWh]	Price of usable energy (taking into consideration device efficiency) [PLN/kWh]	Remarks
1	High methane content natural gas	[m³]	34 380	9.55	0.45	0.05	0.05	
2	Propane-butane	[kg]	46 383	12.88	0.96	0.07	0.08	
3	Hard coal (for stoves)	[kg]	26 045	6.40	0.21	0,03	0.05	(1)
4	Electricity (day-rate)	[kWh]	3 600	1.00	0.17	0.17	0.17	
5	Electricity (night-rate)	[kWh]	3 600	1.00	0.07	0.07	0.07	
6	Electricity (24-hour-rate)	[kWh]	3 600	1.00	0.15	0.15	0.15	
7	Fuel oil (Ekoterm)	[liter]	39 805	11.05	0.72	0.07	0.07	(1)

(1) price of energy without the costs of transportation, storage and heating device maintenance

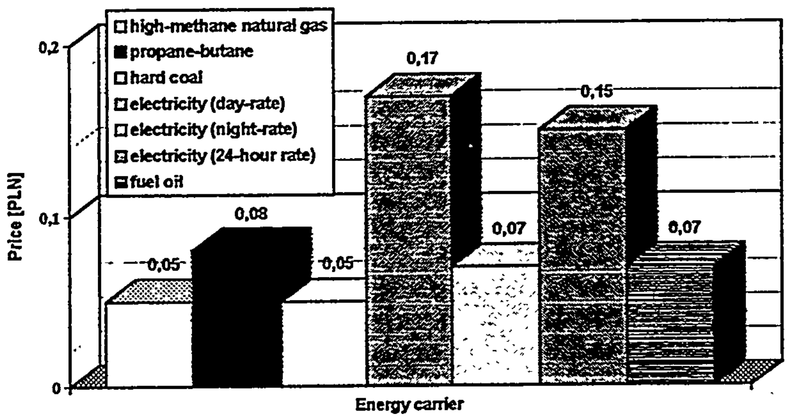

Fig. 4. Comparison of prices of usable energy [PLN/kWh]

MODERN TECHNICAL SOLUTIONS OF GAS-FIRED HEATING DEVICES OF HOUSEHOLD AND COMMUNAL USE AND ANALYSIS OF THEIR TESTING

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INTRODUCTION

The review of technical solutions of gas-fired heating devices of household and communal use cannot be separated from technological problems, production management and the level of technical equipment of enterprises manufacturing such devices. It is well known that in general the level of production of heating units by Polish manufacturers does not conform to the world level. The analysis of this fact shows that the reason of this low level is not within the structure but in the lack of appropriate industry.

If at all the manufacturing of gas-fired heating devices could be called an industry, there are in total four state-owned enterprises and handicraft workshops (at present ca. 100 workshops) not specialized in making separate details, but manufacturing complete devices except of several plants in which boiler automation devices are made.

This state decides the problem of implementation new and new structural solutions, because small handicraft workshops must adapt the solutions to the existing technical potential. Therefore implementation of modern structural solutions of gas-fired heating devices of domestic production is a very slow process possible in few plants.

However, the transformation to the market-oriented economy will force the domestic manufacturers to start works aimed first of all at the reduction of energy and material consumption of a product and at the improvement of quality standards. At present this is the sole way of the manufacturer to maintain its position on the market.

It is also known, that the increase of gas price in Poland, faster than the increase of people's income, results in looking for savings through the maximum possible reduction of gas consumption, i.e. application of high efficient gas-fired heating devices of new generation.

The problems related to the low emission sources used for heating residential housing must be discussed in three basic aspects, and namely:

- choice of the appropriate fuel;
- choice of proper heating unit which guarantees correct combustion and possibly high efficiency;
- elimination of technically groundless excessive heat loss in a building in order to reduce fuel consumption and - consequently - to reduce the emission.

The choice of appropriate fuel is determined by entirely technical and economical reasons and it depends first of all on the availability of so-called ecological fuel sorts, which substitute or even completely supplant the most polluting fuels. Now the motto „economical development with respect to the protection of natural environment value" becomes more and more popular, the environment-oriented policy forces elimination of harmful effects of human activity and various programs are established to support the efforts aimed at environment protection.

The processes of energy generation and consumption play a significant role and the choice of the fuel - energy management strategy frequently takes into consideration both economical aspects and significant environmental reasons. These aspects play a significant role in growing importance of natural gas, which constitutes a unquestionably valuable fuel which could be treated as an environment-friendly carrier of primary energy.

The advantages of natural gas analyzed from the viewpoint of environmental protection and superiority of this fuel to another fossil fuels become evident both directly and indirectly.

- direct environmental advantages (compared with another fuel sorts) are related to the lower content of impurities which form pollutants during combustion process and cause that flue gases are a source of environment contamination;
- indirect advantages consist in the fact that - because of the state of aggregation - gas can mix excellently with air required for combustion and this property facilitates optimal combustion control and guarantees almost complete and perfect combustion; consequently efficiency of energy generation from gas fuels is much higher comparing with other fuels, and thus fuel consumption - and pollution charge corresponding with generation of

a given amount of usable energy is lower. It is a common opinion that both ecological reasons and efficiency of application cause that natural gas should be used first of all in communal economy and in residential housing.

It follows from the chemical composition of different fuels, that:

- natural gas is less harmful fuel with regard to carbon monoxide emission;
- the advantage of natural gas is obvious with regard to the elimination of sulfur dioxide emission and particulates (emission of sulfur dioxide caused by coal combustion is ca. 1 000 higher then in the case of natural gas).

ESTIMATION OF DOMESTIC DEMAND FOR GAS-FIRED HEATING DEVICES

Quick development of individual housing as well as elimination of coal-fired heating units replaced with gas-fired ones, combined with dynamic extension of natural gas distribution network and - in last three years - also liquid gas installations caused wide interest of investors in the possibility to use gas fuel for heating apartments, buildings as well as trade and communal facilities and for generation of district hot water.

The interest grows especially for following reasons:

comfort and efficiency of gas combustion;

high level of automation (in practice the operation needs no service when compared with solid-fuel-fired boilers);

high level of flexibility which allows quick adjustment of heat capacity of the boiler to the current demand;

possible application of programmable control devices improving conservation level.

Therefore the actions planned by the City Council of Cracow include the efforts aimed at replacing harmful coal-fired and coke-fired boiler houses with gas-fired units which allow to reduce significantly the low emission sources.

It should be also pointed out that the replacement of district heating (remote source of energy) with central heating (in-building or individual heating of separate rooms) is connected first of all with the transformation of large systems of high thermal inertia and burdened with many heat losses, both expected (caused by poor thermal insulation) and unexpected (due to leakage), which always charge the final consumers.

On the other hand, replacement of solid fuel used in central heat sources with natural gas (if there exists a system of pipe lines) or with fuel oil (if the gas distribution infrastructure does not exist) gives many advantages. In spite of distinct advantage in the efficiency of adjustment of the system power (lower inertia, better adjustment to the defined local heat demand of the user), also the measurable environmental effects must be taken into consideration. The gas- or fuel-oil-fired boilers emit less carbon dioxide than coal-fired ones per 1 kWh output.

Table 1. Carbon dioxide (CO_2) emission from various fuel sorts [kg CO_2/kWh]

Fuel	Brown coal	Hard coal	Heavy fuel oil	Light fuel oil	Natural gas
CO_2 emission	0.40	0.33	0.28	0.26	0.20

This fact is of not trifling importance for the reduction of thermal effect of Earth atmosphere and reduction of acid rains.

The application of gas fuels for heating purposes is especially common within the areas out of the range of co-generation and heat generation plants.

It follows from the analyzes carried out in late 1994 by Oil Mining and Gas Engineering Institute that 800 000 consumers in Poland use gas for heating their apartments. This constitutes ca. 12.5% of the total number of households (6 400 000) supplied with gas.

Taking into account that ca. 200 000 new consumers are connected to the gas distribution system every year, it could be assumed that the portion of gas fuel used for heating purposes will grow up in future and - consequently - the demand for gas-fired heating devices will increase.

At present in Poland first of all the 20-30 kW boilers used for heating single-family houses are required. Also growing interest in devices to be used for heating separate rooms is observed.

TRENDS OF INVESTIGATIONS IN THE FIELD OF GAS-FIRED HEATING DEVICES

The Oil Mining and Gas Engineering Institute in Cracow, Poland is a certifying institution authorized by the Polish Center of Investigations and Certifications for issuing the „B" safety mark on commonly used gas-fired devices. It means that the Institute is obliged to carry out so called comprehensive investigation of gas-fired devices submitted for evaluation. Therefore the Institute performs for a long time investigations on safe and environmental-friendly application of gas-fired heating devices. These investigations prove that the technical level of tested devices increases following the requirements determined in obligatory regulations. First of all it refers to the energy efficiency of the devices and emission of polluting components of flue gas, i.e. carbon monoxide and nitrogen oxides.

Although the emission of pollutants caused by the combustion of natural gas is much lower than in the case of other fuels, the investigations are still continued on new solutions of burners in order to reduce the emission of pollutants from gas -fired heating devices of communal and household use.

The scope of these investigations is focused on the possible reduction of nitrogen oxides emission, especially NO_2 which is considered to be dangerous for health of the inhabitants.

Nitrogen oxides arise in the devices of household and communal use, predominantly following the thermal mechanism (so-called „thermal No_x"). Formation of these compounds is easier at elevated temperatures of combustion and at higher oxygen concentration and if gas remains for a longer period in the combustion zone.

The new solutions of burners for heating devices of household and communal use consist in lowering the temperature of combustion process by:

- installation of cooling elements which cause increase in flow rate of gas, and - consequently - shorten the period when gas remains in the combustion zone;
- separation of the primary and secondary combustion in order to reduce the maximum temperature of combustion and oxygen concentration;
- combustion in a porous ceramic or metal plate in order to reduce the temperature of combustion process;
- adjustment of lowest possible excess air coefficient (blow, cylindrical, catalytic burners and other special constructions).

GAS-FIRED BOILERS

The gas-fired low-temperature water boilers are predominant for heating purposes. The majority of investigations on boiler modernization refers to this group of heating devices.

The trends of upgrading gas-fired heating boilers include:

- improvement of efficiency in order to reduce gas consumption;
- continuous reduction of CO and NO_x content in flue gases;
- improvement of operating characteristics.

Boiler efficiency depends on following factors:

- heat losses through the boiler walls into the environment;
- chimney loss;
- incomplete combustion loss.

Heat losses through the boiler walls into the environment can be significantly reduced by covering the walls with the layers of insulating material of high heat-transfer resistance. Due to proper insulation, the heat losses through the walls in modern boiler units are ca. 3%, and in the case of boilers operated with low temperature of water (e.g. 60/40 °C) - even ca. 2%. Another method used for reduction of these losses is to guide air flowing round the combustion chamber to the burners.

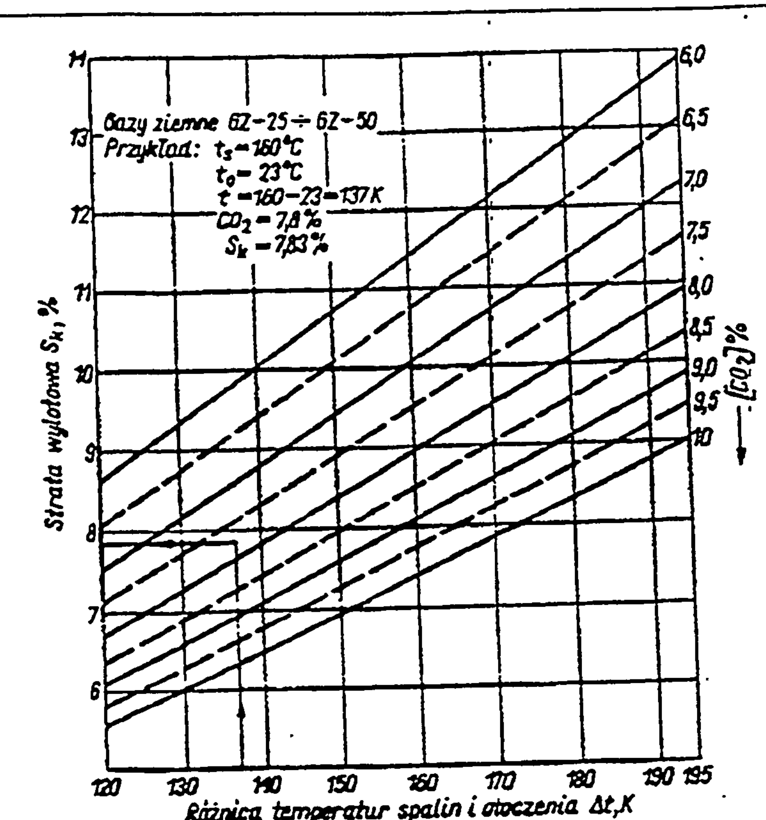
The chimney loss, called also exhaust loss, could be reduced by the reduction of the amount of excess air and - consequently - to reduce the total mass of flue gases. The second parameter influencing the chimney loss is the temperature of flue gases. Certain West European standards define the maximum value of flue gas temperature (up to 300 °C) and determined minimum chimney loss to guarantee proper chimney draught. Excessive reduction of flue gas temperature at the outlet may disturb appropriate operation of the boiler as well as may cause condensation of water vapor on the internal walls of the chimney and - further on - moisturization harmful to the construction of the building.

Therefore, for Polish climate conditions, the minimum permissible temperature of flue gases at outlet has been defined as $t_{fg} \geq 150$ °C.

In order to illustrate the dependence of chimney loss on proper adjustment of combustion process, Fig. 1 presents the chimney loss as a function of carbon dioxide content and temperature difference between flue gas and environment for natural gas combustion.

The incomplete combustion loss appearing due to - first of all - existence of carbon monoxide in flue gases as a product of incomplete oxidation of carbon element to carbon dioxide, can be neglected in practical calculations of boiler heat losses because this loss is as a rule 10-20 time lower than the permissible values.

Natural gas sorts GZ-25 through GZ-50
Example: $t_s = 160$ °C; $t_o = 23$ °C; $t = 160-23 = 137$ [K]
$CO_2 = 7.8\%$
$S_k = 7.83\%$



Chimney loss, S_k [%] vs. Difference between flue gas and ambient temperature, Δt [K]

Fig. 1. Chimney loss as a function of carbon dioxide content and the difference between flue gas and ambient temperature for natural gas combustion

The chimney loss discussed above appear not only during boiler operation, but also at the down-time, i.e. when the burner is put out. These losses can be reduced significantly using the throttles in flue gas channels before the draught stopper (it means boiler cooling) or after the stopper (which results in reduction of air outflow from the heated room). Application of throttles in the flue gas channel may contribute 2% or greater conservation of gas fuel. Many manufacturers offer the throttles as an optional equipment of the boiler.

The next parameter, very important from the point of view of heating costs, is the operating efficiency, i.e. the index of boiler utilization, defined as the relation between amount of heat transferred to the water and the amount of heat supplied in fuel during the entire heating season under current operating conditions. The relation between unit cost of heat generation and the utilization index is presented in Fig. 2.

It is visible on the graph, that the unit heating costs reach a minimum if the utilization index is possibly high. The utilization index is low when the nominal power of the boiler is overestimated comparing with actual demand. Such a situation is observed if the heat output of a boiler chosen is aimed at complete covering the heat losses in the building calculated for extreme weather conditions, which occur rather rarely and make up ca. 10% of the entire heating season. It means that during the remaining part of the heating season, the boiler must be operated at low utilization index, i.e. the burner should be switched off frequently.

The system of controlling heat output of the boiler, most commonly applied in Polish solutions, consists in regulation of water temperature in the boiler by switching „on/off" while many foreign manufacturers - taking into consideration the phenomenon of varying heat demand, which depends on changes in ambient temperature - implemented such a structural improvement, that the burners operate in two ranges of load, i.e. for maximum output (100%) and the partial load, e.g. 60% load with simultaneous controlling the secondary air flow; these two ranges are switched over automatically depending on the ambient temperature. It allows to elongate significantly the time of burner operation and to reduce the burner stoppages, which results in sweeping reduction of boiler stoppage losses. The boilers of this type reach ca. 93% of efficiency.

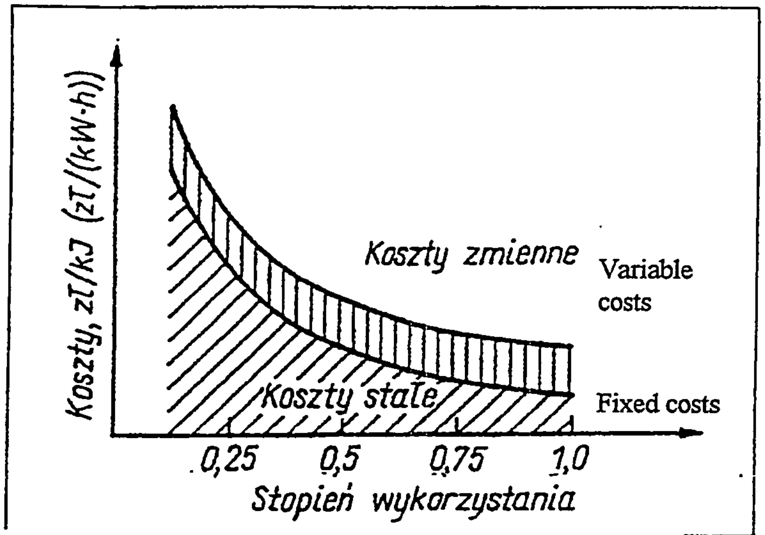


Fig. 2. Unit cost of heat generation [PLZ/kJ PLZ/kWh] as a function of utilization index

The gas fuel consumption can be reduced also by implementing additional control devices. Application of room temperature controllers with 24-hour or 7-day programmers is rather common.

The review of modern trends of boiler development implemented by many West European companies confirms that recently (in particular) the progress in this field is tremendous.

The progress is related first of all to the heat efficiency which determines directly gas consumption reaching already the absolute limit and a distinct reduction of emission of carbon monoxide and nitrogen oxides which becomes lower than severe requirements of the standard and the limitations defined by the institutions responsible for environmental protection.

The gas fired low temperature water boilers of few to 1 000 kW of output are manufactured in numerous versions: heat exchangers made of steel, copper, aluminum, cast iron, alumina-silica pipes and steel panels; opened or tight combustion chamber; standing or hanged on,; with injector or blow-type burners, including the condensing version; to be used in heating systems with natural of forced circulation. The modern structural solutions of heat exchangers (water blocks) of these boilers are very differentiated and unconventional. The version of hanged up boilers is especially popular in case of monotube boilers of small water capacity.

The modern, high efficient gas-fired boilers of different sizes and scope of application are provided with perfect adjustment and protection systems and developed control devices.

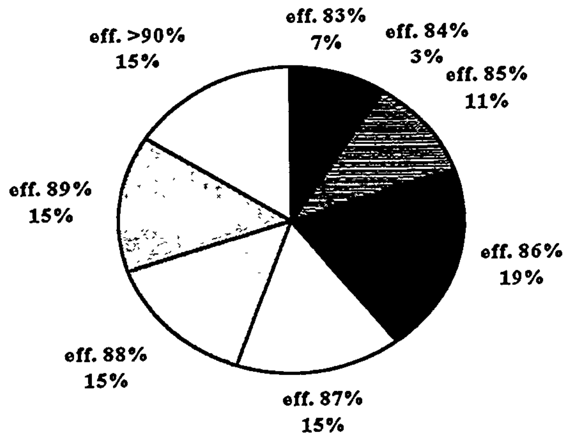
The fitting of West European boilers include as a rule: piezoelectric or electronic igniters, electromagnetic valves, gas pressure control devices (stabilizators), indicators of operating parameters and alarm devices, etc.

Some of these systems improves reliability, economy and safety of boiler operation, the other facilitate the operation and improves the thermal comfort in heated rooms. The efficiency of classic boilers, both Polish and foreign production, investigated at the Oil Mining and Gas Engineering Institute, Cracow, Poland - is presented in Figs. 3 and 4.

