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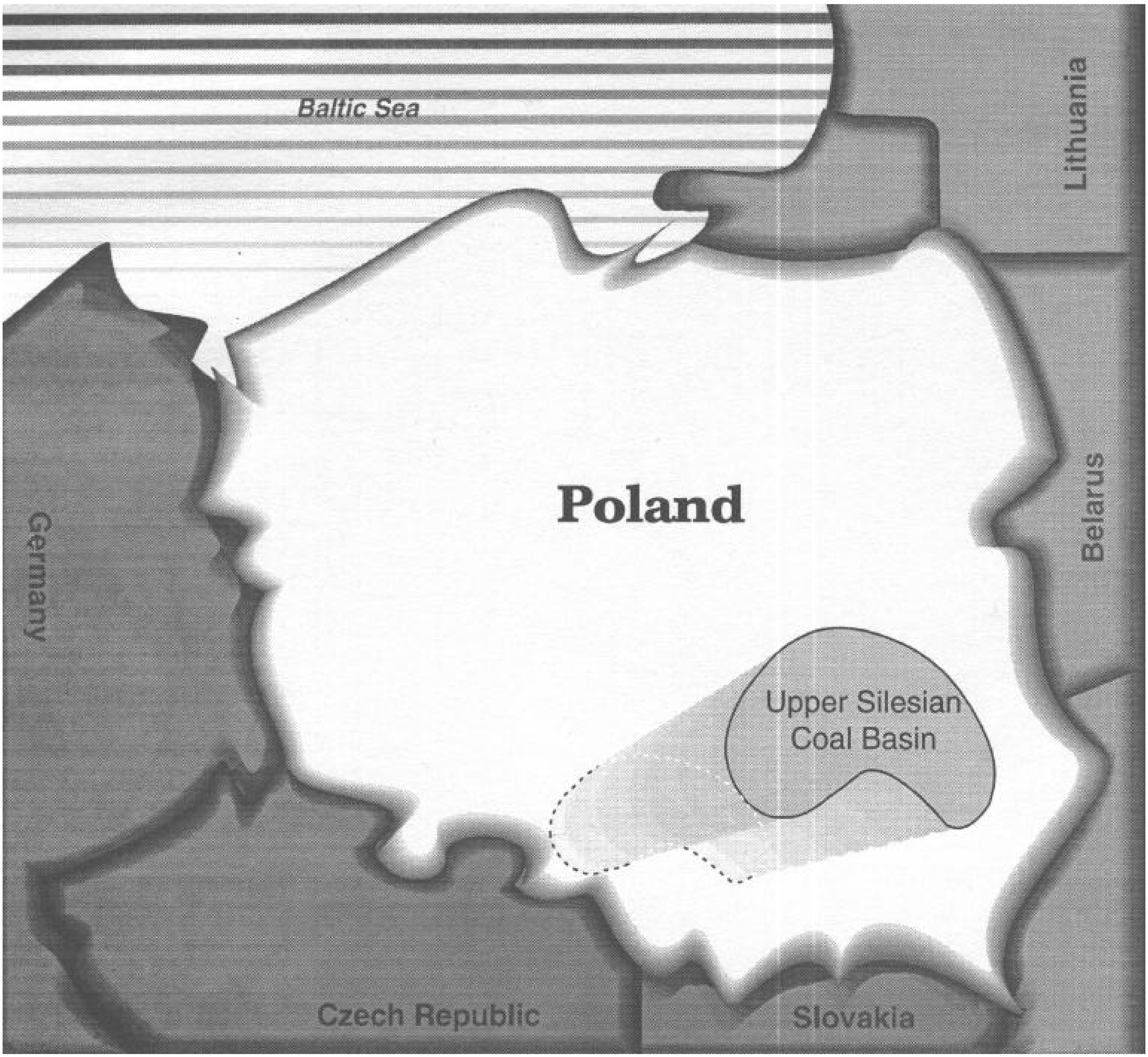
Reducing Methane Emissions from Coal Mines in Poland: A Handbook for Expanding Coalbed Methane Recovery and Use in the Upper Silesian Coal Basin



REDUCING METHANE EMISSIONS FROM COAL MINES IN POLAND: A HANDBOOK FOR EXPANDING COALBED METHANE RECOVERY AND UTILIZATION IN THE UPPER SILESIAN COAL BASIN

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ATMOSPHERIC POLLUTION PREVENTION DIVISION
U.S. ENVIRONMENTAL PROTECTION AGENCY

SUMMARY

INTRODUCTION

This report provides basic information concerning the potential for expanding coalbed methane development in Poland, particularly in the Upper Silesian Coal Basin. The study was prepared by the US Environmental Protection Agency, as part of its efforts to identify cost-effective opportunities to reduce methane emissions to the atmosphere. Part I of the study provides information on Poland's energy economy, its coalbed methane resources, and methane recovery and utilization options in the Upper Silesian Coal Basin. Part II of the study profiles 17 gassy coal mines selected according to the opportunities for expanded methane recovery and utilization that they offer.

The study emphasizes recovery of coalbed methane from mining areas because much of this valuable energy resource is currently being wasted. Methane is also a potent greenhouse gas affecting the global climate.

KEY FINDINGS

Poland is confronting the need for institutional and regulatory reforms of its energy sector. The situation is compounded by environmental and economic pressures that dictate a reduction in coal consumption, and a significant expansion in the use of oil and natural gas, most of which must be imported. Increased use of coalbed methane could reduce economic burdens associated with rising energy imports, and improve financial viability of mines.

- Poland's inefficient hard coal industry is being forced to adapt to the country's new market economy. Hard coal is the main fuel in Poland, but both output and consumption have declined due to a reduction in the gross domestic product, higher prices, and industry restructuring. The sector's newly-formed coal companies must increase efficiency and productivity in order to maintain financial viability.

- Poland's known reserves of oil are nearly depleted, and, even if new fields are discovered, it is likely that Poland will need to continue importing 95 to 99 percent of the oil it consumes. Reserves of conventional natural gas are also limited. Poland currently imports 55 percent of the natural gas it consumes, all of it from Russia; experts predict that, even with increased domestic exploration, by 2010 Poland will need to import 78 to 86 percent of its gas.

- Coalbed methane is an attractive natural gas resource in Poland that has, until recently, been overlooked. It is clean-burning, and is located in coal producing areas that traditionally have been intensely industrialized and highly polluted. Increased recovery and utilization of coal mine methane can help offset import costs, and improve mine productivity and economics.

Coalbed methane is an abundant natural gas resource that is currently underdeveloped in Poland. Although some of the methane liberated by coal mining operations is utilized, most of it is currently vented to the atmosphere and wasted.

- The coalbed methane reserves contained in active mine concessions in the Upper Silesian Coal Basin are estimated to range from 150 billion to nearly 200 billion cubic meters. It has been conservatively estimated that an additional 200 billion cubic meters are contained in virgin coal fields of this basin. The Lower Silesian Coal Basin contains additional (though much smaller) methane resources.

- Large amounts of coalbed methane are emitted by Polish coal mines each year, which represents a serious waste of energy. In 1993, more than 774 million cubic meters were liberated as a result of mining operations in Poland. Nearly 168 million cubic meters (22 percent) of this methane were used. This is a relatively good utilization rate compared to some areas of the world, however, a much higher utilization rate is both desirable and achievable.

There is great potential for expanded methane recovery and use at Poland's coal mines, and many different options are available for expanding utilization of the coalbed methane recovered from mining operations.

- Using demonstrated technologies, such as pre-mining degasification and enhanced gob well recovery, it appears likely that Upper Silesian Basin coal mines could recover and use 45 percent or more of the methane currently being liberated by mining.

- Mines could recover additional resources by using an integrated approach that includes drainage prior to, during, and after mining; in addition, it may in some cases be feasible to use low methane concentration ventilation air as combustion air in power stations. By using this approach at active mines, 80 to 90 percent of the methane that would be liberated and otherwise lost by mining operations could be recovered and available for use.

- Presently, coalbed methane is used successfully to generate steam and electricity at relatively small power plants at many Polish coal mines and a few other nearby industries. The potential for much larger scale utilization of coalbed methane at large public power plants exists. In addition to generating electricity, these plants generate steam which supplies a large district heating network.

- Pipelines can transport coalbed methane directly to end users. Natural gas will soon completely replace the coke oven gas that has been used by households for many years. If problems concerning gas quality and supply are addressed, coalbed methane could displace conventional natural gas in this capacity.

Poland has done much to facilitate coalbed methane development in recent years. To ensure continued progress in encouraging coalbed methane development, however, we recommend additional activities that will promote its recovery and utilization.

- Certain technical issues must still be addressed. In particular, there is a need for expanded gas storage to mitigate fluctuations in supply and demand. It will also be necessary to improve methane drainage systems to maintain drained gas at consistently high quality.

- More favorable tax conditions could help spur coalbed methane utilization. Tax incentives could be provided on a temporary basis, and then be withdrawn once coalbed methane becomes competitive with conventional natural gas.

- Once the best types of incentives for increased coalbed methane development have been identified, national policies and plans to encourage investment need to be coordinated among government ministries, and with regional and local authorities.

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ABBREVIATIONS AND ACRONYMS

Weights and Measures: All units are metric system (S.I.)

cm	centimeter $=10^{-2}$ meter
gW	gigawatts = billion Watts = 10^9 Watts
EJ	exajoule = 10^{18} Joules
kg	kilogram $=10^3$ grams
kJ	kilojoules $=10^3$ Joules
km	kilometer $=10^3$ meters
km^2	square kilometer
kt	kilotons $=10^3$ tons
kW	kilowatt = 10^3 Watts
kWh	kilowatt hours = 10^3 Watt hours
m	meter
m^3	cubic meter
MJ	megajoules = 10^6 Joules
mm	millimeter = 10^{-3} meter
Mt	megatons = 10^6 tons
MW	megawatts $=10^6$ Watts
MWh	megawatt hours $=10^6$ Watt hours
MW_{el}	megawatts of electricity
MW_{th}	megawatts of thermal energy
t	ton = metric ton = 10^3 kg

Acronyms

CHP	combined heat and power
CIAB	Coal Industry Advisory Board
EEE	Eastern European Energy (Financial Times)
EEER	Eastern European Energy Report
EIA	Energy Information Administration
EIU	Economist Intelligence Unit
ESMAP	Joint UNDP/World Bank Energy Sector Management Assistance Programme
FBIS	Foreign Broadcast Information Service
GDP	gross domestic product
GOZG	Upper Silesian Gas Utility = Upper Silesian Regional Gas Works
IC	internal combustion
LCB	Lublin Coal Basin
LPG	liquefied petroleum gas
LSCB	Lower Silesian Coal Basin
MEPNRF	Ministry of Environmental Protection, Natural Resources, and Forestry
OECD	Organisation for Economic Co-operation and Development
PGI	Polish Geologic Institute = Panstwowy Instytut Geologiczny = PIG
POGC	Polish Oil and Gas Company=Polskie Gornictwo Naftowe I Gazownictwo=PGNG
RO	reverse osmosis
ROM	run-of-mine
STIG	steam injected turbine generator
TDS	total dissolved solids
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commisssion for Europe
USCB	Upper Silesian Coal Basin
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency

PART I

THE POTENTIAL FOR COALBED METHANE DEVELOPMENT IN POLAND

CHAPTER 1

COALBED METHANE IN POLAND'S ENERGY ECONOMY

1.1 INTRODUCTION

Poland is the sixth largest producer of bituminous coal, supplying 4 percent of the world's total (USDOE/EIA, 1994) and accounting for an estimated 4 percent of world coal mine methane emissions (USEPA, 1993). The release of methane from coal mines is undesirable because it wastes a valuable energy resource, and contributes to global warming.

Inefficient use of energy, declining resources of hard coal, and increasing dependency on imported oil and natural gas have created a critical need for new indigenous energy sources in Poland. Faced with severe environmental problems resulting from coal mining and burning, Poland is beginning to use more natural gas and less coal and coke oven gas. This will benefit the environment tremendously, but will require significant expenditures for natural gas imports. Utilization of Poland's coalbed methane resources could help offset this expense.

Poland is confronting other serious economic challenges. Forty years of central planning heavily distorted the country’s economic structure: loans from the west financed the push to heavily develop industry. The Economist Intelligence Unit (EIU, 1993) estimated that Poland’s international debt was $US 44.6 billion at the end of 1993. The country appears to slowly be recovering from the deep recession into which it fell in 1990 when its radical stabilization plan was introduced, however. Preliminary figures suggest that there was a modest growth in GDP of 2.5 percent in 1993.

Despite the early signs of success in economic reforms, inflation continues, unemployment is high, and industrial output is declining. The insecurity of national energy supplies is widely recognized as a central cause of these problems (Land, 1993a). A national energy strategy that would diversify energy sources and facilitate economic growth, while addressing environmental concerns, is thus an urgent concern in Poland. It appears that coalbed methane should be an integral part of this strategy.

1.2 THE ENERGY SECTOR IN POLAND

1.2.1 THE ENERGY ECONOMY

The energy sector in Poland yields 10 percent of national income, employs 5 percent of the population, and accounts for 12 percent of total investment (Land, 1993b). During most of the post-war period Poland was a net exporter of energy, but subsidies and an inadequate pricing system created high domestic energy expenditures relative to output, pushing up costs at home and limiting the availability of coal for export. Consequently, despite being one of the world's top coal producers, Poland is no longer a net energy exporter. In 1993, the value of the nation's energy exports (mainly hard coal and coke) was $US 2.5 billion, while value of its energy imports (mainly electricity, oil and natural gas) was $US 3.4 billion (UNECE, 1994a).

Poland is faced with energy shortages that affect most aspects of its economy. Inefficient production, wasteful use of power, and serious environmental damages have led to growing pressure for reform of the energy sector, and Poland's industry planners are thus rethinking the way it must produce and consume energy. A 1993 study by the World Bank concluded that the country must now launch new and sweeping economic reforms affecting the gas, hard coal, lignite, heating and electricity industries. Energy price reforms are already underway; as a result, energy prices are climbing faster than inflation. While price increases mean the energy industry is more profitable, they barely cover the rising cost of energy production, while placing a heavy burden on Polish households (EEER, 1994a).

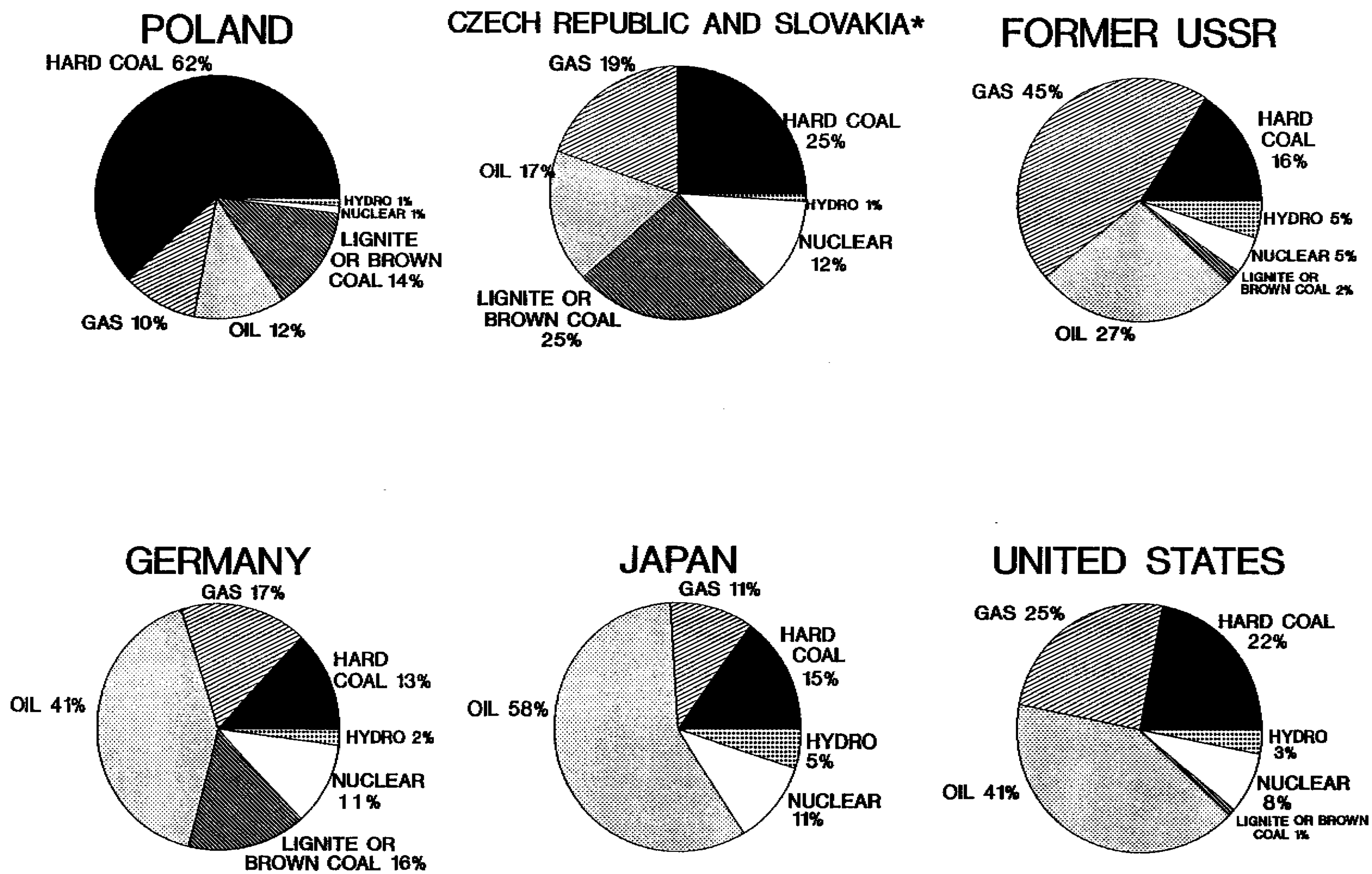
1.2.2 ENERGY CONSUMPTION OVERVIEW

Coal dominates the nation's fuel mix, comprising 76 percent of the energy consumed in Poland in 1992 (Figure I) (USDOE/EIA, 1994). Lignite (brown coal) accounts for approximately 18 percent of all coal consumed; the remainder is hard coal. Though all Eastern European countries rely heavily on coal, Poland is the most dependent nation in the region, and is far more dependent on coal than industrialized nations such as Germany, the United States or Japan. In the United States, for example, coal accounted for only 23 percent of all the energy consumed in 1992. The higher proportion of coal usage in comparison to that of other fuel types means that coal prices heavily influence energy prices in Poland.

In recent years, hard coal production has decreased in Poland, for reasons that are discussed in Section 1.2.4; this has caused a decline in both hard coal exports and domestic coal consumption. For economic reasons, exports are a high priority and must continue, creating a shortage of hard coal available for domestic use. This gap has been filled in part by increasing the domestic consumption of low-energy, high sulfur lignite, especially for generation of electricity; lignite consumption in turn contributes heavily to Poland's severe air pollution. Recent trends indicate that consumption of natural gas and oil are also increasing in response to declining coal production (further details on fuel production, consumption, and trade are presented in Section 1.2.4).

Improvements in energy efficiency will help relieve the growing shortages. Poland is second only to the former Soviet Union in energy intensity, and in 1989 the average Pole consumed almost twice as much energy as the average West European (Land, 1993b). Because the government subsidized energy for so long, prices for heating and electricity still fall well below the cost of production. But conservation alone is insufficient to meet Poland's energy needs. The country is therefore is embarking on radical reform of its energy sector, through privatization and reorganization programs supported in part by the World Bank. The essence of the framework proposed by the World Bank is that domestic energy supplies must be more efficient, reliable, and financially viable, and that Poland must move away from its heavy dependence on coal toward more use of oil and gas.

FIGURE I-1. FUEL MIX OF SELECTED COUNTRIES, 1992



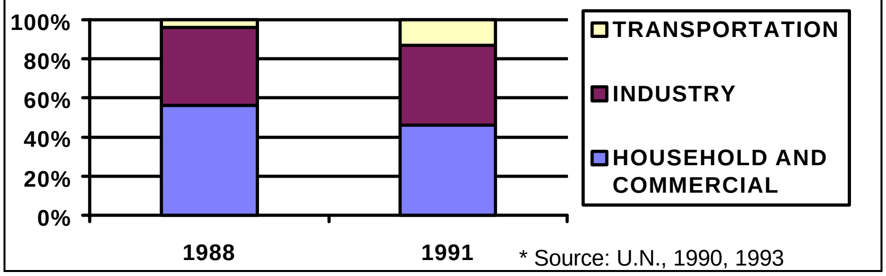
*Czechoslovakia did not divide until January 1993

Source: U.S. DOE EIA, 1994; UNECE, 1992

1.2.3 SECTORAL ENERGY DEMAND

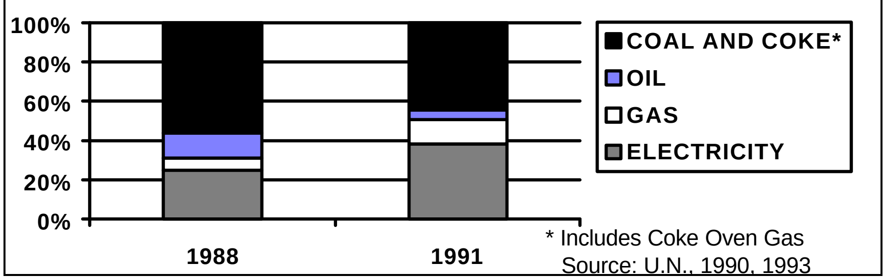
According to the United Nations (1993), Poland's final energy demand in 1991 was 2.56 exajoules (EJ).[1] Energy consumption decreased by 24 percent from 1988 levels, due largely to the decline in industrial output resulting from economic reforms.

FIGURE 2. ENERGY DEMAND BY SECTOR, 1988 VS. 1991



Sectoral end use is divided into three categories which are commonly used in international energy statistics reporting: Industry (including manufacturing, mining and construction), Household And Commercial (which includes agriculture, forestry, and hunting), and Transportation (rail, road, water, and air). In 1991, the household and commercial (1.17 EJ) plus industrial (1.05 EJ) sectors accounted for 87 percent of the energy consumed in Poland (Figure 2). The third sector, transportation, accounted for the remaining 13 percent of energy consumed (0.34 EJ). Transportation's share has increased considerably since 1988, when it accounted for only 4 percent of energy demand; this can be attributed primarily to sharp increase in the number of cars in use. At the end of 1991, 6.1 million private cars were registered, an increase of 15 percent over 1990, and more than twice as many as in 1980 (EIU, 1993).

FIGURE 3. HOUSEHOLD AND COMMERCIAL SECTOR ENERGY SOURCES, 1988 VS. 1991



As shown in Figure 3, about 44 percent of the household and commercial sector's energy in 1991 was derived directly from coal and coke, down substantially from 56 percent in 1988. Indirect use of coal via electricity and steam[2] accounted for 39 percent of this sector's energy demand. In 1991, natural gas made up 12 percent of the sector's fuel mix, while oil accounted for 5 percent. Note the trend toward more use of natural gas and electricity, at the expense of direct use of coal and oil; this pattern is likely to continue in the future, particularly as it is anticipated that all households consuming coke oven gas (as did more than 300 thousand Silesian households in 1992) will be converted to high methane natural gas by the end of 1995 (Fronski et al, 1994).

[1] 1.054 EJ = 1 quadrillion (10^{15}) BTU

[2] 95 percent of Poland's electricity is produced from coal

Most of the energy used by the industrial sector is also derived directly or indirectly from coal, as shown in Figure 4. In 1991, half of industry energy was derived indirectly from coal in the form of electricity and steam, only slightly less than in 1988; direct use of coal and coke accounted for 36 percent of this sector's share in 1991, up from a 30 percent share in 1988. The proportion of natural gas consumed by industry in 1991 remained the same as in 1988, at 10 percent. Oil's share dropped from 8 percent in 1988 to 4 percent in 1991, presumably due to the sharp increase in the cost of imported oil which occurred in that year. Seven percent of the industry sector's energy needs in 1991 were met by derived gases (primarily coke oven gas). The availability of coke oven gas has declined sharply over the period 1988-1993, as a result of the ongoing closure of coking plants. In response to this, the Polish Oil and Gas Company has undertaken a program to switch its consumers from coke oven gas to natural gas (Tokarzewski and Bednarski, 1994). Coalbed methane could help meet this increased natural gas demand.

FIGURE 4. INDUSTRIAL SECTOR ENERGY SOURCES, 1988 VS. 1991

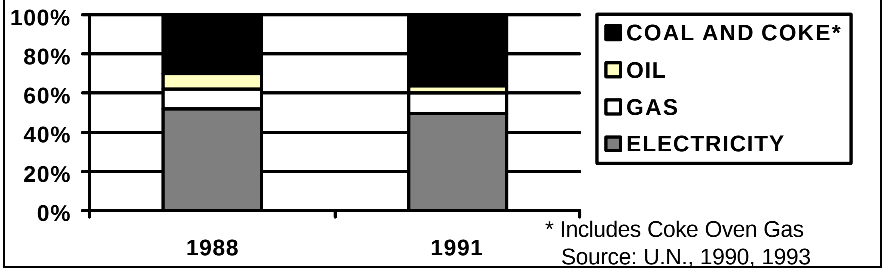
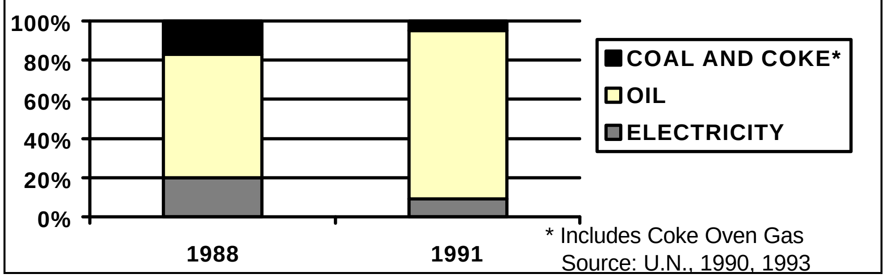


Figure 5 shows that in 1991 the transportation sector was fueled primarily by oil (86 percent), with 9 percent of its energy generated indirectly from coal and coke as electricity and steam, and 5 percent generated directly from coal and coke. Increased passenger-car ownership is responsible for the significant increase in oil's share of the transportation fuel mix over its 1988 value of 63 percent.

FIGURE 5. TRANSPORTATION SECTOR ENERGY SOURCES, 1988 VS. 1991



1.2.4 PRIMARY ENERGY SOURCES IN POLAND

Hard Coal: The Dominant Fuel

Hard coal is produced from three basins: The Upper Silesian Coal Basin (USCB), Lower Silesian Coal Basin (LSCB), and Lublin Coal Basin (LCB). The locations of these basins, as well as other energy producing regions, are shown in Figure 6. The USCB has the highest output, and its 65 mines produced 127 million tons[3] of hard coal in 1993. All coal shipped for export comes from the USCB.

Polish coal production reached a peak of 201 million tons in 1979, declined and then stabilized from 1983-1988, dropped sharply in 1989 (Table I) and has continued to decline. The most profound problem contributing to declining coal production is that although hard coal reserves are ample, increasingly difficult mining conditions have caused coal production costs to increase prohibitively. In recent years this has been compounded by the reduction of GDP, industry restructuring, and, to a more limited extent, the substitution of other fuels for coal.

[3] S.I. ("metric") units are used throughout this report and "tons" thus indicates metric tons.

FIGURE 6. LOCATION OF COAL BASINS, OIL FIELDS, AND GAS FIELDS, POLAND

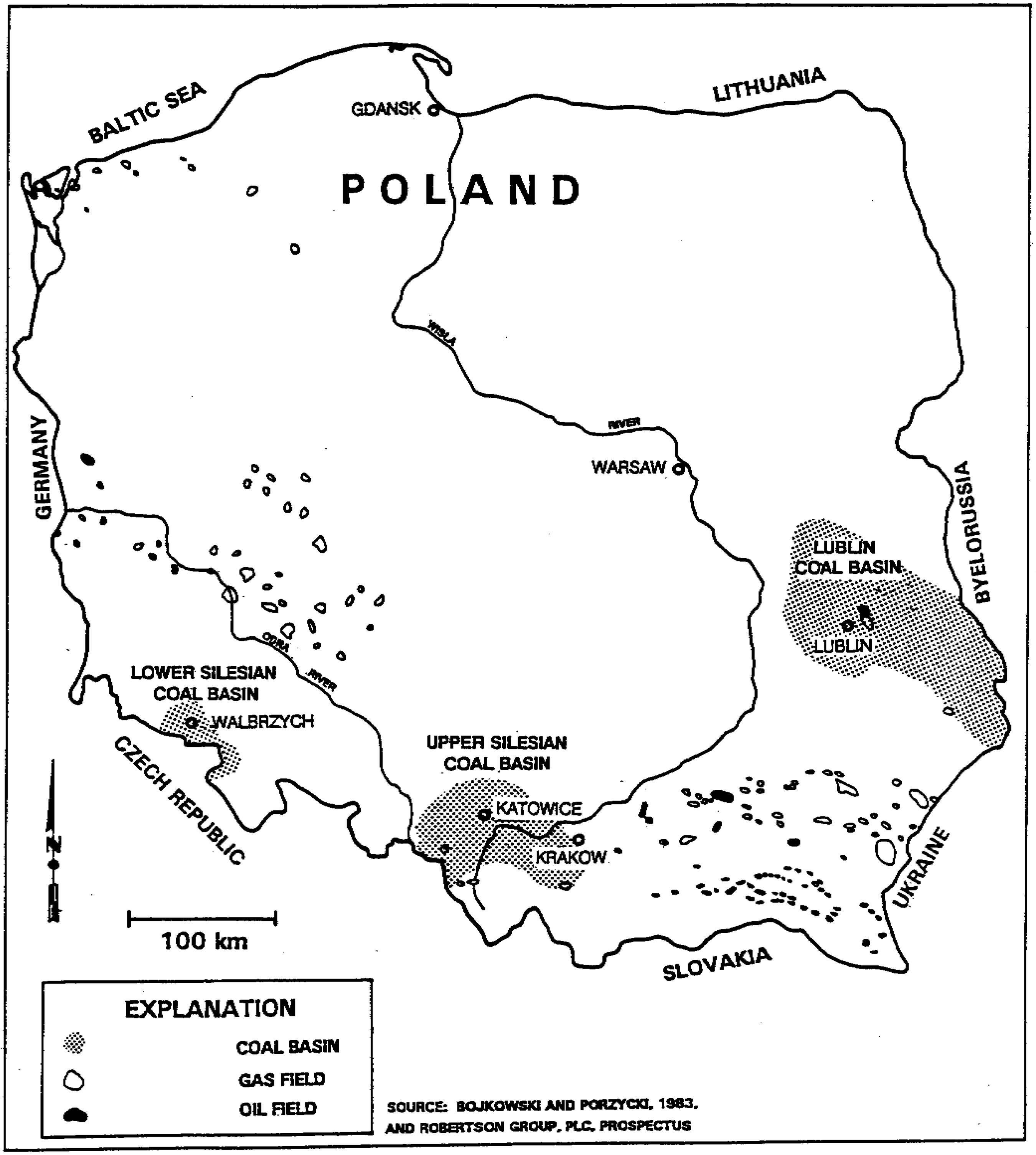


TABLE 1. HARD COAL PRODUCTION, APPARENT CONSUMPTION AND EXPORTS (MILLION TONS)

YEAR	PRODUCTION	APPARENT CONSUMPTION	EXPORTS
1985	191.6	156.5	36.2
1986	192.1	158.9	34.4
1987	193.0	163.2	31.0
1988	193.0	162.0	32.2
1989	177.6	149.7	28.9
1990	147.7	120.2	28.0
1991	140.4	121.0	19.5
1992	131.5	112.0	19.6
1993	130.6	104.6	26.1
SOURCE: PlanEcon, 1992, 1994;UNECE, 1994b			

Production is expected to remain at 1993 levels over the next few years (UNECE, 1994b). The coal produced in 1993 was characterized by higher quality, higher calorific value, and lower ash and sulfur content than previous years, as a result of more selective extraction.