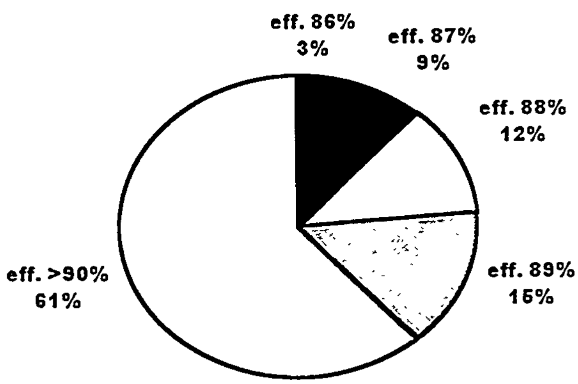
Fig. 3. Heating boilers manufactured in Poland

Portion of boilers reaching given efficiency level [%]

NOMINAL OUTPUT LESS THAN 30 KW



NOMINAL OUTPUT 30 - 120 KW



NOMINAL OUTPUT OVER 120 KW

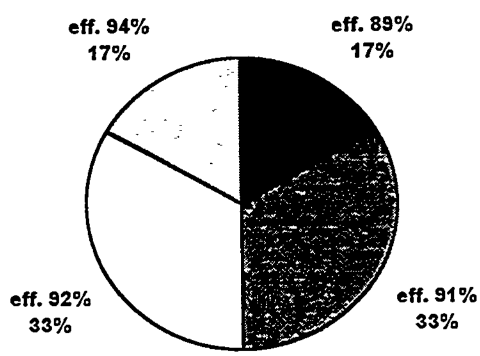
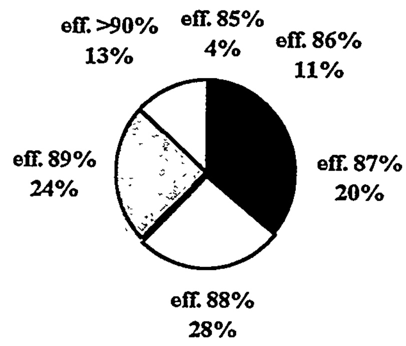


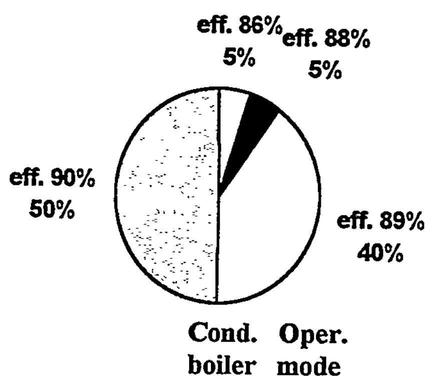
Fig. 4. Heating boilers manufactured abroad

Portion of boilers reaching given efficiency level [%]

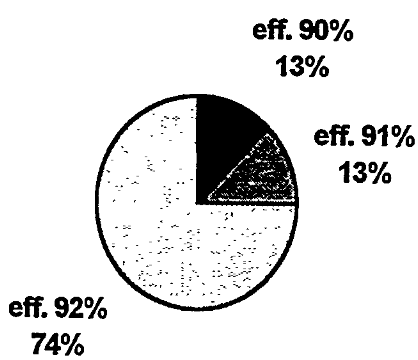
NOMINAL OUTPUT LESS THAN 30 KW



NOMINAL OUTPUT 30 - 120 KW



NOMINAL OUTPUT >120 KW



Following method of conservation in gas-fired heating boilers is the condensation technique. It consists in recovery of the heat of steam condensation from flue gas leaving the facility.

The interest in manufacturing condensation boilers is growing recently especially in West European countries. An appropriate structure of heat exchanger as well as keeping low temperature of feedwater coming back from the network allows to reach partial or even almost complete condensation of steam from flue gases combined with condensation heat recovery and additional heating feedwater. In such a way the boiler efficiency exceeds 100% with regard to heat value of fuel.

Comparing with traditional units, the condensation boilers allow to save ca. 38% energy included in gas. The estimated annual operating efficiency of condensation boilers is 98% while efficiency of traditional boilers reaches ca. 60%. Fig. 5 presents annual efficiency level (operating efficiency) as a function of ambient temperature and boiler rating and compares it with traditional low-temperature boiler.

However it must be taken into consideration that the operation of condensation boilers is accompanied with several structural and operating deficiencies, e.g. obligatory operation at low values of excess air ratio for combustion, required application of water circulation pumps and fans to force flue gas outflow. In order to prevent corrosive action of condensate, the flue gas channels must be made of corrosion-resistant materials and they must be provided with a condensate draining system. In spite of these drawbacks, the condensation boiler become more and more popular in West European countries and it is expected that in France these boilers will constitute 50% of total amount of operated boilers.

The bi-functional boilers, i.e. those used for heating rooms and supplying hot water from a central source are widespread in many countries.

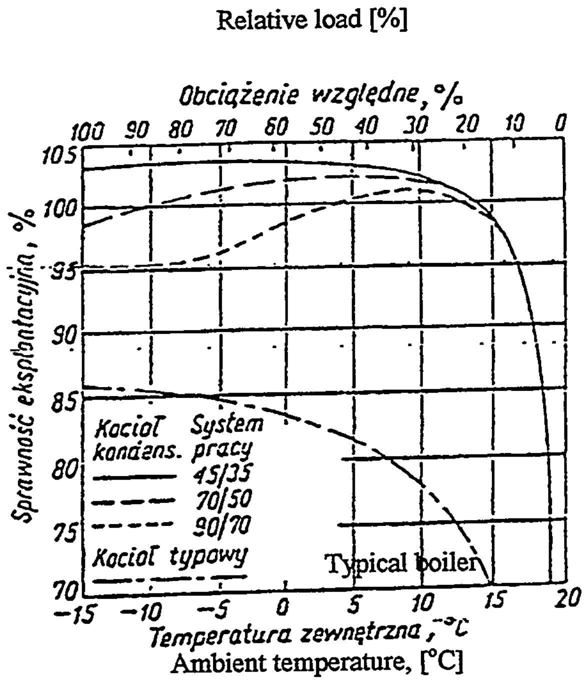


Fig. 5. Operating efficiency as a function of boiler rating and ambient temperature for a typical (traditional) boiler and a condensation unit (type Nefit-Turbo) manufactured by Schäfer Heiztechnik

There exist two structural variants of these devices: monotube boilers of low water capacity or boilers combined with economizer built-into the boiler or installed outside and connected with the boiler unit. Such a boiler is working all the year round; in winter the boiler accomplishes both tasks (with preference to the production of hot water) while in summer time it is used only as a hot water source. The system operation is fully automatic.

The most effective are boiler combined with economizer; such units consist of two elements, i.e. heating drum and an economizer (pre-heater) with defined capacity. The piping of the economizer is included in the boiler piping circuit. The basic requirement is an appropriate chemical, bacteriological and anti-corrosion resistance of the surface in contact with hot water.

ROOM HEATERS

The hitherto existing solutions of convective room heaters (output up to 5 kW) are based upon an opened combustion chamber; they require a room provided with constantly open ventilation channel. The heaters of this type take air required for combustion directly from the room, in which they are installed, and flue gases are taken off into the chimney (type B according to the Polish standards). It follows from the investigations carried out by the Oil Mining and Gas Engineering Institute, that heating efficiency of these heaters ranges between 82 and 85%. In fact heat losses are higher because of energy lost for two streams of additional air, i.e. for:

- air stream sucked in through the installed flue gas draught breaker, ca. 55 m^3 air per 1 m^3 of gas burnt;
- air stream sucked in through the 14*14 cm ventilation channel, ca. 40 m^3/h in average.

Assuming that the heater installed in a given room consumes 0.5 m^3 gas per hour (output ca. 4 kW) and the temperature difference between the outer space and the heated room is 25 °C - heat required for heating these two streams of additional air will reach 0.5 kW/h, i.e. they cause ca. 14.5% surplus loss. Thus the real heat loss of the convection-type room heaters with opened combustion chamber constitutes 29.5%.

Until 1990 only the B-type convection heaters were manufactured and used in Poland. Since 1991 the so-called heaters with closed combustion chamber (C-type) are sold in Polish market. These convection heaters take air for combustion from outside and carry off flue gases outside the room heated, i.e. the combustion chamber is air-tight separated from the room, in which the heater is installed.

Air for combustion is taken from outside through a conduit laid concentric with a channel carrying off flue gases outside the heated room. Thus ventilation of the rooms is not required for correct combustion and the user is allowed to regulate air exchange freely. It leads to significant conservation; maximum saving could reach 14.5%; in the case of a 4-kW output heater and high-methane natural gas price being ZLN 0.45 per m^3 it gives ca. ZLN 0.326 of savings per one hour of heater operation.

However it must be underlined, that the single heaters are able to heat one single room or passage rooms with an opened passage (surface up to 40 m^2). As a rule the power of a heater is selected basing upon the surface of the heated room and the size of installed heaters is adjusted to the requirements. The heaters of such version belong to the safest and their efficiency reach 89%. The evident difference in efficiencies of both discussed types of heaters is caused first of all by the temperature of flue gases.

Recently in addition to the B-type and C-type heaters there appeared also the A-type heaters in Polish market. They take air for combustion from the heated room, and the flue gases are taken off outside. This type of heaters cannot be used in rooms occupied permanently by the users - they are suitable for heating stores, etc., only. The A-type heaters are adjusted mainly for liquid gas.

Recently (1991-1994) the certificates with "B" safety mark has been awarded to 18 foreign and 3 domestic companies for 29 types of heaters with different equipment, combustion chamber type, casing version, output and method of taking-off flue gases.

SUMMARY

Basing upon the presented analysis it can be stated that the power output of Polish and foreign boilers ranges between 9 and 35 kW. The carbon monoxide content in flue gases reaches (in average) 0.005 vol.%, i.e. it is much lower than the maximum permissible level. Temperature of flue gases (excluding condensation boilers and those with air-tight combustion chamber) ranges between 150 and 200 °C and their heating efficiency reaches 87-93%. The best parameters have been stated for condensation boilers, however they are still not widespread in Poland for high cost of the equipment and assembling works.

Among the heaters, the most safe are convection devices with closed combustion chamber; their efficiency is also the highest.

Thus it can be stated that a wide spectrum of high-efficient heating devices with good combustion parameters are available. The range of output is sufficient to meet household and communal requirements. They are however - predominantly - units manufactured abroad.

It is difficult to formulate the program aimed at the improvement of the technique of heating devices made in Poland, and its implementation is uncertain because the production process is broken up into small handicraft workshops.

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CONTRIBUTION OF ELECTRIC ENERGY TO THE PROCESS OF ELIMINATION OF LOW EMISSION SOURCES IN CRACOW

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INTRODUCTION

Power engineering and ecological aspects of residential heating

At present energy supply belongs to the most important global problems. A significant part of energy is consumed for residential heating purposes. Depending on climatic conditions, fuel distribution and the level of technological development, the contribution of these purposes ranges between ca. 50% (Poland) and ca. 12% (Spain).

The power engineering structure in Poland is based almost exclusively upon solid fuels, i.e. hard and brown coal. Chemical compounds (carbon dioxide, sulfur dioxide and nitrogen oxides) produced in combustion process influence negatively the natural environment. The contribution of residential heating in this negative effect is rather significant.

Because of the fact, that the resources of fossil fuels (the most important source of energy at present) are limited and their influence on natural environment is negative, efforts are made to find out more effective ways of energy consumption and to reduce the pollutant emission from heating sources.

This problem is a topical issue in Cracow, especially during the heating season because the coal-fired stoves situated in the central part of the town remain the most important source of pollutant emission. These sources cause serious menace to the health of inhabitants; furthermore the pollutants destroy Cracow monuments entered in the UNESCO world list of human heritage.

Role of electricity in heating

Electric energy plays a special role in heating. It is used as a basic, auxiliary and additional warming up energy. The latter is especially inconvenient with regard to the power distribution system because its appearance is not foreseeable and it intensifies the peak of the curve of daily demand. However the most important is the usage of electric energy as a direct energy carrier. Consumption of electric energy for heating purposes is differentiated in various countries. It depends on different economical potential of individual countries, on costs of electric energy generation and on its relative availability. Norway takes the lead with 53.8% of the total power balance used for heating purposes. The high level of electric energy consumption for heating purposes is reported also in Canada, Israel, and in Europe: in Switzerland and in Sweden (ca. 20%). In Poland only ca. 1% of electric energy is used for heating. It is a low factor in comparison with countries of similar climatic conditions - e.g. in Germany the factor reaches 6%, in the UK - 10.6% and in Austria - 5.8%. Such significant differentiation results not only from technical and economical reasons; it is caused first of all by the power engineering policy implemented in individual countries.

ELECTRIC ENERGY IN CRACOW HEATING SYSTEM

Present state

The present and potential role of electric energy in heat distribution system should be analyzed basing upon the general balance of demand in heat distribution. The estimated present heat balance for Cracow amounts ca. 3 000 MW. Ca. 50% of this amount is covered by professional Cogeneration plants EC Łęg and EC Skawina; slightly over 30% - by local, residential estate and industrial boiler houses and 13% - by home tile stoves fired with coal. The contribution of electricity and gas constitutes 3% and 4%, respectively.

These data are presented in Fig. 1.

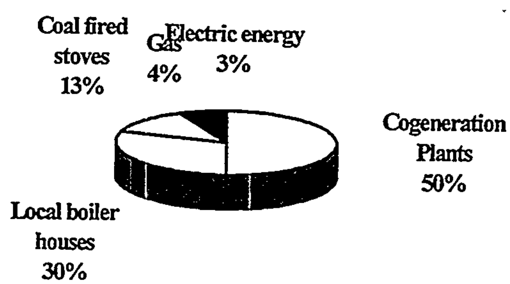

Fig. 1.

The electric energy pool is thus 4 times greater than in average in Poland and growing trend is still observed.
It should be underlined that recently - as a result of intentional actions - the contribution of professional power plants in heat distribution process is growing at the sacrifice of low-efficient local boiler houses. In addition the pools of gas and electricity are growing accompanying the elimination of coal-fired home stoves. This picture should be completed with the estimation of the portion of electric energy used for heating purposes in relation to the remaining purposes of use of electric energy by Cracow industry and residents. These needs cover ca. 20% of the average daily peak power demand observed in winter season.
There is a lack of similar data reported for other towns in Cracow and therefore comparisons are not possible. However this contribution is absolutely significant in the entire balance of electric energy in Cracow.
The basic type of electric heating systems applied at present in Poland for residential heating is called EGA, i.e. electric accumulation radiators. Also in Cracow this is the major system of electric heating. The total output of installed units reaches at present ca. 120 MW, most of them within the second ring area and in Kazimierz - i.e. in those quarters, in which the most valuable monumental urban centers are situated. Also the majority of ca. 100 000 existing coal-fired stoves in residential and utility buildings are situated within this area.

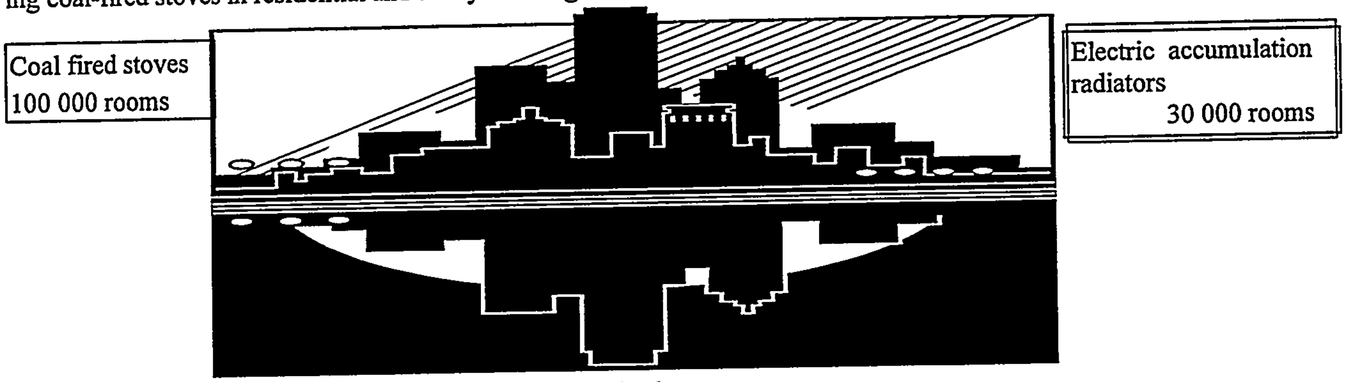

Fig. 2

Basing upon the data gathered by the Power Distribution Plant as well as studies carried out by Cracow Development Office it is estimated that over 30 000 rooms are heated using electric energy. It constitutes a significant portion (ca. 30%) of the total amount of still existing coal-fired stoves. The above mentioned comparisons allow to estimate real feasibility and scale of application of electric energy in heating system of the town and its participation in the program of elimination of low emission sources.

Perspectives

Prior to answer the question about the perspectives of increasing the contribution of electric energy for heating purposes at certain regions of the town, first of all some circumstances and aspects of electric heating should be presented.
The basic statement is that neither technical nor economical criteria do not account for creation a separated network system to supply electric energy for heating purposes. Therefore the feasibility in this field are practically determined by the reserves in the existing distribution system and - to an equal extent - by the reserve in output existing in energy sources understood as supply stations 110/15 kV. Such reserve in sources exists and is estimated as ca. 50-70 MW; however there is no reserve in medium nor low voltage distribution network.
Therefore one criterion determining the feasibility of using electric energy for heating purposes is the usage of existing distribution network and transformer stations supplying energy for this network. The level of network utilization depends on reserve resulting from technical parameters of the network and - to the significant extent - on load distribution curve registered for the given sub-system. The daily graph of network demand in Cracow, for chosen days in summer and in winter are presented on Figs. 3.1. and 3.2.
The existing network infrastructure must cover the communal needs of the residents with regard to electric energy during day and night period, also at peaks. At present, taking into consideration all subsequent reserves and facilitating the analysis it could be stated that the power distribution network is utilized using almost full technical capacity. The reserve in power transmission, which could be used for heating purposes, appears out of the peak demand periods, mainly in so-called load „valleys".

It follows from the presented daily curves of power demand, that certain reserve of energy in the system exists at nights, i.e. within the period between 22:00 PM and 6:00 AM. Some reserve appears also at the noon „valley", i.e. between 13:00 PM and 15:00 PM. It must be taken into consideration that the development of town agglomeration will result in significant increase in peak power demand during the period between 17:00 PM and 21:00 PM for the entire town and especially for the city centre. It will result in necessity of development of the power distribution network in order to cover this increase, and consequently it will allow to increase power supply for electric accumulation radiators beyond peak hours.

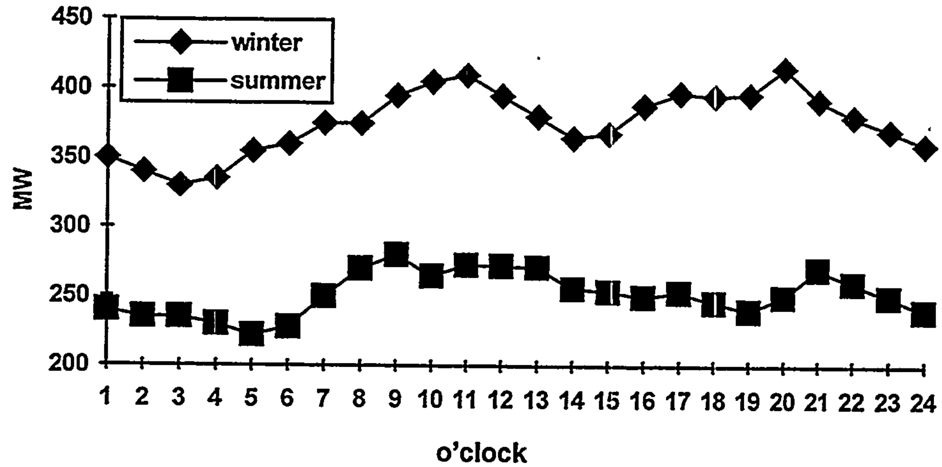

Fig. 3.1.

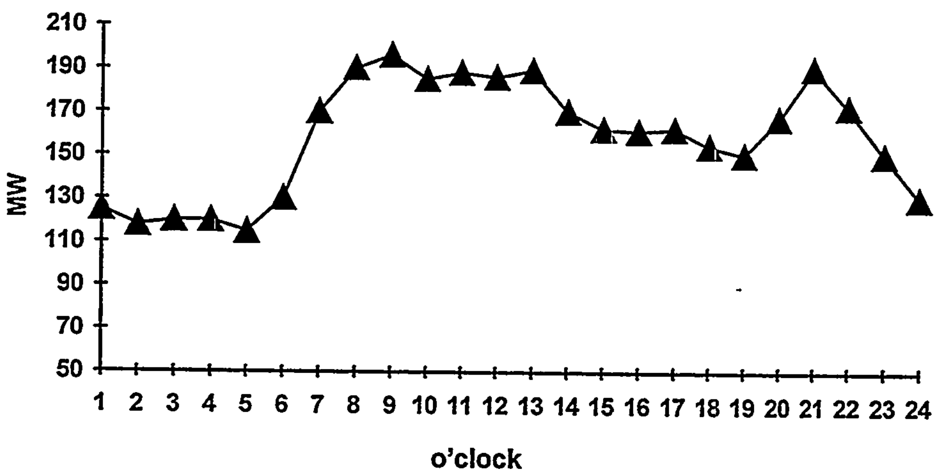

Fig. 3.2. Daily load of electric network for Cracow (excl. „T. Sendzimir" Steel Plant) on May 24, 1995

It must be also underlined that the hitherto observed increase in energy consumption by electric heating devices was possible due to the modification and upgrading the existing network as well as new investment implemented by the Power Distribution Plant in the town. Erection of Łobzów 110/15 kV transformer station belongs to the largest undertakings in this field. Simultaneously the 15 kV cable network has been built in order to make possible transmission of energy towards the centre of Cracow. This action enabled - for example - top assign in Cracow over 17 MW for heating purposes during the short period between January and March 1995. More than 50% of this output is consumed within the city centre. It allowed to eliminate next 6 000 coal-fired tile stoves, mainly in residential buildings. The data are presented in Fig. 4.

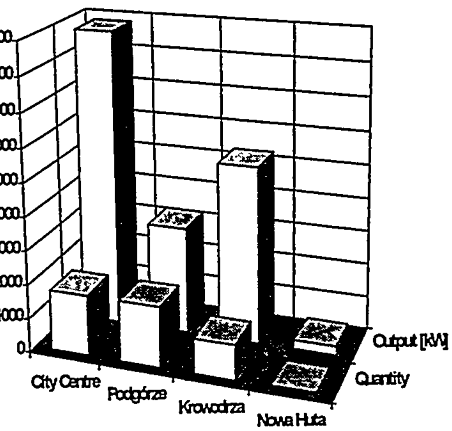

Fig. 4.