Hard coal exports account for a significant portion of Poland's hard currency for use in foreign exchange, and Poland was the world’s fifth largest hard coal exporter in 1993. Exports declined sharply in 1991 and 1992; this was due to largely to a lack of export coordination. This reduction in coal sales resulted in continuous decrease of revenue and a rise in the unit cost of coal production in several mines (Piekorz, 1994). Coal exports rebounded in 1993, however, and preliminary data indicate that the 1994 export volume was equally strong. In 1993, about 85 percent of exports were handled by one company, which before 1990 held the coal export monopoly. Finland, Denmark, Germany, France, the Czech Republic, United Kingdom and Ukraine are among the top importers of Polish coal. In addition to exporting unprocessed coal, Poland exports coke. Poland also imports small amounts of hard coal.

Much of the hard coal production in Poland has been heavily subsidized; in 1992, only six of 70 mines were profitable, with total industry losses amounting to 11,000 billion zlotys (about $US 800 million) (Mining Annual Review, 1993). In 1993, the total sale price of coal did surpass production costs (by a mere 88 zlotys[4] per ton), but the industry was still in bad financial straits (EEER, 1994a). Accordingly, a restructuring program, announced in 1993, called for liquidation of a total of 17 coal mines, thirteen of which are in the USCB and the remaining four of which are in the LSCB. According to the proposal, the entire liquidation process would be completed by the end of 1995. Reduction in the workforce would continue at remaining mines, with an estimated 113,800 jobs eliminated between August 1993 and the end of 1995.

A new parliament was elected two months after this plan was proposed, and while it is likely that some components of the plan will eventually be enacted, it appears that this new government will have a more lax attitude toward mine closures (PlanEcon, 1994). Therefore, the above schedule for mine closures will probably be delayed. Other aspects of the government’s overall plans to restructure the coal mining industry have proceeded, however. Among these is the creation of joint stock companies that are responsible for the exploration and development of coal resources, and the subsequent sale of coal to the developing free market.

Mine closures alone will probably have minimal impact on exports and domestic consumption of hard coal in Poland, as the mines slated for closure account for less than 8 percent of the country’s hard coal production. The future of Poland’s fuel mix and hard coal export capabilities depends more upon the country’s ability to

[4] In 1993, the exchange rate was approximately Zl 20,161 to $1 USD; Zl 88 was thus about $0.004 USD.

meet its goal of increased natural gas use at the expense of coal. If efforts to improve energy efficiency, pricing policies, and environmental problems are successful, domestic coal demand will continue to decline, releasing more coal for export. In the event that these efforts are not successful, however, some forecasters predict that Poland's hard coal consumption could increase to as much as 135 million tons/year by 2000, and that it could become a net importer of hard coal by 2010 (ESMAP, 1993a).

Lignite or Brown Coal

Lignite, sometimes called brown coal, is a low-energy, high sulfur fuel used primarily for electric power generation. Lignite production doubled between 1980 and 1988, and though production began to decrease in 1989, it rose by 1.9 percent in 1993 (Table 2). Lignite is exported, and sometimes imported, in small quantities (Poland was actually a net importer of lignite in 1993).

TABLE 2. LIGNITE PRODUCTION AND APPARENT CONSUMPTION (MILLION TONS)

YEAR	PRODUCTION	APPARENT CONSUMPTION
1985	57.7	57.5
1986	67.3	67.3
1987	73.2	73.2
1988	73.5	73.5
1989	71.8	71.8
1990	67.6	67.4
1991	69.4	68.2
1992	66.9	65.9
1993	68.1	68.2
1994*	68.0	N/A
*1994 data are forecasts made by the UNECE in 1993		
SOURCE: PlanEcon, 1992, 1994; UNECE, 1994b		

Lignite yields only about half the energy per weight as hard coal, and its use in many of Poland's power stations contributes heavily to excessive emissions of sulfur dioxide and other pollutants. Because of these problems, Poland hopes to decrease its lignite consumption.

Oil

Poland has produced oil since the 1870's, but its known reserves are nearly depleted. Present-day oil production is essentially confined to two regions: the southeasternmost part of the country, and along the Baltic coast (Figure 6). The Polish Oil and Gas Company (POGC), whose oil division has been partially privatized, carries out most of the exploration and production activity.

Poland produced 152 thousand tons of crude oil in 1993, less than one percent of the crude oil it consumed (Table 3). Until the end of 1990, the Soviet Union provided most of Poland's oil imports. Presently, Russia supplies about 41 percent of Poland's oil, with the remainder imported from Iran and other Middle Eastern nations. Diversity of oil import sources is considered satisfactory at present (Czerwinski, 1994).

Substantial growth in oil imports is anticipated, partly in response to the increase in car ownership. Investment in expanding and upgrading the country's ten oil refineries, its pipelines, and oil storage capacity is underway. According to the EEER (1994b), the oil sector's annual investment outlay for this purpose is $US 318 million for the period 1994-1997. Oil giants Neste, Conoco, Exxon, Statoil, and Total are interested in buying into

Poland’s oil refining and transportation business (Land, 1993b). Eastern Europe’s largest refinery is at Plock (near Warsaw), with a capacity of nearly 10 million tons/year; two major new units are being installed at this refinery to help meet Polish demand for low sulfur and reformulated fuels (Oil and Gas Journal, 1994a). Another large refinery, with a capacity of about 3 million tons/year, is located in Gdansk. Plans for a new refinery, “Poludnie”, are also being developed. It is expected that the refinery, which will have a projected capacity of 6 million tons per year, will not be built until after 2000 (Czerwinski, 1994).

TABLE 3. CRUDE OIL PRODUCTION AND APPARENT CONSUMPTION IN POLAND (THOUSAND TONS)

YEAR	PRODUCTION	APPARENT CONSUMPTION
1985	196	13,908
1986	167	14,306
1987	149	14,318
1988	163	15,129
1989	159	15,144
1990	163	13,171
1991	158	11,805
1992	156	12,608
1993	152	13,402
SOURCE: PlanEcon, 1992, 1994		

Natural Gas

Natural gas is a relatively new fuel in Poland, with production beginning in the 1950's. The largest gas fields are located in the extreme southeastern part of Poland (Figure 6). Gas is also produced in the west-central part of the country (Gustavson, 1990).

A peak production rate of 7.9 billion cubic meters was attained in 1978; gas production declined sharply after 1985 (Table 4). In recent years, gas consumption has rebounded, and a continued expansion of demand is expected (Tokarzewski and Bednarski,1994; ESMAP 1993b). Table 5 summarizes gas consumption forecasts by the POGC, the World Bank, and the UN for the years 2000 and 2010.

At present, Poland imports about 55 percent of the gas it consumes. Domestic production in Poland has been declining because of depletion of fields and lack of investment. Poland’s gas reserves are limited; according to Tokarzewski and Bednarski (1994), documented (identified) reserves are estimated at 155 billion m^3. Investment in existing fields and production from new fields could raise total domestic production to as much as much as 5.4 billion m^3 annually by 2000. Even if this is possible, however, depletion would cause the level of production in 2010 to decline to 4.9 billion m^3 - the same as 1993 levels.

TABLE 4. NATURAL GAS PRODUCTION AND APPARENT CONSUMPTION (BILLION CUBIC METERS)

YEAR	PRODUCTION	APPARENT CONSUMPTION
1985	6.4	12.3
1986	5.8	13.0
1987	5.8	13.3
1988	5.7	13.2
1989	5.4	13.3
1990	3.9	11.7
1991	4.1	10.7
1992	4.0	10.3
1993	4.9	10.8
Source: PlanEcon, 1992, 1994		

TABLE 5. FORECAST NATURAL GAS CONSUMPTION (BILLION CUBIC METERS)

FORECASTER	YEAR 2000		YEAR 2010	
	Low	High	Low	High
Polish Oil and Gas Company	14.7	21.6	27.0	35.0
World Bank	Not Available	Not Available	38.3	43.4
United Nations	Not Available	23.0	30.0	35.0
Source: Tokarzewski and Bednarski, 1994; ESMAP, 1993b;UNECE 1994c				

The availability of gas imports will be crucial, but there is considerable uncertainty about how reliable supplies can be obtained (ESMAP, 1993b). Currently, all of Poland's imported natural gas comes from Russia via the Siberian Pipeline. The future of this gas supply is increasingly uncertain, as political unrest and a decaying oil and gas infrastructure in Russia contribute to its tendency toward unreliability as an exporter. In fact, Russia abruptly halted the flow of gas to Poland in January 1992 due to Yeltsin's unilateral suspension of a barter agreement with Poland, shutting down 180 of Poland's major steel mills and factories until a new agreement could be reached. Despite these problems, the POGC hopes to sign a long-term agreement with Russia to import 8 billion m^3 of gas through the Siberian pipeline.

Poland is seeking to diversify its sources of imported natural gas. In the medium term, the existing pipeline from Bremen, Germany to Berlin could be used to obtain access to North Sea and Russian gas. There are also several longer-term possibilities under consideration (Tokarzewski and Bednarski, 1994; Clifford Chance, 1994; Knott, 1993):

- A northern route, in which the POGC envisions the installation of a 1100-km pipeline that could carry British, Norwegian or Danish gas to the Polish port of Niechorze, via Denmark. It is anticipated that the project, known as POLPIPE, will begin in 1997.

An eastern link to the existing Northern Lights pipeline. The line, which currently brings gas from Russia's Barents Sea and Tyumen Province to Byelorussia, would be extended westward through Poland into Western Europe. A section is also to be added to the opposite end of the pipeline, extending it northeast to Russia's Yamal Peninsula. When complete, it would transport a projected 67 billion m^3 of gas annually from the Yamal Peninsula to Western Europe. Agreement on construction of the Polish section of the pipeline is to be signed early in 1995.

- A southern route to Algeria and/or Iran. Because of higher costs and longer investment periods, this option is least likely to materialize.

Natural gas prices in Poland must rise to levels that are sufficient to finance the costs of increased development, transmission and distribution. Gas price subsidies have been virtually eliminated, causing gas prices to rise sharply in recent years; in June, 1991 consumers paid 1000 zlotys/m^3 ($US 90/thousand m^3), and in June 1994 they paid 3,648 zlotys/m^3 ($US 166/thousand m^3).[5] Delivered prices are still below those in Western Europe, however, and additional price increases are planned.[6]

In order to meet the transportation sector's growing fuel needs, several liquefied petroleum gas (LPG) stations have begun operating in Poland, and gasoline-to-LPG retrofits in cars are increasing accordingly. There has been some discussion and research in Poland about use of compressed natural gas as a transport fuel, but thus far it is not being utilized on a commercial scale (Coalbed Methane Clearinghouse, 1994).

1.3 THE ROLE OF COALBED METHANE IN POLAND

A 1993 World Bank study concluded that Poland must launch new and sweeping reforms affecting the gas, hard coal, heating, electricity and lignite industries (ESMAP, 1993c). The study emphasized that "an efficient energy sector will be fundamental for sustaining the conditions for growth in the Polish economy." The World Bank concludes that domestic energy supplies must be more efficient, reliable, financially viable, and environmentally sound. This will require an energy sector that encourages competition, harnesses economic incentives, and emplaces effective regulations.

Based on the World Bank's restructuring proposal, the Government of Poland has approved an energy reform program, the details of which are being worked out. According to the working document Development Strategy for Poland's Energy Sector (Czerwinski, 1994) the main objectives of the reform program are commercialization of the energy sector and environmental protection. In order to achieve energy security, the document states, it is necessary to:

- establish a pricing policy for fuel and energy; this will require long-term energy price increases;
- diversify sources of fuel and energy, allowing for substitutions in response to changes in the economy; and
- improve energy efficiency.

To improve energy efficiency, the document maintains, Poland needs to operate coal mines, utilities and energy companies on a sound commercial basis, and also, reduce its heavy dependence on coal by using more oil and gas. This will include diversification of sources for imported gas and increased exploration and development of the country's domestic gas reserves.

1.3.1 POTENTIAL CONTRIBUTION OF COALBED METHANE

Coalbed methane can help Poland meet its goal of increasing the share of natural gas in the primary fuel mix. As discussed in Section 1.2.4, substantial increases in natural gas demand are expected, and Poland is attempting to diversify its sources of conventional natural gas. Increased development of coalbed methane is another option for diversification. Poland contains substantial resources of coalbed methane, at least 2.3 times as much as its conventional natural gas reserves (Chapter 2 contains a complete discussion methane resource estimates). These reserves can be broken in to two categories: those associated with active coal mines (the focus of this report), and those located outside the area of active mining.

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[5] 1 m^3 = 35.3 ft^3; therefore, $90/thousand m^3 = $2.55/mcf, and $166/thousand m^3 = $4.70/mcf

[6] According to Tokarzewski and Bednarski (1994), average delivered gas prices ($US/thousand m^3) are as follows: Industry- W. Europe = $150, Poland = $125; Household - W. Europe = $450, Poland = $170.

Presently, USCB mines liberate 754 million m^3 of methane annually, of which 213 million m^3 are recovered, yielding a recovery efficiency of 28 percent. The Coal Industry Advisory Board (CIAB, 1994) estimates that Poland's recovery efficiency could be increased to 45 percent, which would result in recovery of 340 million m^3 of methane annually. Using the integrated approach to methane drainage described in Chapter 3, it may be possible to increase recovery efficiency even further.

It is likely that much more methane can be produced with aggressive exploration and drilling programs in virgin coal areas. Late in 1994, Amoco Poland started a three-year, $US 10 million program which, if successful, could lead to a $US 150-200 million development program of several hundred wells (FT International Gas Report, 1994). Poland's deputy energy resources minister Wilczynski believes Amoco's exploration program will produce 5 billion m^3 of coalbed methane annually by 2000. When added to the amount of methane that can be recovered from coal mines, this brings Poland's potential coalbed methane production to 5.3 billion m^3 annually, more than one-third of the volume of gas that Poland will otherwise have to import in year 2000 (Tokarzewski and Bednarski, 1994).

1.3.2 BENEFITS OF COALBED METHANE

Environmental Benefits

Unutilized, coalbed methane is a potent greenhouse gas. Utilized, it is a remarkably clean fuel. The burning of methane emits virtually no sulfur or ash, and only about 32 percent of the nitrogen oxides, 35 percent of the carbon dioxide, and 43 percent of the volatile compounds emitted by coal burning (Oil and Gas Journal, 1991; USEPA, 1986). Many of the coking plants in Poland are being closed, and to help Poland meet its air quality goals, natural gas is being substituted for coke oven gas.

One of the most promising utilization options for coalbed methane is for power generation in large public plants (Surowka, 1993). About 378 thousand tons of sulfur dioxide and 77 thousand tons of particulates are emitted from public power plants in the USCB annually. Surowka calculated the amount of sulfur dioxide and particulate emissions that would be avoided if coalbed methane were burned in Silesia's power plants, according to three scenarios:

1. *Coalbed methane recovery remains at present level, but utilization is increased to from 74 percent to 100 percent.* In this scenario, emission of 2.6 thousand tons of SO_2 and 0.5 thousand tons of particulate matter would be avoided.

2. *Recovery of coalbed methane increases by 30 percent, and all of it is utilized.* In this scenario, emission of 13.1 thousand tons of SO_2 and 2.7 thousand tons of particulate matter would be avoided.

3. *Recovery of coalbed methane increases by 300 percent, and all of it is utilized.* In this scenario, emission of 40.3 thousand tons of SO_2 and 8.2 thousand tons of particulate matter would be avoided.

Scenario 1 could be acheived merely by increasing utilization; scenario 2 could be achieved by expanding drainage of methane from active coal mines, and increasing its utilization. Scenario 3 would require development of coalbed methane projects outside of coal mining operations (such as the Amoco project discussed in Section 1.3.1).

Economic Benefits

Poland's import bill for natural gas in 1993 was estimated at $US 560 million. By 2000, based on current gas prices and the POGC's forecast import level of 15.5 billion m^3, that bill will increase to $1,463 million by (unadjusted for inflation). Substituting 5.3 billion m^3 of coalbed methane for the imported natural gas would reduce this bill by $US 504 million, or 34 percent.

Coalbed methane use is cost-effective in other ways. Drainage and utilization of methane improves mine efficiency and profitability--less money is spent on installation and maintenance of large ventilation fans and other safety measures, and a waste product is converted to a useable and marketable energy source (Dixon, 1990). The reduced potential of injury or death to miners as a result of methane explosions is, of course, an immeasurable benefit of methane drainage.

Coalbed methane could also be substituted for hard coal in local power plants through cofiring or direct combustion with burner retrofitting in existing boilers, freeing more hard coal for export from the region or nation, and reducing regional imports of increasingly expensive electricity. An extensive pipeline system is already in place in Poland, and the network is such that delivering methane from mines to nearby power generation facilities, residential, and industrial users would be not be difficult.

1.3.3 POLICIES TO ENCOURAGE DEVELOPMENT OF COALBED METHANE

The Polish government recognizes the potential benefits of increased coalbed methane utilization and is taking an active role in encouraging development of this resource. Poland's Ministry of Environmental Protection, Natural Resources, and Forestry (MEPNRF) has divided the Upper Silesian Coal Basin (USCB) into 14 coalbed methane licensing blocks (Figure 7), all outside the boundaries of the mining concessions. In 1993, Blocks III-XI were awarded to Amoco Poland, Ltd., and Blocks XII and XIII to McCormick Energy Inc. Agreements have been reached with McCormick to develop coalbed methane within two mining concessions, and Amoco began drilling its first coalbed methane well in November, 1994. As discussed in Chapter 3, other companies are also planning methane projects.

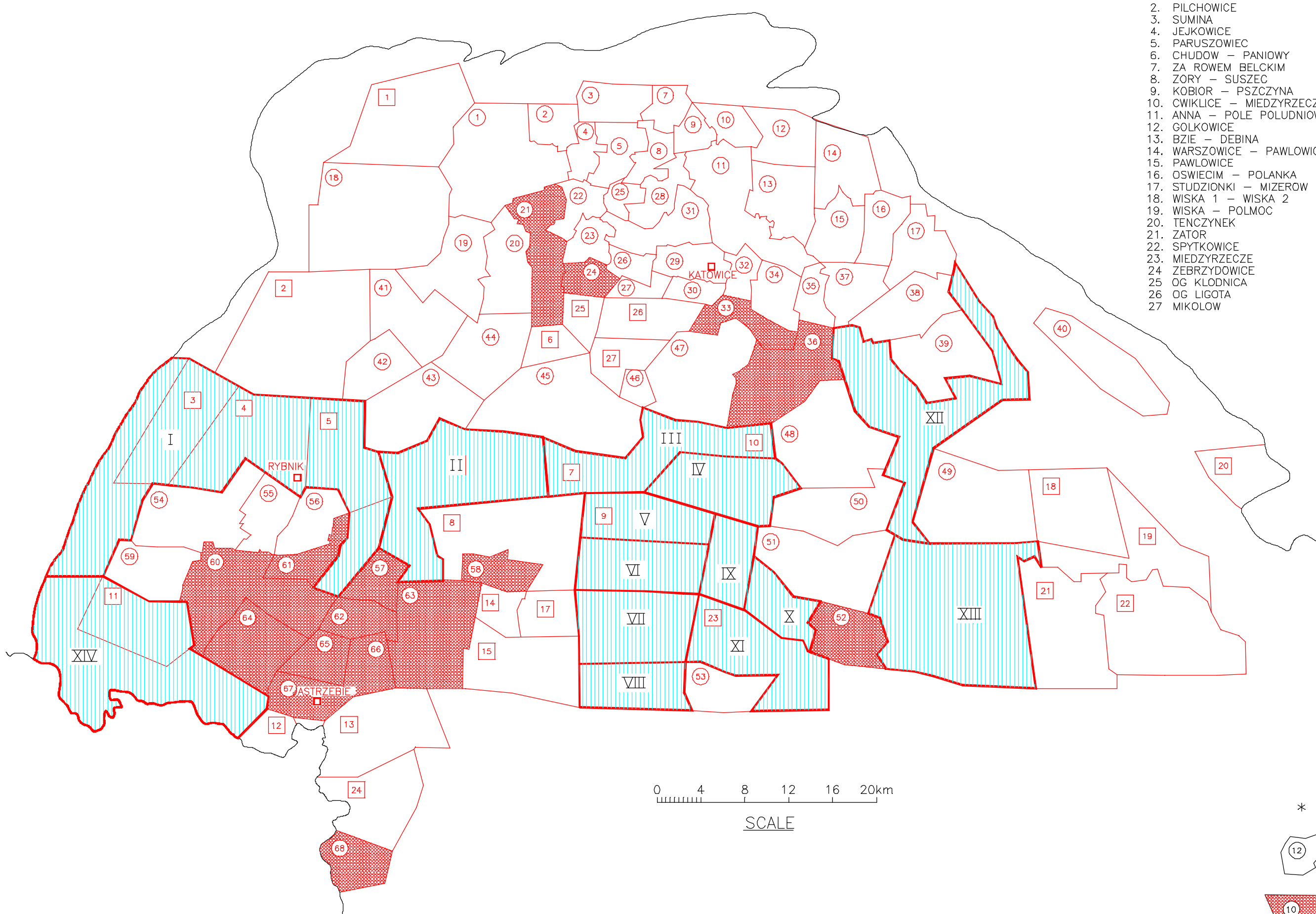
Two recent legislative developments in Poland are relevant to potential investors in coalbed methane projects as they replace outdated laws that served a centrally-planned system. Much of the following discussion on these acts is from a 1994 paper by Ronne.

The Geological and Mining Law of February 4, 1994

The Geological and Mining Law of February 4, 1994 regulates the ownership of, and the right to explore for and extract, natural resources. The draft Energy Law (approved by the government in November, 1994, and awaiting passage by the Sejm) sets out the principles for the regulation of supply and use of energy fuels. These two acts constitute an essential part of the implementation of the energy sector restructuring plan and attempt to provide a sound, clear legal system that will attract private investment - both Polish and foreign - into the industry.

According to the Geological and Mining Law, coalbed methane is one of the so-called "basic minerals", implying that its exploration and exploitation is subject to the most restrictive system of regulation. Among other things, this means that all coalbed methane development activities are subject to the grant of a license/concession by the Minister of Environmental Protection, Natural Resources, and Forestry. Obtaining the exclusive right to produce methane in a specified area is a three-step procedure:

FIGURE 7. LOCATION OF MINING CONCESSIONS AND COALBED METHANE LICENSING BLOCKS, UPPER SILESIAN COAL BASIN, POLAND



EXPLANATION

EXPLORATION FIELDS

1. PYSKOWICE
2. PILCHOWICE
3. SUMINA
4. JEJKOWICE
5. PARUSZOWIEC
6. CHUDOW – PANIOWY
7. ZA ROWEM BELCKIM
8. ZORY – SUSZEC
9. KOBIOR – PSZCZYNA
10. CWIKLICE – MIEDZYRZECZE – BIERUN
11. ANNA – POLE POLUDNIOWE
12. GOLKOWICE
13. BZIE – DEBINA
14. WARSZOWICE – PAWLOWICE – POLMOC
15. PAWLOWICE
16. OSWIECIM – POLANKA
17. STUDZIONKI – MIZEROW
18. WISKA 1 – WISKA 2
19. WISKA – POLMOC
20. TENCZYNEK
21. ZATOR
22. SPYTKOWICE
23. MIEDZYRZECZE
24 ZEBRZYDOWICE
25 OG KLODNICA
26 OG LIGOTA
27 MIKOLOW

COAL MINES

1. PSTROWSKI
2. MIECHOWICE
3. POWSTANCOW SLASKICH
4. BOBREK
5. CENTRUM – SZOMBIERKI
7. JULIAN
8. ROZBARK
9. ANDALUZJA
10. JOWISZ
*11. SIEMIANOWICE
12. GRODZIEC
*13. SATURN
*14. PARYZ
*15. SOSNOWIEC
16. KLIMONTOW – PORABKA
17. KAZIMIERZ – JULIUSZ
18. GLIWICE
19. SOSNICA
20. MAKOSZOWY
21. ZABRZE–BIELSZOWICE
22. WAWEL
23. POKOJ
24. HALEMBA
25. SLASK – MATYLDA
26. NOWY WIREK
27. SLASK
*28. BARBARA CHORZOW
29. KLEOFAS
30. WUJEK
31. POLSKA
32. KATOWICE
33. STASZIC
34. WIECZOREK
35. MYSLOWICE
36. WESOLA
37. NIWKA – MODRZEJOW
38. JAN KANTY (KOMUNA PARYSKA)
39. JAWORZNO
40. SIERSZA
41. KNUROW
42. SCZYGLOWICE
43. DEBIENSKO
44. BUDRYK
45. BOLESLAW SMIALY
46. BARBARA DOSWIADCZAINA
47. MURCKI
48. ZIEMOWIT
49. JANINA
50. PIAST
51. CZECZOTT
52. BRZESZCZE
53. SILESIA
54. RYDULTOWY
55. RYMER
56. CHWALOWICE
57. ZORY (ZMP)
58. KRUPINSKI
59. ANNA
60. MARCEL
61. JANKOWICE
62. BORYNIA
63. PNIOWEK
64. 1 MAJA
65. JASTRZEBIE
66. ZOFIOWKA (MANIFEST LIPCOWY)
67. MOSZCZENICA
68. MORCINEK

* IN PROCESS OF CLOSURE

OUTLINE OF MINING CONCESSION

MINING CONCESSION PROFILED IN PART II OF THIS STUDY

I–XIV COALBED METHANE LICENSING BLOCKS

CITY

SOURCE: BUREAU OF GEOLOGIC CONCESSIONS

1. An open tender for applications (the exploration company that discovered the deposit, however, has a preemptive right over other companies).
2. Entering into an agreement in which the license fee is settled.
3. Issuance of a license by the Minister of Environmental Protection, Natural Resources, and Forestry in agreement with the Ministry of Industry and Trade and local government.

The Draft Energy Law

The draft Energy Law mandates that energy enterprises maintain a continuous and reliable supply of energy. It obliges them to supply and connect customers, meet demand, and initiate actions for reducing consumption. The main principle is that energy supply activities require the prior grant of a license unless they are expressly exempted.

A crucial parameter for the utilization of coalbed methane is how pricing is regulated. The draft Energy Law introduces a new pricing concept, the main idea of which is that within energy markets where competition exists, the market should establish the price. Within some areas, however (typically the gridbased industries), there will always be monopolies, and these prices will need to be regulated in order to assure a balance between the interests of the consumers and the companies. Pursuant to the law, the regulated company will be free to establish its own pricing and tariff structure, but it will be subject to the direction and approval of the Energy Regulatory Authority. The law assures a regulated company with sufficient revenues to reflect the cost of operations and raw materials and a return on investment.

A related ordinance that is especially encouraging was passed by the Minister of Finance on July 6, 1994 and has been in force since August, 1994. The ordinance grants an unusually generous 10-year corporate tax exemption to entities engaged in oil, gas, and methane prospecting and exploration; usually, only three-year exemptions are granted for such activities (Clifford Chance, 1994a).

1.3.4 FOREIGN INVESTMENT IN POLAND

For the benefit of US companies considering investment in coalbed methane in Poland, this section contains an overview of policies and procedures pertaining to investment in that country. For further information, see Price Waterhouse (1994); KPMG Poland (1993); and Ernst and Young (1993). Appendix A of this report contains a list of government and mining contacts, their functions, and addresses.

The Polish government strongly encourages foreign investors. Most of the legislative reforms that have been passed into law during the last two years have made the business atmosphere attractive for foreign investment, and the resultant inflow of capital and business expertise is expediting Poland's transition toward a free market economy. The Joint Ventures Acts, Foreign Exchange Act, Personal Income Tax Act, and a series of banking reforms have been the main legislative changes.

The Foreign Investment Law of 1991 provides a tax exemption to a company whose business activities lead to the transfer of new technology to the national economy. Since coalbed methane recovery projects involving foreign investment may likely be recognized as legitimate technology transfer projects, they may be eligible for this tax exemption.

The formation and operation of private companies in Poland is governed by the Commercial Code of 1934 and the Joint Ventures Act of June 14, 1991. These two laws lay out the conditions under which foreign parties may conduct business activity in Poland. The Minister of Ownership Changes, the central administrative authority on foreign investments, is responsible for all decisions concerning the formation of companies and the issue of permits.

Companies formed under Polish law, even if 100 percent owned by foreign investors, are Polish legal persons to which Polish law applies. The rules and regulations involving the formation of a business entity in Poland are stringent and must be strictly followed in order to avoid any delays or bureaucratic entanglements. There are no shortcuts, and the time involved in the application process should be seen as a prerequisite to doing business in Poland. The different kinds of business entities in which foreigners may participate are:

JOINT VENTURE COMPANY - In Polish terminology, a joint venture is not a separate legal business form in itself. Instead, the term is used to signify a company with foreign participation, which may be wholly owned by foreign investors. A joint venture must be organized either as a limited liability company or a joint stock company that operates in Poland. In principle, all types of entities are open to foreign investment. There are two types of joint venture companies - joint stock, and limited liability.

> **Joint stock company** - This is similar to the German AG, but differs by the fact that capital is composed of transferable shares. The majority of joint stock companies in Poland are medium-to-large size firms with a large number of participants, but many state-owned companies, insurance companies and banks have this form.
>
> **Limited liability company** - This very similar to the German GmbH. Limited liability companies in Poland are typically small- to medium-size businesses with a small number of participants, and may be wholly owned by one person. They are also the most common form of business enterprise that foreign firms establish, as the rules governing this type of company are more flexible than those governing the establishment of a joint stock company. In particular the disclosure requirements are minimal.

REPRESENTATIVE OFFICE - A representative office of a foreign person is permitted to operate in Poland, but may only engage in foreign trade. It is a foreign legal entity under Polish law.

CHAPTER 2

COALBED METHANE RESOURCES OF POLAND

2.1 INTRODUCTION

Coalbed methane has long been viewed as a mine safety hazard, requiring that it be diluted to safe non-explosive levels, and often it is simply vented. In many mines, ventilation alone is not sufficient to maintain safe mining conditions and additional degasification techniques--including in-seam drilling and drainage in advance of mining--have been developed. Many of Poland's coal mines have dangerously high methane concentrations, and the Poles have long relied on degasification techniques to produce coal safely.

In order to evaluate the potential to develop coalbed methane in Poland, it is necessary to estimate the magnitude of the resource. The estimates in this study are based on an evaluation of coal resources, including methane content and other characteristics of the coal that can affect the production of coalbed methane. This chapter provides an assessment of coal resources in Poland, and estimates its coalbed methane resources.

2.2 COAL RESOURCES

As outlined in Chapter 1, coal is mined in three basins in Poland, the locations of which are shown in Figure 6 (page 6). Table 6 summarizes the characteristics of the basins. As the table indicates, the Upper Silesian Coal Basin (USCB) is the largest coal basin in Poland in terms of its coal resources, and most of the coal mining activity is concentrated in this basin; therefore, this report focuses on the USCB and provides only basic information on the other two coal basins.

TABLE 6. SUMMARY OF COAL BASIN CHARACTERISTICS, POLAND (1993)

	COAL BASIN		
Characteristic	Upper Silesian	Lower Silesian	Lublin
Basin Area (square km)	5,800	550	21,000
Documented Coal Resources (10^9 Tons)	56.9	0.2	7.6
Active Mining Concessions	65*	4	1
Concessions in Process of Closure	6	4	0
Hard Coal Production (10^6 Tons) in 1993	127.2	1.2	2.2
Methane Liberated (10^6 m^3) in 1993	753.5	21.1	0
Methane Utilized (10^6 m^3) in 1993	167.7	0	0

* As of 1993 there were 67 total concessions in the USCB; 1 of these (Budryk) was under construction and another (Barbara Doswiadzcaina) was used solely for experimental purposes

2.2.1 THE UPPER SILESIAN COAL BASIN (USCB)

Introduction

Poland owes its long-standing position as one of the top five coal producing countries in the world to the reserves of the Upper Silesian Coal Basin. Coal mining began in the USCB in 1740; 48 mines were developed prior to 1900, and 37 were developed after 1900. As of 1993, there were 65 active mines in the USCB. In addition, one mine (Budryk) was under construction, and another (Barbara) was designated for mining research. All of the underground mines use the longwall method of production.

Geologic Setting

The USCB is bordered on the west by the Moravo-Silesian Fold Zone, on the south by the Brunnia-Upper Silesia Massif, and on the east by the Krakow Fold Belt. The USCB extends southward from the Rybnik area into the Ostrava-Karvina coal mining district of the Czech Republic. However, USCB production and resource data in this report pertain only to the Polish portion of the basin.

Predominant tectonic characteristics (Figure 8) are south-southwest to north-northeast trending folds and thrusts in the west; faults superimposed on dome and basin structures in the center and east; and half horsts cutting the entire basin.

Generally dipping south-southeast, the coal bearing formations are divided into an upper part consisting of continental sediments deposited in limnic-fluvial environments, and a lower part comprised of siliciclastic, molasse sediments deposited in marine, deltaic, fluvial, and limnic environments. The general stratigraphy of the basin is depicted in Figure 9. Formations of Carboniferous age contain the 4,500 m thick productive series, which includes 234 coal seams, of which 200 are considered economic (Kotas and Stenzel, 1986). The total thickness of the coal seams is 339 meters (m). The upper part of the Namurian section includes the Zabrze and Ruda formations, totaling a coal bearing thickness of about 80 m. Also known as the Upper Sandstone Series, the Zabrze and Ruda formations comprise the principal economic section within the basin. They pinch out to the east.

On average, USCB coals contain 0.86-1.99 percent sulfur (average 1.3 percent) and 11.05-16.21 percent ash (average 13.7 percent). Heating value ranges from 28.7-32.1 MJ/kg. Coal rank ranges from subbituminous to anthracite; only subbituminous and bituminous coal is being mined at present. Mining depth ranges from 235 to 1,160 m.

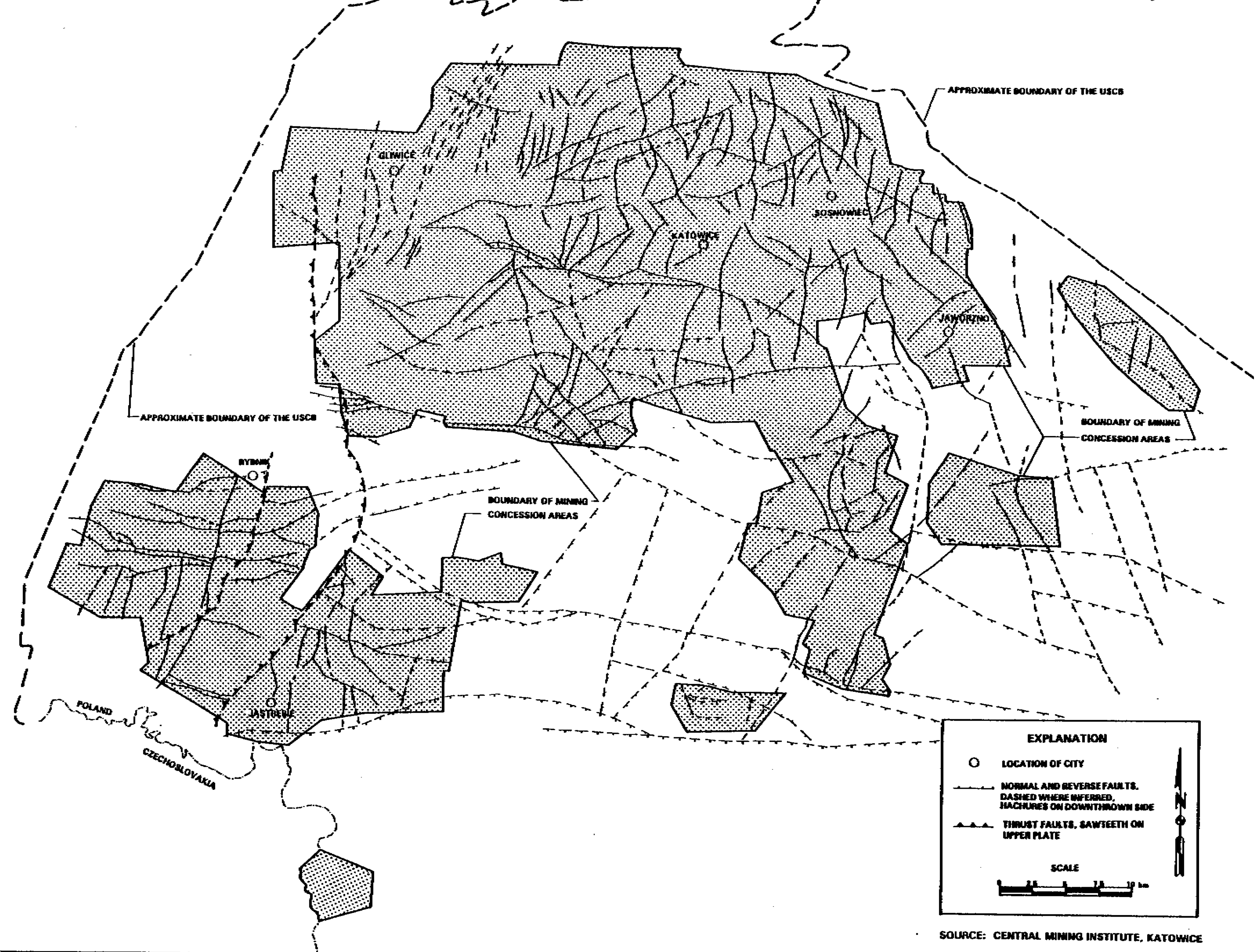
Coal Resources

Total coal resources in the USCB are estimated at 102 billion tons, contained in 100 deposits. Sixty-six of the deposits are classified as "developed" (i.e., with active mines or mines under construction); the remainder are "undeveloped" (i.e., have never been or are not currently being mined). Based on the data in Table 7, about 73 percent of the basin's coal resources are documented (identified), and nearly 28 percent are balance reserves[7] within active mining concessions. Table 8 shows coal resources and other key characteristics of each gassy mine in the USCB. The table also shows total coal production and reserves for all mines (both gassy and non-gassy).

---

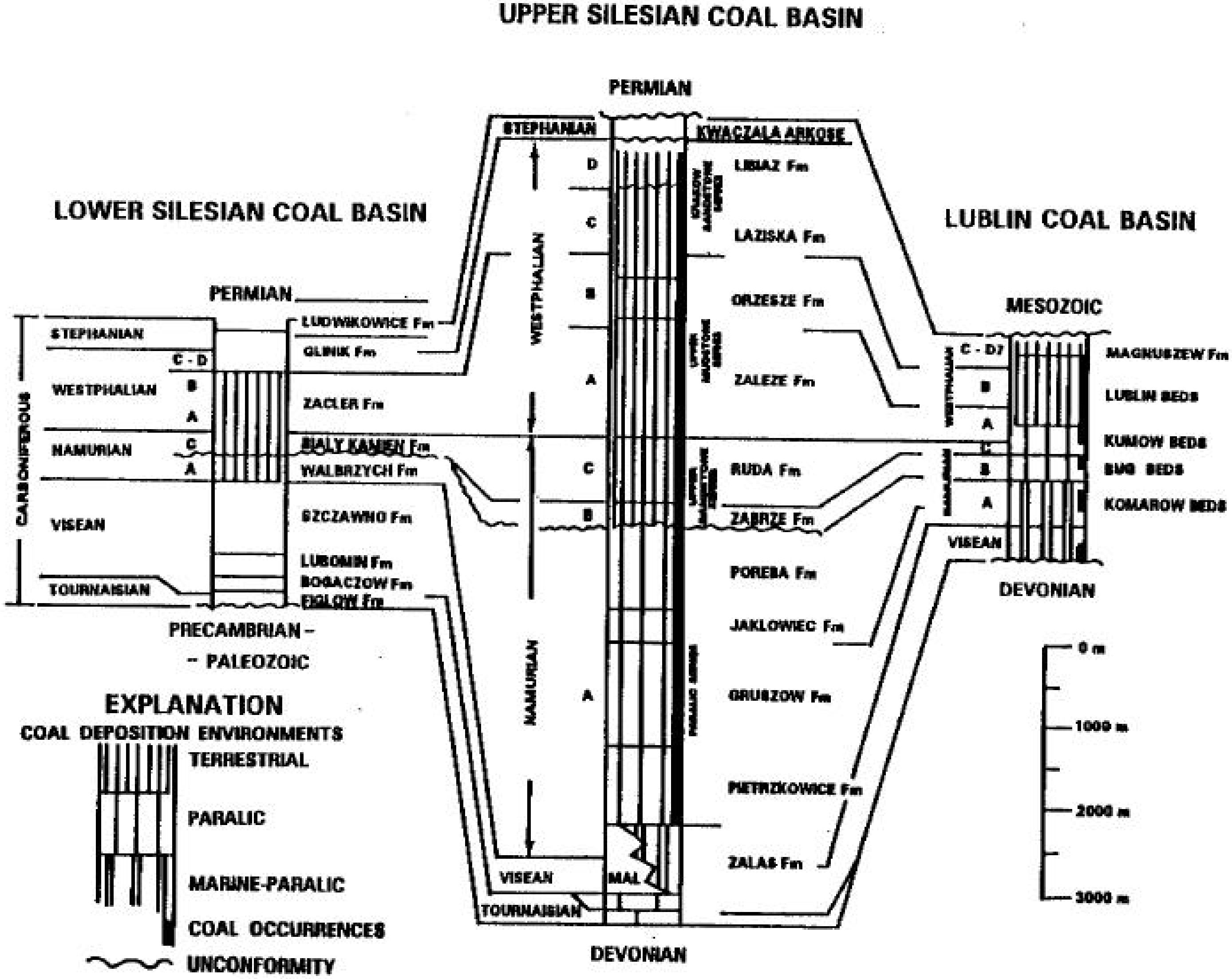
[7] "Balance" reserves are those meeting certain criteria for quality, geologic conditions, and other characteristics. Criteria vary for separate coal mines or companies, but in general they are as follows: maximum depth = 1000 m, minimum thickness = 1 m, maximum ash content = 40 percent. See Appendix B for a more complete explanation of Poland's coal resource classification system.

FIGURE 8. TECTONIC MAP OF THE UPPER SILESIAN COAL BASIN, POLAND



SOURCE: CENTRAL MINING INSTITUTE, KATOWICE

FIGURE 9. STRATIGRAPHIC CORRELATION OF COAL BEARING FORMATIONS, POLAND



(AFTER KOTAS AND PORZYCKI)

TABLE 7. HARD COAL RESOURCES OF THE USCB (IN BILLION TONS)

DOCUMENTED (IDENTIFIED) RESOURCES; INCLUDES A, B, C_1, AND C_2 CATEGORIES	
IN DEVELOPED DEPOSITS (ACTIVE MINES)	
Balance Reserves (meet certain criteria for quality, geologic conditions, etc.)	28.8
Non-Balance Resources (do not meet certain criteria)	12.8
IN UNDEVELOPED DEPOSITS AND INACTIVE MINES	
Balance Reserves	28.1
Non-Balance Resources	5.0
PROGNOSTIC (UNDISCOVERED) RESOURCES; INCLUDES D_1 and D_2 CATEGORIES	27.0
TOTAL RESOURCES	101.7
Source: Documented resources - Polish MEPNRF, 1990; Coalbed Methane Clearinghouse, 1994 Prognostic Resources - Kotas and Porzycki, 1985	

Almost two-thirds of the documented coal resources of the USCB are subbituminous or high volatile C and B bituminous. Most of the remaining coal resources are classified as medium and low-volatile bituminous coal. For a more detailed description of the Polish coal classification system, see Appendix B.

Coal Production and Mine Restructuring

Upper Silesian Coal Basin mines produced 127.2 million tons in 1993 (Table 8), down from 143.2 million tons in 1989. This represents 97 percent of the total hard coal production in Poland, and thus Poland's overall decline in hard coal production (described in Chapter One) is mostly a function of the decline in USCB production. The largest mine, in terms of production, is Ziemowit; this non-gassy mine produced 6.3 million tons of coal in 1993. The average mine produces about 2 million tons annually.

The rapidly worsening financial situation of the hard coal mines has resulted in extensive restructuring of the coal mining sector in Poland, a process which began in earnest in 1993 and is expected to continue through 2000. The goal of the restructuring process is to foster competitive development of the coal industry by addressing the main issues affecting this subsector. These issues include: closure of uneconomical mines, organizational restructuring, financing of coal mining enterprises, ensuring an appropriate labor force, the transition to market-determined prices, environmental protection, and an improved regulatory/legal framework (ESMAP, 1993).

Organizational restructuring began in 1993, and currently, mines of the Upper Silesian Coal Basin are organized into six coal joint stock companies (consisting of 49 mines) and one coal holding company (consisting of 11 mines), as shown in Figure 10. A coal joint stock company groups several mines under one management (Coalbed Methane Clearinghouse, 1995). Major investments (approximately $US 13,000 or greater) in any of the mines in a company can only be made by coal company management (not by mine managers). The individual mines are not legal entities, and the mine managers' authority is limited to maintaining production and managing personnel.

The Katowice Coal Holding Company also groups several mines under common management, but differs from the joint stock companies in that its mines are legal entities (registered as companies) and managers have more decision-making authority. The level of investment that mine managers are authorized to make depends on prior agreement. The holding company thus differs from the joint stock company in that mines have more individual control over investment decisions. However, it is similar to the joint stock companies in that production, employment, selling and marketing policies are consistent within the company.

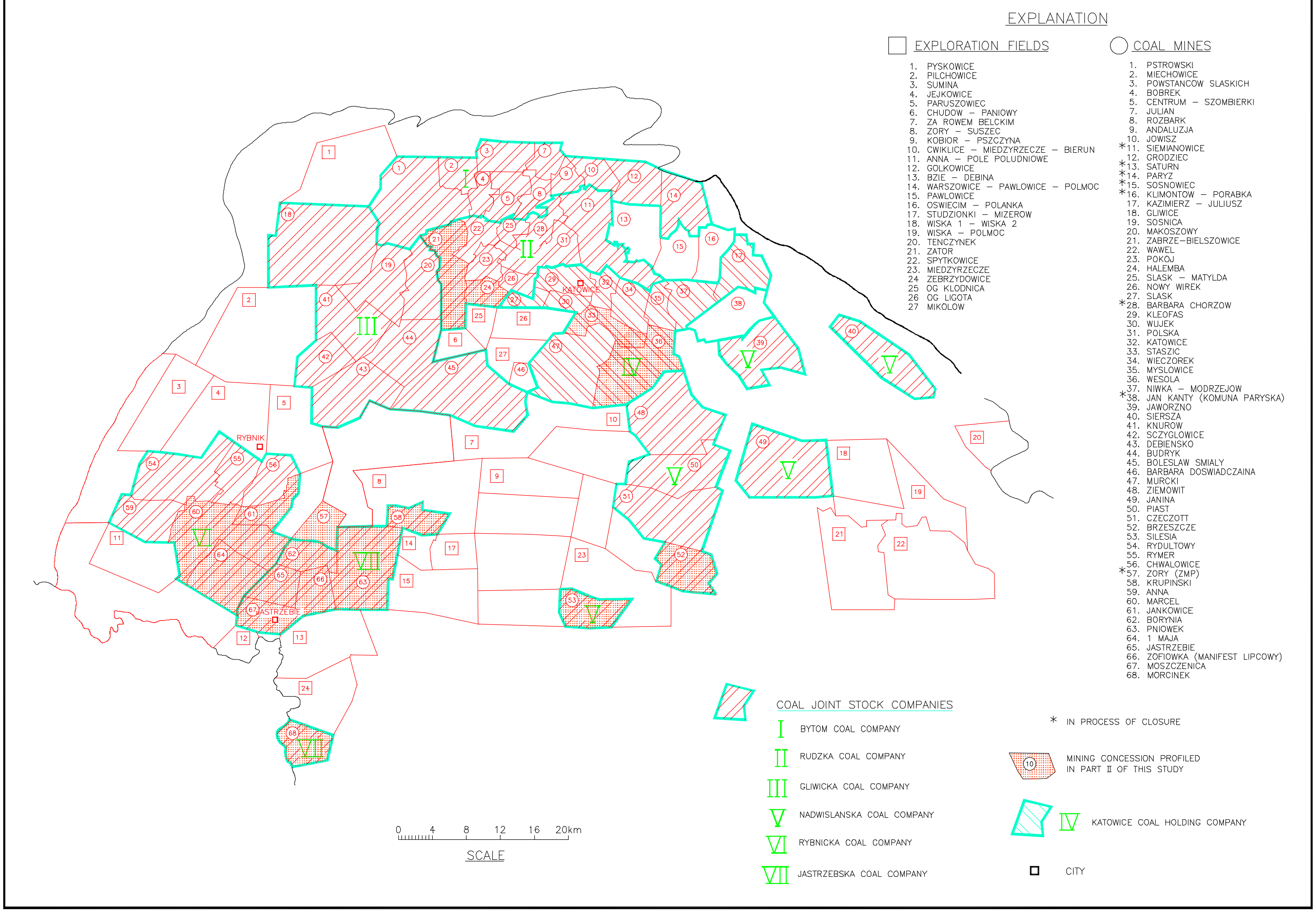
TABLE 8. KEY CHARACTERISTICS OF GASSY* UPPER SILESIAN BASIN COAL MINES

(*Throughout this report, mines termed “gassy” are those which liberated methane in 1993)

MINE	YEAR PRODUCTION STARTED	MAXIMUM MINING DEPTH (m)	1992 COAL PRODUCTION (10^6 TONS)	1993 COAL PRODUCTION (10^6 TONS)	1993 BALANCE COAL RESERVES (10^6 TONS)	1993 METHANE LIBERATED (Mm^3)
1 MAJA	1960	850	1.61	1.69	262.7	32.0
ANNA	1840	700	1.60	1.90	111.7	10.3
BOBREK	*	840	0.90	1.00	112.8	0.7
BORYNIA	1971	713	2.11	2.30	525.0	8.9
BRZESZCZE	1903	740	3.08	2.87	407.5	124.9
DEBIENSKO	*	780	1.50	1.50	983.8	0.3
HALEMBA	1957	1030	2.92	2.78	573.3	53.0
JANKOWICE	1916	565	3.69	3.69	924.9	8.7
JASTRZEBIE	1962	650	2.06	2.04	282.9	20.0
KATOWICE	*	630	1.40	1.40	148.4	2.6
KNUROW	*	850	3.40	2.90	711.9	0.9
KRUPINSKI	1983	620	1.74	1.63	648.3	48.7
MARCEL	1883	800	1.72	2.19	230.9	10.8
MORCINEK	1987	1050	0.96	0.96	390.7	25.6
MOSZCZENICA	1966	640	1.57	1.87	412.3	41.8
MYSLOWICE	*	680	1.90	1.90	121.1	8.9
NIWKA-MODRZ.	*	600	1.40	N/A	253.3	5.2
NOWY WIREK	1955	710	1.90	N/A	127.8	5.3
PNIOWEK	1974	830	2.94	3.02	1038.1	126.5
POKOJ	*	700	1.60	N/A	186.5	0.6
PSTROWSKI	*	1160	1.00	0.70	94.5	1.4
SILESIA	1902	500	1.19	1.13	727.2	41.1
SLASK	1974	N/A	1.20	N/A	261.7	4.1
SOSNICA	*	750	3.00	2.50	418.7	12.4
STASZIC	1964	720	4.30	3.70	637.0	18.9
SZCZYGLOWICE	1961	650	2.50	2.70	959.9	3.2
WAWEL	*	800	1.00	0.90	43.3	4.6
WESOLA	1952	860	3.30	3.77	1025.2	42.5
WIECZOREK	*	580	2.30	N/A	149.9	2.8
ZABRZE-BIELSZ.	1891	840	3.30	3.21	544.8	16.2
ZOFIOWKA	1969	830	2.10	2.30	546.4	59.6
ZORY (ZMP)	1979	700	0.85	0.50	289.8	11.0
TOTAL LISTED MINES (GASSY MINES)			66.04	> 67.30	14,152.3	753.5
OTHER (NON-GASSY) USCB MINES			46.56	N/A	14,647.7	0.0
TOTAL USCB MINES			**112.60**	**127.20**	**28,800.0**	**753.5**

Shaded rows indicate mines profiled in Part II of this report
* Production began prior to 1945; exact year not available
Source: Coalbed Methane Clearinghouse at the Polish Center for Energy Efficiency

FIGURE 10: BOUNDARIES OF COAL MINING CONCESSIONS AND THE SEVEN COAL MINING COMPANIES



As shown in Figure 10, six mines are independent of any coal company. Four of these mines (Saturn, Sosnowiec, Klimontow-Porabka, and Jan Kanty) are slated for closure; a fifth (Zory) was also scheduled for closure, but, according to the Coalbed Methane Clearinghouse (1994), this decision was recently canceled. The sixth (Barbara Doswiadczaina) is used for experimental purposes only.

According to Piekorz (1994) “closure operations” were conducted on the Saturn, Sosnowiec, Zory, Barbara-Chorzow, Siemianowice, and Paryz mines in 1993, and the Szombierki and Centrum mines were merged. A plan presented to the Ministry of Industry and Trade in 1993 calls for closure of the Klimontow-Porabka and Jan Kanty mines by 1995, and the liquidation of an additional five USCB mines by connecting them with neighboring mines: Jowisz will be connected to Andaluzja, Pstrowski and Bobrek to Miechowice, Wawel to Pokoj, and Rymer to Chwalowice (FBIS, 1993).

As of early 1995, however, none of these mines have been fully liquidated. The reasons for this are both social and technical. Socially, mine owners (i.e., the State) must determine how to handle displaced workers and their dependent families. Technically, careful planning is required to ensure that water and/or gas from closed mines does not affect nearby active mines. These problems can be overcome, but they raise the cost and complicate the nature of mine closure activities.

Methane Liberation

Both liberation and emission of methane from USCB mines appears to have peaked in the late 1980’s. Large amounts of methane are still being emitted, however, representing a significant waste of energy. An estimated 754 million cubic meters of methane were liberated from USCB mines in 1993 (Table 9), a 25 percent decrease from 1988 levels. This decrease is primarily a function of decreasing coal production. Less than 168 million m^3, or 22 percent of the liberated methane, were used; the remaining 78 percent was emitted to the atmosphere.[8]

Figure 11 is a contour map of specific emissions (volume of methane liberated per unit weight of coal mined, in m^3 / ton) in the USCB. In general, it appears that the mines with higher specific emissions are in areas that 1) have a thick sequence of Miocene strata unconformably overlying the Carboniferous and 2) are not disturbed by thrust faulting. It may be that the impermeable Miocene formations help to trap methane in the coal, except in areas where the gas is able to escape along a zone of thrust faulting.[9]

[8] Note the distinction between “liberation” and emission”: liberated methane is that released from the coal, whether or not it is utilized; emissions, in the strict sense, refer to liberated methane that has not been utilized and therefore enters the atmosphere.

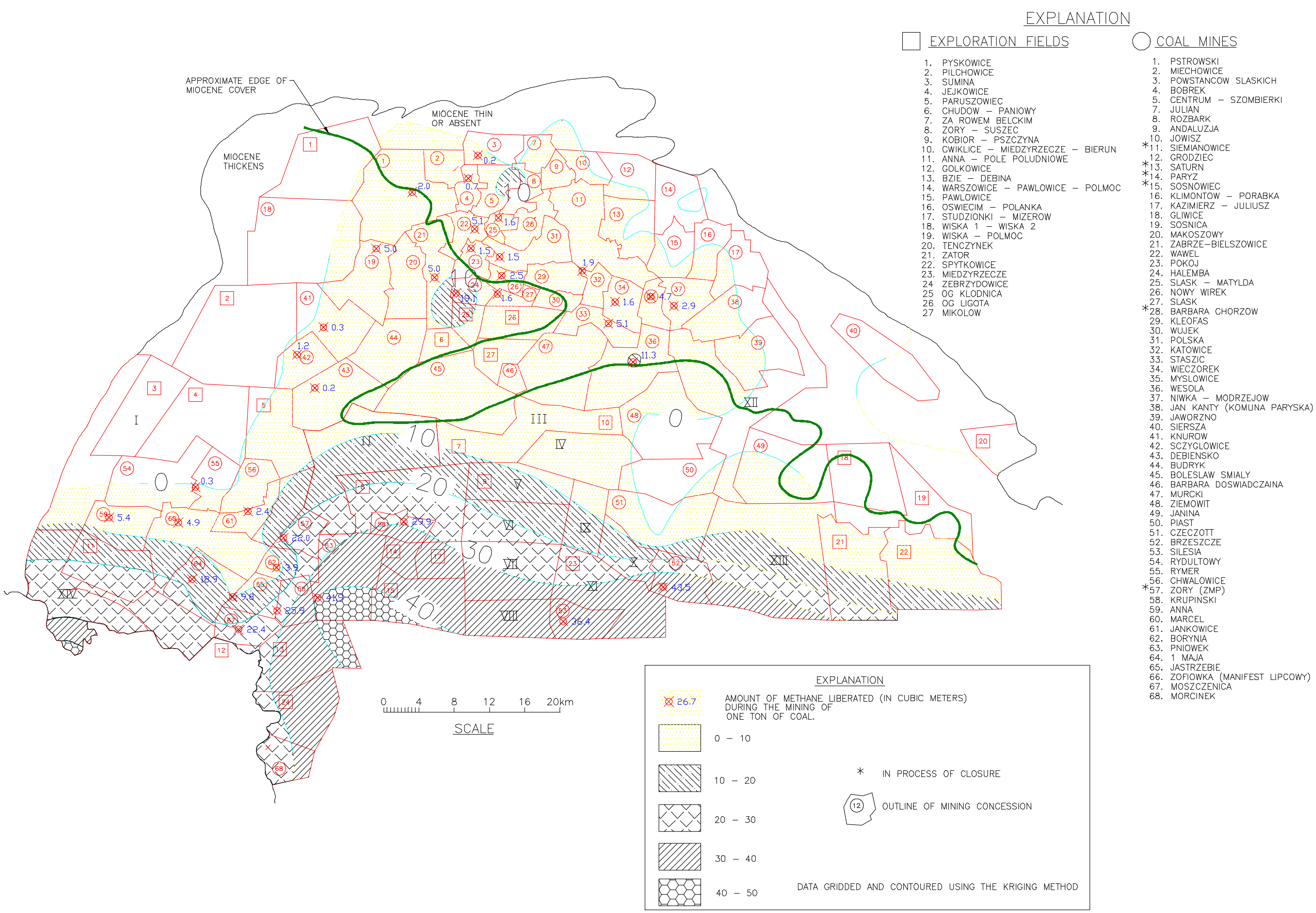
[9] The hydrogeology of the Upper Silesian Coal Basin is also affected by the presence or absence of this Miocene cover. In the northern and northeastern part of the basin, the Miocene cover is thin to absent, so Carboniferous aquifers are directly recharged by river valleys and channels. Water in these Carboniferous aquifers is thus high in volume, but relatively low in mineral content. In contrast, the southern and western parts of the basin are covered by the Miocene sequence, so inflow into Carboniferous aquifers of this region is much smaller, with the result that these aquifers contain less water. The mineral content of this water, however, is much higher, as it is not being diluted by recharge.

TABLE 9. USCB METHANE EMISSION DATA (IN MILLION m^3) FOR 1993 (MINES LISTED IN DESCENDING ORDER OF TOTAL AMOUNT LIBERATED)

MINE	METHANE LIBERATED			METHANE UTILIZED	METHANE EMITTED	% OF LIBERATED METHANE DRAINED	% OF DRAINED METHANE UTILIZED
	DRAINED	VENTED	TOTAL				
PNIOWEK	49.2	77.3	126.5	43.4	83.1	38.9	88.2
BRZESZCZE	44.5	80.4	124.9	44.1	80.8	35.6	99.1
ZOFIOWKA	19.8	39.8	59.6	15.2	44.4	33.2	77.8
HALEMBA	15.6	37.4	53.0	3.0	50.0	29.4	19.2
KRUPINSKI	15.8	32.9	48.7	6.7	42.0	32.4	42.4
WESOLA	5.7	36.8	42.5	2.6	39.9	13.4	45.6
MOSZCZENICA	10.2	31.6	41.8	9.8	32.0	24.4	96.1
SILESIA	7.7	33.4	41.1	7.6	33.5	18.7	98.7
1 MAJA	8.5	23.5	32.0	7.3	24.7	26.6	85.9
MORCINEK	16.9	8.7	25.6	14.4	11.2	66.0	85.2
JASTRZEBIE	3.5	16.5	20.0	3.1	16.9	17.5	88.5
STASZIC	2.1	16.8	18.9	2.0	16.9	11.1	95.2
ZABRZE-BIEL.	1.2	15.0	16.2	1.2	15.0	7.4	100.0
SOSNICA	0.0	12.4	12.4	0.0	12.4	0.0	NA
ZORY (ZMP)	2.0	9.0	11.0	1.4	9.6	18.2	70.0
MARCEL	4.9	5.9	10.8	4.2	6.6	45.3	85.7
ANNA	2.0	8.3	10.3	0.0	10.3	19.4	0.0
BORYNIA	0.9	8.0	8.9	0.0	8.9	10.1	0.0
MYSLOWICE	0.0	8.9	8.9	0.0	8.9	0.0	NA
JANKOWICE	2.3	6.4	8.7	1.7	7.0	26.4	73.9
NOWY WIREK	0.0	5.3	5.3	0.0	5.3	0.0	NA
NIWKA-MODRZ.	0.0	5.2	5.2	0.0	5.2	0.0	NA
WAWEL	0.0	4.6	4.6	0.0	4.6	0.0	NA
SLASK	0.0	4.1	4.1	0.0	4.1	0.0	NA
SZCZYGLOWICE	0.0	3.2	3.2	0.0	3.2	0.0	NA
WIECZOREK	0.0	2.8	2.8	0.0	2.8	0.0	NA
KATOWICE	0.0	2.6	2.6	0.0	2.6	0.0	NA
PSTROWSKI	0.0	1.4	1.4	0.0	1.4	0.0	NA
KNUROW	0.0	0.9	0.9	0.0	0.9	0.0	NA
BOBREK	0.0	0.7	0.7	0.0	0.7	0.0	NA
POKOJ	0.0	0.6	0.6	0.0	0.6	0.0	NA
DEBIENSKO	0.0	0.3	0.3	0.0	0.3	0.0	NA
TOTAL	**212.8**	**540.7**	**753.5**	**167.7**	**585.8**	**28.3**	**78.5**

Shaded rows indicate mines profiled in Part II of this report
Source: Coalbed Methane Clearinghouse at the Polish Foundation for Energy Efficiency

FIGURE 11. CONTOUR MAP OF METHANE LIBERATED DURING MINING, UPPER SILESIAN COAL BASIN, POLAND.



2.2.2 THE LOWER SILESIAN COAL BASIN (LSCB)

Introduction

Strategically positioned in western Poland, coal mining in the LSCB is documented back to the mid-1300's, and industrial scale mining back to about 1760. In the mid-19th century, the entire basin was divided into many small mines. Toward the end of the century, these small mines closed or merged into five large mines. These mine concessions occupy 108 km^2, about 25 percent of the basin. The LSCB is composed of four sub-basins or districts, the most significant being the Walbrzych (central portion of the LSCB) and Nowa Ruda (southeastern portion of the LSCB) districts.

Coal bearing formations of the LSCB were deposited in the Intra-Sudetic Synclinorium. The basin extends westward and southward into Czechoslovakia, where coal is produced in the Trutnov district. However, production and reserves data presented in this report pertain only to the Polish part of the basin.

Formations of Carboniferous age contain the 1,600 m thick productive series, which includes 34 economic coal seams. These seams vary in thickness from 0.6 to 3 m. Coal rank ranges from subbituminous to anthracite; only bituminous and anthracite coal is being mined at present. On average, LSCB coals contain 0.1-0.9 percent sulfur, 7.1-8.5 percent ash, 9.5-10.4 percent moisture, and 17-29 percent volatile matter. Heating value averages from 27.2 to 31.7 MJ/kg (Dziedzica et al, 1979).

Coal Resources and Production

Official Polish estimates of balance coal resources in the LSCB are 194 million tons. Overall, coal in the LSCB is higher in rank than USCB coal. More than two-thirds of the basin's documented resources are high-volatile A bituminous, and almost 30 percent are medium- and low- volatile bituminous and anthracite coal. Less than 3 percent of the basin's resources are sub-bituminous or high-volatile C bituminous.

The LSCB produces less than 1 percent of Poland's hard coal from its five mines, three of which are in the Walbrzych District and two of which are in the Nowa Ruda District.[10] In 1993 the LSCB produced 1.2 million tons of hard coal, less than half the coal it produced in 1989. Most of the region's coal is produced by mines of the Walbrzych District.