Further development of the 15 kV distribution network in Cracow is expected, however the scale of effects depends strictly on the total value of capital investment. Taking into consideration the capacity of the Power Distribution Plant it should be assumed that probable annual increase in consumption of electricity for heating purposes will exceed 5 MW, i.e. it will allow to reach the target value in minimum 6 years.

In spite of investment activity connected directly with the transmission lines and devices, we started actions - aimed at the optimization of the power distribution system - using a modern technique of acoustic frequency control. The variation of daily power demand, discussed earlier as well as the technique of controlling energy consumption by the electric accumulation radiators by means of a control clock were limiting the further increase in the contribution of electric energy for heating.

Such possibilities appeared at present. After certain tests required for implementation and gathering experience, the program of acoustic frequency controlling (AFC) has been started. In this program the 110/15-kV transformer stations situated in the city centre and in Krowodrza were equipped with AFC transmitters to transmit the control signals to a maximum number of receivers.

The power distribution network is used as a transmission path. The application of AFC system for controlling heating demand must be based upon the principle that the receiver must reach heating comfort conditions. Therefore only the time of energy consumption and not the total amount of consumed power can be controlled. Nevertheless, dividing the consumers up into groups for which energy supply is shifted in time, the entire power consumption could be shaped desirably in order to fit this consumption in with the curve of non-heating load. It should be stated that implementation of AFC system influences significantly the possibility of using the existing system for heating purposes and - combined with other actions discussed above - will allow to reach the expected effect contributing in the process of elimination of coal-fired stoves within the city centre. However it will be difficult to keep the assumed rate of increase. A significant barrier seems to be the lack of investment capacity of potential users. According to the non-documented data, at present the cost of implementation of accumulative heating for one room ranges from PLN 1 000 to 1 500 provided that the investment is limited to the internal installation in the building and in the apartment. In the case when the external network supplying given object must be also modernized, the total cost of the task increases significantly. Financing of such task exceeds the capacity of a single consumer. Furthermore such investment can be profitable only in the case of a larger group of devices. The attempts of the Power Distribution Plant in this field has not aroused any interest of neither private building administration nor the Residential Building Management Enterprise. Conclusion can be drawn that this role should be played by municipal authorities within the policy of elimination of low emission sources. The organizational and financial aid addressed directly to the consumer seems to be most effective. These effects may be expected both in reduction of capital cost of investment and in reduction of the cost of elimination of negative results due to the operation of coal-fired tile stoves.

Thus such actions could intensify and optimize the investment in direct energy supply to the user, and mainly to the larger groups of consumers interested in electric heating. As an example the group of residential buildings 65, Zyblikiewicza-St. can be referred. In these buildings modernization of the power distribution network aimed at the creation of conditions for conversion to accumulative heating in 200 rooms has been implemented in combined action of the Cracow Power Distribution Plant and the Residential Building Management Enterprise. This is however an exceptional example, but it gives a picture of potential development.

Other possibilities

Apart from direct actions related to the conversion of coal-fired stoves to electric heating, the power engineering creates circumstances supporting improvement in efficiency of efforts aimed at the elimination of local boiler houses. Taking into consideration the installed total output of these devices, electric energy must be excluded in advance since it cannot replace coke nor coal used in these boiler houses. It is assumed that the solid fuels will be replaced with natural gas; this option allow to install small gas-fired cogeneration units. The authors confirm that there exist a possibility to connect such units to the power distribution network and to purchase energy generated there.

When discussing the problem of application of electric energy for heating purposes it should be mentioned, that electric energy is also used as an auxiliary energy source in such systems, in which the non-electric energy is used. Electricity is used in such systems first of all for transportation of the energy carrier (hot water, air), for supplying pumps, fans and compressors.

Finally one of the greatest consumers of electric energy should be mentioned: a municipal tramway network; the tram cars are heated in winter using electric energy.

External circumstances

It seems impossible to discuss all the problems related to the electric heating systems in a short presentation. Therefore in this chapter only certain important aspects of this problem will be referred to.

First of all it should be mentioned that for a long period the national regulations decided social criteria of implementation of electric accumulation radiators. The present transformations caused that only technical and economical criteria can limit this development. Also the new wholesale pricing system for Power Distribution Plant caused that a former paradoxical situation has been eliminated when the purchase price was higher that selling price at night, when energy is used for heating purposes. The effect is visible at present: output assigned to the purposes of electric accumulation radiators increased significantly.

There exist however certain financial, organizational limitations and also troubles in the process of investment preparation. Since the so-called „re-valuation" funds have been withdrawn in 1990 from financing the power distribution infrastructure within the Old Town area, at present this project if financed by Power Distribution Plant only. This is an element limiting potential development of the use of electric energy for heating purposes. Another important hindrance, which seems even more important, is the problem related to the location of 15/0.4 kV transformer stations which constitute an indispensable element of the development of the power distribution network.

Difficulties in gaining location for such stations, first of all due to the property relations within the centre of Cracow hinders significantly the investment process. In the opinion of the authors, the Power Distribution Plant may not be left alone with these problems. It should be a subject of special interest of the Community authorities, in relation to the two presented questions. It would create circumstances for full implementation of investment means which could be assigned to this purposes by the Plant.

Another problem, not discussed in this paper, is the cost of electric energy in relation to the cost of other energy carriers. It should be stated only, that these relations result from national policy in this field and they play an important role in this project.

FINAL REMARKS

Summarizing it can be stated that although the contribution of electric energy in the entire heat balance of the town is rather small, however electricity may play an important role in the process of elimination of low emission sources within Cracow centre. An advantage of electric energy as a heating source is that it is relatively easy to supply energy to the user especially in these areas, in which distribution of natural gas or district heating is rather difficult. Taking into consideration another heat carriers and circumstances related to electric energy, discussed above, the preferred areas of implementation of electric heating can be defined. These areas are marked in Fig. 5. Resolutely, the most profitable areas are Łobzów and Kazimierz. For these town quarters the lowest investment costs are expected because the 110/15 kV stations are already located there. Relatively difficult - with respect to the investment - is the area within the first ring (Planty park): there appear many problems related to the network development and especially with location of transformer stations because of monumental feature of the buildings. These same problems, however not so intensive, exist also in Kazimierz. Within the remaining part of the city centre electric energy can be used for heating purposes as an additional option together with another heat carriers.

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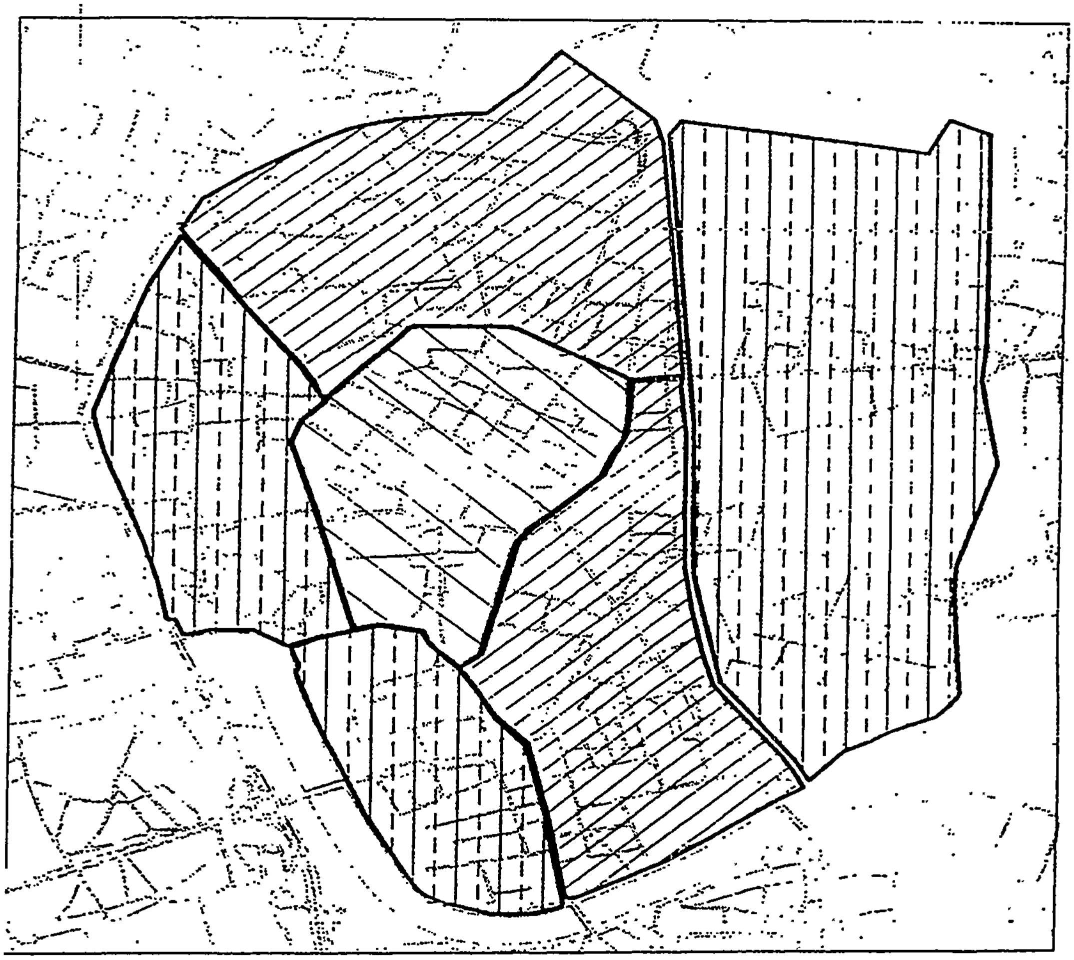

Rys. 5 Fig. 5

(pattern)	**obszary dla CO, gazu i energii elektrycznej**	areas assigned for district heating network, natural gas and electric - energy
(pattern)	**obszar dla gazu i energii el. o szczególnych preferencjach dla energii el.**	area assigned for natural gas and electricity with special preference to the electricity
(pattern)	**obszar dla gazu i energii el.**	area assigned for natural gas and electricity

Fig. 5

Session V

Financing Projects

Co-Chairmen: Jerzy Wertz, Voivodeship of Kraków and Robert Ichord, U.S. Agency for International Development

CAPACITY AND PRINCIPLES OF PARTICIPATION OF THE PROVINCIAL FUND OF ENVIRONMENTAL PROTECTION AND WATER MANAGEMENT IN CRACOW IN CRACOW PROGRAM OF ELIMINATION OF LOW EMISSION SOURCES

Krzysztof Bolek, Henryk Sarzyński
Provincial Fund of Environmental Protection and Water Management in Cracow, Poland

In general the principles of environmental protection and creation are determined in Law issued January 31, 1980. Certain detailed solutions have been included in several amendments in subsequent years and the uniformed text of the Law on Environmental Protection and Creation was published in 1994. The Provincial Fund of Environmental Protection and Water Management was established in 1989 but till 1993 the Fund has no legal status.

The main purpose of creation of such fund was to assign certain financial means to the defined tasks related to environmental protection. This way the fund accumulates financial means from the fees paid for the usage of natural environmental for business purposes and from penalties becoming due in the case of non-observance of the environmental protection standards. On the other hand the Fund spends money for tasks in the field of environmental protection requiring urgent implementation. It should be added here that - after few amendments brought into force - the Provincial Funds are able to assign greater amount of money to the implementation of these tasks.

The basic purposes of Provincial Fund activity, defined in Law, determine the policy and criteria of the selection of undertakings. This is also a base for making programs of activity and for creation of the list of priorities.

The environmental protection problems in the individual provinces are different. Therefore the scope of works partly financed by the Fund is very differentiated both in essence and in the method of financing.

The former system of subsidies is now being replaced with a wide range of partial financing of undertakings in the field of environmental protection.

The system of selection of these undertakings has been changed essentially. At present the selection of tasks and methods of their financing is based first of all on economic criteria.

The change consists in replacing the system of absolute subsidies - if applicable and feasible - with loans. Consequently it resulted in creation of a system of preferential tasks with regard to the defined purposes estimated as the most important in each province. When analyzing the needs, the total amount of money required for the implementation of these tasks in the individual elements of natural environment and then - the available means are split. The tasks in the field of air protection in the town is of basic importance for Cracow environment. Although - as it follows from the measurements carried out recently - emission of particulates in 1993 decreased by ca. 30% and emission of sulfur dioxide (the basic air pollutant) decreased by 2% (compared with 1992 emission), further substantial efforts are required to improve air quality in Cracow. It should be underlined that at present the improvement results first of all from the pro-ecological actions undertaken in „T. Sendzimir" Steel Works, in Kraków Heat and Power Cogeneration Station S.A. and in Skawina Power Plant.

The expenses related to the implementation of investment works in the field of air protection - i.e. first of all to the elimination of low emission sources - constitute 33% of the entire sum spent in 1994.

Since the fees paid for usage of natural environment for business purposes and penalties related to the non-observance of environmental protection standards, defined in the Ordinance of Minister, take into consideration both the national policy and the inflation process, then it should be expected that the total amount of financial means assigned to these tasks will increase every year.

Therefore proper selection of undertakings is very important. It must guarantee equal chances for each type of entrepreneurs authorized to apply to the Fund for financial aid within the defined limits in order to achieve highest possible ecological profits from limited means administered by the Fund.

The procedure of selection of the undertakings includes following stages:

- design works and elaboration of the project;
- financial decisions and negotiation of agreements;
- project implementation supervision;
- estimation of decisions taken and drawing conclusions for the future.

Implementation of the projects related to the elimination of low emission sources is especially important for Cracow. Such hierarchy of undertakings required elaboration of criteria which allow to participate in financing tasks significantly influencing the improvement of environmental conditions (in a form of a grant of a preferential loan).

The highest concentration of air pollutants are measured within the central area of the town. The pollution drops with increasing distance from the centre.

Taking into consideration this criterion, Cracow has been subdivided into two certain zones: within the first ring, within the second ring and outside the second ring. Consequently preference is being given to the elimination of solid-fuel fired boiler houses situated within the Old Town and between the first and second ring.

The total amount of money at the disposal of the Provincial Fund of Environmental Protection and Water Management and assigned for the elimination of low emission sources is limited. Therefore the Fund should participate first of all in such investment projects in which the lowest investment cost causes elimination of as high as possible output of the existing boiler houses.

It is also important to give preference to such investment tasks, in which the lowest amount of money spent for investment causes elimination of the greatest load of pollutants emitted to the atmosphere.

Another important criterion is also the accordance of the suggested conversion method with the solutions in the field of heat engineering and elimination of low emission sources, accepted for implementation in the town.

Also the market-oriented aspects of suggested solutions aimed at the elimination of low emission sources must be taken into consideration. It means that if there appears any possibility to choose between different available solutions, the investor should have the right to choose the optimal option analyzed from the point of view of capital investment costs and future operating costs.

On the other hand, the town authorities are going to prefer the solutions which will allow the use of existing reserves in the central sources of heat and in the basic elements of the municipal district heating network. It means that connection of the existing objects to the municipal district heating network will be preferable if such an option exists.

A compromise between the market-oriented aspect of the solutions and the preference given to the connection of the customers to the municipal district heating system should consist in negotiations aimed at partial or - in well founded cases - even complete financing of the connection and in negotiation of the energy pricing.

The present legal status of the State, Provincial and Communal Funds gives a base for a widespread cooperation in this field and for efficient usage of assigned financial means. It follows from the Law, that the Communal Fund grants awarded to the implementation of defined tasks may be - and in certain cases should be - supported by the Provincial Fund. This rule is especially related to the most significant tasks aimed at the improvement of natural environment in Cracow and related to the elimination of low emission sources.

The program of implementation of these tasks should include a widespread cooperation with other funds, e.g. with State Fund of Environmental Protection and Water Management, with Ekofundusz (Polish Debt-for-Ecology Swap Fund), in order to create a wide financial base for implementation of maximum possible number of such projects. It is well known, that the demand in such undertakings is tremendous, and therefore it seems necessary to use all available capacity.

The authorities of the Provincial Fund are focused on the problem of implementation of the investment tasks aimed at the elimination of low emission sources in Cracow. The Fund assigns to these undertakings significant amount of money remaining at its disposal.

In 1994 the Provincial Fund of Environmental Protection and Water Management in Cracow has participated in the elimination of 56 low emission sources, out of this elimination of 49 coal-coke-fired boiler houses and elimination of tile stove heating at 7 objects.

The implementation of these investments resulted in reduction of annual air pollution: particulates - by ca. 237 Mg, sulfur dioxide - by 165 Mg, carbon monoxide - by 351 Mg, nitrogen oxides - by 28 Mg.

The list of projects related to the elimination of low emission sources in Cracow, implemented with the participation of the Provincial Fund includes elimination of solid-fuel fired boiler houses in following objects:

- Regional Office of „Solidarity" Trade Union at Szczepański-Sq.;
- Institute of Forensic Expertise, Court of Appeal, Westerplatte-St.;
- Botanical Garden, Jagiellonian University, Kopernika-St.;
- Provincial Specialist Health Service Office, Batorego-St. and Dunajewskiego-St.;
- Education Economy Department, Smoleńsk-St.;
- Cracow Rheumatology and Rehabilitation Hospital, Focha-St.;

- Cracow Health Resort Department, Rydlówka-St and in Swoszowice;
- Military Regional Living Accommodation and Building Management, Głowackiego-St, Rakowicka-St., Rydla-St. and many others.

The list of advantages of the new system of financing the ecology-oriented investment undertakings includes:

- possibility to finance the undertakings in cooperation with other legal subjects (e.g. State Fund, Ekofundusz, Communal Fund);
- possibility to increase the amount of money at Fund's disposal through the different forms of raising capital and financial operations;
- more effective use of existing means;
- constant and objective conditions of assigning means to the investors (grants or loans).

An important problem is also to make the investor interested in a prompt implementation of the tasks, fulfilling the expected parameters of ecological effect as well improvement of the financial discipline. These purposes are reached through the preferential conditions (interest rate) of the debts and through possible partial remission of these loans.

The determination of the strategy in the field of elimination of low emission sources is a task of provincial and municipal authorities, while the Provincial Fund of Environmental Protection and Water Management is responsible for effective financial supporting of these strategic programs.

We rejoice at the hitherto reached success but also we are conscious of the scope of future work. The implèmented tasks must be monitored; they projects are subject of final evaluation aimed to current correction of the implementation programs in order to optimize the future ecological effect.

INFORMATION ON THE POSSIBILITIES OF CRACOW COMMUNITY IN THE FIELD OF THE ELIMINATION OF LOW EMISSION UNDER THE COMMUNITY FUND FOR ENVIRONMENTAL PROTECTION AND WATER MANAGEMENT

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The Act dated May 17, 1990 regarding the division of tasks and competencies, as described in the detailed regulations, among the community organs and civil service units has actually awarded no competence to the commune organs as far as the air protection against pollution is concerned (except the matters regarding town and country planning and the location of certain investments).

It arises out of the Act on Environmental Protection that no right to limit or stop any activity causing air pollution by the so-called low emission is granted to the community organs.

Irrespective of the said above, the Council of Cracow Town determined the basic directions and purposes of the social and economic policy and program for Cracow (up to year 2000) by passing a resolution dated November 5, 1993; as the detailed purpose, the following principles of rational energy management have been assumed:

- in the gas networks zone - the use of natural gas-fired heating and technological boiler houses;
- in the area of excess of electric energy - the application of energy-supplied accumulation heating;
- in the area of the existing municipal heat distribution network - the heat exchange stations;
- in the area deprived of gas networks, municipal networks running from thermo-electric power plants and power supply networks - pure oil-fired boiler houses.

The real effect of the Community upon the grade of atmospheric air pollution caused by the so-called low emission could come into operation not but before establishing the commune fund for environmental protection.

The Community fund for environmental protection was established pursuant to the Act dated April 3, 1993 and regarding an amendment in the Law on environmental protection and formation and the Law On use and conservation of inland waters. This act entered into force on June 2, 1993.

According to the Statutes in effect, the means of the Community funds serve for the financing of tasks related with the environmental protection and water management. As in the case of the National and Provincial Funds for Environmental Protection, the profits of the Community fund are proceeds from payments and pecuniary penalties administered and collected basing upon the statutes and those coming from the activities held for the sake of the environmental protection and water management, voluntary contributions from workplaces, private or legal persons or their donations, as well as natural services or means coming from the foundation.

The proceeds collected for storage of wastes contribute in 50% to the fund income of the community where those wastes are dumped.

The community incomes consist as well of all proceeds from payments and penalties coming from the territory of the given community and settled in consequence of having removed trees or bushes and in 10% of proceeds from penalties and payments for other kinds of economic exploitation of the environment and having it modified, as well as for a particular exploitation of water itself and water installations.

According to the law, the Community fund means are apportioned for:

a) ecological education and the propagation of pro-ecological actions;
b) supporting the environmental controlling and measuring systems;

c) the implementation of modernizing and investment tasks serving for the environmental protection and water management;

d) arrangement and maintenance of green areas, afforestation, shrub planting and town parks;

e) the implementation of enterprises related with the economic exploitation and wastes storage;

f) other objectives serving the environmental protection in the commune as determined by its council.