Most mining occurs between 800 and 900 meters. Coal production has fallen significantly in recent years due to the decrease in coal quality with increasing mining depth. Methane hazards, CO_2 emissions and rock outbursts increase with depth, which contributes to decreased production, as do geologic factors, particularly steeply dipping coal seams. The principal mining method in the LSCB is modified longwall; it is not economically feasible to use fully mechanized longwall techniques due to the steeply dipping beds. Approximately 2 tons of material are mined to produce 1 ton of coal. Because of the exceptionally high mining costs associated with these conditions, all of the LSCB mines are in the process of closure, according to Poland's mine restructuring program.

[10] Nowa Ruda is often referred to as a single mine with two producing coalfields, hence some sources state that the LSCB has four, rather than five, producing mines.

Methane Emissions

All of the LSCB mines have high methane concentrations, except for the Piast coalfield of the Nowa Ruda mine, which reports no methane but large amounts of CO_2[11]. Mines do not use advanced techniques to recover methane before or during mining, and there is no methane utilization in the basin. In 1993, methane emissions were 21.1 million cubic meters, accounting for 3 percent of the total methane emitted from Polish coal mines.

According to the UNECE (1994c), the POGC in 1993 initiated collaboration with VERBUNDNETZGAS, a German company, to supply high methane natural gas from German pipelines to Lower Silesia in quantitites gradually increasing up to about 1 billion m^3 annually. This will enable conversion of Lower Silesian coke oven gas users to high-methane natural gas, as the environmentally burdensome coke oven plants in Walbrzych are being phased out. The feasibility of using LSCB methane to displace some of this German gas may be worth investigating.

2.2.3 THE LUBLIN COAL BASIN (LCB)

Introduction

The LCB, shown in Figure 6, is located in eastern Poland and has not been extensively mined. Although seven mines were originally planned for the region, only one mine, the Bogdanka, has been completed. Construction began on the Bogdanka mine began in 1975 and coal production began in December of 1982 (Polish Hard Coal Agency, 1990). A second mine, the Stefanow, is nearly complete, and the other five mines remain in the planning stage.

The delay in further development is due in part to difficulties encountered in the Bogdanka mine, particularly the presence of an aquifer above the coal seams, incompetent roof rocks, and barren layers contained within the coal. It is also due to the fact that run-of-mine quality of the coal will need to be improved by a beneficiation process, for which investment capital is presently lacking.

The rank of LCB coal ranges from subbituminous to bituminous; most of the coal is subbituminous or high volatile C bituminous. Analysis of coal samples taken from the Bogdanka mine in 1987 yielded the following average characteristics: moisture content, 5.1 percent; ash content, 9.5 percent; volatile content, 31.5 percent; heating value, 29.1 MJ/kg. Mining depth is 955 m.

Carboniferous age formations contain the 2500 m thick productive series. Economic coal seams range from 0.8 to 2.7 meters thick. Of 16 coal beds present in the Bogdanka mine, 6 have been designated for mining.

Geologic Setting

The LCB is an elongated, NW-SE trending basin. Coal bearing formations occupy about 21,000 km^2 of the basin, the boundaries of which are not well defined. The LCB continues southeast into Ukraine, where it is known as the Lvov-Volynian Basin. However, production and reserves figures in this report pertain only to the Polish part of the basin.

About 9,000 km^2 of the basin is believed to be most prospective for coal; the overburden thickness in this area ranges from 300-1200 m. The coal formation known as the Lublin Bed (Westphalian A-C)

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[11] It is not uncommon for gases other than methane to be present in coal seams. Various coal basins throughout the world report the presence of carbon dioxide, nitrogen, or propane in their coal seams.

comprises an estimated 92 percent of the LCB coal reserves (A-C_2 classification) and constitutes the main coal bearing section of the basin. These beds reach a maximum thickness of 900 m in the central part of the basin; 24 of the 50 seams they contain are considered to be economic. The seams are from 0.8 to 1.6 m (rarely, up to 2.7 m) thick. Depth of occurrence varies from 650-950 m, locally up to 1100 m.

Coal Resources and Production

According to official Polish government estimates, balance coal resources of the LCB are 7.6 billion tons. Less than 4 percent of these resources are associated with the basin's only active mine, Bogdanka.

Coal in the LCB is of low to medium rank. More than 80 percent of the reserves are of subbituminous or high-volatile C bituminous rank, and the remaining reserves are high-volatile A bituminous coals. None of the coal is classified as medium or low volatile bituminous or anthracite.

Centrally located in the area of thickest coal bearing formations, the Bogdanka mine concession covers 48.4 $km^{2.}$ Production from this mine has increased from 0.4 million tons in 1987 to 2.2 million tons in 1993.

Located about 3 km south of the Bogdanka mine, and connected to it by a tunnel, the Stefanow mine (37.8 km^2 in area) has sunk two shafts, one to 990 m and one to 1020 m. It is estimated that an investment of $US 100 million will be required in order to construct the facilities necessary to achieve planned production.

Methane Emissions

Methane is not considered to be a hazard in the Bogdanka mine. Based on research and exploration conducted by Polish organizations, however, it appears likely that some methane is being emitted by the LCB coal mines. These organizations have reported that the gas content of nearly all Namurian coal seams exceeds 0.02 m^3 / ton clean coal, and that the gas content is highest in high-volatile bituminous A coal.

2.3 COALBED METHANE RESOURCE ESTIMATES

To fully evaluate the development potential of a coalbed methane project requires reliable estimates of coalbed methane resources. Accurate estimates of methane resources use methods based on detailed information on the coal reserves generated by a carefully designed coalbed methane exploration program. Because no large-scale coalbed methane exploration programs have been completed in Poland (even if they had, such data usually remain confidential for a long period of time), less accurate or rigorous methods help give a reasonable order of magnitude.

Different estimates show that the USCB has between 150 and 200 billion cubic meters of methane reserves associated with balance reserves of coal in its active mining concessions. Additionally, virgin coalbeds may hold at least another 200 billion cubic meters. These estimates were established through three different methods of calculating coalbed methane resources. A fourth, more conservative method, estimates balance methane reserves. It's important to understand the four methods, since the best method chosen to estimate methane reserves depends on the available data for each mine.

The specific emissions, methane content, Polish mining, and Polish Geological Institute (PGI) methods use different data and/or criteria to calculate methane reserves:

1. The *Specific Emissions Method* uses specific emissions from each mine, and balance reserves of coal.
2. The *Methane Content Method* uses maximum measured methane contents and balance reserves of coal.

3. The *Polish Mining Method* estimates the reserves that can be recovered using drainage technology that is present at the mine or at other mines which have similar mining conditions; these are called balance reserves.
4. The *Polish Geological Institute Method* uses average methane contents, coal quality, and total coal content (for coal seams whose thickness is greater than 0.3m), to determine the average amount of methane contained per unit area of the basin.

Table 10 shows the results of methods 1 through 3; since method 4 is not performed on a mine-by-mine basis, its results were not included in the table. As Table 10 readily demonstrates, the different methods lead to varying methane contents. A complete discussion of each method follows to identify their relative rigor and accuracy.

2.3.1 SPECIFIC EMISSIONS METHOD

This method estimates methane resources using the specific methane emissions factor associated with coal production at a particular mine. Specific emissions refers to the volume of methane liberated per unit weight of coal mined during a given time period (in this case, one year), commonly expressed in cubic meters per ton. Specific emissions can be calculated for any mine by dividing total methane liberation (as reported by Poland's Central Mining Institute) by coal production. To prepare the resource estimates, the specific emissions of a given mine were multiplied by the balance coal reserves of that mine to yield the estimated methane resource associated with those coal reserves.

The specific emissions method can be useful for the most preliminary of estimates. However, it can lead to inflated resource estimates in that it includes methane contained in the entire coal package, rather than just the potential target coal seams. This method can also potentially overestimate resources when adjacent coal seams included in the coal resource estimate are the source of some of the methane that is emitted into the workings during mining. Where this occurs, the resource estimate may be "double counted" (i.e., the weighted average of the methane liberated during mining would include the methane from adjacent mineable seams and the target seam, but would not consider that some of the methane would be depleted from the resource).

As shown in Table 10, according to this method, the total estimated methane resource contained in balance reserves of in gassy mines of the USCB is 197 million m^3. This likely represents the high-end estimate of coalbed methane resources in active mining areas. Additional methane resources are present in non-balance reserves of coal, however, and perhaps in prognostic coal resources within the mining concessions.

2.3.2 METHANE CONTENT METHOD

Under this method, resource estimates were prepared using methane content data provided to the authors by the Central Mining Institute in 1991. These data consist of the maximum methane content measured from each of the 17 gassy mines profiled in Part II of this report. These methane content values were multiplied by the balance coal reserves of each mine to estimate methane resources.

There are two main sources of uncertainty associated with these estimates and the data on which they are based.

- First, these data represent maximum, rather than average, methane content measurements. Methane contents of other coal seams, or of the same seams in other areas of the mining concession, may be lower. The resource estimate could thus be inflated to the extent that the average methane content for the mine differs from the maximum measured methane content.

TABLE 10. SPECIFIC EMISSIONS, METHANE CONTENT, AND ESTIMATED METHANE RESOURCES CONTAINED IN GASSY COAL MINES OF THE USCB

MINES	SPECIFIC EMISSIONS (m^3/T)	METHANE CONTENT (m^3/T)	ESTIMATED IN-SITU METHANE RESOURCES (Mm^3), BASED ON: SPECIFIC EMISSIONS	ESTIMATED IN-SITU METHANE RESOURCES (Mm^3), BASED ON: METHANE CONTENT	BALANCE* METHANE RESERVES (POLISH MINING METHOD) (Mm^3)
1 MAJA	18.9	18.0	4,965	4,729	216.4
ANNA	5.42	NA	605	NA	14.4
BOBREK	0.7	NA	79	NA	NA
BORYNIA	3.9	6.0	2,048	3,150	741.4
BRZESZCZE	43.5	15.0	17,226	6,113	519.5
DEBIENSKO	0.2	NA	237	NA	NA
HALEMBA	19.1	20.0	10,950	11,466	NA
JANKOWICE	2.4	15.0	2,220	13,874	24.7
JASTRZEBIE	9.8	11.8	2,772	3,338	67.8
KATOWICE	1.9	NA	282	NA	NA
KNUROW	0.3	NA	214	NA	NA
KRUPINSKI	29.9	15.4	19,384	9,984	642.3
MARCEL	4.9	4.4	1,131	1,016	23.7
MORCINEK	26.7	8.0	10,432	3,126	67.4
MOSZCZENICA	22.4	8.1	9,236	3,340	206.6
MYSLOWICE	4.7	NA	569	NA	NA
NIWKA-MODRZ.	3.8	NA	963	NA	NA
NOWY WIREK	2.7	NA	345	NA	NA
PNIOWEK	41.9	15.0	43,496	15,572	659.6
POKOJ	0.4	NA	75	NA	NA
PSTROWSKI	2	NA	189	NA	NA
SILESIA	36.4	10.5	26,470	7,636	532.2
SLASK	3.4	NA	890	NA	NA
SOSNICA	5	NA	2,094	NA	NA
STASZIC	5.1	8.0	3,249	5,096	14.2
SZCZYGLOWICE	1.2	NA	1,152	NA	NA
WAWEL	5.1	NA	221	NA	NA
WESOLA	11.3	11.6	11,585	11,892	723.0
WIECZOREK	2.8	NA	420	NA	92.7
ZABRZE-BIELSZ.	5	11.6	2,724	6,320	NA
ZOFIOWKA	25.9	23.0	14,152	12,567	312.6
ZORY (ZMP)	22	4.8	6,376	1,391	59.5
TOTAL			197,248	NA	NA

Shaded rows indicate mines profiled in Part II of this report. NA=Not Available

*Can be recovered using drainage techniques currently employed at the mine or at similar mines

Using a methodology different from those presented in this table, the Polish Geological Institute (Kotas, 1994) estimates that 150 billion m^3 of methane are contained in the coal reserves of all active mines (see Section 2.3.4).

- Second, according to Polish methane content determinations, a constant lost gas value is assumed in determining the methane content of the coal. Lost gas is the unmeasured gas that desorbs during the time that elapses from the moment a coal sample is cut from the seam, until the moment it is sequestered in an airtight container. The resource estimate could thus be inaccurate to the extent that the actual lost gas content differs from this assumed lost gas content.

As shown in Table 10, the resource estimates calculated by the specific emissions method tend to higher than those calculated using maximum methane contents (in 4 of the 17 cases, however, they are lower). Because methane content data were not available for all of the gassy mines in the USCB, the total methane resource contained in all gassy mines, as estimated by this method, could not be summed in Table 10.

2.3.3 POLISH MINING METHOD (BALANCE METHANE RESERVES)

Each coal mining company (or its subcontractors) estimates the balance methane reserves contained in its mines and submits these estimates to the Ministry of Environmental Protection, Natural Resources and Forestry. Balance methane reserve estimates for all mines profiled in Part II of this report, except Halemba and Zabrze-Bielszowice (whose methane reserves are in the process of being documented) are presented in Table 10.

The estimates use the average measured methane content of coal seams that contain more than 2.5 m^3 of methane per ton of dry, ash-free coal (Kwarcinski, 1994). The depths to which methane reserves are calculated varies widely from mine to mine, anywhere from 900 to more than 1500 meters. The reason that these depths vary widely is twofold: first, the coal reserves (on which the methane resource estimates are based) are themselves estimated to varying depths; in addition, some mine managers are not interested in the methane reserves contained in relatively deep coal seams (Grzybek, 1994), presumably because they do not intend to mine these deep seams.

Note that compared to the other estimates presented in Table 10, the Polish Mining Method estimates are much lower. The reason for this difference is that the Polish Mining Method yields balance methane reserves, whereas the other two methods yield in-situ resources. Balance methane reserves are those which can be recovered using technology present at the mine or at other mines with similar mining conditions; they include only the methane that is a by-product of coal that will be mined. Balance reserves do not include methane that could be recovered using improved drainage programs or techniques. Some of the balance reserve figures shown in Table 10 do not reflect recent upgrades to the drainage system; for example, the estimate for the Brzeszcze mine was made in 1986, but the degasification system has been expanded since then and drainage has increased substantially.

2.3.4 ESTIMATES BY THE POLISH GEOLOGICAL INSTITUTE

In 1990, the Upper Silesian Coal Branch of the Polish Geological Institute (PGI) performed a detailed estimate of methane resources contained in the USCB (Kotas, 1994). The study resulted in resource estimates for both active mining areas and virgin coal fields, although it focused on the latter. Rather than calculating methane reserves on a mine-by-mine basis, the PGI evaluated in-situ gas resources in four selected study areas in the USCB. Each of the four study areas was characterized by a distinct set of geologic characteristics; together, the four study areas were considered to representative all of the various conditions that exist in the basin. Using coal quality and gas content data from more than 2000 deep boreholes and mining shafts, average methane contents were calculated on 100 m intervals for each of the study areas; only those coal seams thicker than 0.3 m were considered. The PGI found that methane contents ranged from a few million m^3/km^2 at the margins of the prospective area to as much as 490 million m^3/km^2 in the most favorable portions of the basin, and estimated that the USCB contains an average of 200 million m^3 per standard km^2. A detailed explanation of the PGI's methodology is presented in Kotas, 1994.

Based on these calculations, the PGI estimates that 150 billion m^3 of methane are contained in the area of active coal mining. The PGI further estimates that an additional 200 billion m^3 of methane are contained in virgin (unmined) exploration fields of the USCB. The PGI states that these estimated resource volumes are “conservative, but realistic in a view of serious environmental, technical and economical constraints which will affect the future methane recovery” (Kotas, 1994).

2.3.5 DISCUSSION OF THE FOUR METHANE RESOURCE ESTIMATES

The four types of estimates presented above represent the only readily available methane resource estimates for the Upper Silesian Coal Basin. While the Specific Emissions Method and the Polish Geological Institute Method employ vastly different methodologies, their results are reasonably close--197 billion m^3 vs. 150 billion m^3 for active coal mines. The Methane Content Method is presented primarily so that the reader may compare, on a mine-by-mine basis, how specific emissions contrast with maximum measured methane contents. The Polish Mining Method estimates are presented because they represent the only mine-by-mine estimates of methane resources, calculated by Polish experts, that are currently available. Of the four methods presented above, the results obtained by the Specific Emissions Method and the Polish Geological Institute method appear to be most valid in terms of potential reserves.

To put these coalbed methane reserve estimates in perspective, consider that, as discussed in Section 1.2.4, Poland’s conventional natural gas reserves are estimated at 155 billion m^3--about the same as the PGI’s estimate of coalbed methane reserves contained in active mines, and less than half of the total coalbed methane resources (350 billion m^3) that, according to the PGI, are contained in the USCB’s active mines and virgin coal seams combined.

Poland’s current consumption of coalbed methane is less than 0.2 billion m^3 annually; as discussed in Section 1.2.4, its total natural gas consumption is about 11 billion m^3 annually, and is expected to rise substantially. At an annual consumption rate of 15 billion m^3/year, this estimated 350 billion m^3 coalbed methane resource would be enough to extend Poland’s indigenous gas supply by 23 years; at an annual consumption rate of 30 billion m^3/year, it would extend Poland’s gas supply by nearly 12 years.

CHAPTER 3

COALBED METHANE RECOVERY AND POTENTIAL FOR UTILIZATION OF COALBED METHANE IN POLAND

3.1 COALBED METHANE RECOVERY

Many opportunities for increased recovery of coalbed methane exist in Poland, particularly in the USCB. Nearly 754 million m^3 of methane were liberated from coal mining activities in this basin in 1993 (Table 8). Of the 65 mines operating in the USCB, 18 had methane drainage systems. These drainage systems recovered 213 million cubic meters, or 28 percent, of the methane liberated by mining. Of this, 168 million cubic meters (79 percent) were utilized. Significantly more gas could be available for utilization with an integrated approach to methane recovery in conjunction with mining operations.

Reduction of the methane concentration in mine ventilation air for safety reasons is a prime concern in gassy coal mines throughout the world. This can be accomplished by increasing ventilation, or by decreasing the amount of gas liberated into the mine workings from the coals. Increased ventilation can be achieved by increasing the size of the fans or adding additional ventilation shafts. As the amount of methane liberated per ton of coal mined increases, the capacity of the ventilation system must also increase. According to 1990 data (Table 11), methane ventilation represents a significant percentage of overall mining costs at the USCB mines studied. These costs ranged from about 1 percent to almost 7 percent of total costs. Several mines (marked with an asterisk) have higher ventilation costs, per unit volume of gas, than drainage costs. Expanded methane drainage can be a profitable means of reducing the methane concentration in ventilation air, since ventilation requirements are reduced, coal can be more rapidly extracted, and gas recovered by drainage is often of saleable quality.

3.1.1 OPTIONS FOR RECOVERY

There are several techniques for recovering methane in conjunction with coal mining. The optimal choice among these methods depends on site specific conditions, including:

- the thickness and depth of the targeted seam;
- the amount of methane contained in the coals;
- the number of mined seams; and
- the efficiency of the ventilation system.

Table 12 summarizes methane recovery and use options, and shows the support technologies that are necessary to apply these techniques.

TABLE 11. ANNUAL METHANE VENTILATION, DRAINAGE AND PRODUCTION COSTS AT PROFILED MINES (1990)

MINE	COAL PRODUCTION (1000 TONS)	METHANE LIBERATED (MILLION m^3)		VENTILATION COST				DRAINAGE COST				VENTILATION + DRAINAGE COST		COAL PRODUCTION COST		% OF TOTAL PRODUCTION COST SPENT ON METHANE CONTROL
		BY VENTILATION	BY DRAINAGE	1000 Zl PER TON MINED	$US PER TON MINED	Zl PER m^3	$US PER 1000 m^3	1000 Zl PER TON MINED	$US PER TON MINED	Zl PER m^3	$US PER 1000 m^3	1000 Zl PER TON MINED	$US PER TON MINED	1000 Zl PER TON MINED	$US PER TON MINED	
1 MAJA	1,927	36.3	11.8	N/A	N/A	N/A	N/A	2.8	0.29	465	48.6	N/A	N/A	251	26.2	N/A
BORYNIA	2,443	13.0	0.9	6.5	0.68	1,226	128.0	0.6	0.06	1,588	165.9	7.1	0.74	204	21.3	3.5
BRZESZCZE	3,014	100.9	47.0	1.9	0.20	58	6.0	2.2	0.23	140	14.6	4.1	0.43	186	19.4	2.2
HALEMBA	4,200	57.7	15.7	2.3	0.24	167	17.5	0.7	0.07	196	20.5	3.0	0.31	156	16.3	1.9
JANKOWICE	3,715	9.0	3.6	0.6	0.06	228	23.8	0.5	0.05	472	49.3	1.1	0.11	137	14.3	0.8
JASTRZEBIE	2,301	19.7	3.5	4.7	0.49	549	57.3	1.4	0.15	953	99.6	6.1	0.64	233	24.3	2.6
KRUPINSKI*	1,364	46.2	24.4	6.8	0.71	201	21.0	2.1	0.22	119	12.4	8.9	0.93	347	36.3	2.6
MARCEL*	1,916	6.2	8.4	2.8	0.29	855	89.3	1.2	0.13	274	28.6	4.0	0.42	201	21.0	2.0
MORCINEK*	683	6.8	6.8	11.1	1.16	1,124	117.4	6.9	0.72	695	72.6	18.0	1.88	427	44.6	4.2
MOSZCZENICA	2,098	42.1	17.2	5.4	0.56	270	28.3	2.7	0.28	324	33.8	8.1	0.85	256	26.7	3.2
PNIOWEK	3,368	102.7	64.8	N/A	0.00	N/A	0.0	2.9	0.30	152	15.9	N/A	0.30	205	21.4	N/A
SILESIA	1,201	36.4	8.3	3.2	0.33	106	11.1	3.0	0.31	428	44.7	6.2	0.65	190	19.8	3.3
STASZIC	4,130	25.5	10.2	N/A	0.00	N/A	0.0	1.5	0.16	600	62.7	N/A	0.16	170	17.8	N/A
WESOLA	3,900	36.4	7.2	2.5	0.26	264	27.5	0.5	0.05	267	27.9	3.0	0.31	139	14.5	2.2
ZABRZE*	3,979	20.6	5.1	3.1	0.32	597	62.4	0.6	0.06	499	52.1	3.7	0.39	183	19.1	2.0
ZOFIOWKA*	2,796	47.9	27.1	11.6	1.21	676	70.6	3.1	0.32	323	33.7	14.7	1.54	222	23.2	6.6
ZORY (ZMP)	841	18.7	2.3	4.1	0.43	182	19.1	3.1	0.32	1,139	119.0	7.2	0.75	374	39.1	1.9
AVERAGE**	**2,581**	**36.8**	**15.5**	**3.2**	**0.33**	**282**	**29.5**	**1.5**	**0.16**	**254**	**26.5**	**4.7**	**0.49**	**197**	**20.6**	**2.7**

* Ventilation costs (per cubic meter of methane) exceed drainage costs at these mines

** Averages are weighted where appropriate

This list includes every mine in the USCB that drains methane, except Anna (for which no cost data were available)

Conversion rate: 9,572 Zlotys =1990 $US 1

Source: Polish Central Mining Institute

TABLE 12. SUMMARY OF OPTIONS FOR REDUCING METHANE EMISSIONS FROM COAL MINING

Considerations	Enhanced Gob Well Recovery	Pre-Mining Degasification	Ventilation Air Utilization	Integrated Recovery *combined strategies*
Recovery Techniques	• In-Mine Boreholes • Vertical Gob Wells	• Vertical Wells • In-Mine Boreholes	• Fans	• All Techniques
Support Technologies	• In-Mine Drills and/or Basic Surface Rigs • Compressors, Pumps, and other support facilities	• In-Mine Drills and/or Advanced Surface Rigs • Compressors, Pumps, and other support facilities	• Surface Fans and Ducting	• All Technologies • Ability to Optimize Degasification using Combined Strategies
Gas Quality	• Medium Quality (11-29 MJ/m^3) (300-800 Btu/cf) (approx. 30-80% CH_4)	• High Quality (32-37 MJ/m^3) (900-1000 Btu/cf) (above 90% CH_4)	• Low Quality (<1% CH_4; usually below 0.5%)	• All Qualities
Use Options	• On-Site Power Generation • Gas Distribution Systems • Industrial Use	• Chemical Feedstocks *in addition to those uses listed for medium quality gas*	• Combustion Air for On-Site / Nearby Turbines and Boilers	• All Uses
Availability	• Currently Available	• Currently Available	• Requires Demonstration	• Currently Available
Capital Requirements	• Low	• Medium/High	• Low/Medium	• Medium/High
Technical Complexity	• Low	• Medium/High	• Medium/High	• High
Applicability	• Widely Applicable • Site Dependent	• Technology, Finance, and Site Dependent	• Nearby Utilization • Site Dependent	• Technology, Finance, and Site Dependent
Methane Reduction*	• Up to 50%	• Up to 70%	• 10-90% recovery	• 80-90% recovery

* These reductions are achievable at specific sites or systems

Source: USEPA, 1993

Poland was among the early pioneers of methane recovery. A coalbed methane drainage project using surface boreholes was initiated the USCB's Rybnik Coal Region in the 1951, but the wells were spaced unsystematically and the program was short-lived. The nation's first in-mine methane drainage system was put into operation at the Jankowice mine in 1952 (Kotas, 1994). Methane was captured from the working faces, which were furnished with air-stoppings. Methane drainage began in earnest in 1959 as new mines were developed in the Rybnik area.

Presently, methane is recovered from 18 mines in the USCB. Data from 17 of these mines indicate that in 1993, 39 percent of the recovered methane was drained at working face (simultaneous with coal extraction), while 34 percent was recovered from gob areas and 27 percent was recovered from pre-mine (development) areas. The proportions vary from mine to mine, and are presented in the mine profiles in Part II of this report.

Over the past few years, many gassy Polish coal mines have become involved in methane recovery activities. Several mines have participated in pre-feasibility and feasibility studies that should lead to project development. Others have developed partnerships with Polish and US companies and are initiating drilling activities to produce methane. Some of the principal activities are summarized in the Box 1 below; additional utilization activities are discussed in Section 3.2.

BOX 1. RECENT COALBED METHANE RECOVERY AND UTILIZATION ACTIVITIES IN THE USCB

- **Nadwislanski Coal Company** has partnered with McCormick Co. (a major US coalbed methane producer) and it is expected that methane will be recovered from the Brzeszcze mine using vertical wells for pre-mining and gob recovery. A feasibility study for power generation at the mine based on coalbed methane-fired turbines has been conducted. McCormick has also received a concession for coal reserve areas bordering the Brzeszcze mine.

- **Jastrzebie Mining Company** has partnered with Pol-Tex Methane, a Polish subsidiary of a US company, McKenzie Methane, to produce coalbed methane from its coal reserve areas. In addition, McCormick energy has begun installation of equipment to generate power and heat from methane recovered from the **Krupinski** mine.

- **Silesia Mine** has partnered with Metanel S.A., a Polish coalbed methane extraction enterprise. Metanel has received a concession to produce coalbed methane in coal reserve areas in addition to its cooperation with the Silesia Mine. Methane will be produced via surface wells. Metanel hopes to provide gas to the combined heat and power plant serving the town of Bielsko-Biala, and the oil refinery and Czechowice-Dziedzdice.

- **Morcinek Mine** is the site of a project to demonstrate the treatment of mine water and coalbed methane produced water. The process will combine reverse osmosis, combustion evaporation and water recovery and will be fueled with methane recovered from the mining operation. The demonstration project is being carried out by Aquatech, a US company, with partial funding provided by the US Department of Energy and the US EPA.

- **Halemba, Pniowek, and Morcinek Mines** are the subject of a feasibility study being funded by the US Trade and Development Agency. John T. Boyd Co., a major US mining equipment manufacturer, together with Resource Enterprises Inc., a mine degasification company, will prepare the study, in conjunction with the Polish State Hard Coal Agency. The study will examine the feasibility of using vertical wells (both pre-mining and gob) to recover coalbed methane and identify the most promising utilization option. A pre-feasibility study of power generation potential has already been prepared by the Polish Coalbed Methane Clearinghouse for the Pniowek mine.

- **Zofiowka and Moszczenica Mines** are the subject of a pre-feasibility study being funded by the US Agency for International Development (US AID) and the US EPA. This study will examine the applicability of US surface gob well recovery technologies for coalbed methane production in Poland. The study is being prepared by the International Coalbed Methane Group, based in Birmingham, Alabama. It is expected that this study will be completed in 1995.

- A pre-feasibility study funded by US AID and US EPA is underway to assess the applicability of US longhole, in-mine recovery methods under Polish mining conditions. Resource Enterprises, Inc., based in Salt Lake City, Utah is carrying out the study. It is expected that this study will be completed during 1995.

3.2 COALBED METHANE UTILIZATION

As stated at the beginning of this chapter, 79 percent of the methane drained in the USCB is utilized. Compared with many coal mining areas of the world, this is a very good utilization rate. Only 28 percent of the total methane liberated is drained, however, and thus improved methane drainage could greatly increase the amount of coalbed methane available for utilization.

Table 13 shows present and potential consumers of methane from USCB mines at which methane is currently being drained. As the table shows, methane can be used for many purposes, including heat and power generation, coal drying, and various industrial needs. The most attractive uses are likely to be local, where high compression, enrichment, or long distance transmission are not required. Expanded use of coalbed methane will develop if the quantity and quality of the gas increases, because this will contribute to the recognition of coalbed methane as a valuable and readily available fuel. Some of the many opportunities for use of this fuel are discussed in the following sections.

3.2.1 DIRECT INDUSTRIAL USE OPTIONS

The USCB is heavily industrialized, and is the largest energy consuming region of Poland. The industrial consumers of energy produce such items as machinery, transport equipment, and other iron and steel goods. Additional industrial consumers are the food and chemical industries, and, of course, the coal industry. The mining, power, and industrial complex which dominates the region was originally developed with an emphasis on large-scale production, often at the expense of efficiency, profitability, and the environment. Hard coal (often of low quality), lignite, and coke oven gas, are typically used to fuel these industries. Increased coalbed methane utilization would clearly benefit the region by helping it meet increasing energy needs with a less polluting, yet local, energy source.

As shown in Table 13, most of the mines that drain methane are presently using it on-site, for heating mine facilities, drying coal, or power generation. In these situations, the methane is often displacing low-quality hard coal or brown coal as a fuel. Table 13 also shows that methane from three of the mines is being consumed by a chemical plant, a steel mill, and an oil refinery. In these cases, the coalbed methane is probably displacing coke oven gas as well as coal. Due to decreasing steel production and stricter environmental regulations, coke oven gas production is decreasing in the region, and methane is an ideal substitute, as it is much less polluting.

There may be other innovative options for direct use of coalbed methane, such as desalination of mine waters. The disposal of highly saline water in nearby rivers remains a serious environmental problem. Desalination of effluent mine waters offers an opportunity for use of methane as the primary fuel for what can be an energy intensive process. In the San Juan Basin of the U.S., coalbed methane is used to concentrate brines produced by coalbed methane wells (Hycnar et al, 1994). At the Morcinek mine in Poland, a pilot demonstration of a desalination process that uses coalbed methane as its primary energy source is being conducted (Brandt and Bourcier, 1994). The process is an energy-efficient method of desalination, although it may not be an economically feasible alternative for all mines (Gatnar,1994).

The process uses a reverse osmosis (RO) unit, a submerged combustion evaporator, and a pulse combustion dryer. In a typical operation, a mine water feedstream of 1000 m^3/day that may have a total dissolved salt (TDS) concentration of 31,100 ppm will be separated, via RO, into a product water of 580 m^3/day with a TDS of 500 ppm, and a brine stream of 415 m^3/day with a TDS of 74,300 ppm. The product water can be used for agricultural or other applications. The brine stream, meanwhile, is further concentrated via a coalbed methane-fueled submerged combustion evaporator which concentrates it to 300,000 ppm and reduces the volume to 104 m^3/day. The submerged combustion evaporator uses about 90 m^3 of methane per m^3 of brine that is produced by the RO unit. Coalbed methane could also be used to further process the brine that is discharged from the combustion evaporator into a dry salt that may have a commercial value.

TABLE 13. PRESENT AND POTENTIAL METHANE UTILIZATION AT WITH METHANE DRAINAGE SYSTEMS (1993)

MINE	METHANE DRAINED	METHANE UTILIZED	METHANE DRAINED BUT NOT UTILIZED	PRESENT CONSUMERS (AS OF 1993)	POTENTIAL CONSUMERS*
	(IN THOUSAND CUBIC METERS)				
1 MAJA	8,500	7,300	1,200	Prep plant dryer, POGC**	N/A
ANNA	2,000	0	2,000	None	N/A
BORYNIA	868	0	868	None	Use in mine boiler, prep plant dryer
BRZESZCZE	44,500	44,100	400	Mine, Chemical plant	Proposed power plant at mine
HALEMBA	15,600	3,000	12,600	Mine; Other nearby mine	Expanded use at mine; proposed power plant; nearby households
JANKOWICE	2,300	1,700	600	Mine	N/A
JASTRZEBIE	3,521	3,114	408	Mine boiler, POGC**	Use at prep plant; expanded use in boiler
KRUPINSKI	15,843	6,665	9,178	Mine boiler, prep plant dryer	Proposed power plant at mine
MARCEL	4,900	4,200	700	Mine	Gas plant; prep plant dryer
MORCINEK	16,880	14,412	2,469	Mine boiler, prep plant dryer, POGC**	Miner; desalination plant; heating plant at Cieszyn
MOSZCZENICA	10,207	9,829	379	Mine boiler, CHP plant, prep plant dryer, POGC**	Expanded use at mine
PNIOWEK	49,173	43,441	5,732	Mine boiler, other nearby mines, POGC**	Prep plant dryer; power plant
SILESIA	7,700	7,600	100	Mine, Oil refinery	CHP plant; Expanded use at refinery
STASZIC	2,100	2,000	100	Steel Mill	Mine; nearby households
WESOLA	5,700	2,600	3,100	Mine	Proposed heat plant at mine; nearby households
ZABRZE	1,200	1,200	0	Mine	Nearby households
ZOFIOWKA	19,802	15,218	4,584	CHP plant, POGC**	Prep plant dryer
ZORY	2,000	1,400	600	Nearby Mine	N/A

*As identified by mine managers and/or Poland's Coalbed Methane Clearinghouse
Sources: Coalbed Methane Clearinghouse; Gatnar (1994)
**POGC, via GOZG Zabrze, ceased purchase of methane on October 1, 1993 (See Section 3.2.3, Box 3)

3.2.2 POWER GENERATION OPTIONS

Power generation is perhaps the most attractive utilization option for coalbed methane in the USCB. According to Surowka (1992), the majority of large industrial enterprises and mines have their own combined heat and power (CHP) plants[12] or heat only boilers (HOB). In addition, there are 15 public power or CHP plants in the region. The public and industrial CHP and HOB plants supply hot water to a large district heating network. All of these power plants use hard coal as their primary fuel. Several options for using coalbed methane to generate power are discussed below.

Cofiring With Natural Gas

Cofiring is the concurrent firing of natural gas and coal in a boiler (with the gas typically providing 5 to 15 percent of the thermal input). The only modifications to the boiler required are the addition of gas supply piping, gas ignitors, and warmup guns. Cofiring with gas has many potential benefits, including reduced sulfur dioxide emissions, greater fuel flexibility (allowing the utilization of lower cost, lower quality coal without the effects of increased pollutants), improved plant capacity factor, and production of saleable fly ash. Cofiring can be accomplished at very low capital costs and with low technological risk; if for any reason natural gas is no longer available, the boiler could continue to operate entirely on coal. At some power plants in the United States, cofiring has reduced operating costs by millions of dollars per year (Vejtasa et al, 1991; CNG, 1987). It is also being used successfully at power plants at the Moszczenica and Zofiowka mines in the USCB (see box at right).

BOX 2. COFIRING OF METHANE AT THE ZOFIOWKA CHP PLANT

The Zofiowka mine in the Rybnik-Jastrzebie area of the USCB cofires methane and pulverized coal at its CHP plant, whose capacity is 64 MW_{el} + 320 Mw_{th}. The plant supplies heat and power to the mine and the town of Jastrzebie. About 10 percent of the fuel energy consumed by this power plant is delivered in gas. During the first six months of 1994, 20.8 million m^3 of gas, with a methane concentration of 46.5 percent, were consumed by the plant.

Methane is combusted in the startup burners and the backup combustion supporting burners (Zimny, 1994). Each 1000 m^3 of methane yields 12.9 MWh of steam, which produces 3.1 MWh of electricity, 4.7 MWh of heat energy, and 5.1 MWh of regeneration feedwater. Each m^3 of methane produces 1,764 zlotys ($0.08 USD) worth of electricity and 731 zlotys ($0.03 USD) worth of heat. Use of coalbed methane in this CHP plant is very cost effective, due in part to the low price of coalbed methane (the only cost to the mine is gathering the fuel). Using conventional natural gas to cofire with the coal would cost four to five times as much, substantially reducing the economic attractiveness.

Gas Turbines

Gas turbine generators are widely used in the United States by electric utilities to provide power during peak demand times. Gas turbines are more efficient than coal-fired generators, cost less to install, and are available in a large range of sizes. This allows for the addition of smaller increments of capacity to handle peak consumption, rather than investing in larger, capital intensive coal-fired units that would be underutilized.

In addition, gas turbine exhaust is a good source of waste heat which can be utilized to generate steam in a heat recovery boiler. When the steam is used for process or district heating, this process is known as cogeneration. If this steam is used in a turbine generator for additional electrical power production, the system is known as a combined cycle. If the steam were injected into the hot gases flowing to the thermal turbine, the system would be known as a steam injected turbine (STIG). All of these uses improve the thermal efficiency of the system.

[12] Combined heat and power plants are so called because they produce both electricity and thermal energy. Thermal energy is produced in the form of either steam or hot water, and is commonly used for district heating.

Gas turbines fueled by coalbed methane recovered from mining gob areas have been successfully operated in England, Australia, Germany, and China, and have undergone experimental use in the United States (Sturgill, 1991). In most of these cases the waste heat is being recovered from the turbine stack for use in an auxiliary thermal process. These projects range in size from about 3 to 20 MW, which can frequently supply a significant portion of the mine's electrical needs. Gas turbines can use medium to high-quality methane, and are under consideration for use in the USCB (Zimny, 1994).

Internal Combustion Engines

Internal combustion (IC) engines can generate electrical power utilizing medium to high-quality coalbed methane. Typical capacities of IC engines range from several kilowatts to several megawatts. These sizes are much smaller than gas turbines and would be more compatible with the production of coalbed methane from a single well. As an example, a 1 MW IC engine would require approximately 10,000 m^3 of methane per day. IC engines can use medium quality gas (30-80 percent methane) such as that produced by pre-mining drainage and surface gob recovery.

Internal combustion engines are modular in design and require little specialized expertise to install and maintain. Due to their small size they can be relocated easily if the gas supply is depleted. Previously, variations in gas quality caused some problems with the use of mine gas in IC engines, but with modern integrated control systems it now appears possible to accommodate these fluctuations.

3.2.3 NATURAL GAS PIPELINE SYSTEMS

Coalbed methane that is produced in sufficient quantity and quality can be transported in natural gas pipeline systems to end-users. Several US coal mines have been able to do this with methane recovered during coal mining, and it has been done on a limited basis in the USCB (see Box 3).

BOX 3. THE UPPER SILESIAN GAS UTILITY AND THE SWIERKLANY COMPRESSION STATION: THE NEED FOR GAS STORAGE AND IMPROVED METHANE DRAINAGE SYSTEMS

About 14 km south of the town of Rybnik, in the southwestern portion of the USCB, lies the Swierklany Compression Station. Ten of the mines profiled in Part II--Zory, Jankowice, Marcel, Borynia, 1 Maja, Zofiowka, Pniowek, Jastrzebie, Moszczenica, and Morcinek--are connected to the station by medium-pressure pipelines. Until October, 1993 the compressor station collected coalbed methane from these mines, compressed it, and transported it to industrial consumers and the municipal gas network.

Unfortunately, the Swierklany compressor station is no longer operating because the POGC's Upper Silesian Gas Utility (GOZG Zabrze) withdrew from its contract for buying coalbed methane. For a short period of time following this decision, the resulting excess was vented, but now the mines are using most of this gas, except during the summer when heating and power requirements are not as high.

GOZG's reasons for ceasing purchase of the gas are:

1. Lack of permanent consumers
2. Lack of sufficient storage
3. Demand fluctuations
4. Variable methane concentration

The creation of gas storage facilities in the Rybnik coal district would directly address Items 2 and 3 (gas storage is discussed further in Section 3.2.6). Improved methane drainage systems (both surface and underground) including monitoring and management systems to maintain drained gas at consistently high quality, would help eliminate the problem of variable methane concentration (Item 4). If items 2, 3, and 4 could be mitigated, it is likely that there would be sufficient permanent consumers (Item 1) available. Use of the Swierklany Compression Station and mine gas sales to the Upper Silesian Gas Utility (or other outside consumers) could then resume.

The Polish gas pipeline system has a total length of 82,400 km, of which 16,400 km are transmission pipelines and 66,000 km are distribution pipelines (UNECE, 1994c). The system is complex, and as described below and shown in Figure 12, there are three distinct distribution systems, each carrying a different type of gas. The pressure control system is complicated and somewhat inefficient, which may cause interruptions and some variations in quality. Furthermore, the system is currently operating near its full capacity, which limits the ability to add potential new users. As natural gas use expands in Poland, it will likely be necessary to expand and upgrade the natural gas distribution system.

Coke Oven Gas System

As shown in Figure 12, the coke oven gas distribution system is present in southwestern Poland (Upper and Lower Silesia). In recent years there has been a sharp decrease in coke oven gas supplies from coke oven plants, due to declining demand for coke resulting from the contracting steel industry. As a result, coke oven gas consumption in Silesia has decreased from nearly than 1.8 billion m^3 1987 to 0.5 billion m^3 in 1993 (Fronski et al, 1994; Tokarzewski and Bednarkski, 1994). Coke oven gas, which has a heating value of 19 MJ/m^3, accounted for 2.6 percent of all gas consumed in Poland in 1993.

Most of the coke oven gas is distributed to residential consumers; at the end of 1993, about there were about 280 thousand domestic consumers of coke oven gas and 30 industrial users. It is anticipated that by the end of 1995, all USCB households consuming coke oven gas will be converted to high-methane natural gas. Since most of the gassy mines are located in the vicinity of towns that possess a gas network, It may be possible to distribute medium or high quality recovered coalbed methane through these pipelines, once problems with variable supply and methane concentration are addressed.

High-Methane System

Figure 12 shows that the high methane natural gas system covers nearly all of Poland. High methane natural gas dominates Poland's gas mix, accounting for nearly 77 percent of all gas consumed in Poland in 1993 (Tokarzewski and Bednarski, 1994). This gas is supplied to the system from fields in the Carpathian region of Poland and from Russia, and is distributed by pipeline throughout Poland. Its heating value is typically 39 MJ/m^3.

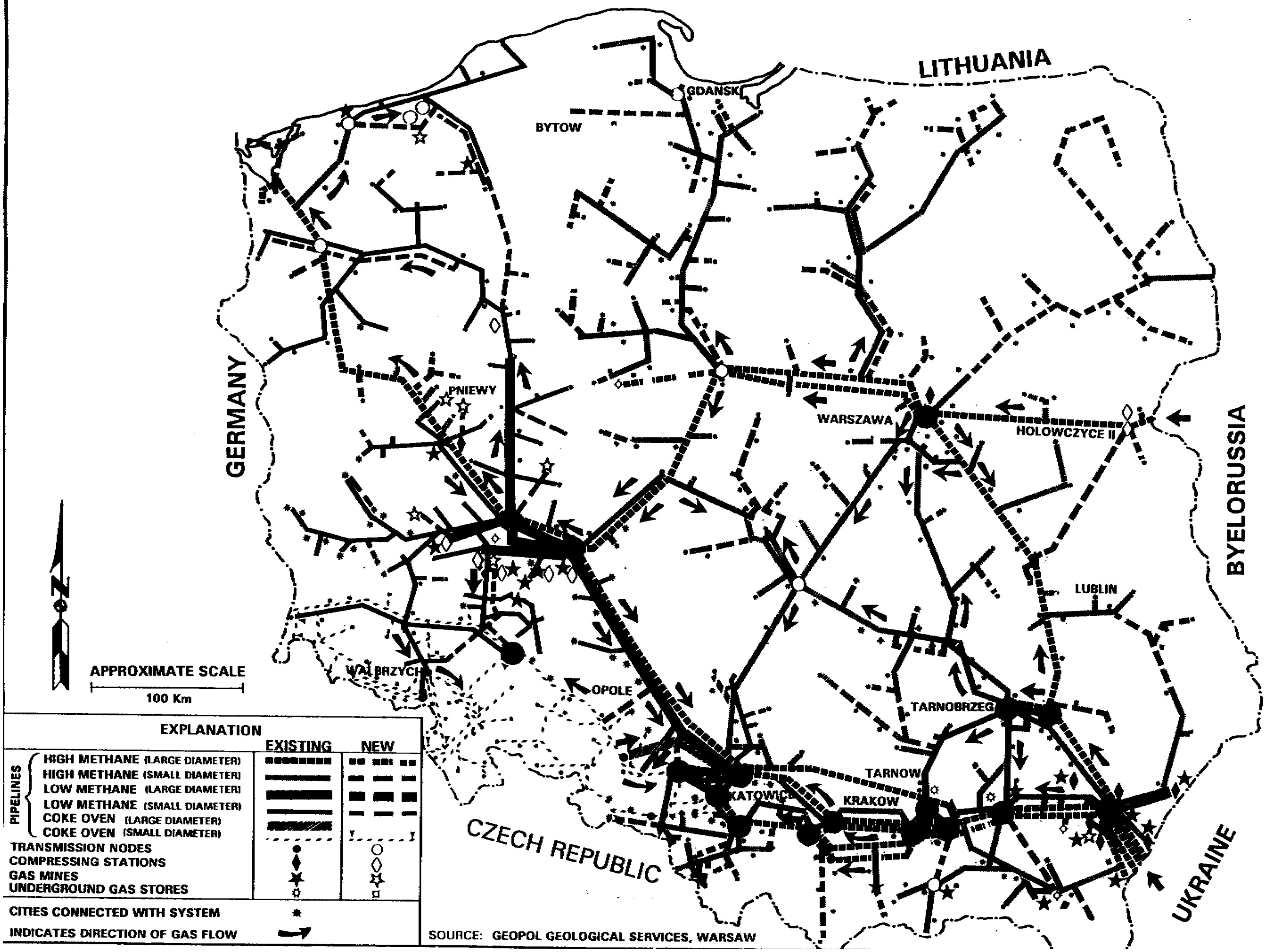
In cases where the quality of recovered mine gas is sufficiently high and the mine is located near the distribution system, it may be possible to inject recovered methane directly into this distribution system. This methane could then be distributed to conventional residential, commercial, and industrial users. Problems with variable supply and methane concentration must be addressed, however, before large-scale sale of coalbed methane to the high-quality gas network can occur.

High Nitrogen/Low-Methane System

As shown in Figure 12, the high nitrogen/low methane natural gas system is limited to western Poland. It accounts for less than 21 percent of Poland's gas mix, and its customers, all of which are industries, are expected to decrease in number (Tokarzewski and Bednarksi, 1994). The gas, whose nitrogen content ranges from 10 percent to more than 80 percent, is produced in the lowlands of western Poland.

The possibility for using this system to transport coalbed methane exists in areas where the distance between mines and the low methane natural gas system is relatively short, gas production is high, or several mines could use a common pipeline. The average gas quality of this system is reportedly 55-65 percent methane, which could be maintained with coalbed methane through gas monitoring and blending techniques. Because the low-methane system extends from Katowice northwestward, the mines that are currently draining methane in the southern part of the basin are not in close proximity to this pipeline. Some of the mines in the northern part of the basin, however, are reasonably close to this pipeline. These include the Staszic mine, about 8 km south of the pipeline, and Halemba mine, about 10 km west of the pipeline.

FIGURE 12. GAS DISTRIBUTION NETWORK IN POLAND



3.2.4 VENTILATION AIR UTILIZATION OPTIONS

Currently, there are no demonstrated uses for methane contained in mine ventilation air, due to its low concentration. Numerous studies have examined the possibilities of purifying this gas, but with currently available technology, the expense is prohibitive. However, as technology progresses, it may become economically feasible to enrich the gas contained in mine ventilation air using some of the methods discussed in Section 3.2.5.

At present, the best options for utilization of ventilation air appear to be as part of the fuel mixture in steam boilers or gas turbines for power generation. The ventilation air could supply all or most of the combustion air required, while the methane in the air would supply a portion of the needed fuel.

In order to assess the potential for use of ventilation air, the following issues should be investigated (Energy Systems Associates, 1991):

- Characteristics of mine ventilation systems, including the number of ventilation shafts and the flow rates of ventilation air.
- The methane concentration in the ventilated air.
- The distance between the ventilation shafts and the mine power plants.
- Detailed information on power plant characteristics, annual generation, efficiency, and projected utilization.

The feasibility of using recovered ventilation air must also be evaluated. If it is feasible, the use of ventilation air should be considered as part of an integrated methane drainage program. It is important to note that for this to be economic, the targeted boiler should be within about 2 km of the source for the ventilation air.

3.2.5 IMPROVING GAS QUALITY

Much of the 45 million m^3 of gas recovered annually by mine methane drainage systems, and then vented to the atmosphere has methane concentrations ranging from 30 to 50 percent. This gas is not considered “pipeline quality” (more than 90 percent methane). Furthermore, its concentration may decrease over the life of producing well.

There are three primary means of improving the quality of gas recovered from coal mines:

1. Improved monitoring and control. One of the most economical methods to improve the quality of gas is to reduce air entrainment in the gas stream during the production process. This can only be accomplished by finding the equilibrium production rate of the well, i.e., the rate at which the ratio of methane liberation in the coal equals the rate of production at the well head.

Since the rate of methane liberation generally declines with time it is necessary to adjust critical production parameters frequently in order to be able to control the bottom hole pressure (BHP) and maintain a high methane concentration in the product gas. Continuous monitoring of the oxygen content at the well head is used in conjunction with adjusting the production rate to maintain a desired gas quality. This production control technique automatically maintains the BHP at the required level without the need of having to determine its actual value. Since the mine ventilation system and the wellbore are in communication it is customary (and advisable for safety reasons) to also monitor the mine ventilation system at appropriate check points.

2. Increased pre-mining drainage. Gas drained in advance of mining usually has a higher methane content than that drained from working faces or gob areas. Advanced pre-mining drainage techniques include:

   - Use of vertical wells drilled from the surface. This strategy is not widely employed in Poland at present, but has been highly successful in the US (Diamond et al, 1989).

   - Use of more numerous, and more strategically placed, cross-measure boreholes drilled in advance of mining. Predictive techniques can be used to maximize recovery (Lunarzewski, 1994).

Polish mines could use these techniques to help shift their predominant gas recovery efforts from drainage of working faces and gob areas, to drainage in advance of mining.

3. Gas enrichment. Current research suggests that two types of gas enrichment technologies are best suited to small-scale applications, such as coal mines, typically producing less that 300 thousand m^3 of gas per day. These technologies are pressure swing adsorption and membrane gas separation. Cost comparisons among various processes are complex and situation dependent. Because these technologies do not have a long history, actual costs are not yet well established. However, the following cost approximations provide general guidelines. To enrich a feed gas containing 70-80 percent methane to pipeline quality, operating costs range from approximately \$US 0.01/m^3 to \$0.04/m^3 for pressure swing adsorption systems (Sinor, 1992; Meyer et al, 1990). The cost of enriching a mixture of 30-50 percent methane is not known and should be researched in considering such projects for coal mines. It is important to bear in mind that, because this gas would otherwise be vented to the atmosphere, the cost of the feed gas is effectively zero, enhancing the economics.

   Typically, the methane concentration in mine gas presently being drained from USCB mines is less than 70 percent (average methane concentrations in the 17 mines profiled in Part II of this report range from 45 percent to 62 percent). The economic feasibility of enriching mine gas from these levels to pipeline quality is undetermined at present. If the quality of drained gas can be improved via the other two methods discussed above, however, further enrichment to pipeline quality may indeed become cost-effective.

3.2.6 UNDERGROUND GAS STORAGE

Underground storage should be considered an integral part of any coalbed methane use strategy. With storage facilities, gas can be used as demand dictates. For example, gas produced when demand is low (such as during the summer) can be stored and used during periods of higher demand. This strategy would also reduce the dependency on imported gas.

In many gas producing areas of the world, underground storage is the most common means of storing gas to meet peak seasonal market requirements. Preferred sites are porous reservoirs, including depleted oil and gas fields as well as aqueous reservoirs. Other sites used for storage are man-made salt and rock caverns. Underground gas storage was first utilized in the United States in 1916, and today there are more than 400 storage fields with a total capacity of over 228 billion m^3 of gas, which is equivalent to almost half the annual US gas consumption. In addition, utilization of underground gas storage is beginning to allow capitalization of spot gas market purchases, and managing of marketing and production by producers (Thompson, 1991).

At present, Poland's total gas storage capacity is about 620 million m^3, in three depleted gas fields located in the southeast (ESMAP, 1993b; UNECE, 1994c). This is insufficient to meet Poland's storage needs, and the POGC has had to rent additional storage in Ukraine. At present, no large gas storage reservoirs have been developed in or near the USCB, but the POGC has identified about 250 potential sites in aquifers in western Poland.

Development of underground gas storage in the USCB could play a key role in expanding methane recovery and utilization. The chief users of coalbed methane in the USCB are the mines themselves, which use methane largely for heating ventilation air and surface facilities; during the winter months, most of the methane that is recovered is utilized, but during the summer months, much of it is wasted. As discussed in the box in Section 3.2.3, these seasonal fluctuations in supply have discouraged gas utilities from purchasing coalbed methane. Storage facilities could help make the supply more reliable, eliminating the summer waste, and allowing for expansion of utilization systems.

In addition to conventional storage facilities, another available option is gas storage in abandoned coal mines. Two abandoned mines have been utilized for imported natural gas storage at two locations in Belgium since the early 1980's (Moerman, 1982). Potential locations for gas storage in the USCB include those mines that are scheduled for closure in the near future, as well as inactive shafts of operating mines (see Box 4 for an example). A thorough evaluation of the geologic and hydrologic conditions at these mines is, of course, necessary to determine feasibility.

BOX 4. MORCINEK MINE METHANE STORAGE PILOT PROJECT

Coalbed methane is presently being stored in an inactive shaft in the Morcinek mine (Gatnar, 1994). The storage facility, developed in 1994, has a capacity of 35,000 m^3. Methane drained from the mine is normally delivered to its prep plant drying station, and its boiler house. When there is no demand at these facilities, the gas is delivered to the storage reservoir. When demand for methane exceeds that which can be supplied by the drainage station, methane flows from the storage reservoir to the drainage station, and then to the boiler house and/or prep plant.

The storage facility has completely eliminated emissions of drained methane during working days, although it is not large enough to store the methane surplus that accumulates on weekends. The results of this project are encouraging, and opportunities for expanding methane storage in mines are increasing as the closure of mines, or at least portions of mines, proceeds.

CHAPTER 4

CONCLUSIONS

The Polish government recognizes the many benefits associated with coalbed methane production, and since 1990 much has been accomplished toward encouraging recovery and utilization of this resource. In that respect, Poland is a model for other countries wanting to develop their coalbed methane resources. Some of the major achievements affecting development of coalbed methane in Poland include:

- **Granting of Concessions and Other Agreements** - As noted in previous chapters, coalbed methane licensing blocks, all of which lie outside of the boundaries of USCB mining concessions, were awarded to US energy firms and their Polish subsidiaries in 1993. Furthermore, the Polish government and mining companies have made agreements with Polish and foreign firms interested in developing coalbed methane within mining concessions. These major steps in encouraging outside investment in coalbed methane development in Poland are beginning to yield results; in November, 1994 Amoco began drilling Poland's first coalbed methane well.

- **New Geological and Energy Legislation -** As discussed in Chapter 1, a new Geological and Mining Law was passed in 1994 and a draft Energy Law awaits passage by the Sejm. These two acts constitute an essential part of the implementation of the energy sector restructuring plan and attempt to provide a sound, clear legal system that will attract private investment to the coalbed methane industry.

- **Coal Industry Restructuring** - As discussed in Chapter 2, Poland's coal mining sector is undergoing extensive restructuring. One outcome is that most of the 65 coal mines in the USCB have been grouped into seven coal companies. Preliminary results indicate better organization in management and increased profitability, which should make the coal companies more viable partners for foreign companies and financial institutions considering investment in coalbed methane.

- **Rationalization of Energy Prices -** This is an ongoing process, part of Poland's overall economic restructuring. The removal of energy price subsidies, and reduction of subsidies to the coal industry, will allow the real of value of coalbed methane to be recognized over time.

- **Stricter Environmental Regulation -** Laws controlling pollution are being more strictly enforced. This has several positive implications for coalbed methane utilization, as methane can be used to replace fuels (particularly low-quality coal and coke oven gas) whose extraction and combustion create serious environmental problems.

- **Coalbed Methane Clearinghouse** - To address information needs in Poland, the Coalbed Methane Clearinghouse, operating at the Polish Foundation for Energy Efficiency (FEWE), was established in 1992. It is currently funded by the US EPA and the Regional Fund for Environmental Protection, Katowice Voivodeship. The Clearinghouse collects and disseminates Polish and international information on coalbed methane technologies and techniques. The Clearinghouse publishes, in Polish and English, a technical newsletter on coalbed methane developments in Poland. In October 1994, the Clearinghouse held the first Silesian International Conference on Coalbed Methane

Utilization, and it is anticipated that similar conferences will be conducted by the Clearinghouse in the future.

To ensure continued progress in encouraging coalbed methane development, additional institutional activities that will promote its recovery and utilization are recommended. These include:

- **Establishing more favorable tax conditions**. This could take the form of temporary, government-provided financial incentives. These incentives would be provided only until coalbed methane reaches parity with imported natural gas, and would then be withdrawn, much as the Unconventional Fuels Tax Credit spurred coalbed methane development in the US, and was eliminated as soon as coalbed methane became competitive with conventional natural gas.

- **Improved transfer of information between various government agencies and related institutions.** Once the best types of incentives for increased coalbed methane development have been identified, national policies and plans to encourage investment need to be coordinated among the government ministries. They should also be coordinated with regional and local authorities (voivodas and gminas), to increase their awareness of the local benefits of coalbed methane recovery and utilization.

- **Improved transfer of information between Polish and foreign experts.** There are experienced coalbed methane experts in Poland and other countries. It is important for them to share their knowledge, and recognize the potential contributions of one another to various coalbed methane projects in Poland. Programs should be established so that experts in various technologies can provide training to others; and foreign investors should avail themselves of Polish expertise.

Certain technical barriers to widespread coalbed methane utilization via the national gas transmission system still remain. These include:

- **Variations in gas supply and demand.** In some areas, expanded gas storage capacity is required in order to effectively utilize the methane that is produced. The ability to store coalbed methane can result in more effective utilization by allowing for seasonal fluctuations in demand. Gas storage experts should identify potential storage sites, and evaluate the most attractive storage options.

- **Variable or low gas quality.** Improved methane drainage systems (both surface and underground), including monitoring and management systems to maintain drained gas at consistently high quality, would help eliminate this problem. Depending upon the energy needs in the vicinity of particular mines, and the methane recovery programs that are most feasible, it may be necessary in some areas to upgrade medium-quality methane in order to develop uses for it. The need for gas enrichment should be considered as part of ongoing pre-feasibility studies, to ensure that the most effective utilization options are identified.

If these problems can be solved to the extent that gas purchasers (i.e., the POGC) can be assured an adequate year-round supply, consistently high quality, and long term contracts, it then follows that the POGC would pay producers the same price for this gas as it does for conventional natural gas. For methane that cannot meet pipeline standards, many local and regional utilization opportunities remain.

For coalbed methane to achieve its full potential as a viable, economical fuel source in Poland, substantial investment will be required. Polish and foreign governments, lending institutions, and private investors must provide the capital to finance various types of methane recovery, storage, and utilization projects The potential return on this investment, in economic, environmental, and energy security terms, appears promising.

PART II

PROFILES OF SELECTED GASSY MINES IN THE UPPER SILESIAN COAL BASIN

MINE PROFILES USER'S GUIDE

FORMAT

This section profiles 17 USCB mining concessions, summarizing salient features pertaining to the mines' coal and coalbed methane resources. Three appendices follow the profiles. Appendix A lists Polish government and mining contacts, along with their functions and addresses, which may be useful to the potential foreign investor. Appendix B explains Polish terminology regarding resources, coal rank, mining hazards, and other frequently used terminology pertaining to coal and coalbed methane. *Please consult Appendix B for information which, to avoid repetition, is not included in the individual mine profiles.* Appendix C consists of selected tables compiled on the 17 mines.

TERMINOLOGY

Economic and non-economic coal seams: Economic coal seams are those that can be mined economically using presently available mining methods. Non-economic coal seams are those that cannot be mined economically because they are too thin or too deep, are of insufficient quality, or are located in adverse mining conditions.

Run-of-mine (ROM) averages and mean averages: Average values pertaining to coal quality (ash content, heating value, and moisture content) are ROM values; that is, they are the average characteristics of the coal as reported by producers. Other values (not related to coal quality) presented as averages are simply mean values.

See Appendix B for additional terms.

MONETARY CONVERSIONS

Poland's energy prices and exchange rates change rapidly. Values are shown in zlotys, 1990 US Dollars, and where specified, 1994 US Dollars. The conversion rates used are: 1990: 9,572 Zlotys = $US 1; 1994: 22,795 Zlotys = $US 1.

COALBED METHANE RESOURCE ESTIMATES

Each of the mine profiles presents estimated methane reserves are presented based on the data in Table 9 (in Section 2.3 of Part I). Estimates of the total in situ methane resources were calculated by the Specific Emissions Method and the Methane Content Method (estimates are presented as a range). The estimation methods, and the uncertainties associated with each, are described in Section 2.3

CARBON DIOXIDE EQUIVALENTS

Investing in a coalbed methane recovery project may be a very cost-effective way to reduce greenhouse gas emissions. A number of US entities are initiating projects overseas to reduce greenhouse gas emissions as part of voluntary programs, such as the Department of Energy's *Climate Challenge* program with electric utilities. These organizations report their reductions under a program administered by the Department of Energy mandated by Section 1605(b) of the Energy Policy Act of 1992. Reductions are transferable, which makes potential reductions both very flexible and efficient.

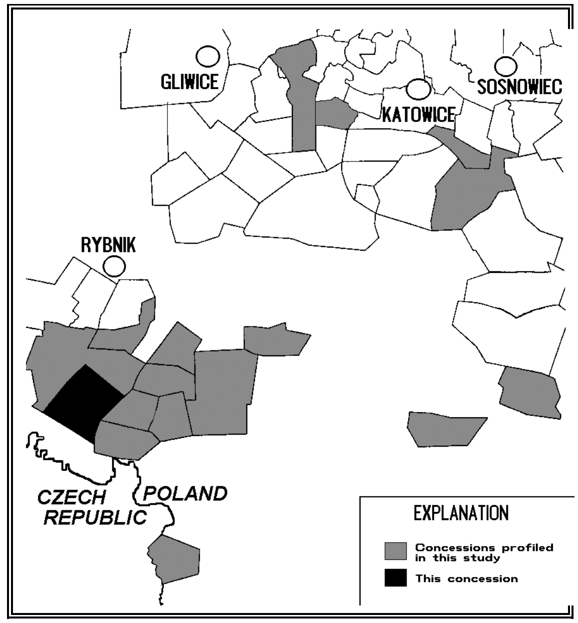
Under the 1605(b) guidelines, methane emissions reductions should be reported in units of methane. Methane is a very potent greenhouse gas, estimated to be between 19 and 43 times more potent than carbon dioxide (CO_2) on a weight basis over a 100-year period. In this report, a factor of 22 was used, because this is the US Government's current view of the relative potency of methane as compared to

CO_2. This factor implies that each ton of methane emissions avoided is equivalent in impact to reducing CO_2 emissions by 22 tons.[13]

For more information on the Section 1605(b) voluntary reporting program, contact the U.S. Department of Energy, Voluntary Reporting of Greenhouse Gases Program, Energy Information Administration, EI-81, 1000 Independence Avenue, SW, Washington, DC 20585.

[13] 1.49 billion cubic meters of methane is equal to 52 billion cubic feet (Bcf) or one million tons of methane.