The Regulations of the Community Fund for Environmental Protection and Water Management in Cracow passed by the resolution of the Council of Cracow, dated August 25, 1994, provide that the means from the Community Fund for Environmental Protection and Water Management are first of all apportioned for additional financing of the Cracow Community's own tasks serving for the environmental protection and water management, pursuant to the guide-lines of the social and economic program of Cracow as approved of by the Council of the Cracow Town on November 5, 1993.

In relation thereto, motions for supplementary financing of the tasks from the Community Fund mentioned may be, in the first place, placed by the municipal structural units as well as other candidates having a legal status and realizing the tasks constituting the community's own ones. According to the Regulations of the Community Fund said, the investment tasks serving for the environmental protection and water management may be financed up to 50% of the task costs and only exceptionally up to 70%. At the same time it is allowed to finance the tasks performed in whole by the community.

According to the Regulations, the condition for obtaining a financial aid in relation with the fund is placing a proper application at the Office; instead, the indispensable requirement for a supplementary financing of a task is having the technical documentation and estimates considered as one's own means.

This requirement limits the number of motions placed to a considerable extent.

In 1994 - in the first year of practical operation of the Community Fund said in Cracow - the proceeds amounted to ZLP 23 700 000 000; by decision of the Council of Cracow Town dated April 8, 1994, from this sum ZLP 13 500 000 000 was apportioned for modernization tasks and investments. By resolution passed on August 25, 1994, according to the sum mentioned, a detailed list of 8 modernization and investment tasks complying with the fund's regulations-related conditions and serving the elimination of low emission and totaling ZLP 3 000 000 000 was elaborated. Pursuant to the Regulations, such municipal structural units, like schools, kindergartens, créches and youth sports and cultural centers were granted subventions.

The investments given supplementary financing consisted in eliminating the solid-fuel-fired boiler houses being noxious to the environment through a total eradication of local boiler houses via either connecting to the municipal heat distribution network (4 cases) or modernization of the local heating system by applying modern gas- (three cases) or oil-fired (one case) boilers.

An important criterion for selecting the tasks to be given supplementary financing from the Community Fund was the location of the structure - because the highest concentration of air pollutions brought about by low emission takes place in the central regions of the town, the structures situated at the center were preferred.

All scheduled tasks given supplementary financing from the Community Fund in 1994 and related with the elimination of low emission were completed in time and have already generated an ecological effect in the heating season 1994/95.

PERSPECTIVES OF CO-OPERATION WITH THE WORLD BANK TOWARDS ELIMINATION OF LOW EMISSION SOURCES IN KRAKÓW

Dr Krzysztof Görlich

PREAMBLE

I am not going to speak about or for the World Bank. More time and a different scope of the conference would be needed in order to more deeply assess the role of the Wold Bank and other international lenders and donors in the environmental and energy sectors in Poland. I am going to stay within the context of the Kraków Clean Fossil Fuels and Energy Efficiency Project financed by the US AID and managed by the US DOE (called here for simplicity the '*Kraków Programme*').

However, in order to assess a role of the World Bank and other international lenders and donors in the pro-environmental transformation of the energy systems of Kraków, one needs to briefly discuss:

- the possibilities and confinements related to the 'technology' of disbursement of the financial resources by the multilateral development banks (MDB's) in Poland
- the type of results obtained within the 'Kraków Programme' and a concept of involving American commercial companies to implement the clean-air policy for Kraków.

THE MULTILATERAL DEVELOPMENT BANKS

As regards multilateral development banks' role (not only the World Bank, but also EBRD, EIB, IFC, the Nordic Bank) , there are many successes and many problems on the lender and borrower sides. These problems many times inhibited implementation of the environmentally and economically attractive procjects. Only in Kraków the projects not implemented include two important avantgarde concepts of privatisation of the ECKSA heat-and-power plant, and creation of the revolving fund to eliminate local solid-fuel biolers.

The World Bank and other MDB's do the following things in order to lend their money in Poland:

- secure their own expertise and technical assistance financed from the project money or as an additional grant,
- apply conditionalities which are formulated as the terms of reference for the project definition and a sequence of tenders; the conditionalities favour:
  - geothermal energy and coal-to-gas conversion within the Global Warming environmental programme (e.g. Global Environment Facility)
  - energy conservation in buildings,
  - no subsidies for fuels,
  - world-level fuel prices according to the Bank's predicted trajectories of change,
  - open international bidding procedures for all purchases of services and equipment.
- set certain institutional requirements for the borrower side,
- adopt procedures with specified decision steps; whereby decisions are taken by the Bank, based on the feasibility studies, and evaluations done by the project officers after a sequence of missions to the site.

The process is somewhat rigid and time-consuming, but usually carried out very professionally. The whole process brings with it a lot of educational potential either in a form of direct training for the local staff involved or indircetly, by the working co-operation among the foreign and local experts.

In Kraków and in the whole of Poland the World Bank has introduced many new financial, insitutional and technical concepts and did a lot to expend understanding of free market and of how environment, energy and finances may be linked to bring better use of natural resources, cleaner air and better economic efficiency. The World Bank projects in Kraków and in the region expanded also a scope of the environmental consideration of Polish authorities by coupling the local environmental projects with the regional (acid rain) and global (green house gases) problems.

The World Bank, within last years, under the late Mr. Lewis Preston, has adopted even stricter criteria of preparation and evaluation of the projects in order to avoid 'problem loans' (which currently are estmiated at 15.2%). This results in the fact, that the World Bank loans become more difficult from purely financial-technical point of view. However, the Bank also changed its strategy from 'preocupation with the lending volumes' to an 'overriding concern with the development results in the field of the Bank-supported operations'. This again means that the development or environmental improvement targets and economic criteria for the loans will be stricter in order to secure environmental improvement targets rather than increase *par force* the volumes of disbursement. The change in the Bank's policy results also from an intensive criticism on part of the environmental NGO's who accuse the bank of a lack efficiency in reaching environmental targets or of a disregard for the needs of sustainable development,

THE 'KRAKÓW PROGRAMME'

Let us now describe, in about the same way, the process and targets of the US AID 'Kraków Programme', There are some specific features which make difference between the World Bank approach to the environmental projects in the Kraków region and the US AID 'Kraków Programme'. These differences made donor co-ordination and the replicability of the 'Kraków Programme' results, difficult.

The 'Kraków Programme' is being executed using the following procedure:

- it split money into the analytical phase I ($5.5 million) and a implementation phases II and III. (c. 14.5 million).
- during phase I the programme secured its own expertise and technical assistance by using c. 70% of resources for American experts and c. 30% for Polish experts.
- during phases II and III the U.S. (sometimes jointly with Polish) companies were asked to implement projects consistent with the findings of phase I and to make on 50/50 cost sharing base making sure that the projcets will become commercially viable after the government funding ends
- although the programmeme applied no direct conditionalities, the terms of reference for the commercial projects selected to implement the policies based on the U.S. Government subsidy, did result in the fact that no coal-to-gas conversion and few energy conservation projects were submitted.

Based on the Programme criteria, built on the results of Phase I, the US DOE selected 9 projects proposed by the US companies. A few of the Phase III projects of the 'Kraków Programme' would meet current criteria of financing based on the development (the World Bank conditionalities); especially criteria listed in one of the above paragraphs. However, there are projects which, without any managed co-operation allowed for a parallel use the US AID and the World Bank funds for environmental improvement in Poland.

These are activities around the MPEC (Municipal District Heating Company) capital improvement and retrofit programme. MPEC is party to the 'Krakw Programme' but independently, and prior to this programme it has passed through the procedure of obtaining a $25 million World Bank loan. The loan was preceded by two generations of district heating master plans produced under the World Bank project. These master plans set the terms of reference for the purchase of services and equipment by MPEC to improve heat transmission technology and install modern flow controls (to replace the existing temperature-controlled system).

Independently, within the 'Kraków Project', analysis of energy conservation measures were made on 4 buildings heated by MPEC. The analyses showed the advantage for the users from installing of the thermostatic valves. The programme of installing these is now being implemetned by MPEC.

Finally, based on the network master study and sales analysis, MPEC, along with ECKSA, the Kraków's major heat and power plant, undertook an effort to connect as many local networks heated by the local solid-fuel boilers as possible. This joint (producer-distributor) programme included in the process an American company selected within the 'Kraków Programme'.

CONSTRAINTS TO THE CO-OPERATION WITH THE WORLD BANK

Of the MPEC projects, the only projcects which couple in one way or the other the US AID 'Kraków Programme' with the World Bank projects are those related to the district heating network extension and improvement in automatic control of the system. These projects have never been explicitly designed as co-ordinated, joint projects. Also designing of the World Bank loan preceded the results of Phase I of the 'Kraków Programme' and was undertaken under a separate analytical effort. So, there is little experience in Kraków at the moment in applying project analysis done under one aid programme to the actual project implementation and using financial resource of the other. This in short means that so far, the World Bank programmes were alone standing programmes not really coupled to the other external or city-own programmes.

Where the World Bank really tried to couple with the City's (and also 'Kraków Programme's') projects, it failed due to many reasons. Such was the case of the planned establishment of the $15 million revolving fund for the district heating network exension and local solid-fuel boiler replacement (concieved already in 1990!). This type of fund should have become a huge help and a substantial solution to the financing problem of the eliminations of low emission sources in Kraków. However, in spite of an effort, especially on the part of ECKSA (Kraków CHP Plant) it did not happen.

The Municipality of Kraków used boiler survey data compiled prior to and during the US AID 'Kraków Programme' to start a $25 million project with the World Bank, called now: 'Kraków Coal-to-Gas Conversion Project'. However, during the project preparation and execution there was no link to Phase III of the 'Kraków Programme'. Due to the current World Bank procedures there could not have been any interaction between those two projects.

It would be beneficial for the City of Kraków to have environmental projects prepared in cooperation among various expert groups (local and external) and financed in an optimum way by combining various sources of financing. One may conclude this short summary of the state of affairs by saying that in fact, taking into account the policies of both, the World Bank, the US AID and Kraków Municipality, there should be a lot of economically viable and environmetally sustainable projects suitable for the World Bank and other MDB's financing. However, a lot needs to be done at the stage of the original design and the project preparation to be able to do that. Theoretically, everything boils down to the will of the local and foreign parties to include already at the early stage of the the project design a World Bank loan as a contribution to the financial package, be it local environmental project or the project aimed primarily at solving global environment issues. Little has been done so far to do this.

REFINANCING OF THE UPGRADE OF HEATING CONVERSION AS A FINANCIAL INSTRUMENT USED IN BYTOM COMMUNITY TO REDUCE LOW EMISSION

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SHORT INFORMATION ON BYTOM COMMUNITY

Surface 82,58 km^2	
Inhabitants	228 160
Number of apartments	80 265
incl.	36,2% - communal apartments
incl.	ca. 50% heated with coal
length of gas distribution loop	312 km
number of households supplied with gas	61 534
length of the municipal district heating loop	80,9 km

SUMMARY

High concentrations of SO_2, suspended particulates and benzo-α-pyrene measured in Bytom town especially during heating season result first of all from the process of coal combustion in households. The analysis of solutions aimed at the reduction of these concentrations basing upon the principles of:

- maximization of the unit effect obtained understood as a cost spent by the town to reduce by a single unit the emission of pollutants into atmospheric air,
- implementation of tasks consistent to the „company mission" (formally: Master Plan of Environmental Protection for Bytom City) understood as actions aimed at the improvement of living standard of city residents and its value,
- minimization of the investment risk under the free market circumstances

resulted in the creation of a local law - Resolution of Bytom City Hall dated April 28, 1994 dealing with refinancing of the upgrade of space heating systems. Thus, as a result of this resolution, it appeared that the residents who implemented the conversion from coal to gas, oil or electricity are authorized to apply for partial refund of capital costs covered by themselves.

Results (state - September 1995)

- number of residents who used this regulation 404
- total refinance amount paid back 304 444 z^3
- quantity of saved coal (not burnt) 2 704 t/year
- surface to be heated 72 520 m^2

The second stage which allows to minimize the investment threshold is a low-interest-rate credit line created basing upon the „Agreement on co-operation in financing the upgrade of heating systems in residential houses in Bytom town" signed by Bytom Community, Environmental Protection Bank BOŚ SA - Katowice Branch and the Provincial Fund of Environmental Protection and Water Management in Katowice. This Agreement serves as a base for a very profitable credit line characterized with following conditions:

- amount of a loan — 4 000 z^3
- pay-back period (max.) — 24 months
- interest rate — 0,5 of the refinance credit interest rate

Basing upon the hitherto reported effect we are sure that the above presented program belongs to the most efficient and very effective economic and financial instruments aimed at the reduction of low emission.

DEVELOPING A STRATEGY FOR IMPROVING EFFICIENCY IN THE HEATING SECTOR IN CENTRAL AND EASTERN EUROPE

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INTRODUCTION

Heating is a vital energy service in Central and Eastern Europe, but the current delivery mechanisms are riddled with problems. District heating (DH) in its present technical form and with the present management structure is an inefficient system which produces expensive heat. Customers cannot control it and react to overheating by opening windows, even in winter. DH facilities together with other forms of individual heating are responsible for air pollution, causing severe impacts on the health of urban residents.

In the following the issues relating to DH are laid out, the first World Bank activities and experiences with projects in Poland are analyzed, and in the final part the cornerstones of a strategy to support future World Bank financing and the development of sound heating policies in CEE are presented.

THE CHALLENGE OF IMPROVING EFFICIENCY IN THE HEATING SECTOR

Importance of District Heating. In most CEE countries DH is the major source of heat for the urban residential and commercial sectors as well as an important source for industrial heat use. In larger cities, DH can supply up to 90% of residential and commercial buildings, especially in the central, densely populated areas. Large, centralized DH systems started to be widely promoted in the 1950s as a means to improve the global energy balance by using the waste heat recovered from power generation. In most cases, DH is used for both space heating and supply of hot tap water.

DH Technology. While the DH technology is by no means uniform in the CEE countries, the design philosophy is fundamentally different from the design prevalent in Western and Northern Europe. The main difference is that DH systems in CEE are based on constant flow with a maximum supply temperature of up to 170^{o}C, i.e., hot water flow from the DH plant is constant throughout the heating season, while the temperature is varied at the heat production plant according to the outside temperature. In practice, this almost always results in inefficient utilization of heat from DH plants, since controls at the distribution and consumer level are lacking. Another source of inefficiencies are the huge water and heat losses resulting from, in particular, the corrosion of the DH network pipes, which are caused by insufficient insulation, duct flooding, the use of untreated make-up water, and the direct connection of many consumers to the primary network. Further waste of energy is caused by a share of combined heat and power (CHP) which is considerably lower than the 70% share in Western and Northern Europe, by low efficiency of heat-only-boilers (HOB), and by pumping large volumes of hot water irrespective of the real heat needs.

DH and cogeneration. The main source of heat for big DH networks are CHP plants, either in the power sector or the industrial sector. In winter, CHP producers and DH utilities operate additional heat-only boilers (HOBs) to make up for those additional heat needs that cannot be supplied by the steam recovered from the main CHP units. But in many DH systems, expensive peak heating plants are used in the intermediate load range. Smaller DH islands are often supplied exclusively by HOBs. The expected gains from CHP production are significantly reduced due to highly variable and fluctuating heat loads which do not permit the operation at design temperature for the majority of total operating hours.

Residential demand for DH. The residential sector is the main consumer of DH. In cities and towns apartment buildings are almost always supplied by DH, both for heat and hot water. Buildings are both badly maintained and suffer high energy losses due to the lack of insulation, controls and heat meters; heat regulation often can only be achieved by opening windows. In the past, highly subsidized heat tariffs based on apartment size as well as monthly flat rates did not provide incentives for efficient consumption of heat.

In many CEE countries households have been severely affected by the energy crisis triggered by sharply increased prices for imported energy and resulting supply problems. DH suppliers reduced the temperature in the DH systems, leaving consumers either uncomfortably cold or making them switch to alternatives such as electric space heaters. In most countries heat subsidies to heat suppliers are being abolished or at least sharply reduced and heat prices are gradually being increased towards cost recovery levels. This leaves many households unable to pay their utility bills since this would mean spending a considerable share of their income just for heat consumption; e.g., up to 100% for low-income households in Latvia. In this situation, many governments have introduced targeted subsidies, to be financed by both central and local authorities. The issues of affordability, high cost heat and low incomes raise the more general question of the appropriateness of the level of heat service as delivered by DH systems.

DH and the industrial sector. In many DH systems a substantial share of heat is supplied to industrial consumers in the form of steam. Industrial consumption is usually metered. During the last few years, the decline in industrial output and bankruptcies in the industrial sector have led to a considerable decline in heat consumption and to huge billing arrears of many industrial consumers, further undermining the ability of DH suppliers to cover operation and maintenance costs. An important issue for further DH efficiency improvements is the upgrading of substations, which are usually owned by industrial consumers, with controls and heat exchangers. In many DH networks, industry plays an important role as supplier of heat. During the current transition phase with industrial restructuring and cash flow problems of DH enterprises this creates additional problems: Heat supply may be in jeopardy, but also, many industrial suppliers are not being paid for their heat deliveries.

Other heating fuels. Depending on the energy resources of the individual country, natural gas, coal, lignite, biomass and electricity are other sources for heating at the end user level. In general in CEE, they can be found in less densely populated suburbs and in rural areas. With increasing DH supply problems, many consumers have invested in additional heating appliances, mostly small electric stoves. Especially many industrial users of DH have opted for different energy supplies in the light of the uncertain supply situation at ever increasing heat prices which are well above cost levels.

Natural gas is used in most CEE countries as a source of energy for households and commercial and industrial activities. Although gas networks often reach a large proportion of dwellings, in particular in urban areas (up to 80% of the dwellings stock in some countries), gas is generally used mainly for cooking, and, to a limited extent, for hot water production and space heating. Gas networks were designed to carry limited loads, mainly of gas produced from coal in gas-works, using designs based on low-pressure, large size steel pipes. The advent of natural gas made such a distribution policy obsolete because large quantities of gas had become available for water-heating and space-heating, not to mention industrial uses. Today, construction and operating techniques are still very much the same as they were thirty years ago, resulting in inefficient and costly network operation. Considering that (i) in a standard household gas demand for cooking represents a small fraction of the total demand, including space heating and water heating, (ii) the construction of a gas network is highly capital intensive and does not vary significantly with its capacity, and (iii) operating cost is virtually independent of consumption, it appears that restricting the use of gas to cooking is not an efficient way of using gas as it does not enable any investor to take full advantage of his investment. The increased use of natural gas for decentralized or individual heating is therefore considered in many instances.

Pricing issues. For both district heating and natural gas, tariff levels and structures are set in most countries on historical and socio-political grounds and do not reflect the real cost of delivering energy to consumers. Tariffs generally consist of flat prices, one for industry and one for households, i.e., the tariff structure does not provide for any capacity or standing charge. Prices are generally uniform throughout the country, not reflecting the portion of the cost that varies according to geographical location. Residential consumers of heat and gas are not individually metered so that heat and gas bills are based on the size of the dwelling and the individual household rather than on actual consumption. Utility bills are usually included in the rent, further separating the demand/cost relationship for the consumer. Industrial tariffs were almost uniformly set above cost to provide cross subsidization for residential consumers.

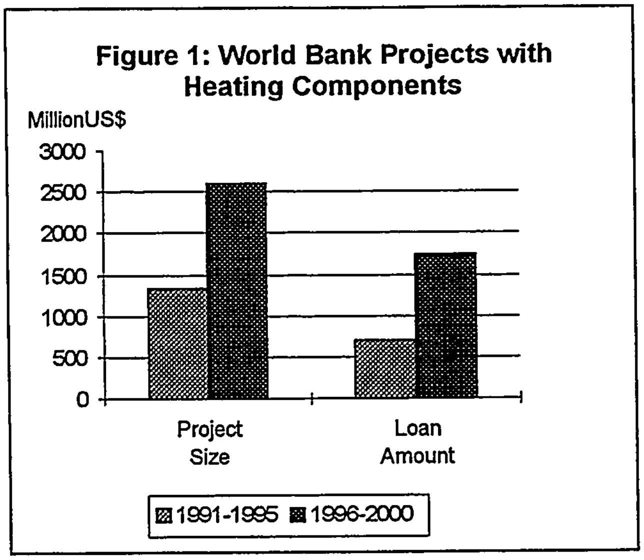
The economic reform process and energy prices which are approaching world market levels have forced governments to abandon subsidization of heat and to increase heat prices, bringing them more in line with costs. Distortions between higher industrial tariffs and lower residential tariffs have been widening though with recent price increases. This high cost of heat is now driving many industrial consumers away from DH. In many countries DH utilities have to cope with an unclear situation about who pays the heating bill in a period of transition from public ownership and administration of most dwellings towards privatization and individual ownership.