The 1 Maja mining concession is located in the southwest quarter of the Polish part of the Upper Silesian Coal Basin, approximately 13 km south of the city of Rybnik, in the Rybnik coal region. 1 Maja is one of seven mines that comprise the Rybnicka Coal Company. The concession area occupies about 43 km^2. The mine commenced operation in 1960.



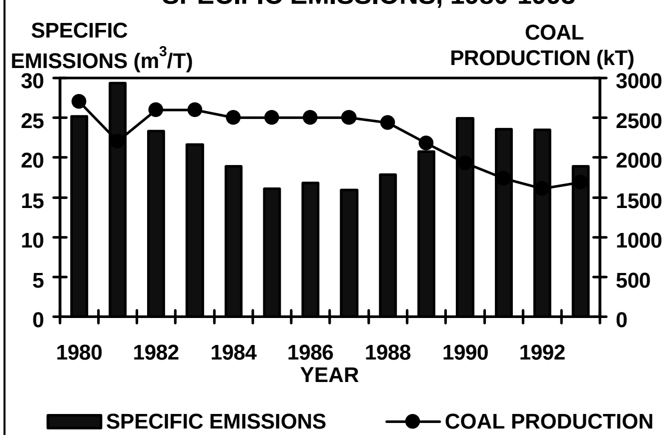
Geologic Setting. The 1 Maja concession is bounded on the east and west by two major thrust faults: the Michalkowice-Rybnik overthrust near the western boundary of the concession, and the Orlowa-Boguszowice overthrust near the eastern boundary of the concession. The southeast-northwest trending Marklowicki IV normal fault forms the northern boundary of the concession. Two other southeast-northwest trending normal faults also cross the concession. Carboniferous formations are overlain by a thick unconformable Miocene sequence which is not faulted. The average geothermal gradient is 2.78° C per 100 m.

Coal Rank. Coal rank ranges from sub-bituminous to low volatile bituminous (types 31 through 36), with medium and low volatile bituminous (type 35) accounting for 61 percent of the reserves.

COAL PRODUCTION AND SPECIFIC EMISSIONS

The mine has 2 working levels accessed by 7 shafts, 4 of which are ventilation shafts. Coal is mined by longwall methods from 19 working faces, with a combined length of 3,324 m. As of 1993, mining extended to a depth of 850 m. In 1990, all of the coal produced was medium and low volatile bituminous (type 35). Clean coal production was 1,400 tons per working day based on the combined surface and underground work force, and 3,700 tons per working day based solely on the underground work force.

GRAPH 1. COAL PRODUCTION AND SPECIFIC EMISSIONS, 1980-1993

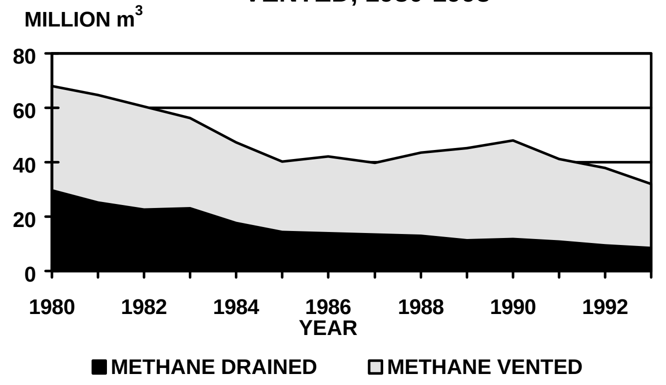


As shown in Graph 1, coal production was relatively steady during the period 1982-1987, then declined steadily through 1992. Production rose slightly in 1993, to 1.7 million tons. Graph 1 also shows that, following an increase during the period 1988-1992, specific emissions decreased slightly in 1993, to 18.9 m^3 of methane per ton of coal mined. This decrease may reflect a temporary shift in the stage of mine development.

METHANE LIBERATION, VENTILATION, RECOVERY, AND RESERVES

In 1993, a total of 32.0 million m^3 of methane were liberated from the 1 Maja mining concession. Of this, 8.5 million m^3 were drained, and 23.5 million m^3 were emitted via the ventilation system. Of the methane drained, 7.3 million m^3 were used, and the remaining 1.2 million m^3 were emitted.

GRAPH 2. METHANE DRAINED AND VENTED, 1980-1993



Trends in methane ventilation, drainage, and total liberation from 1980 through 1993 are shown in Graph 2. Note that the amount of methane vented and drained has been decreasing since 1990, in conjunction with an overall decrease in coal production. Mine management, however, would like to increase methane drainage, and forecasts that by year 2000 the amount of methane being drained will increase to about 10.2 million m^3 per year.

Desorption tests on coal samples from the concession indicate that methane content ranges up to 18 m^3 per ton. All of the coal mined from the 1 Maja concession in 1990 belonged to methane hazard Class IV, and the Central Mining Institute forecasts that this will still be the case in year 2000. According to Kotas (1994) however, there is evidence that the methane hazard for seams 600 and 700 (the primary seams mined at 1 Maja) is declining due to recovery of methane from sandstone surrounding the seams (the methane originates from the coal seams but migrates to the sandstone). This methane recovery is part of a surface drainage project in the nearby Marklowice area, launched in 1949 and continuing today; produced methane is sent to the local gas transmission network.

Mine Ventilation. Four ventilation shafts operate at the 1 Maja mining concession. The average concentration of methane in the ventilation shafts is 0.11 percent, and the maximum concentration is 0.22 percent. Air flow into the ventilation shafts is 33,132 m^3 per minute, and air flows out of the shafts at the rate of 38,423 m^3 per minute. Total power of the vent motors is 5,140 kW.

Methane Recovery. There were 786 drainage boreholes operating at the 1 Maja mining concession in 1991, with a total length of 66.8 km. Total length of the demethanization pipelines is 99.1 km, and their diameter ranges from 100 to 300 mm. Eight pumps and compressors are operating, with a total capacity of 352 m^3 per minute. In 1993, the average methane concentration in the gas used from 1 Maja was 59 percent, among the highest of any of the mines profiled.

In 1993, 64 percent of the methane recovered was drained from development areas, 6 percent was from working faces, and 30 percent was from gob areas.

Methane Resources. In-situ methane resources associated with balance reserves of coal are estimated to be 4.7-5.0 billion m^3.

PRESENT AND PLANNED UTILIZATION OF MINE METHANE

In 1993, 7.3 million m^3 of methane drained from the 1 Maja concession were used; this represents 86 percent of the methane drained from the concession. The mine's coal drying plant consumed some of this methane; additional gas was purchased by GOZG Zabrze (the POGC's Upper Silesian Gas Utility for transport to industrial users).

Pipelines from Shafts II and III of the 1 Maja mine are connected to the Swierklany gas compression station, approximately 8 km northeast of the mine. The pipeline connecting Shaft II is 250 mm in diameter, and is 7.3 km long; the pipeline connecting Shaft III is 350 mm in diameter and is 5.1 km long. GOZG Zabrze ceased purchasing mine gas in October, 1993, for reasons cited in Section 3.2.3 of Part I. As a result, some of this gas was vented to the atmosphere for a short period of time, but the 1 Maja mine and/or neighboring mines soon began using the additional gas on-site.

Mine management has not identified potential additional consumers of the concession's methane. However, estimates of the 1 Maja mine power plant's fuel use indicated that it could use as much as 36 million m^3 of methane annually (Pilcher et al, 1991). Although annual methane liberation from the mine totaled only 32 million m^3, and only 8.5 million of this was from drainage, improved techniques could substantially increase methane drainage from the working face and gob areas. This combined with pre-mining drainage could produce enough methane to supply most of the 1 Maja power plant's fuel needs.

MINING ECONOMICS[1]

In 1990, coal production costs at the 1 Maja mining concession totaled 493 billion zlotys ($US 52 million), or 251 thousand zlotys ($US 26) per ton of coal mined. Coal from the concession sold for 212 thousand zlotys ($US 22) per ton, at a loss of 39 thousand zlotys ($US 4) per ton.

Methane drainage costs totaled 5.5 billion zlotys ($US 575 thousand). Methane sales recovered 1.5 billion zlotys ($US 157 thousand). Methane thus cost 465 zlotys ($US 0.05) per m^3 to drain, and sold for 149 zlotys ($US 0.02) per m^3.

SALINE WATER

The 1 Maja mine discharges about 2200 m^3 of water containing 80 tons of chlorides and sulfates each day. The water quality is Group 3 and 4, indicating that its Cl and SO_4 concentration exceeds 1,800 mg/l, which is polluting. Mine water is initially held in the Olza Reservoir, which also gathers mine water from nine other coal mines, and is then discharged to a tributary of the Olza river. The purpose of the collecting reservoir is to protect the upper course of the Olza River and its tributary, the Szotkowka River. As of 1990, no other water management method was in use, and it is not clear how mine management intends to improve its saline water management.

[1] Both monetary conversions and energy prices are rapidly fluctuating. The cost and price data are from 1990. See the "Mine Profiles User's Guide."

SUMMARY DATA TABLES

COAL RESOURCES*

Number of Seams	Coal Seam Thickness (m)		Overburden Thickness (m)	Balance Coal Reserves* (Million Tons)			
	Economic	Non-Economic		A+B+C_1	C_2	1990 Total	1993 Total
34	0.7 - 1.6	0.3 - 0.7	54 - 471 m	118	150	268	263

COAL QUALITY

Ash Content (%)		Heating Value (kJ/kg)		Moisture (%)
As Received	ROM Average	Range	ROM Average	ROM Average
3-40	9	27,595-34,005	31,176	3.1

HAZARD DATA

Gas and Rock Outburst	Rock Bump Hazard	Dust Hazard	Water Hazard	Methane Hazard	Spontaneous Combustion
No Hazard	No Hazard	B (Present)	I (Low) and II (Medium)	IV (Very High)	I (Low)

CARBON DIOXIDE EQUIVALENTS (Million Tons)

CO_2 Equivalent of Total Methane Liberated (Vented and Drained), 1993	CO_2 Equivalent of Total Methane Drained, (Used and Released), 1993
0.47	0.11

PIPELINE DATA (1995)

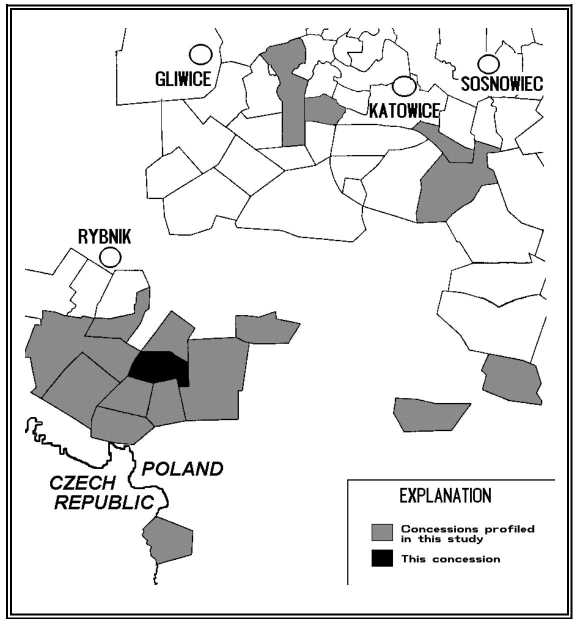
Distance to Nearest Pipeline	Owner / Manager of Pipeline
Connected by pipeline to Swierklany Compressor Station	GOZG Zabrze (subsidiary of the POGC)

MINE LIFE EXPECTANCY: Until 2005

PREP PLANT LOCATED ON SITE?: Yes

* A+B+C1 and C_2 sub-categories reflect 1990 data; 1993 sub-categorized reserve data were unavailable

The Borynia mining concession is located in the southwest quarter of the Polish part of the Upper Silesian Coal Basin, approximately 13 km southeast of the city of Rybnik. The concession area occupies 17.4 km^2. The mine opened in 1971, and since 1993 has been part of the Jastrzebie Coal Company.



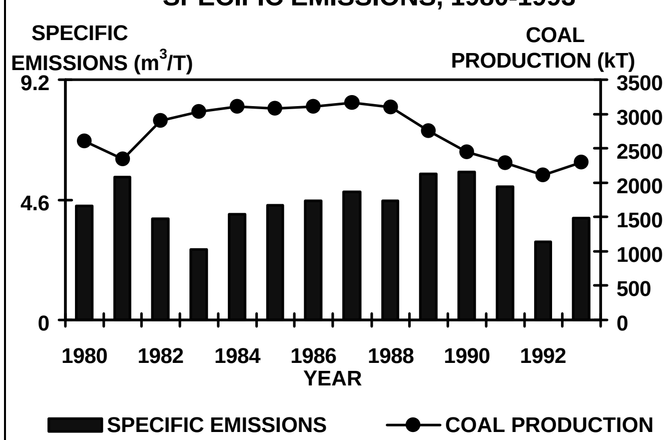
Geologic Setting. The Borynia mining concession lies in a structurally complex area. The Orlowa-Boguszowice thrust fault, with a local displacement of 1,100 m, lies just within the western boundary of the concession. Several north-south trending normal faults cross the concession, the largest of which is the Gogolowski fault; strata west of this fault are downthrown up to 140 m. Carboniferous formations are overlain by an unconformable Miocene sequence that is up to 300 m thick and is not penetrated by faults. The average geothermal gradient is 3.63° C per 100 m.

Coal Rank. Coal rank ranges from high volatile B bituminous to low volatile bituminous (types 34 through 36), with medium and low volatile bituminous (type 35) accounting for 92 percent of the reserves.

COAL PRODUCTION AND SPECIFIC EMISSIONS

The mine has 4 working levels accessed by 9 shafts, 5 of which are ventilation shafts. Coal is mined by longwall methods from 14 working faces, with a combined length of 2,402 m. As of 1993, mining extended to a depth of 713 m. In 1990, a total of 2.4 million tons of coal were produced, all of which were medium and low volatile bituminous (type 35). Clean coal production was 1,815 tons per working day based on the combined surface and underground work force.

GRAPH 1. COAL PRODUCTION AND SPECIFIC EMISSIONS, 1980-1993



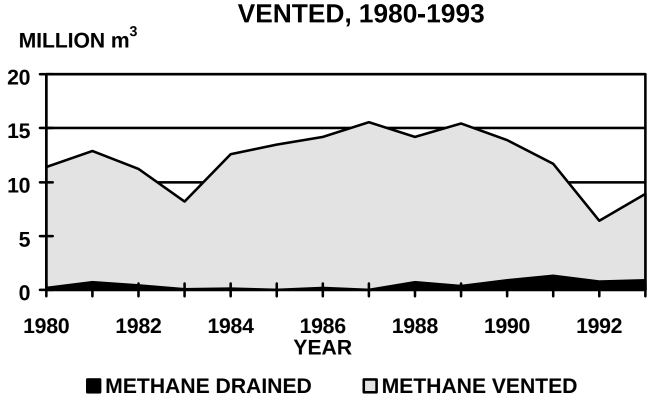
As shown in Graph 1, coal production was relatively constant during the period 1982-1988, then declined steadily through 1992. Production rose slightly in 1993, to 2.3 million tons. Graph 1 also shows that, trends in specific emissions have followed those in coal production since 1990; both were relatively low in 1992, but rebounded in 1993, when 3.9 m^3 of methane were liberated per ton of coal mined from the Borynia concession. This is the lowest ratio of any of the mines studied.

METHANE LIBERATION, VENTILATION, RECOVERY, AND RESERVES

In 1993, a total of 8.9 million m^3 of methane were liberated from the Borynia mining concession. Of this, 0.9 million m^3 were drained, and 8.0 million m^3 were emitted via the ventilation system. No methane was utilized.

Trends in methane ventilation, drainage, and total liberation from 1980 through 1993 are shown in Graph 2. The 1992 drop in methane drainage corresponds with an all-time low in coal production in the same year. The percentage of methane recovered by drainage at the Borynia mine is small; recovery efficiency is only 10 percent, one of the lowest of the 17 mines studied.

GRAPH 2. METHANE DRAINED AND VENTED, 1980-1993



Desorption tests on coal samples from the concession indicate that gas content ranges up to 6.0 m^3 per ton. All of the coal mined from the Borynia concession in 1990 belonged to methane hazard Class III; unlike most of the other concessions studied, no methane hazard Class IV coal seams are present at Borynia. The Central Mining Institute forecasts that by year 2000, all of the coal mined at Borynia will still be from methane hazard Class III. According to Kotas (1994), methane content is not expected to increase because the sorption capacity of the coal mined at Borynia decreases with depth.

Mine Ventilation. Three ventilation shafts operate at the Borynia mining concession. The average concentration of methane in the ventilation shafts is 0.05 percent, and the maximum concentration is 0.06 percent. Air flow into the ventilation shafts is 40,000 m^3 per minute, and air flows out of the shafts at the rate of 50,900 m^3 per minute. Total power of the vent motors is 4950 kW.

Methane Recovery. There were 32 drainage boreholes operating at the Borynia mining concession in 1991, with a total length of 2.3 km. Total length of the demethanization pipelines is 4.8 km (the shortest of any of the 17 mines studied), and their diameter ranges from 150-300 mm. Two pumps and compressors are operating, with a total capacity of 120 m^3 per minute. Concentration of methane in the main drainage pipeline was 57 percent.

In 1993, 6 percent of the methane recovered was drained from development areas, and 94 percent was drained from working faces; no methane was drained from gob areas.

Methane Resources. In-situ methane resources associated with balance reserves of coal are estimated to range from 2.0 - 3.2 billion m^3.

PRESENT AND PLANNED UTILIZATION OF MINE METHANE

None of the methane drained from the Borynia concession is used. Potential consumers include the mine's boiler and prep plant dryer. Estimates of the Borynia mine power plant's fuel use indicated that it could use as much as 11 m^3 of methane annually (Pilcher et al, 1991). Although annual methane liberation from the mine totaled only 8.9 million m^3, and only 0.9 million m^3 of this was from drainage, improved techniques could substantially increase methane drainage from working faces and gob areas. This combined with pre-mining drainage could produce enough methane to meet most of the power plant's fuel needs.

MINING ECONOMICS

In 1990, coal production costs at the Borynia mining concession totaled 495 billion zlotys ($US 52 million), or 204 thousand zlotys ($US 21) per ton of coal mined. Coal from the concession sold for 185 thousand zlotys ($US 19) per ton, at a loss of 19 thousand zlotys ($US 2) per ton.

In July 1994, coking coal from the Jastrzebie Coal Company (to which Borynia belongs) sold for 1.25-1.42 million zlotys ($US 55.3 - $62.4) per ton, depending on rank. Coal prices have thus risen substantially since 1990, as a result of coal price adjustments that have been made as a part of Poland's energy sector restructuring programs. Information on increases in production costs were unavailable.

In 1990, methane drainage costs totaled 1.4 billion zlotys ($US 146), or 1,588 zlotys ($US 0.17) per m^3 ; ventilation costs were 15.9 billion zlotys ($US 1.7 million), or 1,226 zlotys ($US 0.13) per m^3 . The total cost of methane control in 1990 was 17.3 billion zlotys ($US 1.8 million). More recent data concerning methane control costs were unavailable.

SALINE WATER

The Borynia mine discharges about 3200 m^3 of water containing 50 tons of salts each day. This water ranges from Group 1 (suitable for drinking) to Group 4 (highly polluting) in quality. Mine water is initially held in the Olza Reservoir, which also gathers mine water from nine other coal mines, and is then discharged to a tributary of the Olza river. The purpose of the collecting reservoir is to protect the upper course of the Olza River and its tributary, the Szotkowka River. Other details regarding present or planned saline water management methods were not available.

SUMMARY DATA TABLES

COAL RESOURCES*

Number of Seams	Coal Seam Thickness (m)		Overburden Thickness (m)	Balance Coal Reserves* (Million Tons)			
	Economic	Non-Economic		$A+B+C_1$	C_2	1990 Total	1993 Total
53	0.7-4.5	0.3	247-590	454	138	592	525

COAL QUALITY

Ash Content (%)		Heating Value (kJ/kg)		Moisture (%)
As Received	ROM Average	Range	ROM Average	ROM Average
3.2-34.8	13	27,000-34,000	31,000	1.75

HAZARD DATA

Gas and Rock Outburst	Rock Bump Hazard	Dust Hazard	Water Hazard	Methane Hazard	Spontaneous Combustion
No Hazard	No Hazard	B (Present)	I (Low) and II (Medium)	III (High)	I (Low)

CARBON DIOXIDE EQUIVALENTS (Million Tons)

CO_2 Equivalent of Total Methane Liberated (Vented and Drained), 1993	CO_2 Equivalent of Total Methane Drained, 1993
0.13	0.01

PIPELINE DATA

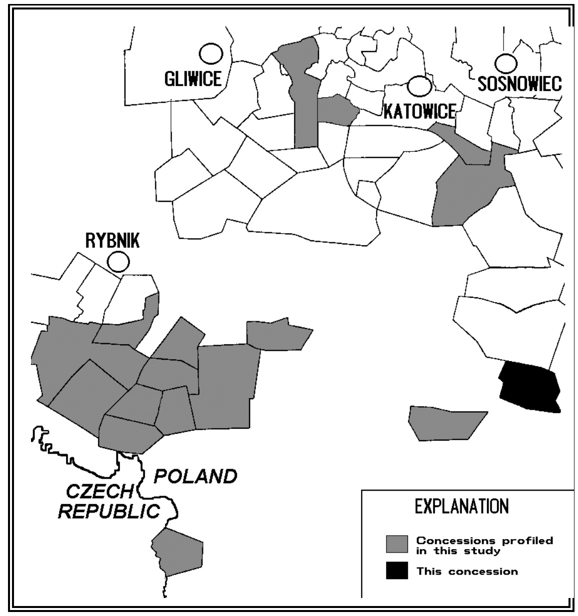
Distance to Nearest Pipeline	Owner / Manager of Pipeline
Connected by pipeline to Swierklany Compressor Station	GOZG Zabrze (subsidiary of the POGC)

MINE LIFE EXPECTANCY: More than 20 years

PREP PLANT LOCATED ON SITE?: Yes

*$A+B+C_1$ and C_2 sub-categories reflect 1990 data; 1993 sub-categorized reserve data were unavailable

The Brzeszcze mining concession is located in the southeastern part of the Upper Silesian Coal Basin at the junction of the Wisla and Sola rivers, approximately 33 km south of the city of Sosnowiec. The authors' estimate of the concession area, based on a digitized map, is about 32 km^2, but a report written by mine management states that it is 26.2 km^2. The mine commenced operation in 1903, and in 1993 became part of the Nadwislanska Coal Company.

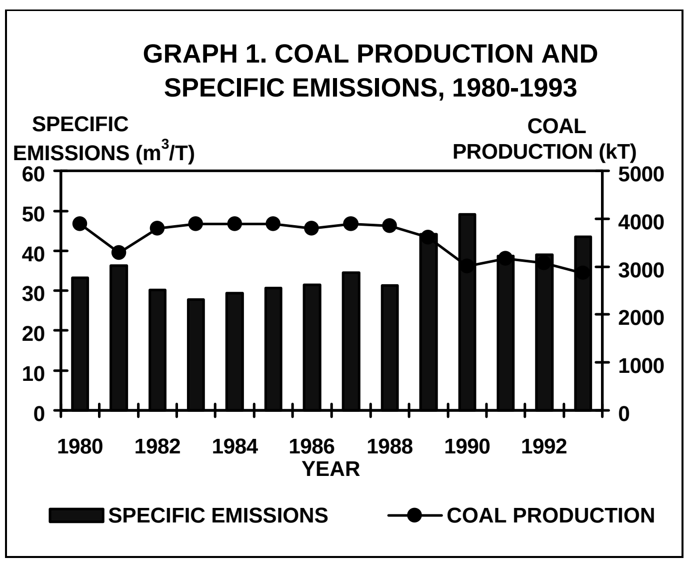


Geologic Setting. The concession is bounded on the south by the Jawiszowice fault, which has a displacement of up to 350 m and dips 45°. Coal seams along this fault are very gassy; methane content decreases eastward across the concession. The Wisla fault, which plunges 55°, forms the northwest boundary of the concession. A series of horsts and grabens is present in the concession. Carboniferous formations are apparently overlain by an unconformable Miocene sequence in at least part of the concession. Coal seams contained in the Orzesze, and Rudy formations are characterized by especially high methane contents. The average geothermal gradient is 4.0° C per 100 m.

Coal Rank. Coal rank ranges from sub-bituminous through high volatile bituminous A (types 31 through 34) with sub-bituminous to high volatile bituminous B (types 31 and 32) accounting for 71 percent of the reserves.

COAL PRODUCTION AND SPECIFIC EMISSIONS

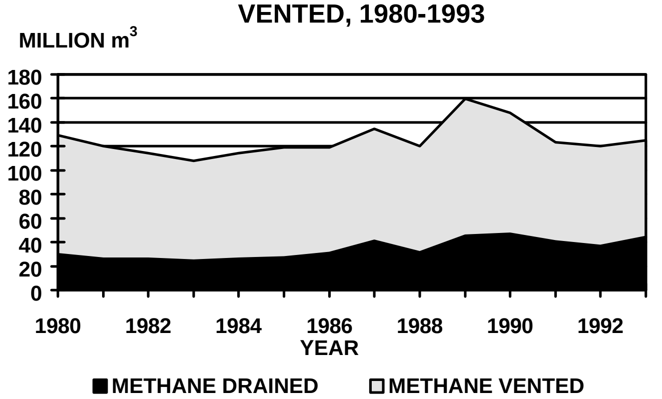
The mine has 9 working levels accessed by 7 shafts, 4 of which are ventilation shafts. Coal is mined by longwall methods from 10 working faces, with a combined length of 1,791 m. As of 1993, the maximum mining depth at Brzeszcze was 740 m. In 1990, all of the coal produced was sub-bituminous to high volatile bituminous B (type 31 and 32). Clean coal production was 2,100 tons per working day based on the combined surface and underground work force, and 3,900 tons per working day based solely on the underground work force.



As shown in Graph 1, coal production was relatively steady during the period 1982-1988, and has since declined, with 2.9 million tons produced in 1993. Specific emissions have remained high in recent years, with 43.5 m^3 of methane liberated per ton of coal mined from the Brzeszcze concession in 1993.

METHANE LIBERATION, VENTILATION, RECOVERY AND RESERVES

GRAPH 2. METHANE DRAINED AND VENTED, 1980-1993



The Brzeszcze mine is one of the most gassy in Europe, and in Poland is second only to Pniowek in terms of methane liberation. In 1993, a total of 124.9 million m^3 were liberated by mining. Of this, 44.5 million m^3 were drained, and 80.4 million m^3 were emitted via the ventilation system. Of the methane drained, 44.1 million m^3 were utilized, and the remaining 0.4 million m^3 were emitted to the atmosphere.

Trends in methane ventilation, drainage, and total liberation from 1980 through 1993 are shown in Graph 2. Methane liberation reached its highest levels in 1989 and then declined until 1993. According to mine's chief ventilation engineer, methane liberation is expected to increase in the years to come, as deeper levels of the mine are exploited.

Desorption tests on coal samples from the concession, unadjusted for lost gas, indicate that gas content is up to 15 m^3 per ton. All of the coal mined at the Brzeszcze concession is from methane hazard Class IV seams, and this is expected to remain the case in the future.

Mine Ventilation. Four ventilation shafts operate at the Brzeszcze mining concession. The average concentration of methane in the ventilation shafts is 0.36 percent, and the maximum concentration is 0.62 percent. Air flow into the ventilation shafts is 29,700 m^3 per minute, and air flows out of the shafts at the rate of 35,500 m^3 per minute. Total power of the vent motors is 3,800 kW.

Methane Recovery. There were 643 drainage boreholes operating at the Brzeszcze mining concession in 1991, with a total length of 51.04 km. Total length of the demethanization pipelines is 48.20 km, and their diameter ranges from 100-500 mm. Eight pumps and compressors are operating, with a total capacity of 480 m^3 per minute, making it one of the larger-capacity systems at the profiled mines. In 1993, the average concentration of methane in gas used from the Brzeszcze mine was 50 percent.

In 1993, 13 percent of the total methane recovered was drained from development areas, 44 percent was from working faces, and 43 percent was from gob areas.

According to a report by mine management, difficulties in recovering methane from development areas have been encountered due to the high sorption characteristics of the coal. To address this issue, the mine would like to improve its pre-mining methane drainage techniques. Drainage from gob areas has increased during the past decade as a result of extensive sealing of gob areas. The mine plans to focus on improving methane drainage at the working face as its primary means of increasing overall methane recovery. Use of vertical wells for pre-mining degasification and gob gas recovery is also planned.

Methane Resources. In-situ methane resources associated with balance reserves of coal are estimated to be 6.1 - 17.7 billion m^3.

PRESENT AND PLANNED UTILIZATION OF MINE METHANE

In 1993, 44.1 million m^3 of methane drained from the Brzeszcze mining concession were used; this represents more than 99 percent of the methane drained from the concession and 35 percent of the total methane liberated. Most of the methane was consumed by the Oswiecim chemical plant, while the remainder was consumed by the heating plant at the Brzeszcze mine.

Mine management has recently increased methane drainage, by using larger diameter degasification pipes, modernizing drilling equipment, building the second phase of methane compressors at the demethanization station, and generally improving compressor parameters.

McCormick Poland (a major US coalbed methane producer) has partnered with the Nadwislanska Coal Company and it is expected that methane will be recovered from the Brzeszcze mine using vertical wells for pre-mining and gob recovery. A feasibility study for power generation at the mine based on coalbed methane-fired turbines has been conducted.

MINING ECONOMICS

In 1990, coal production costs at the Brzeszcze mining concession totaled 552 billion zlotys ($US 58 million), or 186 thousand zlotys ($US 19) per ton of coal mined. Coal from the concession sold for 112 thousand zlotys ($US 12) per ton, a loss of 74 thousand zlotys ($US 7) per ton.

Methane drainage costs totaled 6.6 billion zlotys ($US 690 thousand). Methane sales recovered 3.8 billion zlotys ($US 397 thousand). Methane thus cost 140 zlotys ($US 0.015) per m^3 to drain (among the lowest of any of the mines studied), and sold for 81 zlotys ($US 0.008) per m^3. Ventilation costs were 5.8 billion zlotys ($US 606 thousand), or 58 zlotys ($US 0.006) per m^3. The total cost of methane control in 1990 was 12.4 billion zlotys ($US1.3 million), at a loss of 59 zlotys ($US 0.007) per cubic meter.

More recent data concerning economics at the Brzeszcze mine were unavailable. It is likely that the sales price of methane from this mine is now higher than it was in 1990. If its 1994 sales price was roughly equal to that received by the Jastrzebie Coal Company, methane drainage is now likely to be profitable at the Brzeszcze mine.

SALINE WATER

The Brzeszcze mine discharges about 10,400 m^3 of water containing 62 tons of chlorides and sulfates to the Wisla River drainage each day. Mine water is initially held in the Brzeszcze Reservoir, which was intended as a storage pond from which saline water would be discharged to the Wisla during periods of high flow. However, the capacity of the reservoir (1 million m^3) is too small to contain the quantity of water discharged from the mine, and thus the saline water is discharged to the river regardless of its flow rate.

Recently, the mine has begun a program of capturing the most highly saline waters in back fillings. Fly ash is mixed with preparation plant waste materials to yield a solid back filling that captures about 30 percent of the saline water.

SUMMARY DATA TABLES

COAL RESOURCES

Number of Seams	Coal Seam Thickness (m)		Overburden Thickness (m)	Balance Coal Reserves* (Million Tons)			
	Economic	Non-Economic		$A+B+C_1$	C_2	1990 Total	1993 Total
34	0.8 - 3.5	0.6 - 2.0	6.5 -258 m	118	150	268	263

COAL QUALITY

Ash Content (%)		Heating Value (kJ/kg)		Moisture (%)
As Received	ROM Average	Range	ROM Average	ROM Average
7.6 - 20	12.7	26,500-29,300	27,400	5.5

HAZARD DATA

Gas and Rock Outburst	Rock Bump Hazard	Dust Hazard	Water Hazard	Methane Hazard	Spontaneous Combustion
Hazardous	No Hazard	B (Present)	I (Low)	II (Medium) - IV (Very High)	I (Low) - IV (Very High)

CARBON DIOXIDE EQUIVALENTS (Million Tons)

CO_2 Equivalent of Total Methane Liberated (Vented and Drained), 1993	CO_2 Equivalent of Total Methane Drained, (Used and Released), 1993
1.84	0.66

PIPELINE DATA (1995)

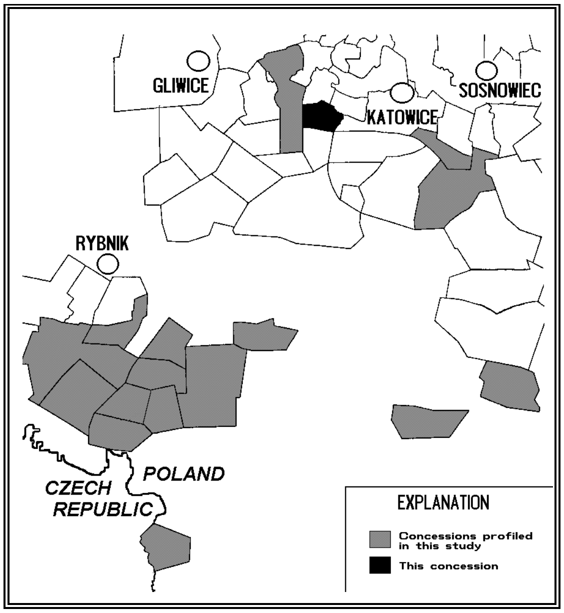
Distance to Nearest Pipeline	Owner / Manager of Pipeline
Connected by pipeline to Oswiecim Chemical Plant	GOZG Zabrze (subsidiary of the POGC)

MINE LIFE EXPECTANCY: More than 20 years

PREP PLANT LOCATED ON SITE?: Yes

* A+B+C1 and C_2 sub-categories reflect 1990 data; 1993 sub-categorized reserve data were unavailable

The Halemba mining concession is located in the northwest quarter of the Upper Silesian Coal Basin, within the town of Halemba-Ruda Slaska. Halemba is one of nine mines that comprise the Rudzka Coal Company. The concession area occupies about 13 km^2. The mine commenced operation in 1957.



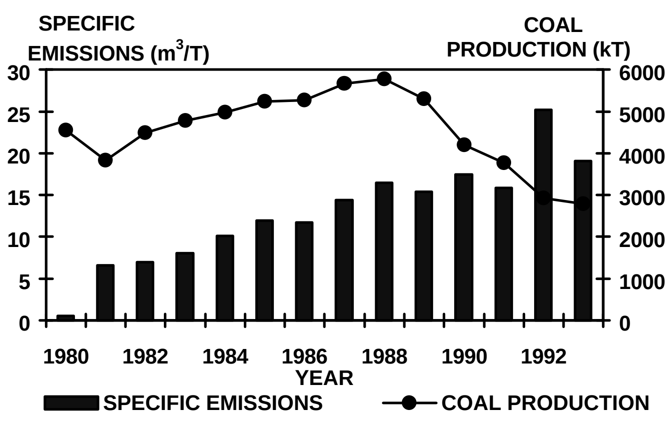
Geologic Setting. Strata underlying this concession generally dip southward. An east-west trending zone of normal faulting, comprising the Klodnicki and Dorotka faults, essentially forms the southernmost boundary of the Halemba mining concession. Strata south of the fault zone are downthrown approximately 400 m relative to those north of the fault zone. Several north-south trending normal faults are also present, with displacement to 60 m on the eastern side of the concession. The average geothermal gradient is 2.78° C per 100 m.

Coal Rank. Coal rank ranges from high volatile C bituminous to medium volatile bituminous (types 32 through 35) with high volatile A and B bituminous (type 34) accounting for 56 percent of the reserves.

COAL PRODUCTION AND SPECIFIC EMISSIONS

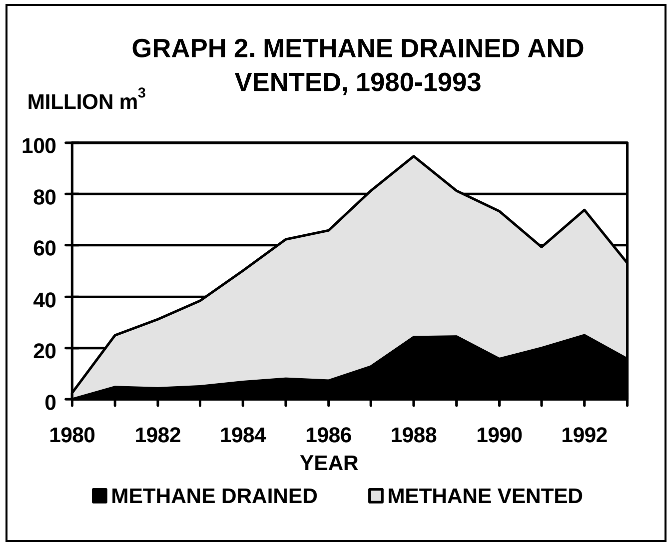
The mine has 4 working levels accessed by 9 shafts, 5 of which are ventilation shafts. Coal is mined by longwall methods from 9 working faces, with a combined length of 1500 m. As of 1993, mining extended to a depth of 1,030 m. In 1990, a total of 4.2 million tons of coal were produced, 3.9 million tons of which were high volatile B bituminous (type 33, power coal) and the remainder of which were high volatile A and B bituminous (type 34, coking coal). Clean coal production was 2,400 tons per working day based on the combined surface and underground work force, and 5,011 tons per working day based solely on the underground work force.

GRAPH 1. COAL PRODUCTION AND SPECIFIC EMISSIONS, 1980-1993



As shown in Graph 1, coal production increased gradually from 1981 through 1988, then began declining sharply. In 1993, 2.8 million tons were produced. Graph 1 also shows that specific emissions were higher in 1992 than any previous year. It is possible that very gassy coal was mined during that year, perhaps reflecting new development at the mine. Specific emissions decreased in 1993 to 19.1 m^3/ton.

METHANE LIBERATION, VENTILATION, RECOVERY, AND RESERVES



In 1993, a total of 53.0 million m^3 of methane were liberated from the Halemba mining concession, ranking it fourth, of all mines studied, in terms of methane liberation. Of this, 15.6 million m^3 were drained, and 37.4 million m^3 were emitted via the ventilation system. Of the methane drained, 3.0 million m^3 were used, and the remaining 12.6 million m^3 were emitted. Mine officials predict decreasing levels of methane liberation in the future.

Desorption tests on coal samples from the concession, unadjusted for lost gas, indicate that gas content is up to 20 m^3 per ton. Coal of all classes of methane hazard was mined from the Halemba Concession in 1990; 33 percent of the coal was from Class IV seams, 24 percent was from Class III seams, 12 percent was from Class II seams, 16 percent was from Class I seams, and 15 percent was from Class 0 seams. The Central Mining Institute forecasts that by year 2000, the mine will be gassier, with 50 percent of the coal mined from the Halemba concession from Class IV seams, 23 percent from Class III seams, 10 percent from Class II seams, 5 percent from Class I seams, and 12 percent from Class 0 seams.

Mine Ventilation. Five ventilation shafts operate at the Halemba mining concession. The average concentration of methane in the ventilation shafts is 0.15 percent, and the maximum concentration is 0.4 percent. Air flow into the ventilation shafts is 40,000 m^3 per minute, and air flows out of the shafts at the rate of 50,900 m^3 per minute. Total power of the vent motors is 6,965 kW.

Methane Recovery. There were 42 drainage boreholes operating at the Halemba mining concession in 1991, with a total length of 3.39 km. Total length of the demethanization pipelines is 20.5 km, and their diameter ranges from 100 to 350 mm. Eleven pumps and compressors are operating, with a total capacity of 406 m^3 per minute, making it one of the larger-capacity systems of the mines profiled. In 1993, the average concentration of methane in gas utilized from the Halemba mine was only 45 percent.

In 1993, 13 percent of all methane recovered was drained from development areas, 73 percent was drained from working faces, and 14 percent was drained from gob areas. The relationship between gas recovery sources varies from year to year depending on the number of drainage holes, the position of the longwalls, and coal production levels.

Methane Resources. In-situ methane resources associated with balance reserves of coal are estimated to be 11.0-11.5 billion m^3.

PRESENT AND PLANNED UTILIZATION OF MINE METHANE

In 1993, 3 million m^3 of methane drained from the Halemba mining concession were used; this represents only 15 percent of the methane drained from the concession. Most of the methane was consumed by the heat plant at the Halemba mine; some may also have been used by the Lech heating plant at the nearby Pokoj mine.

Halemba used only 3 million m^3 of the nearly 16 million m^3 of methane it recovered from the mine. The unused methane represents about 436 terajoules of energy, or 121 GWh of electricity. Future mine management plans for methane use include building a boiler heat plant at the main shaft, and possibly installing a gas turbine. The US Trade and Development Agency, in conjunction with the State Hard Coal Agency, is presently examining the feasibility of using vertical wells (both surface and gob) to recover coalbed methane and identify the most promising utilization option. Elektrogas Ventures has also expressed interest in building a power plant fueled by methane from the mine. Residential users of natural gas in the surrounding community of Ruda Slaska-Halemba are another potential consumer.

MINING ECONOMICS

In 1990, coal production costs at the Halemba mining concession totaled 667 billion zlotys ($US 70 million), or 156 thousand zlotys ($US 16) per ton of coal mined. Coal from the concession sold for 135 thousand zlotys per ton ($US 14), at a loss of 21 thousand zlotys ($US 2) per ton.

Methane drainage costs were reportedly 3.1 billion zlotys ($US 324 thousand). Methane sales recovered 197 million zlotys ($US 21 thousand). Methane thus cost 196 zlotys ($US 0.02) per m^3 to drain, and sold for 129 zlotys ($US 0.013) per m^3. Ventilation cost 9.6 billion zlotys ($US 1 million), or 167 zlotys ($US 0.017) per m^3. The total cost of methane control was thus $12.7 billion zlotys ($US 1.3 million), or 363 zlotys ($US 0.038).

More recent data concerning mining economics at Halemba were unavailable. It is likely that the sales price of methane from this mine is now higher than it was in 1990. If its current sales price is roughly equal to that of methane from the Jastrzebie Coal Company, methane drainage may now be profitable at the Halemba mine.

SALINE WATER

The mine discharged about 4,500 m^3 of water containing 31 tons of chlorides and sulfates to the Klodnica River each day. It is not known what type of saline water management program is presently employed or planned for the future.

SUMMARY DATA TABLES

COAL RESOURCES

Number of Seams	Coal Seam Thickness (m)		Overburden Thickness (m)	Balance Coal Reserves* (Million Tons)			
	Economic	Non-Economic		A+B+C_1	C_2	1990 Total	1993 Total
40	0.7 - 8.6	0.4 - 6.2	2 - 95 m	449	106	555	573

COAL QUALITY

Ash Content (%)		Heating Value (kJ/kg)		Moisture (%)
As Received	ROM Average	Range	ROM Average	ROM Average
20-50	40	13,000-24,000	17,500	6

HAZARD DATA

Gas and Rock Outburst	Rock Bump Hazard	Dust Hazard	Water Hazard	Methane Hazard	Spontaneous Combustion
No Hazard	None-III (High)	Present	I (Low) - II (Medium)	0 (Very Low) -IV (Very High)	I (Low) - IV (High)

CARBON DIOXIDE EQUIVALENTS (Million Tons)

CO_2 Equivalent of Total Methane Liberated (Vented and Drained), 1993	CO_2 Equivalent of Total Methane Drained, (Used and Released), 1993
0.79	0.24

PIPELINE DATA (1995)

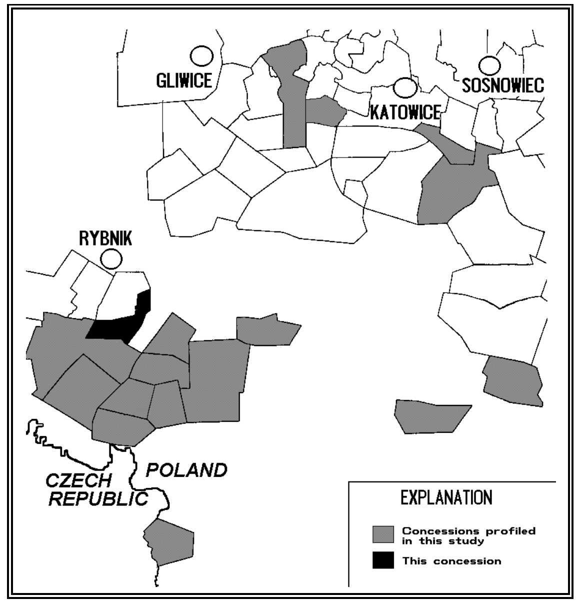
Distance to Nearest Pipeline	Owner / Manager of Pipeline
Surrounding community contains pipeline network	GOZG Zabrze (subsidiary of the POGC)

MINE LIFE EXPECTANCY: More than 20 years

PREP PLANT LOCATED ON SITE?: Yes

***** A+B+C_1 and C_2 sub-categories reflect 1990 data; 1993 sub-categorized reserve data were unavailable

JANKOWICE

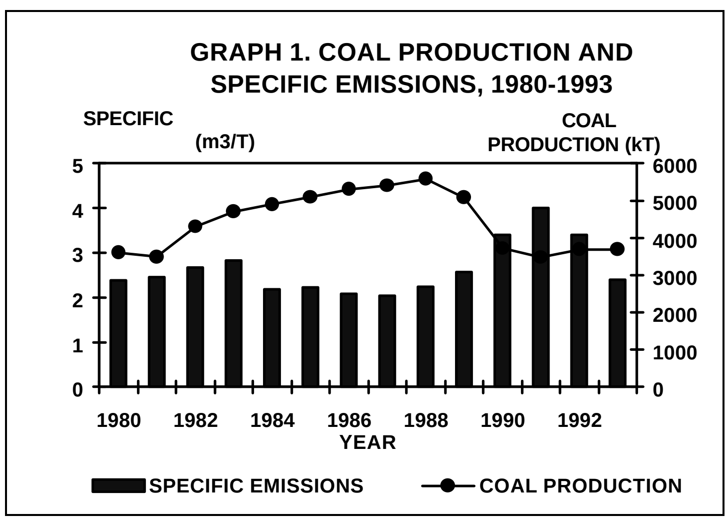


The Jankowice mining concession is located in the southwestern portion of the Polish part of the Upper Silesian Coal Basin, approximately 6 km southeast of the city of Rybnik. Jankowice is one of seven mines that comprise the Rybnicka Coal Company. The concession area occupies about 19 km^2. The mine commenced operation in 1916.

Geologic Setting. The concession is bounded on the west by the Michalkowice-Rybnik thrust fault. A series of normal faults form the northern boundary of the concession. Of these normal faults, the greatest displacement (200 m) is along Fault "E", located at the extreme northeast boundary of the concession. Carboniferous formations are unconformably overlain by a Miocene sequence, which is not penetrated by faults. The average geothermal gradient is 3.33° C per 100 m.

Coal Rank. Coal rank ranges from sub-bituminous through high volatile bituminous A (types 31 through 34) with sub-bituminous to high volatile bituminous B (types 31 and 32) accounting for 73 percent of the reserves.

COAL PRODUCTION AND SPECIFIC EMISSIONS



The mine has 7 working levels accessed by 7 shafts, 3 of which are ventilation shafts. Coal is mined by longwall methods from 14 working faces, with a combined length of 2,269 m. As of 1993, mining extended to a depth of 565 m. In 1990, all of the coal produced was sub-bituminous to high volatile bituminous (types 31 and 32). Clean coal production was 2,291 tons per working day based on the combined surface and underground work force, and 5,164 tons per working day based solely on the underground work force.

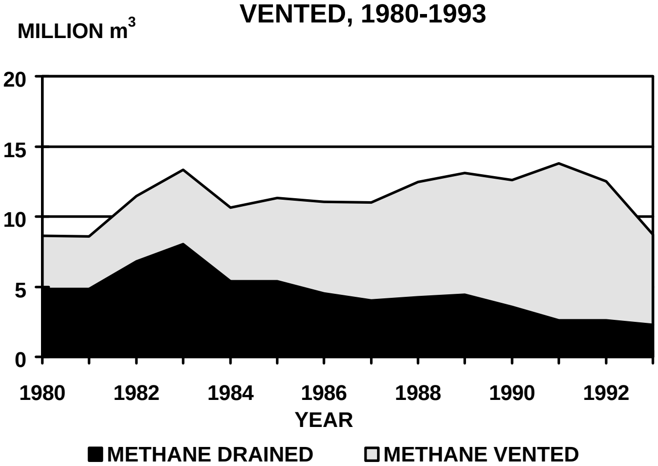
As shown in Graph 1, coal production peaked in 1988, then declined sharply until 1990, remaining fairly steady since then; in 1993, the mine produced 3.7 million tons of coal. Specific emissions peaked in 1991, perhaps reflecting new development at the mine, and have since declined to near 1989 levels. In 1993, 2.4 m^3 of methane were liberated per ton of coal mined from the concession.

METHANE LIBERATION, VENTILATION, RECOVERY, AND RESERVES

In 1993, a total of 8.7 million m^3 of methane were liberated from the Jankowice mining concession. Of this, 2.3 million m^3 were drained, and 6.4 million m^3 were emitted via the ventilation system. Of the methane drained, 1.7 million m^3 were used, and 0.6 million m^3 were emitted to the atmosphere.

Trends in methane ventilation, drainage, and total liberation from 1980 through 1993 are shown in Graph 2. In 1993, methane drainage was at its lowest level of any time during this period. Recovery efficiency has generally declined throughout the period.

GRAPH 2. METHANE DRAINED AND VENTED, 1980-1993



In 1993, 2.4 m^3 of methane were liberated per ton of coal mined from the Jankowice concession. Desorption tests on coal samples from the concession indicate that gas content is up to 15 m^3 per ton. Class II and III seams each accounted for 35 percent of the coal mined in 1990; the remaining 30 percent was mined from Class I seams. The Central Mining Institute predicts that by year 2000 the mine will be gassier, with 50 percent of the coal mined from Class III seams, 30 percent from Class II seams, and 20 percent from Class I seams. This could cause an increase in methane emissions.

Mine Ventilation. Three ventilation shafts operate at the Jankowice mining concession. The average concentration of methane in the ventilation shafts is 0.05 percent, and the maximum concentration is 0.07 percent. Air flow into the ventilation shafts is 41,720 m^3 per minute, and air flows out of the shafts at the rate of 44,530 m^3 per minute. Total power of the vent motors is 5,500 kW.

Methane Recovery. The first methane drainage system in Poland was put into operation at the Jankowice mine in 1952. By 1991, there were 153 drainage boreholes operating, with a total length of 10.41 km. Total length of the demethanization pipelines is 9.59 km, and their diameter ranges from 100-300 mm. Three pumps and compressors are operating, with a total capacity of 90 m^3 per minute. In 1993, the average concentration of methane in gas consumed from the Jankowice mine was 54 percent.

In 1993, 55 percent of all methane recovered was drained from development areas, 20 percent was drained from working faces, and 25 percent was drained from gob areas. The relationship between gas recovery sources varies from year to year depending on the number of drainage holes, the position of the longwalls, and coal production levels.

Methane Resources. In-situ methane resources associated with balance reserves of coal are estimated to range from 2.2 billion to 13.9 billion m^3.

PRESENT AND PLANNED UTILIZATION OF MINE METHANE

In 1993, 1.7 million m^3 of methane drained from the Jankowice mining concession were used; this represents 74 percent of the methane drained from the concession. The Jankowice mine power plant, located 6 km from the mine, was the primary consumer of this methane; additional gas was purchased by GOZG Zabrze (the POGC's Upper Silesian Gas Utility) for transport to industrial users.

The mine is connected to the Swierklany compressor station, which is south of the mine, by 1.6 km of pipeline with a diameter of 350 mm. GOZG Zabrze ceased purchasing mine gas in October, 1993, for reasons cited in Section 3.2.3 of Part 1. As a result, some of this gas was vented to the atmosphere for a short period of time, but the Jankowice mine and/or neighboring mines soon began using the additional gas on-site.

Mine management has proposed increasing methane drainage in advance of, during, and after mining, but has not identified any additional potential methane consumers. However, estimates of the Jankowice mine power plant's fuel use indicated that it could use up to 67 million m^3 of methane annually (Pilcher et al, 1991).

MINING ECONOMICS

In 1990, coal production costs at the Jankowice mining concession totaled 493 billion zlotys ($US 52 million, or 137 thousand zlotys ($US 14) per ton of coal mined. Coal from the concession sold for 103 thousand zlotys ($US 11) per ton, at a loss of 34 thousand zlotys ($US 3) per ton.

Methane drainage costs totaled 1.3 billion zlotys ($US 136 thousand) in 1990. Methane sales recovered 337 million zlotys ($US 35 thousand). Methane thus cost 472 zlotys ($0.05 USD) per m^3 to drain, and sold for 150 zlotys ($US 0.02) per m^3.

More recent data concerning mining economics were unavailable.

SALINE WATER

The Jankowice mine discharges about 5100 m^3 of water containing 73 tons of chlorides and each day. Mine water is initially held in the Olza Reservoir, which also gathers mine water from nine other coal mines, and is then discharged to a tributary of the Olza river. The purpose of the collecting reservoir is to protect the upper course of the Olza River and its tributary, the Szotkowka River. Other details regarding present or planned saline water management methods were not available.

SUMMARY DATA TABLES

COAL RESOURCES

Number of Seams	Coal Seam Thickness (m)		Overburden Thickness (m)	Balance Coal Reserves* (Million Tons)			
	Economic	Non-Economic		$A+B+C_1$	C_2	1990 Total	1993 Total
80	0.8-15.5	0.7-1.0	40-300	430	505	935	573

COAL QUALITY

Ash Content (%)		Heating Value (kJ/kg)		Moisture (%)
As Received	ROM Average	Range	ROM Average	ROM Average
2-35	16	18,000-32,500	27,000	5.7

HAZARD DATA

Gas and Rock Outburst	Rock Bump Hazard	Dust Hazard	Water Hazard	Methane Hazard	Spontaneous Combustion
No Hazard	No hazard	Present	I (Low) and II (Medium)	I (Low) - III (High)	II (Medium) - IV (Very High)

CARBON DIOXIDE EQUIVALENTS (Million Tons)

CO_2 Equivalent of Total Methane Liberated (Vented and Drained), 1993	CO_2 Equivalent of Total Methane Drained, (Used and Released), 1993
0.13	0.03

PIPELINE DATA (1995)

Distance to Nearest Pipeline	Owner / Manager of Pipeline
Connected by pipeline to Swierklany Compressor Station	GOZG Zabrze (subsidiary of the POGC)

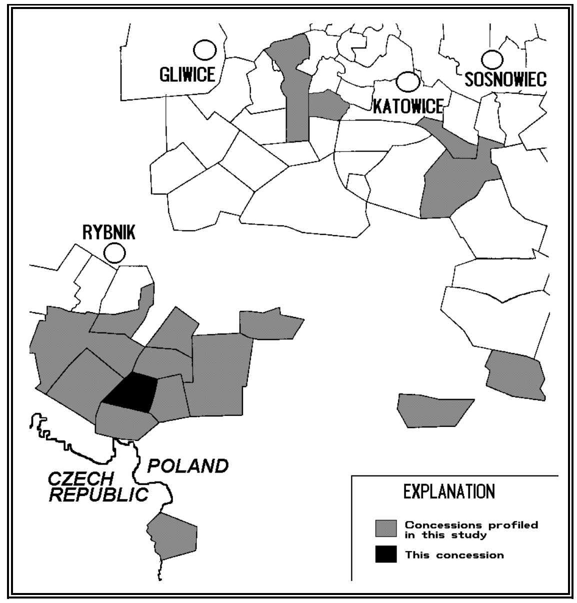
MINE LIFE EXPECTANCY: More than 20 years

PREP PLANT LOCATED ON SITE?: Yes

* $A+B+C_1$ and C_2 sub-categories reflect 1990 data; 1993 sub-categorized reserve data were unavailable

JASTRZEBIE

The Jastrzebie mining concession is located in the southwestern portion of the Polish part of the Upper Silesian Coal Basin, approximately 14 km south of the city of Rybnik. The concession area occupies 16.4 km^2. Coal production started in 1962, and the mine became part of the Jastrzebie Coal Company in 1993.



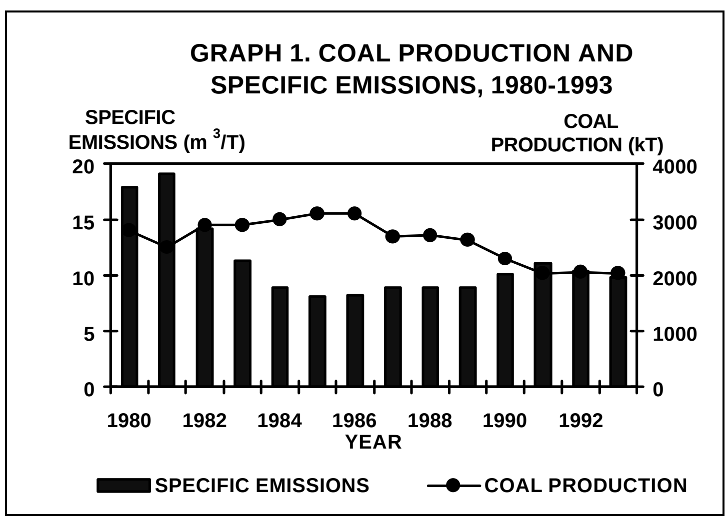
Geologic Setting. The concession is bounded on the west by the Orlowa thrust fault. Other, low angle reverse faults related to this feature are present, and they extend through unconformably overlying Miocene strata to the surface. Several north-south trending normal faults are also present, but there is little displacement along these faults. The average geothermal gradient is 3.33° C per 100 m.

Coal Rank. Coal rank is medium and low volatile bituminous (types 35 through 37) with medium volatile bituminous (type 35) accounting for 80 percent of the reserves.

COAL PRODUCTION AND SPECIFIC EMISSIONS

The mine has 3 working levels accessed by 6 shafts, 4 of which are ventilation shafts. Coal is mined by longwall methods from 16 working faces, with a combined length of 2,456 m. As of 1989, mining extended to a depth of 650 m. In 1990, a total of 2.3 million tons of coal were produced, 1.9 million tons of which were medium volatile bituminous (type 35) and 0.4 million tons of which were low volatile bituminous (types 36 and 37). Clean coal production was 1,749 tons per working day based on the combined surface and underground work force, and 4,203 tons per working day based solely on the underground work force.

As shown in Graph 1, coal production declined from 1986 until 1991; output has been fairly steady since 1991. In 1993, 2.0 million tons of coal were produced from the Jastrzebie concession.

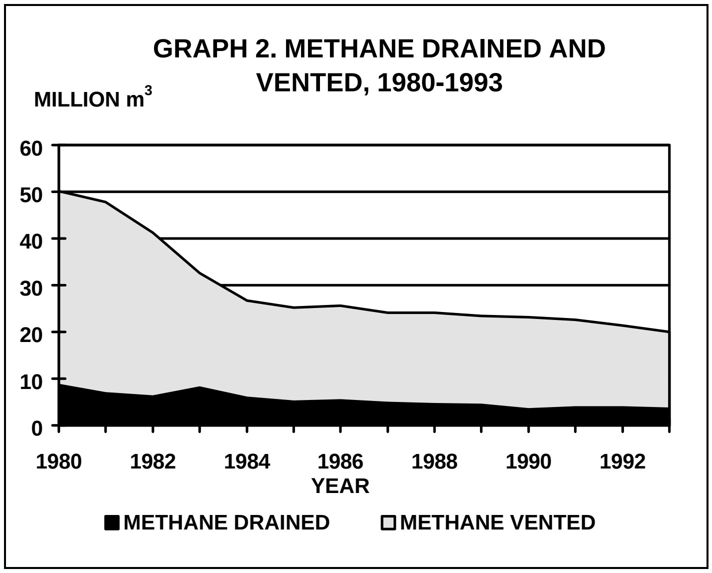


Graph 1 also shows that specific emissions were highest in the early 1980's, but declined to relatively low levels in the latter part of that decade. The slight increase in specific emissions in recent years is largely a function of decreased coal production; methane emissions have decreased at a slower rate than coal output. In 1993, 9.8 m^3 of methane were liberated per ton of coal mined from the Jastrzebie concession.

METHANE LIBERATION, VENTILATION, RECOVERY, AND RESERVES

In 1993, a total of 20.0 million m^3 of methane were liberated from the Jastrzebie mining concession. Of this, 3.5 million m^3 were drained, and 16.5 million m^3 were emitted via the ventilation system. Of the methane drained, 3.1 million m^3 were used, and the remaining 0.4 million m^3 of which were emitted.

Trends in methane ventilation, drainage, and total liberation from 1980 through 1993 are shown in Graph 2. These values were highest in the early part of the period. Ventilation and total liberation declined sharply after 1982, and drainage declined after 1983.



Desorption tests on coal samples from the concession indicate that gas content ranges to 11.8 m^3/ton. All of the coal mined in 1990 was from Class IV seams. The Central Mining Institute forecasts that by year 2000, this will still be the case.

Mine Ventilation. Four ventilation shafts operate at the Jastrzebie mining concession. The average concentration of methane in the ventilation shafts is 0.07 percent, and the maximum concentration is 0.14 percent. Air flow into the ventilation shafts is 40,000 m^3 per minute, and air flows out of the shafts at the rate of 42,000 m^3 per minute. Total power of the vent motors is 4,800 kW.

Methane Recovery. There were 840 drainage boreholes operating at the Jastrzebie mining concession in 1991, with a total length of 69.30 km. Total length of the demethanization pipelines is 23.05 km, and their diameter ranges from 100-300 mm. Three pumps and compressors are operating, with a total capacity of 180 m^3 per minute. In 1993, the average concentration of methane in gas utilized from the Jastrzebie mine was 61 percent, among the highest of any of the mines studied.

Currently, about 73 percent of all methane recovered from the Jastrzebie mine is drained from development areas; 21 percent is drained from working faces, and 6 percent from gob areas.

Methane Resources. In-situ methane resources associated with balance reserves of coal are estimated to range from 2.8 - 3.3 billion m^3.

PRESENT AND PLANNED UTILIZATION OF MINE METHANE

In 1993, 3.1 million m^3 of methane drained from the Jastrzebie mining concession were used; this represents 89 percent of the methane drained from the concession. Of this, 1.6 million m^3 were used by the Moszczenica mine's combined heat and power plant and the Jastrzebie mine's heat and coal drying plant. The remaining 1.5 million m^3 were sold to GOZG Zabrze (the POGC's Upper Silesian Gas Utility) for transport to industrial consumers.

The Jastrzebie mine is connected to the Swierklany compressor station, located about 10 km to the north, by a 500 mm diameter pipeline. GOZG Zabrze ceased purchasing mine gas in October, 1993, for reasons cited in Section 3.2.3 of Part I . As a result, some of this gas was vented to the atmosphere for a short period of time, but Jastrzebie and/or neighboring mines soon began using the additional gas on-site.

Mine management estimates that in the future, the Jastrzebie mine heat and coal drying plants may use up to 18.4 million m^3 of methane per year. Increased methane drainage has been proposed by mine management. The Jastrzebie Mining Company has partnered with Pol-Tex Methane, a Polish subsidiary of a US company, McKenzie Methane, to drill a proposed 400 surface wells from the mine's coal reserve areas. The wells are expected to produce pipeline quality methane to be sold to the national grid.

MINING ECONOMICS

In 1990, coal production costs at the Jastrzebie mining concession totaled 537 billion zlotys ($US 56 million), or 233 thousand zlotys ($US 24) per ton of coal mined. Coal from the concession sold for 196 thousand zlotys ($US 21) per ton, at a loss of 37 thousand zlotys ($US 3) per ton.

In July 1994, coking coal from the Jastrzebie Coal Company (to which the Jastrzebie mine belongs) sold for 1.25 - 1.42 million zlotys ($US 55.3 - $62.4) per ton, depending on rank. Coal prices have thus risen substantially since 1990, as a result of coal price adjustments that have been made as a part of Poland's overall economic restructuring as well as its coal mining industry restructuring programs.

In 1990, methane drainage costs totaled 3.3 billion zlotys ($US 345 thousand). Methane sales recovered 449 million zlotys ($US 47 thousand).Methane thus cost 953 zlotys ($US 0.10) per m^3 to drain, and sold for 135 zlotys ($US 0.01) per m^3. Methane ventilation cost $10.8 billion zlotys ($US 1.1 million) or 551 zlotys ($US 0.06) per m^3.