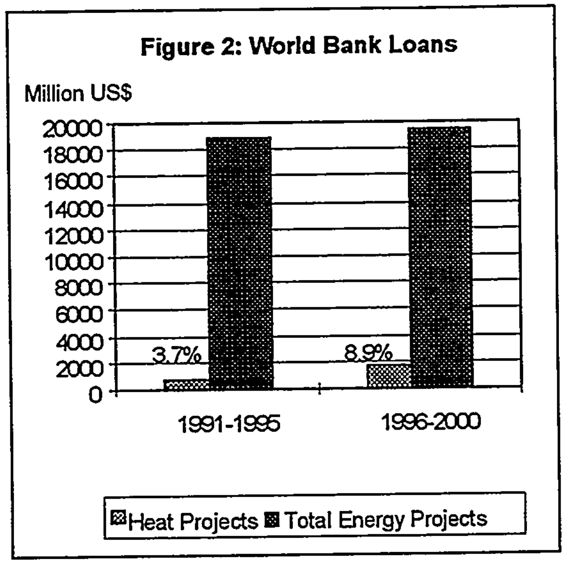
Institutional issues. The DH industry used to be part of the communist state enterprise system. With economic reforms, heat supply is becoming a local responsibility and DH enterprises are being transferred to municipalities, restructured and often transformed into joint stock companies. The first phase of reforms and the energy supply crisis in many countries have resulted in weakening the DH sector both financially and institutionally. In the future, the energy sector reform process will be confronted with issues of cooperation and competition: power sector companies are supplying heat from CHP plants; natural gas companies may want to become heat suppliers especially with decentralized heating options; and municipalities may not keep exclusive concessions for heating services as opposed to heat distribution.

Environmental issues. A principle cause of urban air pollution in CEE is the heavy reliance of households and small enterprises upon poor-quality coal. Smoke and soot from low chimneys are especially harmful to health. In many towns and cities more than half the population is exposed to high levels of particulate and gas emissions from thousands of small coal stoves used in homes for domestic heating, and in small- and medium size enterprises burning coal for space heating and process heat (see World Bank, June 1994). In CEE, DH systems are much less environmentally benign than e.g. in Western and Northern Europe, since many CHP and HOB plants burn low quality fuels, e.g. heavy fuel oil or coal with high sulfur and vanadium content. Burner systems are not optimized and especially HOBs are often not equipped with suitable instrumentation and controls. The resulting soot and particulates, sulfur dioxide and nitrogen oxide emissions impact large populations, since DH plants are often located in densely populated areas. Many of the current pollution "hot-spots" in CEE characterized by high levels of dust and/or SO_2 are in areas where power and district heating plants are located, e.g. in Krakow and Bucharest. In some parts of CEE, the current waste of water in DH systems is exacerbating general water supply problems.

WORLD BANK ACTIVITIES IN THE HEATING SECTOR

After an initial period of funding energy sector assessments and other studies on energy sector issues and advising on energy sector reform in CEE, international financing agencies such as the World Bank or EBRD are now increasingly financing investment in rehabilitation of energy sector installations. Given the importance of heat consumption in final energy consumption and the vast problems of the heating sector as described above, the World Bank started getting involved in lending operations to the heating sector in 1991 with its biggest loan in this sector so far: the Polish Heat Supply Restructuring Project. Projects currently being implemented (1990-1995) amount to \$1.3 billion, 50% of which is financing by the World Bank. The project pipeline (1996-2000), including three projects in the housing sector which have energy efficiency components, has a size which would double investment and lending for heating (see Figure 1 and for more details Table A1 in the Annex). Figure 2 shows that with this development the importance of heating projects within the total energy project pipeline would more than double in percentage terms.





EXPERIENCE WITH DISTRICT HEATING PROJECTS IN POLAND[1]

Current and proposed World Bank financed projects in the heating sector in Poland are listed in more detail in Table 1. The heat supply projects which are currently implemented have the objectives to:

- support the government's ongoing energy sector restructuring program;
- enhance energy efficiency and conservation in the district heating sector;
- extend the life of existing district heating assets through rehabilitation and introduction of modern technologies, thereby reducing capital expenditures and operating and maintenance costs;
- reduce environmental pollution through investments in energy efficient equipment and systems and by supporting a program to eliminate polluting coal-fired heat-only-boilers.

The results so far of the heat supply project are very satisfactory: the implementation of the optimization programs in the four cities has led to a reduction of water losses to about a third of their level before project start. Almost 100% of heat purchases as well as a large percentage of heat sales are now metered. District heating enterprises have developed an in-house capacity to carry out international procurement, long-term planning, monitoring of project performance and project economic analysis and to update the masterplan studies. On the sector policy level, direct subsidies to residential consumers have been reduced from almost 70% of cost in 1991 to basically zero.

In the next phase of the project the district heating enterprises will carry on with the implementation of the optimization programs, improve cooperation with the heat sources, play a proactive role in promoting energy efficiency at the end-user level, design a retail tariff system inducing end-use energy efficiency, negotiate alternative pricing methods of bulk heat from CHP plants, and promote quality assurance concepts to achieve organizational efficiency and consumer-oriented thinking among management and personnel.

1 Based on a presentation by R. Benmessaoud in the World Bank Workshop on District Heating, 23 February 1995.

Table 1: World Bank Projects in the Heating Sector in Poland

Under Implementation
• Heat Supply Restructuring and Conservation Project (1991, US$285 mio)
  • Direct Loans to 4 DH Enterprises
    • Gdansk $ 40 mio
    • Gdynia $ 25 mio
    • **Krakow $ 25 mio**
    • Warsaw $100 mio
  • Sector Adjustment Loan to the Government ($75 mio)
  • Credit Line to a Commercial Bank for Onlending ($70 mio, incl. $50 mio EBRD Cofinancing)
• Katowice Heat Supply and Conservation Project (1994, $45 mio)
• GEF Coal-to-Gas Conversion Project (1994, $26 mio)
  with Pilot Project in Krakow

Under Preparation • Cogeneration Privatization Project ($120 mio) • Geothermal and Environment Project (Podhale, $70 mio)
Identified Projects • Greenfield CHP Privatization Project (100 mio) • Heat Supply and DSM Project ($75 mio) • Geothermal II (Skierniewice Voievodship, $40 mio) • DH and Geothermal III (Szczecin, $45 mio)

Source: World Bank

In many countries in Central and Eastern Europe emission sources with low stacks generate a large share of emissions. E.g. in Krakow,[2] these sources, consisting of coal-fired boilers and stoves, contribute more than 30% of emissions of sulfur dioxide (SO_2) and a significant part of the emissions of nitrogen oxides (NOx), and are the primary sources of particulates and carbon monoxide (CO). These sources have a major impact on air quality during the winter, especially in the downtown area where access to a district heating network is not yet available. A survey of low-stack emission sources by the Krakow Bureau of City Planning listed about 130,000 coal stoves and about 1,300 small coal-fired boiler houses. More than 50% are located in downtown Krakow. An improvement in air quality could be achieved through the following measures in downtown Krakow: elimination of local boilers and connection to the district heating system (about 54% of boiler capacity), conversion to gas-firing (21%) and oil-firing (9%), and boiler retrofitting (16%). These measures would also contribute to reducing CO_2 emissions[3].

The coal-to-gas conversion project financed by a grant from GEF (Global Environmental Fund) will address the problem of curbing emissions stemming from coal-fired boiler houses. To facilitate project preparation, the city of Krakow was selected for an initial pilot project, consisting of the conversion of two coal-fired boiler houses, one to a

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[2] For the following see in more detail World Bank (October 1994).

[3] A World Bank Research project (World Bank 1995) investigated the impacts of alternative environmental policy instruments on aspects of local air pollution in the Krakow region. According to the modelling carried out in this project, small boiler houses, small businesses and households in Krakow are responsible for only about 5% of SO2 and PM emissions, but they contribute about two thirds of the peak annual average of concentration of both pollutatnts in the old town. This disproportionate impact on local air quality occurs because emissions from low-stack sources are not much dispersed. Small sources of emissions also have much higher abatement costs than big sources. Therefore, a cost-effective strategy to improve air quality should rely on both market-based environmental policy instruments such as taxes and permits for high-stack sources and on command and control measures such as a ban on coal use for low-stack sources.

modern gas-fired condensing boiler and the other to a base-load small gas-fired cogeneration unit together with peak hot water boilers and steam boilers.

The GEF project not only addresses the supply side but also the energy-user side. It will provide financing for improvements in the efficiency of building equipment, thereby lowering the heat demand, reducing energy consumption and emissions (for more details see World Bank October 1994).

But while the experience with DH projects in Poland has been very positive in general, these projects suffer from similar deficiencies as most other studies and projects in the heating sector by taking a rather short-term view, concentrating on the rehabilitation of existing plants and heat transmission and distribution systems, complemented by some pilot projects on the consumer side. Lacking are comprehensive investigations of the technical and economic efficiency of heating supply and demand. Since especially the DH systems were not initially designed on the basis of an economic evaluation, it appears that such an evaluation is more than overdue.

PROPOSAL FOR A STRATEGY TO IMPROVE THE EFFICIENCY OF HEATING

The World Bank within its Energy Sector Management Assistance Program (ESMAP) is carrying out a study to assess the comparative advantages of various types of space and water heating in residential and commercial buildings and for industrial use in Central and Eastern Europe (CEE) and the role of energy conservation. The study will (i) identify the key parameters affecting the economics of alternative heating systems, especially DH which is currently the main source of heat supply in CEE; (ii) from a selected sample of cities in several CEE countries identify the main factors affecting the efficiency of heating systems; and (iii) give decision makers a well-defined framework to develop appropriate policies for the heating subsector, including institutional and pricing issues.

Scope of Work

The proposed study will aim at establishing under which technical, economic, and institutional conditions a global rationalization of heat supply and demand could be achieved, as well as the impact of the various heating systems on the environment. Thus, the scope is to develop a framework for decision making on space and water heating systems which will support Bank staff as well as member governments in the development of appropriate policies to improve the efficiency of fuel conversion and end-use as well as the functioning of energy markets.

The study will be conducted in a sample of countries in Central and Eastern Europe and the Former Soviet Union. It is broken down into seven activities:

Activity I. *A definition of the methodology* to be used in the country case studies and identification of the main parameters affecting the economics and technical efficiency of heating systems, including the role and pricing of CHP, the relative costs of fuels, the degree of urbanization, the installations being used, unavoidable energy losses, the potential for competition among heating alternatives, the role and impact of energy conservation on future demand, and the institutional setting and impact of deregulation in the power and fuel supply sectors.

Activity II. *A review of the existing district heating systems*, including (i) the review of the technical conditions of the current operation of the systems, including system efficiency, technically unavoidable level of losses, quality of service, peak demand management, possible suppressed demand, etc.; (ii) the review of the expansion plans of the district heating and power utilities, and an assessment of their ability to meet future demand; (iii) an assessment of the short-term cost of generating, transmitting and distributing heat; (iv) an assessment of the economic costs of the same, based on the long-run marginal cost; (v) institutional issues, such as concession regimes, ownership of facilities, the relationship between power utilities and DH enterprises, especially with respect to pricing of waste heat and CHP electricity, options for the organization of the heating subsector, including the potential role of the private sector and the foerderung of industrial heat supply, and the introduction of economic heat dispatch; and (vi) their environmental impact.

Activity III. *An investigation of the comparative economics of alternative heating systems.* In many instances, decentralized or individual heating systems based on natural gas will be the main competitors to DH. In these cases, design, capacity and quality of existing gas distribution networks and the scope (technical, economic) of upgrading its quality and efficiency will be reviewed; an assessment of the short-term and long-term cost of distributing gas, including operating cost, will be carried out. Also, gas supply constraints, supply cost and typical gas institutional issues and environmental aspects will be part of the analysis. In countries where fuels such as *coal, fuel oil and biomass* are or can become important for heating, the technical, economic and environmental issues related with their use will be investigated. The repercussions of using alternative heating systems on power sector development will be taken into account. The analysis will also examine how the comparative economics may change when new DH network development is considered as opposed to operating, maintaining and extending existing networks.

Activity IV. *An inventory of end-use appliances* for space and water heating systems for individual dwellings, as well as decentralized systems which could be used to supply heat for apartment and commercial buildings. These appliances (both locally produced and imported) will be compared based on price, energy efficiency, emissions, installation and maintenance requirements and other relevant parameters, such as fuel supply. Also, an assessment of required installation and maintenance skills will be part of this activity.

Activity V. *The scope and impact on demand for heating services of energy conservation improvements in residential and commercial buildings, and in the industrial sector.* Energy end use in CEE has historically been extremely wasteful. On the other hand, the economic reform process has indirectly led to a sharp reduction in energy and especially heat consumption. This activity will assess the baseline consumption and the impact of changing the structure and level of heating tariffs on demand for heating services and the uptake of energy conservation measures on the demand side. Energy conservation measures will be recommended which are cost-effective and have short pay-back times. The impact of energy conservation on future demand for heat and the economics of heating systems will be assessed and the consequences of ownership patterns for DH installations and buildings (especially common spaces) for heating and conservation policies investigated. For commercial and industrial consumers of DH, the merits of applying techniques such as energy monitoring and targeting to help them manage their energy use, reduce waste and cost will be assessed. The possibility of expanding cogeneration in the industrial sector will also be looked into. Another important aspect of this activity will be the evaluation of the local appliance and building materials industry and renovation/maintenance services and recommendations for improvement of their performance.

Activity VI. *An investigation of pricing strategies for DH and other fuels (mainly gas) during the transition period,* taking into account practicalities such as improving the financial performance of DH companies and gas utilities and providing life-line services to households, given their ability to pay. The still existing cross subsidization of residential consumers by industrial consumers has led to withdrawal of industrial consumers from the DH system, aggravating the financial problems of the DH enterprises and their inability to finance maintenance and rehabilitation investment. On the other hand, increasing residential heating prices to their cost level creates major affordability problems in some countries. The activity will investigate these issues and explore practical solutions to pricing and subsidization where consumers cannot afford to pay the full price of heat, such as well-targeted life-line tariffs and alternative mechanisms for cost recovery.

Activity VII. *The potential of DH or alternatives in improving the environment in CEE.* The results of the previous activities will be put together to assess the impact and the cost-effectiveness of different heating options to mitigate environmental problems in CEE. The results will feed into a study for the Ministerial Conference in Sofia "Environment for Europe," which the Bank is currently preparing. There is a strong possibility of applying the "Environmental Manual for Power Development", which is currently being developed and tested under a project funded by Germany, the Netherlands, Switzerland and the World Bank, to evaluate and compare emissions under different heating alternatives.

Although network design and operation as well as building practices show strong similarities across CEE countries, it is proposed that the study be conducted in a sample of cities in five CEE countries to highlight the importance of the institutional and economic framework to operate the heating sector in an efficient manner. It is proposed to include cities in the following countries: Poland, Lithuania, Ukraine, Russia, Bulgaria and Romania. These countries are in different states of resource endowment, of dependency on energy imports, of power sector characteristics (i.e., nuclear energy), and of economic reform. Furthermore, in these countries Bank projects are either ongoing or in preparation in the district heating, gas and housing sectors.

Expected Output

The reviews and analyses carried out under the above activities will result in the development of conceptual frameworks and recommendations for:

- the determination of the key parameters affecting the economics of supply of heat from both centralized and decentralized options;
- the most effective of the economically and financially viable demand management techniques for households and commercial/industrial consumers to manage their energy services;
- the policies required for the implementation of an efficient and cost-effective heating strategy, with respect to pricing of heat during the transitory period, the development of sound institutions both within the heating sector and in relation to the power sector, the role of the private sector and the roles and functions of regulators;
- the strategies for phasing in new heating policies involving any of the alternatives under consideration;
- an assessment of the environmental impacts of heating systems and options for mitigation; and
- the required program to strengthen the institutional capability and attitudes within central and local governments to implement and monitor programs and policies and to support private sector participation and initiatives.

References

World Bank (June 1994) Environmental Action Programme for Central and Eastern Europe, Report No. 10603-ECA.
World Bank (October 1994) Coal-to-Gas Conversion Project, Report No. 13054-POL.
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ANNEX

Table A1: World Bank Projects with Heating Components

Country	Name District Heating	Fiscal Y.	Status	Amount ($mio) Project	Loan
Poland	Heat Supply Restruct.	1991	Active	739	340
	Katowice Heat Supply	1995	Active	45	45
	Coal-toGas-Conversion,GEF grant	1995	Active	45	(26)
	Geothermal I	1996	Active	70	70
	Cogen. Privatization	1997	Reserved	378	120
	Geothermal II	1997	Reserved	60	60
	Gas II	1997	Reserved		
	Heat Supply and DSM	1998	Active	75	75
	Greenfield CHP Priv.	1998	Reserved	100	100
Belarus	Power & Distr. of Heat	1997	Stand-By	110	75
Bulgaria			?		
China:	Beijing Environment	1992	Active	299	125
Croatia	Energy	1998	Reserved	65	65
Estonia	District Heat/Conservation	1994	Active	65	38
Kyrgyz Rep.	Power	1997	Stand-By	81	20
	Hydro Infrastructure	1999	Stand-By	50	15
Latvia	Jelgava District Heat	1995	Active	18	14
	Energy II	1997	Stand-By	20	20
Lithuania	Power Rehabilitation	1994	Active	33	26
	Geothermal Demonstration	1996	Stand-By	18	6
	Heating Efficiency	1998	Stand-By	70	50
Mongolia	Energy Sector	1998	Stand-By	35	35
Russia	Gas Distr. + Effic.	1995	Active	131	107
	District Heating	1998	Active	300	300
Slovak Republic	Geothermal	1998	Reserved	100	100
	Heat Cons. & DSM	1997	Reserved		
Slovenia			?		
Tajikistan	Power	2000	Stand-By	36	36
Ukraine	Thermal Power Rehab.	1996	Stand-By	500	200
	District Heating	1997?	?		
	Housing				
Lithuania	Energy Efficiency Housing	1997	Active	17	10
Estonia	Energy Efficiency Housing	1997	Active	20	15
Russia	Enterprise Housing Divest.	1996	Active	500	300
TOTAL				**3935**	**2492**

Note: $ amounts might change since projects are evolving.
Source: World Bank, Energy Practice Management

ABSTRACTS OF COMMERCIAL PRESENTATIONS

U.S. COMPANIES

Acurex Environmental Corporation, Wojciech Josewicz and David E. Natschke

Business Development Corporation Inc., Stanley Jasek

Control Techtronics, John West

Electrotek Concepts Inc., Larry Markel

Global Environmental Solutions Inc., Peter V. Smith

LSR Technologies Inc., S. Ronald Wysk

Shooshanian Engineering Associates Inc., Michael Selig

Thermo Power Corporation, Tecogen Division, Ronald Breault

Honeywell, Jacek Łukaszewski

Ecocoal, Tomasz Szweczyk

The Technology Transfer Network, Vananc Walder

CLEAN FUEL FOR DEMANDING ENVIRONMENTAL MARKETS

Wojciech Josewicz and David E. Natschke
Acurex Environmental Corporation

Acurex Environmental Corporation is bringing Clean Fuel to the environmentally demand Kraków market, through the cooperative agreement with the U.S. Department of Energy. Clean Fuel is a proprietary clean burning coal-based energy source intended for use in stoves and hand stoked boilers. Clean Fuel is a home heating fuel that is similar in form and function to raw coal, but is more environmentally friendly and lower in cost.

The heating value of Clean Fuel is 24,45 kJ/kg. Extensive sets of confirmation runs were conducted in the Academy of Mining and Metallurgy in the Kraków laboratories. It demonstrated up to 54 percent reduction of particulate matter emission, up to 35 percent reduction of total hydrocarbon emissions. Most importantly, polycyclic aromatic hydrocarbons (toxic and carcinogens compounds) emissions were reduced by up to 85 percent, depending on species measured. The above comparison was made against premium chunk coal that is currently available in Kraków for approximately $83 to 93/ton. Clean Fuel will be made available in Kraków at a price approximately 10 percent lower than that of the premium chunk coal.

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BUSINESS DEVELOPMENT CORPORATION, INC.

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International Investment, Financial and Development Services

Business Development Corporation, Inc., is a company specializing in opportunity seeking and business development activities in the "new" post communist Central and Eastern Europe, with particular emphasis on the Republics of Poland and Slovakia.

Business Development Corporation, Inc. was founded in 1990, and is based in the United States with the main office located in Grand Haven, Michigan. Other locations from which principal partners conduct business are Chicago, IL, New York, NY, and Washington, DC.

The headquarters for the European operations are in Warsaw, Poland. The company operates three separate development companies in Poland: Business Development Corporation Poland, Environmental Services Poland (ESP), and Clean Energy Environmental Corporation, Inc. (CEEC).

The company currently focuses its expertise on strategic investing and business development between Central Europe and the United States of America. In Poland and Slovakia, the company specializes in developing large scale energy and environmental "infrastructure" development projects on the federal, state, and local level. In addition, the company assists large state owned industries in the transformation and privatization process. Business Development Corporation has assisted and continues to assist in projects of national importance working directly with President Walesa's office, Ministry of Industry and Trade, Ministry of Environmental Protection, Ministry of Finance and the National Bank of Poland and similar institutions in the Slovak Republic.

Our staff of experts advise numerous large Polish and Slovak companies, most owned or in the process of privatization, on matters of restructuring, finance, capital structure, strategic partnerships or investors, mergers, acquisitions and joint ventures with U.S. based firms. The company also assists and advises on a variety of environmental and energy matters in the public and private sector.

In the United States, the Business Development Corporation focuses on seeking qualified major U.S. based firms interested in developing a major presence in Central Europe, and particularly in Poland and Slovakia.

Business Development Corporation has advised numerous U.S. based clients such as: Waste Management-WMX, Inc., Waste Management International plc., Detroit Diesel Corporation, Ford Motor Company, Chicago Title and Trust Company, Ogden Energy and Environmental Corporation, U.S. Turbine Corporation, Inc., Rolls-Roye Plc. and Rolls-Royce Power System, Nalco Fuel Tech. Inc., and Masco Corporation.

Business Development Corporation continually evaluates and tracks market developments in Central Europe, covering the economic, social, environmental and political scene, during the process of opportunity screening and selection.

As opportunities are selected and verified, the firm then begins the quest for suitable partners and/or clients who can best develop and capitalize upon the specific opportunities selected.

Upon the successful negotiation and establishment of a working relationship with a Client, the Business Development Corporation team of professionals works closely with the Client's team to formally develop and define the launch mission, set goals and develop an action plan to achieve the goals.

Business Development Corporation allows for Client companies to enter these "new" markets in the fastest and most efficient manner possible. Our staff of highly trained and experienced professionals are proven and "battle" ready. With backgrounds in marketing, sales, law, environment and energy, finance and international sales, our team of professionals insure the best possible development and execution of a firm's entry strategy into these new markets.

Time, money and manpower are used efficiently, projects come on-line faster, revenue streams and profits are developed more quickly. Coupled with our network of proven professionals, on the ground experience and thorough understanding of the market, the Business Development Corporation becomes the "launch team" of choice for firms seeking to capitalize on the opportunities present in the "new" Eastern and Central Europe.

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CONTROL TECHTRONICS INTERNATIONAL

John West

Polish graded coal can be burned on existing stoker boilers and meet the 1998 Air Quality standard. This is accomplished with Control Techtronics microprocessor-based combustion controller accurately and repeatedly:

a. Matching the combustion air to the coal firing rate, with continuous stack sensor feedback
b. Continuously varying the boiler's firing rate based on output water temperature or steam pressure
c. Continuously varying the exhaust fan's speed to maintain minimum negative pressure in the boiler's combustion chamber
d. Recirculating a portion of the flue gas, at varying amounts throughout the boiler's firing rate.

Systems for five boilers have been installed and are operating on MPEC's Balicka plant in Kraków.

Control Techtronics International has $10 million of U.S. Export-Import Bank funds available for similar projects throughout Poland. Please stop by our booth in the Forum Hotel to discuss specific applications.

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ENERGY PLANNING AND ENERGY EFFICIENCY ASSISTANCE

Lawrence Markel
Electrotek Concepts, Inc.

Electrotek is an engineering services company specializing in energy-related programs. Our clients are mostly utilities, large energy users, and the U.S. Electric Power Research Institute. Electrotek has directed energy projects for the U.S. Agency for International Development and the U.S. Department of Energy in Poland and other countries of Central Europe. Our objective is to assist the host country organizations to identify and implement appropriate energy efficiency and pollution reduction technologies, to transfer technical and organizational knowledge, so that further implementations are market-driven, without needed continuing foreign investment.

We were the project leader for the energy efficiency demonstration at Wolasa Street in Phase I of the Kraków Clean Fossil Fuels and Energy Efficiency Project (Sub-Project 1). Other energy efficiency installations have resulted from this demonstration, implemented by FEWE-Kraków (Fundacja na rcecz Efektywnego Wykorzystania Energii), on a commercial basis, without further U.S. government support. The results of the program, and information on what techniques and materials were successful, has been communicated to other Polish cities through the Energie Cities network, as well as through papers, conferences, newsletters, articles, etc. Currently, there are similar ongoing projects in other Kraków buildings, as well as in additional cities in Poland.

Electrotek has worked with the Silesian Power Distribution Company (Górnoślaski Zaklad Electroenergetyczny S.A.) to design an energy efficiency program for industrial customers that has proven to be profitable for GZE and for its customers. The program has both saved energy and costs, and reduced pollution. As with the Kraków building efficiency demonstration, the GZE program is expanding to include additional customers, without needed more funding from the U.S. government.

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CATALYSTS FOR CLEANER COMBUSTION OF COAL, WOOD AND BRIQUETTES

SULFUR DIOXIDE REDUCTION OPTIONS FOR LOW EMISSION SOURCES

Peter V. Smith
Global Environmental Solutions, Inc.

Coal fired, low emission sources are a major factor in the air quality problems facing eastern European cities. These sources include: stoker-fired boilers which feed district heating systems and also meet local industrial steam demand, hand-fired boilers which provide heat for one building or a small group of buildings, and masonry tile stoves which heat individual rooms.

Global Environmental Systems, Inc. of Morton Grove, Illinois is marketing through Global Environmental Systems of Poland, Inc. catalysts to improve the combustion of coal, wood or oil fired in these combustion systems. PCCL-II Combustion Catalyst promotes more complete combustion, reduces or eliminates slag formations, soot, corrosion and some air pollution emissions and is especially effective on high sulfur-high vanadium residual oils. Glo-Klen is a semi-dry powder continuous acting catalyst that is injected directly into the furnace of boilers by operating personnel. It is a multi-purpose catalyst that is a furnace combustion catalyst that saves fuel by increasing combustion efficiency, a cleaner of heat transfer surfaces that saves additional fuel by increasing the absorption of heat, a corrosion-inhibiting catalyst that reduces costly corrosion damage and an air pollution reducing catalyst that reduces air pollution type stack emissions.

In addition to injecting these catalysts directly into the boiler furnaces or tile stoves, Global Environmental Solutions of Poland, Inc. will be offering Glo-Klen impregnated coal or wood produced pellets. These pellets will be produced in Poland and will contain all of the necessary catalyst to obtain the same benefits as the injected catalyst.

The reduction of sulfur dioxides from coal or oil fired boilers of the hand fired stoker design and larger, can be controlled by the induction of the Glo-Klen combustion catalyst and either hydrated lime or pulverized limestone. This technology known as Dense-Phase Furnace Sorbent Injecting is also available and is custom designed for each particular boiler condition.

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PARTICULATE EMISSION ABATEMENT FOR KRAKÓW BOILER HOUSES

Ron Wysk
LSR Technologies, Inc.

Among the many strategies for improving air quality in Krakow, one possible method is to adapt new and improved emission control technology. This project focuses on such a strategy. In order to reduce dust emissions from coal-fueled boilers, a new device called a Core Separator has been introduced in several boiler house applications. This advanced technology has been successfully demonstrated in Poland and several commercial units are now in operation. Particulate emissions from the Core Separator are typically 3 to 5 times lower than those from the best cyclone collectors. It can easily meet the new standard for dust emissions which will be in effect in Poland after 1997.

The Core Separator is a completely inertial collector and is based on a unique recirculation method. It was developed and patented by the American firm, LSR Technologies, Inc. It can effectively remove dust particles below 10 microns in diameter, the so-called PM-10 emissions. Its performance approaches that of fabric filters, but without the attendant cost and maintenance. It is well-suited to the industrial size boilers located in Krakow. Core Separators are now being marketed and sold by EcoInstal, one of the leading environmental firms in Poland, through a cooperative agreement with LSR Technologies.

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SHOOSHANIAN ENGINEERING ASSOCIATES, INC.

Michael A. Selig

Shooshanian Engineering Associates, Inc., in conjunction with Miejskie Przedsiebiorstwo Energetyki Cieplnej (MPEC) and POLINVEST, Ltd., is pleased to present this progress summary of our project, District Heating Network Extension under the Kraków Clean Fossil Fuels and Energy Efficiency Program.

The results of our project to date have shown a high degree of success. The primary objective of the project - to reduce air pollution in Kraków by eliminating coal-fired boiler plants and connecting them to the district heating network - is very much on the path to achievement. Our emissions reduction goals for the project will be substantially exceeded by the end of the work.

In addition to the above, we prepared and presented a comprehensive series of training seminars in marketing and customer service to the Marketing Department of MPEC. These seminars, which were held in Boston and Kraków, were accompanied by a detailed 400-page manual prepared in both English and Polish. The purpose of the training program was to assist MPEC in its long-term objectives of retaining existing customers and attracting new ones.

The remainder of the project will see very substantial and productive construction activities, with many new customers already committed to the conversion to MPEC. Training and marketing activities will continue, as will the identification and consideration of various value-added services that MPEC may offer to existing and future customers to enhance their competitive positive in Kraków's energy marketplace. These services include, but are limited to, technical advice, energy conservation assistance, and financing.

Founded in 1961, Shooshanian Engineering Associates, Inc., located in Boston, Massachusetts, is one of New England's largest mechanical and electrical engineering firms specializing in study, design, and construction services for utilities, government, corporations, and architects worldwide. Shooshanian employs a staff of 90, which includes professional engineers, designers, draftspersons, construction administrators, computer applications specialists and energy conservation and management experts.

We hope to continue to assist MPEC, and other utilities in the region, not only to improve air quality, but also to enhance competitiveness and profitability in an increasingly market-oriented energy sector.

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Shooshanian Engineering Associates, Inc.

BOILER HOUSE MODERNIZATION THROUGH SHARED SAVINGS PROGRAM

Ronald W. Breault
Tecogen Division, Thermo Power Corporation

Throughout Poland as well as the rest of Eastern Europe, communities and industries rely on small heat only boilers to provide district and process heat. Together these two sectors produce about 85,000 MW from boilers in the 2 to 35 MW size range. The bulk of these units were installed prior to 1992 and must be completely overhauled to meet the emission regulations which will be coming into effect on January 1, 1998. Since the only practical fuel is coal in most cases, these boilers must be either retrofit with emission control technology or be replaced entirely. The question arises in how to accomplish this given the current tight control of capital in Poland and other East European countries.

A solution that we have for this problem is shared savings. These boilers are typically operating with a quite low efficiency as compared to western standards and with excessive manual labor. Installing modernization equipment to improve the efficiency and to automate the process provides savings. ECOGY provides the funds for the modernization to improve the efficiency, add automation and install emission control equipment. The savings that are generated during the operation of the modernized boiler system are split between the client company and ECOGY for a number of years and then the system is turned over in entirety to the client. Depending on the operating capacity, the shared savings agreement will usually span 6 to 10 years.

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JACEK ŁUKASZEWSKI

HONEYWELL: COMFORT AND ECONOMY

The presentation of the Company starts with having it ranked among the ones operating on the customers' market or those acting on the professional market. But it is not so. Honeywell is beyond such simple criteria. We are a company supplying products, systems and services related with generally conceived automatic control engineering, yet the operational range does comprise so many apparently diversified fields, for instance automatic control in aeronautics, heavy power engineering, building of apartment buildings, detached houses, heat engineering and some others. Nevertheless, our targets are always the same: maximum increase in efficiency and reliability of the process lines controlled by our systems as well as securing the best comfort of work and rest for people who stay in the buildings controlled by our devices. Simultaneously, the utilization of energy sources and the natural environmental resources must be as sensible as possible.

Honeywell Company was established in 1885 in Minneapolis, USA (the avenue to success was the construction of a simple bimetallic thermostat). The first European subsidiary was set up in 1934 in the Netherlands. Nowadays, the Company operates in 95 countries of the world, on six continents. The activity of the Concern in Poland dates back to the early sixties. At the beginning, the collaboration regarded automatic control in chemical industry; a license with Mera Pnefal for manufacturing an analog electronic automatic control system „Vutronik" was also signed. New economic conditions have enabled further development of the Company's activity in Poland. In 1990 the Company's agency in Warsaw was inaugurated; in 1993 the agency was converted into Honeywell Ltd. (Sp. z o.o.). Nowadays, there are almost 50 employees of the Company in Warsaw at disposal of Polish customers; then, there are more than 20 firms constituting a network of licensed partners located all over Poland and representing all the operational sectors of Honeywell: industrial, house and building automatic control systems.

For over a year we have been an active participant of the Polish - US program of elimination of low emission in Cracow. We have got a very ambitious task: implementing a heat saving program and therefore having the emission coming from coal burning decreased; at the same time the operational costs - from the producer to the user must be reduced. Thus, we realize a complex modernization of a part of Cracow's heat distribution network situated at Balicka Borough - starting from a coal-fired boiler house generating thermal energy, through substituting ineffective hydroelevating systems with automatic control system-equipped compact junctions and ending with home thermostatic valves. The target being the minimization of the pollution level we reach on one hand by optimizing the combustion process, and on the other - by the optimum utilization of the heat consumed by its users. The application of the most updated control systems in all the said parts of the heat distribution system and interlinking them with a monitoring system permits to have the demand side management secured.

Honeywell

NAFTOKRAK-NAFTDBUDOWA & MPEC

Tomasz Szewczyk and Janus Mazur

Polish graded coal is being burned on existing stoker boilers at MPEC's Balicka plant, using Control Techtronics microprocessor-based system. Pictures will be shown on the equipment controlling 3 (three) hot water WR-10 boilers, and 2 (two) steam 22.5 boilers. The results of this installation include:

a. 85% reduction in stack particulate emission
b. 25% increase in boiler energy efficiency
c. 65% reduction in fan electrical energy
d. achieving "ultra low fire" which provides 3 or 4 to 1 turndown, versus 2 to 1, for substantially reduced fuel use at low heating requirements
e. 2 to 3 year payback on invested capital

Visits to MPEC Balicka plant can be arranged.

AN ENERGY/EMISSIONS/ECONOMIC ANALYSIS RESOURCE FOR NORTH MORAVIA, UPPER SILESIA, AND KISUCA

Vananc Walder
The Technology Transfer Network

The United States Agency for International Development (USAID) is sponsoring the Technology Transfer Network (TTN) which is centered in Ostrava, Czech Republic. The primary objective of the TTN is to provide a resource for municipalities, industries, and companies interested in reducing air pollution, improving energy efficiency, and implementing projects in North Moravia, Upper Silesia, and Kisuca.

The TTN is providing a communications network (newsletters, mailings, and other media), seminars, workshops, software, access to past and ongoing studies, and a database of U.S. vendors supporting the region. Seminars and major communication material of the TTN will be provided in Czech/Slovak, Polish, and English as appropriate.

USAID had commissioned Gilbert/Commonwealth, (G/C) Inc., a subsidiary of The Parsons Corporation, to support the TTN activities. G/C has contracted a local not-for-profit organization, the Economic Union of North Moravia, (EUNM) to perform the in-country activities.

To receive more information on the TTN, its seminars, activities, free newsletter, or a mid-October Project Development seminar, contact one of the following:

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The Technology Transfer Network

ABSTRACTS OF COMMERCIAL PRESENTATIONS

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Ekorex, Andrzej Włodkowski

FEWE, Jerzy Piszczek

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MAREK BARCIK

MOTTO: WE WORK FOR PEOPLE AND ENVIRONMENT

This target has been under Danfoss realization for over 60 years - both in Denmark - the motherland and all over the world. The operational range of our Enterprise is very wide. Danfoss manufactures a large assortment of products, starting from heat automatic control systems, through heat metering devices, industrial and refrigeration automatic control, compressors, flow meters, frequency converters, ending in control systems and monitoring.

The four mainstays our Enterprise's activity is based upon, are:

- high quality products;
- advanced manufacturing technology;
- care of the environment, and
- engagement of the staff.

In Poland, since 1992 Danfoss has been manufacturing heat radiator thermostats.

A unique solution - namely the use of a gas thermostatic head secures the highest energy saving and operational reliability.

In 1993, Danfoss as the sixth company in Poland and the first in its business field, gained an ISO 9002 certificate.

The quality system comprises:

- a system for gaining new co-operating parties (presently, we have got 8 Polish sub-suppliers);
- a supervisory system for home and Danish supplies;
- inserting control processes into the manufacturing one, securing a 100% control of critical parameters;
- a statistical control of the ready products;
- tests checking the conformity with the requirements of the standard EN215;
- a control system for contracts, agreements with distributors, servicing and warranty maintenance.

The ready series of products are subject to a random control carried out by autonomous laboratories in Germany.

Since 1993 Danfoss has already experienced three periodical ISO audits without any objections. All technological processes are at each manufacturing stage subject to two basic purposes: the quality of products manufactured and care of the environment.

An example hereof may be the relinquishing of nickel coating of the thermostatic valve bodies as this process is noxious to the environment.

In all Danfoss factories the consumption of water for technological processes has been diminished by 80% during the last 10 years; instead, the contents of heavy metals in manufacturing waters has fallen considerably too, that is by about 20%. The state of water, air and soil around the production works has been still under monitoring. Our heat automatic control system permits of an appreciable diminution of energy consumption. Any fall in the energy consumption stands for a lower contamination of the environment. In Denmark, in the years 1972 - 1980, there was a 45% fall in the energy consumption required for heating up 1 m2 of the usable floor area. Danfoss products also had a share in that fact.

It is not known when such a progress might be achieved in Poland, however we have already participated in the elimination of low emission sources.

Danfoss

The Danfoss automatic control systems are applied in the geothermal water supplied installations in the Podhale region, at Bańska - Biały Dunajec. The first stage is the elimination of stoves in 250 detached houses at Bańska-Niżna. Nowadays, the second stage is under implementation. Finally, geothermal waters will supply 1000 houses. A modernization of the heat distribution system for all Zakopane is also aimed at in future.

In three years Danfoss has already paid over ZLP 270 billion of taxes to the Treasury. It should be hoped for that a part of this amount shall be assigned for the environmental protection.

Since 1992 MarCo Company has been participating actively in the program „Elimination of low emission sources" in Cracow.

In consequence of the won bids held by the MPEC Cracow, Danfoss has fitted over 50 centers in lieu of the boiler houses located nearby Królewska Street.

By participating in the elimination of the boiler houses, MarCo would supply devices and be a general contractor - starting from designing, through assembly and staff training.

The operational range included building adaptation works, full ranges of electric works, assemblies of compact exchangers and connecting them to the heavy duty performance.

The supplied compact thermal stations comprised:

- pipe exchangers manufactured by LPM
- automatic control systems manufactured by Tour &Andersson
- circulating pumps of Grundfoss.

Substituting coal-fired boilers with automatic control system exchanges not only has limited the flue wastes emission, but also appreciably influenced the thermal energy savings.

The applied automatic control systems enable to have the supplied thermal output adjusted to the current weather conditions and the construction of the building under heating.

Since 1992 MarCo in collaboration with MPEC Cracow has updated many thermal centers. All those operations have led to considerable savings in thermal energy. The energy saved in this way might be used for heating the buildings covered by the program of „Elimination of low emission sources".

The largest works related with the modernization of thermal centers include the redevelopment of the pump mixing station into a 14 MW collective thermal center in Masarska-Street performed in 1993. The center has been equipped with a set of LPM plate exchangers, „weather" automatic control systems made by TA Co. and additionally with an efficiency infinitely variable adjustment system for the circulating pumps.

The applied automatic control, in conjunction with the pumps control systems, not only save thermal energy, but also much electricity.

In that same year MarCo had other two collective thermal stations, namely: in Prądnik Biały Borough (10 MW output) and in Bajana-Street (3.5 MW), equipped with similar devices. Hitherto, we have completely updated about 100 thermal centers of a total output exceeding 20 MW.

The largest projects under realization in Cracow include the modernization of the automatic control systems in 67 thermal stations, of a total output of 420 MW.

Those works have been performed since the beginning of 1994 as soon as TA had won the bid called by MPEC Cracow.

The contract conditions comprised the supply of devices, supervision over the assembly, start-up and training. According to the specifications, the delivered automatic control systems are based upon the freely programmable units, adjusted to the operation in the remote control systems.

As TA's representative for Poland, MarCo has wholly serviced the contract in our country. The operational range included: supervision, a partial share in designing and assemblies, start-up of the systems and staff training.

All works were divided into 2 stages:

Stage I - comprised the works related with designing, assembly and start-up of the automatic control systems on 67 thermal stations before the heating season 1994/95;

Stage II - comprised the construction of a supervisory remote control system, based upon SYSTEM7 MICRO made by TA, and fitted in 40 out of 67 thermal stations.

The implementation of the system will take place at the beginning of the heating season 1995/96. The communication in the system will occur via the municipal telephone network with modems. The selection of 40 out of 67 stations is connected with the existing telephone lines in those stations.

The remote control system enables: monitoring and changes in the thermal center parameters,, remote operational forcing of the pumps and control valves and alarm maintenance (should any alarm occur, the communication devices in the center will automatically dial the central office number and transmit information on the alarm).

Danfoss

By determining the codes, some authorized persons will gain access to the system at the proper level (only reading of the parameters, reading and a possibility of altering the parameters or access to changing the system configuration).

The system's chief control station is located at the pilot house of the MPEC's building.

The station is equipped with two PC computers (one for monitoring and recording the station's parameters, the other for alarm services), and a printer on which all reports, alarm levels and interference's in the systems are continuously recorded.

In addition, the control, measurement and automation staff dealing with the servicing of the automatic control systems is equipped with portable and stationary computers that enable the staff members to react fast in case of any break-down.

The experience gained in the heating season 1995/96 and related with the operation of the remote control system will be used for constructing a system comprising far and away a larger number of the stations, basing upon the new product of TA - the TA Vista system.

It is also connected with the LPM's realization of a contract for the supply of 253 compact thermal centers equipped with TA's automatic control systems and adjusted to the remote control operational conditions.

Another big project under MarCo's performance in Cracow is the construction of a reading system for heat meters.

In 1992 ICM won the bid for the delivery of over 3.000 heat counters.

The contract provided additionally the presentation of an idea and the supply of the devices indispensable for making a remote reading system for counters.

ICM has supplied both software and devices for constructing SIOX network.

MarCo as ICM's representative for Poland, like in TA's case, did completely serve the contract in Poland) viz. the supervision over the assembly, training and consulting). The proposed idea of SIOX network, simultaneously with the assembly of counters, enabled the introduction of a system for their reading. Completed the assembly, at the beginning of 1995 all the counters together with those previously fitted (in total over 4 000) have been covered with a uniform reading system.

The data from the counters are read out via portable terminals and transferred to the computer with the data base of the installed counters and a program processing the supplied data.

SIOX network enables a simple grouping of the counters in a mini-network and their read-out through portable terminals or telephone and/or modems.

Mini-networks are grouped in larger systems and it naturally leads to the construction of big counter remote read-out networks.

While enlarging the network, the program in the control computer will not be changed; at each redevelopment stage of the network, different forms of data input are allowed (via hand terminals, telephone/ radio modems, direct cable connections).

SILESIA DRYVIT
Krzysztof Presz

INFORMATION ON THE SCOPE OF ACTIVITY OF THE COMPANY:

MT International, as a manufacturer and distributor of a US company named Dryvit Systems is focused on weatherization techniques as well as on façade and external wall finishing. The materials manufactured by Dryvit for building and construction purposes (plaster masses, building binders, insulating materials, reinforced fabric, etc.) are used at many sites. The consistent and well-selected composition of these materials guarantees highest quality of façade finishing in building structures of any type. The first implementation of Dryvit system in Warsaw was completed in 1974 and it remains the first example of professionally weatherized building in Poland.

Different versions of Dryvit system have been elaborated for various plaster base types. Consequently the assembling procedure differs, too. The main classification includes methods used directly on-site by a specialized contractor as well as prefabrication systems in which the ready-made elements prefabricated in a central plant or in a movable unit are mounted on the walls.

Distribution of materials and systems is based upon a network of branch offices and plaster mass mixer plants located in Warsaw, Szczecin, Lublin, Gdañsk and Zabrze. There exists also in Zabrze an Advisory-Training Center named Pro-Gor, dealing with training for contractor's teams using Dryvit materials. The network includes also dealers and contractors operating in major Polish towns.

ACTIONS OF DRYVIT SYSTEM, INC. (USA) aimed at the reduction of the effect of gaseous and particulate pollutants of air on durability and quality of weatherization techniques of dryvit systems basic remarks:

1. The Dryvit system has been developed as an international corporation during the years of global energy sources crisis (the 1970s) when the environmental friendly technologies became more and more significant. Growing demand in energy conservation systems in building industry has been answered by the Dryvit offer and therefore the company grew up quickly. This offer is continuously widened with new proposed products. The strategy of the company is oriented on environmental protection requirements.

2. The condition of natural environment, especially emission of particulates and gaseous pollutants, effects significantly the program of production of building materials used in Dryvit system. It results from a well-known correlation between thermal protection of buildings and the level of pollutant emission. This is the focal point of the economic purpose of Dryvit corporation - i.e. production of building materials and application of energy saving and durable weatherization techniques, and the social purpose - i.e. environmental protection by reducing fuel consumption and thus - indirectly - reduction of particulates emission into the atmosphere.

Dryvit Systems

3. The pollutants existing in air cause e.g. corrosion of building materials, contamination and consequently destruction of building façades, including weatherization systems. These processes result in reduction of the efficiency of thermal protection of the buildings. The emission of pollutants cannot be stopped, and there exist certain regions, where the concentration of pollutants exceeds all the standard regulations. There are many such regions in Poland: Silesia, Cracow... - this list is rather long. Therefore in spite of actions aimed at the elimination or reduction of low emission sources, a comprehensive program of actions should be elaborated to reduce the effect of particulates and gaseous pollutants of air on the durability and quality of weatherization systems. With this regard, Dryvit implements its own program which contains following main purposes:
    a. Protection of building walls and insulating material against rain precipitation and providing proper resistance against climate conditions (hydrophobous and diffusory).
    b. Protection against the effect of SO_2- and CO_2-based salts and other chemical compounds contained in water and in air.
    c. Protection against micro-fractures and gaps in the building façade due to the influence of building structure, mining works, etc. - so-called Elastic formula.
    d. Protection against low adhesion of contaminated plaster base and adhesion disturbances..
    e. Protection against deposition of air pollutants - the DPR (Dirt Pickup Resistance) formula and providing plaster washability.
    f. Protection against moisture penetration inside the building structure - systems: PE (Pressure Equalized) and MD (Moisture Drainage).
    g. Protection against development of microbes, fungus and mildew - the PMR (Proven Mildew Resistance) formula.
    h. Elimination of organic solvents in the composition of Dryvit products - 100% water dispersion of acrylic resins are used.
    i. Environmental-friendly chemical compound used for façade cleaning.

4. The proper combination of binders, fillers, pigments and various additives modifying the Dryvit material properties guarantees the implementation of all these tasks. A reliable composition of the product together with high quality of all the components, guarantees long-term proper features of the plaster masses, binders, façade paints, etc. Thus Dryvit is the oldest professional weatherization technique applied in Poland.

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ANDRZEJ WŁODKOWSKI

Our Enterprise originates from „EKODEX Co. Ltd." set up in 1989. In January 1992 it was converted into „The Przedsiębiorstwo Produkcyjno Usługowo Handlowe „EKOREX; Sp z o.o. (EKOREX Co. Ltd., Production, Services and Trade Enterprise, Co. Ltd.), without changing but extending its operational range. In the first period of its activity our Enterprise employed skilled and experienced specialists from the ex-Military College for Army Chemical Engineers in Cracow; therefore, the Enterprise dealt chiefly with elimination of environmental contamination. Nowadays, the Enterprise's operational range comprises:

- consulting and training services related with ecology;
- study on environmental contamination;
- elimination of environmental contamination;
- participation in the US program of low emission elimination in Cracow;
- designing, consulting in the realization of projects „GEF" (Global Environmental Facility);
- designing, construction, servicing, operating the sewerage and water treatment plants, boiler-houses, incinerators etc.;
- designing of heat networks, exchangers junctions, central heating and household hot water installations.

Hitherto, we have performed some works in the following provinces: Opole, Katowice, Bielsko-Biała, Częstochowa, Cracow, Kielce, Tarnów, Rzeszów, Tarnobrzeg, Krosno, Lublin and Włocławek.

Since 1991 our employees have individually participated in making the program and next in testing boilers and fuels verified in the boiler houses covered by the Polish -US program of reduction of low emission sources in Cracow. We have also been co-authors (in collaboration with Brookhaven National Laboratory, the Cracow Development Office, the Cracow Technical University and Energoekspert sc) of a paper submitted at the Conference held at Pilzeň (Czech Republic) in April 1994.

We have actively joined the program of elimination of heating network boiler houses (industrial and local) by designing (for the Cracow Co-generation Plant and MPEC) new connections among some structures and the municipal thermal distribution network and exchangers stations. In 1994 we made 47 such designs and have been working on successive projects to be carried out in Cracow.

Our Enterprise is a member of the Scientific and Technical Advisory Board of the GEF (Global Environmental Fund). This Fund realizes and finances the program of reduction and limitation of hotbed gas emission in the world. The Cracow project, for being one of the two in the world to be performed, consists in substituting the energy generation process - not basing upon solid but on gaseous fuels - with the use of gas turbines. Since 1993 we have been participating the works conducted at the Cracow Technical University aimed at replacing the heat source. The members of our measurement panel headed by the National Inspection of Environmental Protection have conducted ecological, technical and economical monitoring of our project. Both research program and its performance have been given a positive evaluation on the part of the international GEF's representative; the report on tests has been approved of by the International Bank of Environmental Protection in Washington acting as a payer on behalf of the GEF.

The program of environmental contamination elimination we participate in the tests performed on a new incinerating plant for industrial wastes to be started up, organize and conduct pilot research on the industrial utilization method for petrochemical waste materials par excellence.

In April 1994 we met the first Polish waste gases catalyst whose operation causes a reduction in the emission of pollution into the air. Some implementation tests on the catalyst we conducted by ourselves in the Cracow Cable Factory on the boiler **OR-10**.

EKOREX

In August 1994, in collaboration with the Department of Environmental Protection of the Municipality in Cracow and Vet-Agro Co. Ltd., we held in Cracow a seminar aimed at the one-and-a-half-year implementation test results on the first Polish catalysts EUKAT-1. At that seminar we presented also the results of our own research on this catalyst, obtained in the boiler-house of the Cracow Cables and Cable Machines Factory in Cracow. Since the catalyst was worked out in 1993, a several dozen or so implementation tests have been performed on different boilers and boiler houses aimed at the optimization of the catalysis process.

In September there was a seminar held at GIGA-Świdnik Co-generation Plant and dedicated to the limitation of the emission of toxic flue gases by using catalysts; at the seminar the positive results reached in most of cases of the hitherto performed implementations, were discussed.

I would like to present the hitherto obtained implementation results and the basic data on the catalyst itself. The catalyst called EUKAT-1 is a mixture of high processed mineral ingredients containing no calcium salts nor heavy metals. The active phase of the catalyst is formed during the coal combustion and therefore, the catalyst operates at the stage of burning coal, not as late as in the gaseous phase of the system.

The catalyst acts in three directions:

- it diminishes the coal ignition point and, thus, causes its deeper and more exact combustion and eventually raises the furnace temperature
- it reduces the concentration of sulfur dioxide at the stage of its generation by binding the coal sulfur with the oxide residues and forming sulfur compounds hardly soluble even in aqua regia itself;
- it reduces the concentration of nitrogen oxides (or stops the process of their generation) by using high temperature, heterogeneous surface reaction of oxygenolysis of carbon monoxide by means of nitrogen oxides.

Finally, in consequence of the catalyst's operation, the following results can be expected:

- rise in furnace temperature
- diminution of heat losses, chiefly of outlet loss, loss of non-complete combustion, of non-complete combustion via decreasing the emission of both hydrocarbons and carbon monoxide,
- reduction of the volume of the coal consumed
- improving of the boiler's efficiency
- cleansing of the boiler's heating surfaces
- a considerable diminution of the emission of sulfur dioxide and nitrogen oxides.

The proportion of proportioning catalyst against the solid fuel depends on the concentration of sulfur in coal and furnace temperature.

The mechanism of binding sulfur compounds consists in that an alloy containing EUKAT's ingredients and carbon appears on a catalyst-coated coal grain, following a heating-up over 773 K. The sizes of the alloy are of micrometric order of magnitude; in the case of an ideal reciprocal mixing fuel - catalyst, the alloy covers the whole of burning coal grain. All combustion processes occur, therefore, in the alloy layer. Eventually, the combustible sulfur present in the fuel is bound into complex chemical compounds with participation of furnace residues. Active ingredients of „Eukat-1" catalyst play an intermediate role in this process, yet they themselves do not get bound as sulfur compounds.

In the reduction of nitrogen oxides down to molecular nitrogen, the high temperature oxygenolysis of carbon monoxide by means of nitrogen oxides is used. A competitive oxidant of carbon monoxide in this process is air oxygen. For being specifically selected, the active phase of the catalyst operates efficiently even at big excesses of oxygen in the boiler (as high as at O_2 16% vol.).

The operational principle of the catalyst active phase being a CO intermediate oxidation agent is as follows:

- CO chemisorption
- NO_x chemisorption
- NO_x dissociation into ingredients
- a surface reaction occurring between CO and the oxygen from nitrogen oxides, recombination of a nitrogen molecule, desorption of CO_2 and N_2 from the contacting surface (a renewal of the catalyst surface for successive reactions).

The reaction rate is controlled by the slowest process; chemisorption of CO and NO_x is supposed to play this role. Too high a concentration of water vapor in the reaction renders the process more complicated as the reaction of carbon monoxide conversion by means of water vapor may occur. The reduction process of nitrogen oxides via carbon is a reaction of Langmuire-Hinschelwood type and takes place on the heterocentric contacting surface, through a series of surface intermediate compounds. 1873 K is to be taken as the limiting temperature of efficient operation of the catalyst active phase. Above this point the efficiency of the active phase of Eukat-1 catalyst falls drastically.

EKOREX

I would like to show now the results obtained from the first EUKAT's implementation at the Cracow Cable Company. The tests on the operational efficiency of the catalyst were carried out on boiler OR-10; thermal tests of the boiler, of the emission of dust and gaseous pollution (SO_2, NO_x, CO) before and after the application of the catalyst were performed and one determined the operational efficiency of the fuel basing upon the tests, measurements and chemical analyses. Boiler OR-10 was being supplied with a mixture fuel-EUKAT for 17 days, the ratio being 0.5 kg of catalyst per 1 ton of fine coal.

The computed volume of emission after having applied the catalyst, against the emission volume without the catalyst, amounted to:

- for carbon monoxide - the maximum diminution 39%, the average : 35%;
- for nitrogen oxide: the maximum diminution was 37%, the average: 24%;
- for sulfur dioxide - the maximum diminution was 70%, the average: 56%.

The energy parameters took up the following values against the base value - without catalyst:

- the outlet loss - a reduction reaching even up to 49%, the average level being 28%
- the boiler efficiency increased maximum by 23%, the average level being 13%-
- the fuel consumption per generation of 1 GJ of energy - was maximally reduced by 26%, on an average by 15%.

For having the tests conducted in a boiler directly after its repair, it was not possible to determine the effect of using the catalyst upon the purity of the heat surfaces, although an increase in the thermal value and a fall in the outlet loss attest to a better utilization of the physical heat of waste gas.

I would like to present also some measurement results obtained in January 1995 by the Environmental Protection Agency at Koszalin for the Heat Distribution Enterprise at Białogard.

The tests were performed on a small coal-fired boiler WR-10, its efficiency being 78% and the catalyst rate per coal ton being 0.8 kg.

- The average coal consumption before using the catalyst amounted to 65 kg/GJ; instead, following the use of catalyst - 53 kg/GJ and the reduction of the mass of the fuel consumed amounted to approx. 19%.
- Emission of dusts fell by 47% - from 2.53 kg/h down to 1.32 kg/h
- SO_2 emission diminished by 44% - from 13.58 kg/h down to 7.57 kg/h
- NO_2 emission diminished by 44% - from 1.93 kg/h down to 1.10 kg/h
- CO emission dropped by 36% - from 4.99 kg/h down to 3.21 kg/h.

The measurements performed allowed to compare the test results with the data of permissible emissions as provided in the Ordinance of the Minister of Environmental Protection, Natural Resources and Forestry concerning the air protection against contamination (Government Regulations and Laws Gazette No. 15, item 92, 1990). The use of the catalyst caused that for all the three standardized substances both present and future legal regulations are complied with.

A very interesting is a study on the savings when using the catalyst.

For a coal consumption of about 3 900 t/year, the accepted optimum catalyst dose being 0.65 kg/ton of fuel, regarding the decrease in the costs of purchase, transportation and coal transshipment, a fall in the electricity consumption by about 15%, a 40% extension of the time between the boiler's overall repairs, computing the fees for the environmental usufruct of the environment as for 1994 price level, without and with the use of EUKAT, one may achieve savings for the Enterprise as high as of an order of PLN 250 000 - 300 000 per year (PLZ 2.5-3.0 billion).

As EUKAT-1 is the first Polish patented catalyst, our Enterprise has taken up activities regarding an extension the use of the patent, among others holding final talks in the Power Plant of the „Sendzimir" Steelworks, the Complex of Thermal and Power Plants at Bielsko-Biała, and promoting among smaller entrepreneurs a detailed description of implementations and the operational principles of the catalyst. We are the exclusive dealer of EUKAT - of course, in factory prices, in some provinces in South Poland.

At the end of the presentation of our Enterprise, please be informed that bearing in mind the importance of the ecological problems to be solved in future, we would like to extend yet the activity as far as the utilization of industrial wastes, included toxic substances, is concerned.

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BASIC INFORMATION

FEWE - Polish Foundation for Energy Efficiency was established in Poland at the end of 1990. FEWE, as an independent and non-profit organization, has the following objectives to fulfill:

to strive towards an energy efficient national economy, and

to show the way and methods by use of which energy efficiency can be increased.

The activity of the Foundation covers the entire territory of Poland through three regional centers: in Warsaw, Katowice and Cracow.

FEWE employs well-known and experienced specialists within thermal and power engineering, civil engineering, economy and applied sciences.

The organizer of the Foundation has been Battelle Memorial Institute - Pacific Northwest Laboratories from the USA.

FEWE has the following methods of operation:

- Studies and analyses to support energy efficiency within the country, region and on a local scale.
- Support for development of the private sector including joint ventures with foreign companies in order to transfer into Poland new energy efficient technologies, know-how and expertise.
- Training and education of Polish professionals as well as execution of demonstration projects within the energy efficiency field.
- Education of public at large.

The expertise of the Foundations currently being used in the following branches:

- industry;
- power industry, natural gas and district heating sectors;
- buildings;
- commerce and services;
- individual consumers of fuels and power.

FEWE carries out its objectives among others through:

- Analyses of various aspects and environment policies at country, region and local and enterprise levels resulting in new legal, organizational, technical and economic proposals of solutions;
- Integrated Resources Planning in relation to the production, distribution and consumption of energy.
- Energy Audits along resulting in Energy Conservation Opportunities in industry, housing sector and public utility facilities.
- Elaboration of investment strategies based on Least Costs Planning principle.
- Search of Polish partners for well defined foreign proposals, market analyses for energy efficiency and environmental protection technologies.
- Setting up a database of Polish companies searching for new technologies and foreign support.
- Project Feasibility Studies and financial evaluation of these projects.
- Implementation of energy efficient and environmentally sound technologies (pilot and demonstration installations).
- Organization of the special-purpose courses, workshops, seminars and conferences.
- Publication of bulletins, newsletters, information leaflets, etc. on energy efficiency.
- Translations and publication of professional foreign literature on innovative ideas and implementations within the energy efficiency field.
- Setting up and running special-purpose libraries devoted to energy efficiency.
- TV educational programs and information leaflets for individual consumers of energy to promote efficient use of this precious commodity.

FEWE cooperates both on the national and international levels.

NATIONAL COOPERATION

- Government of Poland: Ministry of Environmental Protection
- Government of Poland: Ministry of Industry and Trade
- Ministry of Building Construction and Physical Planning, Central Planning Office (CUP)
- Province and local governments, local municipalities, self-governments, etc.
- European Energy Centers in Warsaw and in Katowice
- Energy Conservation Agencies both national and regional
- Polish Power Grid Company, regional electric and gas utilities, district heating utilities
- Building cooperatives
- Industrial facilities
- Non-government Environment and Energy Organizations
- Financing institutions active in the energy and environment sectors

INTERNATIONAL COOPERATION

- United States Environmental Protection Agency (US EPA)
- United States Department of Energy (US DOE)
- Commission of the European Communities (European Union), Brussels, Belgium
- Battelle Memorial Institute - Pacific Northwest Laboratories (BMI-PNL), USA
- World Bank and its branch - International Finance Corporation, USA
- Dutch Agency for Energy and Environment - NOVEM, The Netherlands
- French Agency for Energy Management - ADEME, France
- Danish Energy Agency, Denmark
- Lawrence Berkeley Laboratory, USA
- Swedish Agency for Technical Development - NUTEK, Sweden
- American Council for Energy Efficient Economy, USA
- Synergic Resources Corporation, USA
- Danish Energy Analysis, Denmark
- RCG Hagler Bailly, Inc., USA
- Charles Stewart Mott Foundation, USA
- Lulea University of Technology, Sweden
- Twin Energy Efficiency Centers in Czech Republic - SEVEN, in Russia - CENEF, in Bulgaria - ENEFFECT
- European Energy Centers throughout Europe

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KRYSTYNA KUBICA

ECOLOGICAL SOLID FUELS, EFFECTIVE HEATING DEVICES FOR COMMUNAL MANAGEMENT AND THEIR TESTING METHODS

The national balance of primary energy consumption is almost in 90% based upon coal. Coal is used not only in electricity production, but also in the communal sector - in heating facilities comprising chiefly local boiler houses and private households.

Pro-ecological activities in the recent years have substantially influenced a decrease in the emission of pollution from large, industrial sources. In this situation the effects of 'low' emission on the environment and no progress in their elimination - as far as both the application of ecological fuels and legal regulations are concerned, are yet more blatant. Making the law on the ecological use of the environment on the part of individual users and the creation of a strategy of planning and establishing a supervision over the solid fuels management in the communal and utilities sectors should be anticipated by operations aimed at working out some methods for issuing fuel certificates and the criteria of permitting the use of fuels in communal management.

At the Institute of Chemical Processing of Coal some actions aimed eventually at working out a testing method for solid fuels and heavy power devices for the communal management, bearing in mind the energy and emission aspects, have been taken up. A design of a certificate issuing system has been elaborated; a laboratory for testing fuels and low power heating devices was started up. Finally, a series of energy and emission tests on the started-up stand for testing fuels and low power devices has been performed.

It was shown that substituting coal with a smokeless or low emission fuel caused an appreciable decrease in the indices of the emission of environmentally noxious substances, especially of pitch ones, including cancerogenic benzopyrene and SO_2; this decrease depends on the fuel's ecological efficiency which, in turn, is determined by the technological parameters of fuel production.

Tests carried out on different boilers having a power from 25 to 45 kW have shown that changes in the construction of the furnace concerning the way of supplying the fuel to the furnace, flue gas circulation, air distribution, are also a factor contributing to an effective reduction and elimination of low emission - both by improving the energy efficiency of a device and by diminishing the emission indices of the environmentally noxious agents.

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KRZYSZTOF DRESZER

ACTIVITIES OF THE INSTITUTE OF CHEMICAL PROCESSING OF COAL AT ZABRZE

The Institute of Chemical Processing of Coal at Zabrze was established in 1955. The works on carbochemical technologies have been therefore carried out at the Institute for 40 years.

The targets of the Institute's activities are research, scientific and developing works regarding a sensible utilization of fuels via their processing into more refined forms, safe environment, highly efficient use of energy carriers and technological products of special quality.

The Institute of Chemical Processing of Coal has been dealing with the following:

- optimized use of home hard coals;
- improvement of classic coal coking technologies, processing and utilization of volatile coking products;
- production technologies of low emission rate fuels for communal management;
- analyses of coal processing technologies;
- new technologies aimed at increasing the efficiency of coal utilization for energy-generating purposes, especially in industry and studies on the ecological aspects of these processes;
- production technologies of sorbents and carbon activating agents and technologies of their utilization (treatment of industrial wastes and potable water);
- rationalization of water and wastes management in the metallurgical and chemical industries in connection with removal of pollution especially dangerous to the environment from.wastes;
- utilization technologies of refined materials (electrode cokes, binders, impregnating agents) for making electrodes, refractories and new generation construction carbon materials;
- production technologies of high quality bituminous and bituminous-and -resin coating, anti-corrosive and insulation materials;
- environmentally friendly utilization technologies for power station, mine and other wastes;
- dedusting processes in industrial gas streams.

The Institute of Chemical Processing of Coal employees 160 persons, among others:

3 professors
17 Ph.D./D.Sc., doctors and assistant professors
60 university graduates - with M.Sc., M.Sc.Eng. and Eng. titles

The Institute's staff deals with the following fields:

- chemical engineering;
- carbochemistry;
- chemical and instrumental analysis;
- mechanical engineering;
- computer science;
- heavy power engineering.

The operation of the Institute of Chemical Processing of Coal is guided by the Director and his two Deputies:

the Deputy Director for Research and Development
the Deputy Director for Technology and Economics

The consulting and advisory organs of the Director are:

- the Scientific Council
- the College
- the Panel of Director's Attorneys
- the Council for Quality System

The methodological activity of the Institute is realized by the following administration units:

- the Division of Planning and Co-ordination;
- the Division of Economics and Finances;
- the Department of Marketing and Collaboration with Abroad;
- the Department of Thermal Technology;
- the Department of Physical Chemistry;
- the Department of Chemistry of Coke;
- the Department of Carbochemistry;
- the Department of Environmental Protection Technology;
- the Design Office;
- the Department of Engineering.

The Laboratories and Research Panels constitute the Scientific Departments.

In 1994, the motion for having our three laboratories given below accredited, namely:

1) The Laboratory of Physical Chemistry (Department of Physical Chemistry)
2) The Laboratory of Carbochemistry (Department of Coke Chemistry)
3) The Laboratory of Coal Sorbents, Waters and Wastes (Department of Environmental Protection Technology).

was placed at the Polish Center of Research and Certification.

The Institute's laboratories have at their disposal some technical facilities and special instrumental apparatuses enabling the use of modern analytical techniques. The Institute has got, among others, a stand for solid fuel testing designed according to international standards.

Apart from the research submitted for the accreditation, the Institute performs also other activities resulting from the customer's needs and research-and-scientific elaboration, technological works and expertise including:

- testing of physico-chemical, technological, heavy power, ecological properties of coke, coal, processed solid fuels, coal derivatives, like: benzole, coke gas, pitch, tars, oils, ammonium sulfate, asphalt and binders,
- elaboration of coal base for metallurgy and heavy power industry
- testing of polluted waste gases and organic waste products
- testing of active carbons, coal sorbents, waters and wastes
- testing of the quality of binders and impregnating agents for electrode making industry.

The Institute performs, among others:

- technical, chemical, petrographic studies and analysis of coal coking properties;
- testing of the composition of liquid, gaseous products of coal pyrolysis and other organic substances;
- testing of the chemical composition of industrial wastes and the possibilities of their utilization;
- testing of pitches and carbon-derived binders for electrode, aluminum and refractories industries;
- emission and energy-aimed evaluations for solid fuels used in industry and heavy power sectors, paying particularly attention at the communal management, depending upon fuels composition, its physico-chemical, processing, energy properties, the character and volume of the pollution produced;
- testing of the character and emission indices of gaseous, liquid, dust, organic and inorganic pollution, emitted in the environment and generated in communal management, heavy power industry, metallurgy, casting technologies, varnishing shops and others;
- testing physico-chemical, adsorption and mechanical properties of active carbons and coal sorbents;
- adsorption tests on carbon sorbents in relation with their usability in many fields of application;
- determination of the contents of organic/inorganic ingredients in communal, soil, process waters and in various waste waters and soils;

- elaboration of safety charts for carbon derivatives and others;
- sampling and supervision over sampling procedures.

The filing of a motion for accreditation as issued for an institution issuing certificates for such products, like: coal, coke, processed solid fuels, coal derivatives, products of their processing, activated carbons and coal sorbents, is scheduled for 1995. Should an autonomous unit issue certificates for products, the confidence of receivers and customers of the products as far as the quality and manufacturers are concerned, will increase. We deal with training and consulting services regarding the quality systems and having the laboratories ready for accreditation.

In addition, the Institute of Chemical Processing of Coal renders general technological services in the following fields:

- testing of chemical, structural and technological properties of solid fuels and carbochemical products
- conformity certification with consideration of energy and emission
- conformity certification of activated carbon
- quality evaluation of gases, pitches, tars, tar oils
- coking and degassing tests of coals
- ecological and sozological tests of industrial processes, in particular related with coal processing and utilization
- evaluations of the character and volume of emitted organic and inorganic substances in communal management and industrial works
- analysis of physico-chemical properties; assessment of usability of anti-corrosive, protective and insulation materials
- evaluations of investment outlays and computations related with investment efficiency
- making of process, technical and operational designs of atypical apparatuses and devices for new technologies
- supervision over the control and operation of industrial furnaces (coke oven batteries).

Basing upon the Institute's works, some utilization technologies of the coal won in Poland have been under way. The works carried out at the Institute have been also applied also in the installations working abroad.

Be mentioned here:

- development of the composition of coke mixtures used as batch for all cokeries in operation in Poland
- implementation of works on the modernization of national cokeries
- a formed coke producing plant
- pilot installations for coal pyrolysis and producing smokeless formed fuel
- a hard coal briquetting plant
- studies performed by the Institute of Chemical Processing of Coal for foreign customers
- production technology of electrode coke and electrode pitch from coke tar
- carbonic insulation materials for protecting pipelines and steel constructions working in particularly aggressive conditions (sea water, salted mine waters, cokeries)
- isolating technology for p.p.a. compounds and pitch oils (biphenyl oxide, naphthalene, acenaphthene, indole, anthracene, phenanthrene, methylnaphthalene, etc.)
- production technologies for pure anthracene and carbosole implemented at the „Blachownia" Chemical Works - in collaboration with the Institute of Industrial Chemistry in Warsaw
- production technologies for carbobituminous road binders: asphaltic pitches, tar asphalt, pitch asphalt
- winning technologies for binders and impregnating agents for electrode making industry (implemented in the „Sendzimir" Steelworks in Cracow and in Chemical Works at Blachownia).

JOHNSON CONTROLS INTERNATIONAL CO. LTD.

JACEK GNIAZDOWSKI

GENERAL COLLABORATION OFFER OF JOHNSON CONTROLS REGARDING THE PERFORMANCE OF AIR CONDITIONING AUTOMATIC CONTROL SYSTEMS AND OTHER BUILDINGS' AUTOMATIC CONTROL SYSTEMS

Herewith we would like to send you information on the activities held by Johnson Controls on the Polish market as well as present a collaboration offer.

JOHNSON CONTROLS INTERNATIONAL Co. Ltd. constitutes a branch of the JOHNSON CONTROLS INC. USA, with the seat in MILWAUKEE, WISCONSIN. The Company JOHNSON CONTROLS Inc., USA was established in 1885. After 109 years of a continuous operation, it employs nowadays 55 000 persons in its own 5 000 structures located in 30 countries and is the world's leader on the market of buildings' automatic control systems. The total turnover of the sale and services for 1994 reached $6.92 billion. In the ranking of the 500 biggest US enterprises (according to the „Fortune" magazine) JOHNSON CONTROLS occupies the 88-th place.

JOHNSON CONTROLS manufactures measuring and control equipment (800 types, 3 000 sorts) and is as well a „turn-key" supplier of complete automatic control systems for heating, air conditioning, ventilation and refrigerating engineering branches. The Company also supplies Buildings' Computer-Based Supervision and Monitoring Systems that may be applied in both small and large structures, among others in:

- Hotels
- Banks
- Hospitals
- Museums
- Offices and public administration buildings
- Airports
- Trade centers
- Assembling plants & factories

Since 1990 we have been performing full-range trade and contracting activities on the Polish market. We have our own well-trained technical staff and we collaborate with a series of designing and contracting enterprises that enable us to have our projects carried out all over Poland. The prices of our supplies and services correspond with the level of the Polish market.

OUR OFFER

JOHNSON CONTROLS INTERNATIONAL offers you supplies of measuring, control and signaling equipment, as well as complete „turn-key" supplies of BUILDINGS' AUTOMATIC CONTROL SYSTEMS, which may include following systems:

- Air Conditioning Installation Automatic Control System (ATC)
- Computer-Based Supervisory and Monitoring System (BAS)
- Fire Protection Alarm Signaling System (FAS)
- Closed-Circuit Television Supervisory System (CCTV)
- Access Control System (ACC)
- Anti-Burglar Alarm Signaling System (IAS)
- Energy Management System (EMS)
- System of Integrated Supply and Control Cabinets (MCC)
- Amplification Emergency System (AES)
- Watchmen Tour Monitoring System (WTMS)

Our offer may include following technical services:

- Conceptual projects of systems or feasibility studies
- Elaboration of preliminary design
- Elaboration of design documentation
- Performance of system software documentation
- Complete deliveries of equipment, devices and assembling materials (manufactured at our Company or elsewhere)
- Performance of assembly works or assembly supervision
- Performance of the system start-up
- Customer's staff training
- Guarantee and post-guarantee services (periodical maintenance services)
- Current servicing of systems

According to your wishes, we may either render full-range services or only some items desired. We offer the devices of the highest world's standard, based upon the digital-circuit engineering of the newest generation, manufactured at our plants in the USA, Germany, Italy, Netherlands, England, Argentina and Hong Kong. All the technical and maintenance services are performed in Poland.

Our references may be either some structures already completed or under performance as specified on the References List.

We are ready for a full-range collaboration with your Enterprise in the process of either a partial or complex implementation of your projects.

Should you find our offer interesting, please fix a term for our meeting that might allow us to present closer the operation of our Company in Poland and to arrange a visit to see the structures already completed or under realization, so as to show the quality of both our works and technical documentation.

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MAŁGORZATA KASPERSKA
HENRYK BUŃKA

The **MarCo Engineering Company Ltd.** has its registered seat at Gdynia and was established in 1990.

We are the exclusive representative for Poland of the world's renowned manufacturers of heat distribution network products - ***Tour & Andersson Control AB***, Sweden, ***Tour & Andersson Hydronics AB***, Sweden, ***International Control Meters AB***, Sweden, ***Meinecke***, Germany.

Through six subsidiaries (Gdynia, Warsaw, Wrocław, Cracow, Gliwice and Lublin) and our dealers' network all over Poland we offer:

- automatic control systems for heating and air conditioning -**TA**;
- a supervisory remote control system for heat distribution centers - **TA**;
- compensating devices for central heating and household hot water installations - **TA**;
- radiator thermostatic valves - **TA**;
- ***„Meinecke"*** water meters;
- thermal energy counters - **ICM**;
- a remote calorimeter data reading system SIOX - **ICM**;
- an electronic central heating costs sharing system - GT-15 - **ICM**;
- compact thermal stations;
- compact and pipe exchangers.

The modern, high standard devices offered by us have achieved a spectacular success on the Polish market and that fact can be corroborated by a still increasing references list.

NALCO FUEL TECH

STANISŁAW MICHALAK

NALCO FUEL TECH COMPANY AND ITS RANGE OF ACTIVITY

The **Nalco Fuel Tech** with its seat at Naperville (near Chicago), Illinois 60563 - USA, is an engineering company working in the field of technology and equipment for environmental protection. The **Nalco Fuel Tech** is 50% owned by a well-known US chemical company NALCO with its seat located also in Naperville, IL. A major portion of NALCO products constitute chemical materials and additives used in environmental protection technologies (waste-water treatment plants, water treatment, fuel modifiers, etc.).

Basing in part on the experience, laboratories and RD potential of the mother company, the **Nalco Fuel Tech** Company developed and implemented in power industry a series of technologies aimed at the reduction of environment-polluting products of fuel combustion (some examples are presented in this paper).

The engineering solutions of **Nalco Fuel Tech** belong to a new generation of environmental protection techniques developed in the USA. They consist in actions focused on the sources of pollutants, i.e. in upgrading the combustion chambers of power engineering plants, e.g. boilers or communal and/or industrial waste combustion units. The **Nalco Fuel Tech** development and research group cooperates with leading US investigation and research institutes, e.g.:

- Industrial Environmental Research Laboratory - Research Triangle Park NC,
  and with federal government institutions dealing with environmental protection, e.g.
- US Department of Energy - Washington
- US Environmental Protection Agency (EPA)
- Electric Power Research Institute (US EPROM)

The **Nalco Fuel Tech** leads also an intensive activity out of the USA, e.g. in Asia - China and in Europe, having affiliated companies and representative offices in Germany, UK, the Netherlands, France, and recently in Poland and Czech Republic.

The NFT technology of the US company **Nalco Fuel Tech** includes comprehensive technical solution for cleaning flue gases emitted by boiler houses and other power generation systems. This comprehensive character consists in the fact that the separate steps of reduction of emission of main pollutants emitted into the atmosphere after fuel combustion are combined into a single process. Following steps are taken into consideration:

- reduction of emission of sulfur dioxide (SO_2) and chloride compounds (HCl);
- reduction of nitrogen oxides NO_x (NO and NO_2) formed during combustion process;
- elimination of particulates from flue gases by means of bag filters, in which also final desulfurization of flue gases takes place;
- reduction of CO by optimization of combustion chamber and application of activating substances.

Thus the **NFT - Nalco Fuel Tech** technology meets the requirements defined in the Ordinance of the Ministry of Environmental Protection, Natural Resources and Forestry of February 12, 1990 on significant reduction of permissible emission of these pollutants, i.e. SO_2, NO_x and particulates. It should be underlined that the **NFT** process can be used in boiler houses, cement furnaces, waste combustion units, i.e. it is useful for combustion of various fuel sorts, incl. hard coal, brown coal, coke as well as liquid and gas fuels. The **NFT** can be applied especially in industrial process plants, heating plants and co-generation plants of 10-300 MW_m output per unit for which the application of wet or semi-dry methods of flue gas cleaning outside the combustion chamber is not worthwhile because of high investment costs as well as the lack of space for such big installations.

NALCO FUEL TECH.
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NALCO FUEL TECH.
53-332 Wrocław, 95, Powstańców-Śląskich St., 18-th floor
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A customized air pollution control system is being installed for a district heating plant in Poland. The system consists of a boiler that controls SO_2 and NO_x, a small humidification chamber that enhances sulfur removal, and a fabric filter baghouse that collects dust and further reduces SO_2. More than 80% sulfur capture (to 150 g/GJ), 50% NO_x removal (to 78 g/GJ), and 99.8% particulate collection has been achieved on an OR-32 and a WRp-46 boiler during the performance demonstration. The corresponding removal costs of USD 95/ton fly ash, 550-600/ton NO_x, and 250-330/ton SO_2 are among the lowest for these small sizes (approximately 32-46 ton steam/hr) of boilers. These boilers are common in developing countries such as Poland, Czech, and China. The successful design and performance of this customized system makes it possible for the technology to be implemented on a large scale.

Contact in U.S.:
Vincent Albanese
NALCO Fuel Tech
Naperville, ILL
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Fax: 708-983-3240.

PRZEDSIĘBIORSTWO
PRODUKCYJNO-USŁUGOWE
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Tel. kom. (0-90) 30-47-88

Kierownictwo firmy:

Mgr inż. Jerzy Polak - Prezes

Mgr Bernard Janosz - Wiceprezes

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Cellular (0-90) 30-47-88

Company management:

Jerzy Polak, M.Sc. Eng. - President

Bernard Janosz, M.Sc. - Vicepresident

BERNARD JANOSZ
RYSZARD GRYGIEL

Basic information:

established in:	1992 (four production years)
staff:	about 60 persons
production range:	pre-insulated pipes and profiles for underground central heating pipelines
	SPIRO-coated pipes to be laid on trestles
	pre-insulated, zinc-plated pipes for household hot water pipelines
equipment:	process line for pipe assembling
	foaming set ELASTOGRAN - PUROMAT 300
	welding machine for casing pipes OMIKRON
	complete workshop accessories

Abstract of the presentation:

- a short information on the Company
- basic data on the production range
- advantages of pre-insulated pipelines
- basic specifications of the RAFAKO-EKO system (description of parts)
- assembly principles for pre-insulated parts
- universal character of the offer (production, designing, servicing, workmanship)
- ordering conditions
- references from the performed heat distribution networks

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DOBIESŁAW NAZIMEK

INFORMATION ON THE COMPANY

VET-AGRO Co. Ltd., a multibranch enterprise started its business in 1989. It is a private company owned by two persons constituting its managing board: Jan Głuszak and Stanisław Klimont.

The Company employs 35 persons.

Currently, the Company deals with:

1) Production of veterinary drugs
2) Production of catalyst EUKAT-1
3) Trade in household articles (varnishes, lacquers)

The development strategy of VET-AGRO Multibranch Enterprise is based upon pro-ecological actions:

- production of new formula veterinary drugs, consisting in limiting the volume of antibiotics and chemiotherapeutic agents in veterinary treatment;
- manufacturing of a new generation catalyst EUKAT-1 serving for the reduction of gas pollution emission generated by coal combustion;
- production of ecological fuels based upon solid ones (e.g. briquettes);
- production of a liquid fuel catalyst;
- trade in environmentally friendly varnishes and lacquers based upon natural ingredients (water soluble).

VET-AGRO collaborates with some research institutions in Poland and employs a high-qualified staff of specialists in physical chemistry, pharmacy and environmental engineering. At its disposal there are proper production facilities - compartments, devices and analytical laboratories complying with the quality requirements to be met for VET-AGRO's products.

In order to have its rights to the achieved intellectual scientific and technological property secured, VET-AGRO has provided for itself a patent protection, in effect both home and abroad.

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DRY ADDITIVES - REDUCTION CATALYSTS FOR FLUE WASTE GASES ORIGINATING FROM THE COMBUSTION OF SOLID FUELS

Abstract

Hard coal is the basic energy generating raw material in Poland. In 1990, 60% of electricity and thermal energy was totally obtained from it. It means that 100 million tons of raw materials must have been burnt. The second position is held by lignite - generating 38% of electricity and heat (67.3 million tons)[1]. It is to be underlined that coal combustion is particularly noxious to the environment. The coal composition appreciably influences the volume of pollution emitted in the air. The contents of incombustible mineral parts - ashes - oscillates from 2 to 30 %; only 0.02 comes from plants that had once originated coal and cannot be separated in any way. All the rest, viz. the so-called external mineral substance enters the fuel while being won. The most undesirable hard coal ingredient is sulfur whose level depends on coal sorts and its origin. The worst the fuel quality, the more sulfur it contains. In the utilization process of this fuel its combustible part is burnt: therefore, sulfur dioxide is produced. At the present coal consumption, the SO_2 emission reaches the level of 3.2 million per year[2]. The said menaces do intensify the pressure on working out new coal utilization technologies, improving old and developing of pollution limiting methods. Research is also directed towards such an adaptation of technologies in order that individual users may also make use thereof (household furnaces) as their share in the pollution emission is considerable.

Table 1

Average emission indices for substances noxious to the atmosphere in gram per ton of burnt coal

Emitted by	Agent emitted [g/ton]				
	particulates	CO	SO_2	pitchy substances	benzo(α)pyrene
heavy power industry	3 400	1 000	19 000	27	0.01
household furnaces	7 500	45 000	21 000	5 000	20

A real menace to health caused by the presence of various hydrocarbons, sulfur, nitrogen and coal oxides and other toxic compounds as well as still increasing ecological consciousness have made heavy power and automobile industries[3] start some actions aimed at limiting the emission of those substances. Apart from many solutions proposed by engineers, the research has comprised as well catalytic after burning of combustion gases.

The **EUKAT-1** catalyst is an example of practical using supra-catalysis. The modern character of the catalyst consists in separating the active phases between two precursors, not like in the traditional catalysis with one agent - the precursor of catalyst. Active phase **A** called **EUKAT-1** is added to the fuel constituting phase **B**, supplementing ingredient **A**. The compounds contained in coal ballast and constituting its part are treated as ingredient. For mass and quality variability of agent **B**, the control phase is the mass of agent **A**.

The standard composition of phase **A** determined basing upon the distribution of active centers **B-L** and $\mathbf{H_o}$ function (Bamett's) allows theoretically to perform some maneuvers within wide intervals of the composition of phase **B**, both qualitatively and quantitatively. Such an approach to the problem of reduction of pollution generated in the combustion of mineral solid fuels eliminates wastes because sulfur is permanently bound with

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1 Data reported by the Chief Central Statistics Office, 1990.

2 Data for 1990.

3 It refers also to other industrial branches in which the applied technological process is based upon combustion at various stages of production process.