More recent data concerning mining economics were unavailable.

SALINE WATER

The mine discharges about 5100 m^3 of water containing 62 tons of chlorides and sulfates each day. Mine water is initially held in the Olza Reservoir, which also gathers mine water from nine other coal mines, and is then discharged to a tributary of the Olza river. The purpose of the collecting reservoir is to protect the upper course of the Olza River and its tributary, the Szotkowka River. It is not known what plans exist for improved saline water management.

SUMMARY DATA TABLES

COAL RESOURCES

Number of Seams	Coal Seam Thickness (m)		Overburden Thickness (m)	Balance Coal Reserves* (Million Tons)			
	Economic	Non-Economic		$A+B+C_1$	C_2	1990 Total	1993 Total
50	0.7-12.8	0.4-0.7	90-650	228	77	305	283

COAL QUALITY

Ash Content (%)		Heating Value (kJ/kg)		Moisture (%)
As Received	ROM Average	Range	ROM Average	ROM Average
2.2-34.5	9.7	22,981-34,553	30,962	6

HAZARD DATA

Gas and Rock Outburst	Rock Bump Hazard	Dust Hazard	Water Hazard	Methane Hazard	Spontaneous Combustion
No Hazard	I (Low)	Present	I (Low) and II (Medium)	IV (Very High)	I (Low)

CARBON DIOXIDE EQUIVALENTS (Million Tons)

CO_2 Equivalent of Total Methane Liberated (Vented and Drained), 1993	CO_2 Equivalent of Total Methane Drained, (Used and Released), 1993
0.30	0.05

PIPELINE DATA (1995)

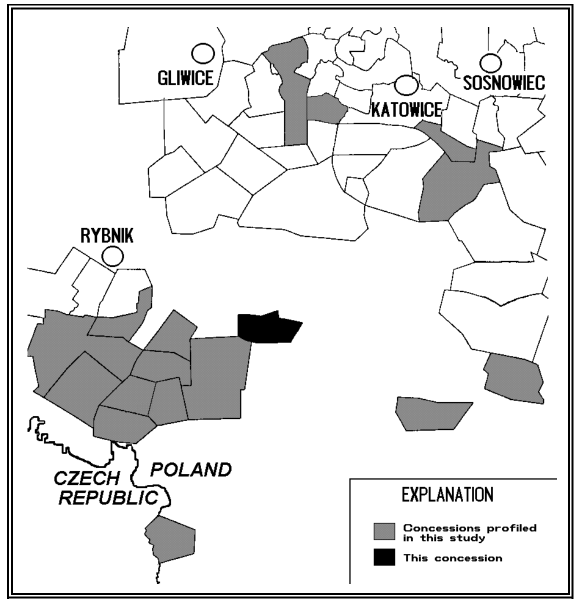
Distance to Nearest Pipeline	Owner / Manager of Pipeline
Connected by pipeline to Swierklany Compressor Station	GOZG Zabrze (subsidiary of the POGC)

MINE LIFE EXPECTANCY: More than 20 years

PREP PLANT LOCATED ON SITE?: Yes

***** $A+B+C_1$ and C_2 sub-categories reflect 1990 data; 1993 sub-categorized reserve data were unavailable

KRUPINSKI (SUSZEC)



The Krupinski mining concession is located in the southwestern portion of the Polish part of the Upper Silesian Coal Basin, approximately 19 km southeast of the city of Rybnik. The concession area occupies 28.4 km^2. This is one of the newest mines in the basin, with coal production starting in 1983. Krupinski became part of the Jastrzebie Coal Company in 1993.

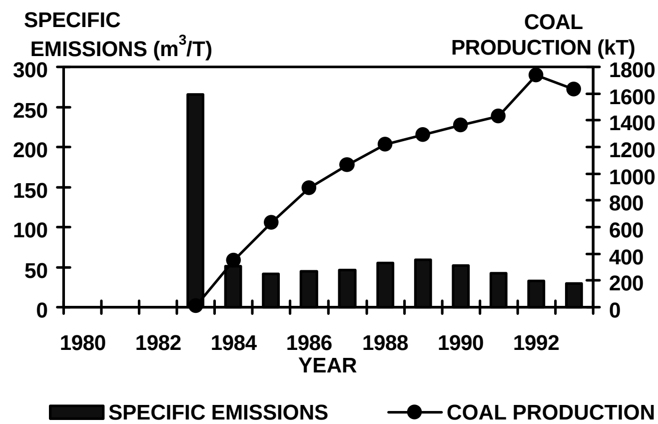
Geologic Setting. The area is structurally complex, with several normal faults cross the concession. The greatest displacement occurs along the northwest-southeast trending Kryry fault, which forms the southwestern boundary of the concession. Strata south of this fault are downthrown 250 m relative to strata north of the fault. Faults do not penetrate the Miocene sequence that unconformably overlies the Carboniferous formations. The average geothermal gradient is 3.31° C per 100 m.

Coal Rank. Coal rank is sub-bituminous to low volatile bituminous (types 31 through 36) with high volatile bituminous A and B (type 34) accounting for 56 percent of the reserves.

COAL PRODUCTION AND QUALITY

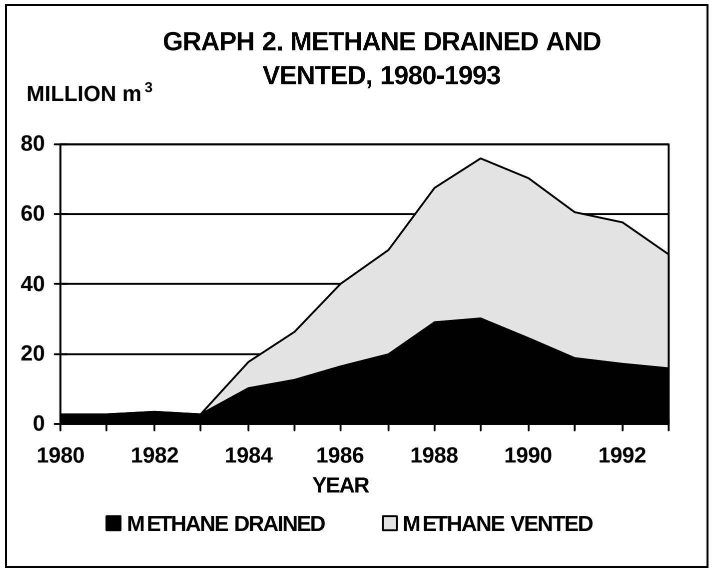
The mine has 3 working levels accessed by 4 shafts, 2 of which are ventilation shafts. Coal is mined by longwall methods from an average of 6.5 working faces, with a combined length of 1,176 m. As of 1993, mining extended to a depth of 620 m. In 1990, half of the coal produced was sub-bituminous to high volatile B bituminous (type 31 and 32, power coal) and half was high volatile A and B bituminous (type 34, coking coal). Clean coal production was 1,541 tons per working day based on the combined surface and underground work force, and 5,129 tons per working day based solely on the underground work force.

GRAPH 1. COAL PRODUCTION AND SPECIFIC EMISSIONS, 1980-1993



As shown in Graph 1, coal production increased steadily from the onset of mining in 1983 until 1992. In 1993, 1.6 million tons were produced. Graph 1 also shows that specific emissions were by far the highest in 1983, when coal production began. After 1983, they decreased dramatically but still remain relatively high in relation to other mines studied. In 1993, specific emissions were 29.9 m^3 of methane per ton of coal mined.

METHANE LIBERATION, VENTILATION, RECOVERY, AND RESERVES



In 1993, a total of 48.7 million m^3 of methane were liberated from the Krupinski mining concession. Of this, 15.8 million m^3 were drained, and 32.9 million m^3 were emitted via the ventilation system. Of the methane drained, 6.7 million m^3 were used, and the remaining 9.1 million m^3 were emitted.

Trends in methane ventilation, drainage, and total liberation from 1980 through 1993 are shown in Graph 2. Although coal production did not begin until 1983, methane was being drained as early as 1980. Drainage has decreased in recent years, and according to a 1992 report by mine managers this is due in part to the fact that abandoned (gob) areas are being filled with tailings, and therefore less methane is available for drainage from gob areas.

Desorption tests on coal samples from the concession indicate that gas content ranges to 15.4 m^3 per ton. All of the coal mined in 1990 was from Class IV seams. The Central Mining Institute forecasts that by year 2000, this will still be the case.

Mine Ventilation. Two ventilation shafts operate at the Krupinski mining concession. The average concentration of methane in the ventilation shafts is 0.25 percent, and the maximum concentration recorded is 0.28 percent. Air flow into the ventilation shafts is 28,400 m^3 per minute, and air flows out of the shafts at the rate of 29,450 m^3 per minute. Total power of the vent motors is 7,800 kW.

Methane Recovery. There were 632 drainage boreholes operating at the Krupinski mining concession in 1991, with a total length of 72.94 km. Total length of the demethanization pipelines is 38.64 km, and their diameter ranges from 150-300 mm. Six pumps and compressors are operating, with a total capacity of 353 m^3 per minute, making it one of the larger-capacity systems at the profiled mines. In 1993, the average concentration of methane in gas utilized from the Krupinski mine was 61 percent, among the highest of any of the mines profiled.

In 1993, about 56 percent of the methane recovered from the Krupinski mine was drained from development areas; 20 percent was from working faces; and 24 percent was from gob areas.

Methane Resources. In-situ methane resources associated with balance reserves of coal are estimated to range from 10.0 - 19.4 billion m^3.

PRESENT AND PLANNED UTILIZATION OF MINE METHANE

In 1993, 6.7 million m^3 of methane drained from the Krupinski mining concession were used; this represents 42 percent of the methane drained from the concession. The methane is consumed by the boiler in the Krupinski mine heat plant, and to fuel a prep plant drier.

McCormick Power Company has been granted rights to develop coalbed methane production on 11.3 km^2 at the concession. The company plans to focus on methane drainage in advance of coal mining, and estimates that the concession could produce more than 1 billion m^3 of methane per km^2 (11.3 billion m^3) over the next 20 years (Mining Engineering, 1993). McCormick intends to build a methane-fueled heat and power plant at the mine; installation of equipment for this project has begun. Mine management is also considering building a methane-fueled desalination plant to concentrate brines.

MINING ECONOMICS

In 1990, coal production costs at the Krupinski mining concession totaled 472 billion zlotys ($US 49 million), or 347 thousand zlotys ($US 36) per ton of coal mined. Coal from the concession sold for 132 thousand zlotys ($US 14) per ton, at a loss of 215 thousand zlotys per ton ($US 22).

During July 1994, coking coal from the Jastrzebie Coal Company (to which the Krupinski mine belongs) sold for 1.25 - 1.42 million zlotys ($US 55.3 - $62.4) per ton, depending on rank. Coal prices have thus risen substantially since 1990, as a result of coal price adjustments that have been made as part of Poland's overall energy sector restructuring programs.

In 1990, methane drainage costs totaled 2.9 billion zlotys ($US 303 thousand). Sales to the mine's heat plant recovered 811 million zlotys ($US 85 thousand). Methane thus cost 119 zlotys ($US 0.012) per m^3 to drain (the lowest of any of the mines studied) and sold to the mine's heat plant for 150 zlotys ($US 0.016) per m^3. Ventilation costs in 1990 were 9.3 billion zlotys ($US 970 thousand), or 201 zlotys ($US 0.021) per m^3 (note that drainage is cheaper, per unit volume of methane, than ventilation). The total cost of methane control at the mine was thus 12.2 billion zlotys ($US 1.3 million), or 320 zlotys ($US 0.033) per m^3.

During the first six months of 1994, methane from the Jastrzebie Coal Company sold for an average of 478.7 zlotys ($US 0.021) per m^3. Data concerning 1994 methane drainage costs were unavailable, but based on 1990 costs, it appears that it could now be more profitable to recover and sell methane.

SALINE WATER

There is a high inflow of saline water into underground workings of the Krupinski mine, with the result that about 5900 m^3 of water containing 200 tons of chlorides and sulfates are discharged each day. Mine water is initially held in the Olza Reservoir, which also gathers mine water from nine other coal mines, and is then discharged to a tributary of the Olza river. The purpose of the collecting reservoir is to protect the upper course of the Olza River and its tributary, the Szotkowka River. Mine management has recently undertaken ambitious programs in hope of reducing saline water discharge. As noted above, they are considering building a methane-fueled desalination plant to concentrate brines, and are currently experimenting with storing the most highly mineralized waters in gob areas. There are also radioactive isotopes present in some of the waters drained from the mine, which mine management has been striving to mitigate.

SUMMARY DATA TABLES

COAL RESOURCES

Number of Seams	Coal Seam Thickness (m)		Overburden Thickness (m)	Balance Coal Reserves* (Million Tons)			
	Economic	Non-Economic		$A+B+C_1$	C_2	1990 Total	1993 Total
73	0.7-7.2	0.4-1.0	75-324	348	231	579	648

COAL QUALITY

Ash Content (%)		Heating Value (kJ/kg)		Moisture (%)
As Received	ROM Average	Range	ROM Average	ROM Average
1.37-40	17.9	15,365-30,936	26,998	4.6

HAZARD DATA

Gas and Rock Outburst	Rock Bump Hazard	Dust Hazard	Water Hazard	Methane Hazard	Spontaneous Combustion
No Hazard	No Hazard	Present	I (Low)	I (Low) to IV (Very High)	I (Low) to III (High)

CARBON DIOXIDE EQUIVALENTS (Million Tons)

CO_2 Equivalent of Total Methane Liberated (Vented and Drained), 1993	CO_2 Equivalent of Total Methane Drained, (Used and Released), 1993
0.73	0.24

PIPELINE DATA (1995)

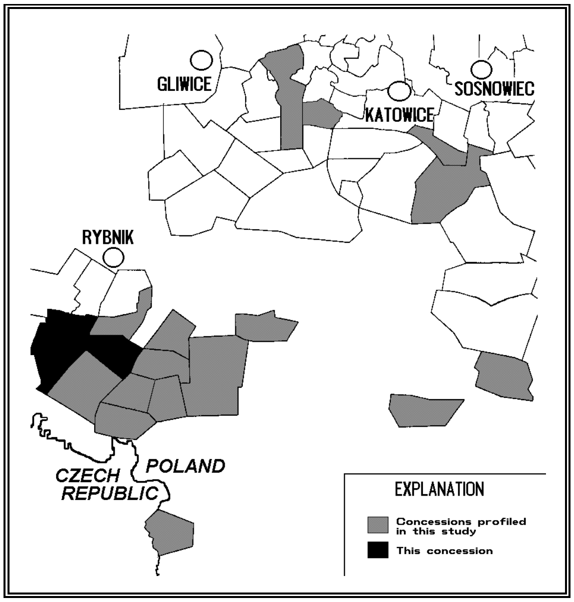
Distance to Nearest Pipeline	Owner / Manager of Pipeline
6 km from pipeline at Zory mine	GOZG Zabrze (subsidiary of the POGC)

MINE LIFE EXPECTANCY: Probably more than 20 years

PREP PLANT LOCATED ON SITE?: Yes

***** $A+B+C_1$ and C_2 sub-categories reflect 1990 data; 1993 sub-categorized reserve data were unavailable

MARCEL



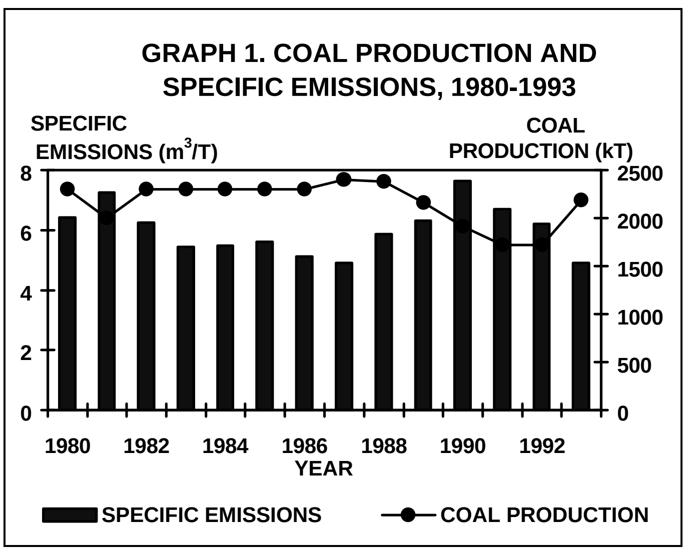
The Marcel mining concession is located in the southwestern portion of the Polish part of the Upper Silesian Coal Basin, approximately 7 km southwest of the city of Rybnik. Marcel is one of seven mines that comprise the Rybnicka Coal Company. The concession area occupies about 72 km^2. Coal production started in 1883.

Geologic Setting. The western part of the concession is crossed by the Michalkowice thrust fault and associated thrust faults. Displacement on these faults is up to 700 m. Several north-south trending normal faults are also associated with this zone of thrusting, typically with 20-30 m displacement. The eastern part of the concession contains two major normal faults, with displacement up to 160 m. Although no geologic cross section was available, Carboniferous formations are presumably overlain by Miocene strata. The average geothermal gradient is 3.37° C per 100 m.

Coal Reserves and Rank. Coal rank ranges from sub-bituminous through high-volatile A bituminous (types 31 through 34) with high volatile A and B bituminous (type 34, coking coal) accounting for 39 percent of the reserves, and high volatile B bituminous (type 33, power coal) accounting for 34 percent of the reserves.

COAL PRODUCTION AND SPECIFIC EMISSIONS

The mine has 4 working levels accessed by 7 shafts, 2 of which are ventilation shafts. As of 1993, mining extended to a depth of 800 m. In 1990, a total of 1.9 million tons of coal were produced, all of which were high volatile A and B bituminous (type 34). Clean coal production was 1,870 tons per working day based on the combined surface and underground workforce, and 4,120 tons per working day based solely on the underground workforce.

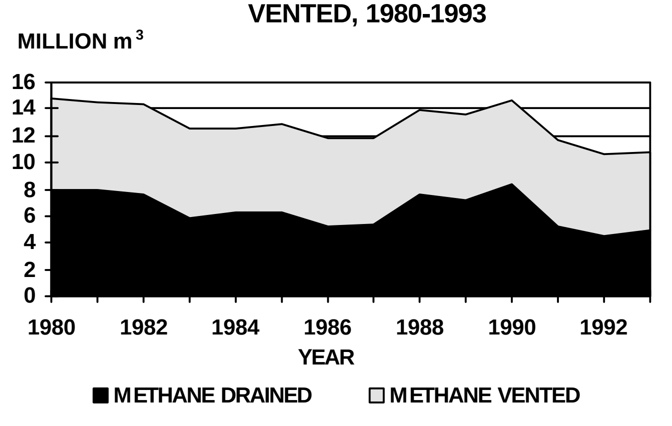


As shown in Graph 1, coal production was relatively steady from 1982 through 1988, then decreased from 1989 through 1992. Coal production rebounded in 1993 to 2.1 million tons.

Graph 1 also shows that specific emissions were highest in 1990, the year in which when methane drainage levels peaked due to the mine's focus on recovery from development areas (85 percent of the methane drained in 1990 was from development areas). Specific emissions ubsequently declined, and in 1993, 4.9 m^3 of methane were liberated per ton of coal mined from the Marcel concession.

METHANE LIBERATION, VENTILATION, RECOVERY, AND RESERVES

GRAPH 2. METHANE DRAINED AND VENTED, 1980-1993



In 1993, a total of 10.8 million m^3 of methane were liberated from the Marcel mining concession. Of this, 4.9 million m^3 were drained, and 5.9 million m^3 were emitted via the ventilation system. Of the methane drained, 4.2 million m^3 were used, and the remaining 0.7 million m^3 were emitted to the atmosphere after being recovered by drainage.

Graph 2 shows that trends in methane liberation remained fairly steady throughout the past 13 years, and that recovery efficiency has been both consistent and relatively high; in 1993, 45% of the total methane liberated from the mine was captured by the drainage system. As shown in Graph 2, specific emissions were highest in 1990, the year in which when methane drainage levels were highest due to the mine's focus on recovery from development areas (85 percent of the methane drained in 1990 was from development areas).

Desorption tests on coal samples from the concession indicate that gas content is up to 4.4 m^3/ton. In 1990, 75 percent of the coal mined was from methane hazard Class III seams, and the remaining 25 percent was from Class II seams. The Central Mining Institute forecasts that by year 2000, 80 percent of the coal mined at Marcel will be from methane hazard Class III seams, and that the remainder will be from Class II seams.

Mine Ventilation. Two ventilation shafts operate at the Marcel mining concession. The average concentration of methane in the ventilation shafts is 0.03 percent, and the maximum concentration is 0.05 percent. Air flow into the ventilation shafts is 27,871 m^3 per minute, and air flows out of the shafts at the rate of 29,653 m^3 per minute. Total power of the vent motors is 2,850 kW.

Methane Recovery. There were 256 drainage boreholes operating at the Marcel mining concession in 1991, with a total length of 25.83 km. Total length of the demethanization pipelines is 10.52 km, and their diameter ranges from 50-300 mm. Three pumps and compressors are operating, with a total capacity of 180 m^3 per minute. In 1993, the average concentration of methane utilized from the mine was 56 percent.

In 1993, 13 percent of the methane recovered was drained from development areas, and the remaining 87 percent was drained from working faces.

Methane Resources. In-situ methane resources associated with balance reserves of coal are estimated to range from 1.0 to 1.1 billion m^3.

PRESENT AND PLANNED UTILIZATION OF MINE METHANE

In 1993, 4.2 million m^3 of methane drained from the Marcel mining concession were used; this represents 86 percent of the methane drained from the concession. Much of the methane was used at the Marcel mine and/or other mines in the Rybnik Coal Region; some of it was sold to GOZG Zabrze (POGC's Upper Silesian Gas Utility) for transport to industrial users. A 6.4 km, 200 mm diameter pipeline connects the mine to the Swierklany compression station, located east of the mine. GOZG Zabrze ceased purchasing mine gas in October, 1993 for reasons discussed in Section 3.2.3 of Part I. As a result, some of this gas was vented to the atmosphere for a short period of time, but the Marcel mine and/or neighboring mines soon began using the additional gas on-site.

Mine management has proposed increasing methane drainage from development areas and preparatory workings, and implementing a program for surface borehole drainage. One potential use for additional recovered methane is to fuel the mine's prep plant dryer.

MINING ECONOMICS

In 1990, coal production costs at the Marcel mining concession totaled 354 billion zlotys ($US 37 million), or 201 thousand zlotys ($US 21) per ton of coal mined. Coal from the concession sold for 185 thousand zlotys ($US 19) per ton, at a loss of 16 thousand zlotys ($US 2) per ton.

Methane drainage costs totaled 1.7 billion zlotys ($US 178 thousand) in 1990. Methane sales recovered 552 million zlotys ($US 58 thousand). Methane thus cost 274 zlotys ($US 0.03) per m^3 to drain, and sold for 88 zlotys ($US 0.01) per m^3. Ventilation costs in 1990 were 5.3 billion zlotys, ($US 556 thousand), or 855 zlotys ($US 0.09) per m^3 ; note that drainage was less expensive (per unit volume of methane) than ventilation at the Marcel mine. Total methane control costs at Marcel mine were thus 7 billion zlotys ($US 734 thousand), or 1,129 zlotys ($US 0.12) per m^3 .

More recent data concerning mining economics were not available.

SALINE WATER

The Marcel mine discharges about 5,300 m^3 of water containing 41 tons of chlorides and sulfates each day. Mine water is initially held in the Olza Reservoir, which also gathers mine water from nine other coal mines, and is then discharged to a tributary of the Olza river. The purpose of the collecting reservoir is to protect the upper course of the Olza River and its tributary, the Szotkowka River. It is not known what attempts are being made to improve saline water management at the mine.

SUMMARY DATA TABLES

COAL RESOURCES

Number of Seams	Coal Seam Thickness (m)		Overburden Thickness (m)	Balance Coal Reserves* (Million Tons)			
	Economic	Non-Economic		$A+B+C_1$	C_2	1990 Total	1993 Total
46	0.7-9.0	0.4-1.0	3-400	194	42	236	231

COAL QUALITY

Ash Content (%)		Heating Value (kJ/kg)		Moisture (%)
As Received	ROM Average	Range	ROM Average	ROM Average
6-32	14.6	19,711-31,687	27,862	7

HAZARD DATA

Gas and Rock Outburst	Rock Bump Hazard	Dust Hazard	Water Hazard	Methane Hazard	Spontaneous Combustion
No Hazard	I (Low) and III (High)	Present	I (Low) and II (Medium)	II (Medium) and III (High)	II (Medium)

CARBON DIOXIDE EQUIVALENTS (Million Tons)

CO_2 Equivalent of Total Methane Liberated (Vented and Drained), 1993	CO_2 Equivalent of Total Methane Drained, (Used and Released), 1993
0.16	0.73

PIPELINE DATA (1995)

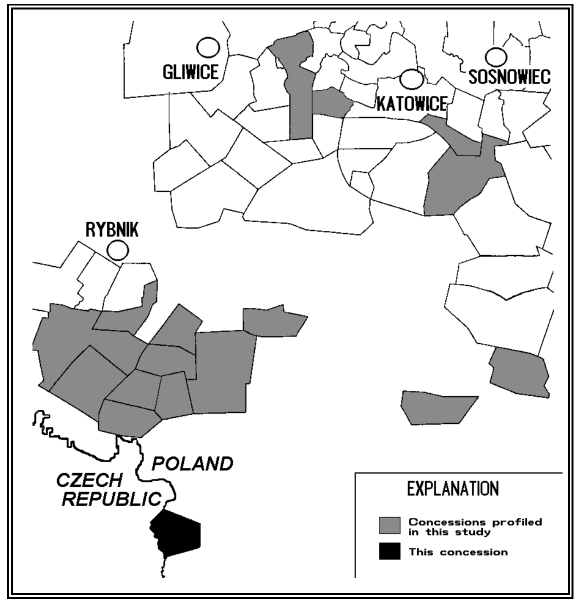
Distance to Nearest Pipeline	Owner / Manager of Pipeline
Connected by pipeline to Swierklany Compressor Station	GOZG Zabrze (subsidiary of the POGC)

MINE LIFE EXPECTANCY: More than 20 years

PREP PLANT LOCATED ON SITE?: Yes

* $A+B+C_1$ and C_2 sub-categories reflect 1990 data; 1993 sub-categorized reserve data were unavailable

MORCINEK (KACYZE)



The Morcinek mining concession is located in the southwestern portion of the Polish part of the Upper Silesian Coal Basin, approximately 29 km southeast of the city of Rybnik. The concession, which is bounded on the west by the Poland-Czech Republic border, occupies 22.6 km^2. Coal production started in 1987, and the mine became part of the Jastrzebie Coal Company in 1993.

Geologic Setting. The Morcinek concession lies in a structurally complex area. The northern end of the concession is underlain by a thrust fault. A high angle normal fault, which displaces strata by as much as 300 m, crosses the northwest boundary of the concession. A zone of normal faults also occurs in the western part of the concession, near the border with the Czech Republic. Carboniferous formations are unconformably overlain by a thick sequence of Miocene strata which includes a basal conglomerate. The average geothermal gradient is 3.6° C per 100 m.

Coal Rank. Coal reserves are sub-bituminous through anthracite (types 31 and 32, 34 through 37, and 42) with medium and low volatile bituminous (type 35) accounting for 79 percent of the reserves.

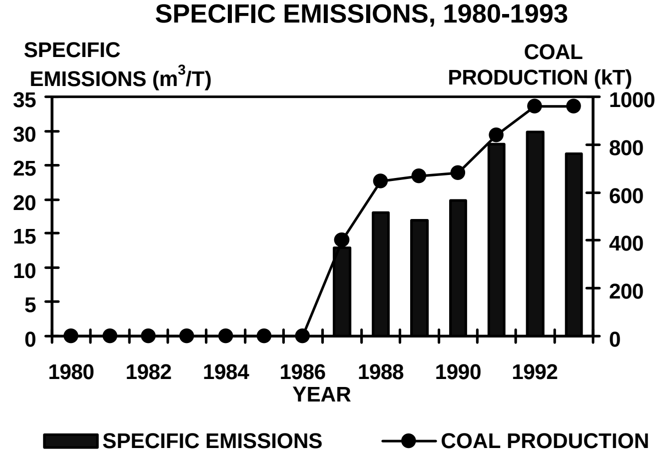
COAL PRODUCTION AND SPECIFIC EMISSIONS

The mine has 2 working levels accessed by 4 shafts, 1 of which is a ventilation shaft. Coal is mined by longwall methods from 3 working faces, with a combined length of 832 m. As of 1993, mining extended to a depth of 1050 m. In 1990, all of the coal produced was medium and low volatile bituminous (type 35, coking coal). Clean coal production was 1,283 tons per working day based on the combined surface and underground work force, and 3,533 tons per working day based solely on the underground work force.

Ash content (as received) of coal mined from the concession ranges from 4.68 to 19.86 percent, with a run-of-mine (ROM) average of 14.56 percent. Heating value ranges from 26,569 kJ/kg to 33,581 kJ/kg; the ROM average is 28,878 kJ/kg. ROM average moisture content is 2.5 percent.

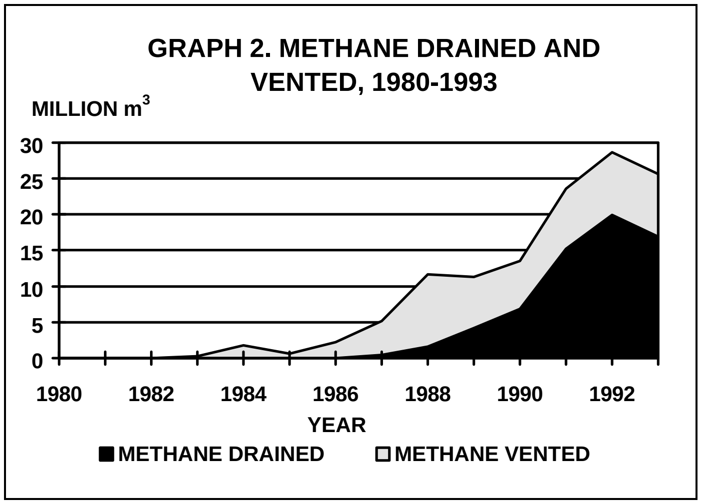
As shown in Graph 1, coal production has increased substantially since the onset of mining in 1987. In 1993, 960 thousand tons of coal were produced. Graph 1 also shows that specific emissions increased until 1993, when they declined slightly. In 1993, 26.7 m^3 of methane were liberated per ton of coal mined.

GRAPH 1. COAL PRODUCTION AND SPECIFIC EMISSIONS, 1980-1993



METHANE LIBERATION, VENTILATION, RECOVERY, AND RESERVES

In 1993, a total of 25.6 million m^3 of methane were liberated from the Morcinek mining concession. Of this, 16.9 million m^3 were drained, and 8.7 million m^3 were emitted via the ventilation system. Of the methane drained, 14.4 million m^3 were utilized (ranking the Morcinek concession fourth among those studied, in terms of methane utilization) and the remaining 2.5 million m^3 were emitted to the atmosphere after being recovered by drainage.



Trends in methane ventilation, drainage, and total liberation from 1980 through 1993 are shown in Graph 2. Although coal production did not begin until 1987, methane was being vented as early as 1983. Drainage did not begin until 1987, so all of the methane liberated until then was the result of ventilation. In 1993, Morcinek had the highest recovery efficiency (66 percent) of all mines studied.

Desorption tests on coal samples from the concession indicate that gas content is up to 8.0 m^3 per ton. All of the coal mined in 1990 was from methane hazard Class IV seams. The Central Mining Institute forecasts that by year 2000, this will still be the case.

Mine Ventilation. There is one ventilation shaft at the Morcinek mining concession. The average concentration of methane in the ventilation shafts is 0.09 percent. Air flow into the ventilation shafts is 17,800 m^3 per minute, and air flows out of the shafts at the rate of 19,400 m^3 per minute (the least ventilation air intake and outflow of any of the mining concessions studied). Total power of the vent motors is 1,600 kW.

Methane Recovery. There were 195 drainage boreholes operating at the Morcinek mining concession in 1991, with a total length of 16.20 km. Total length of the demethanization pipelines is 10.80 km, and their diameter ranges from 150-400 mm. Four pumps and compressors are operating, with a total capacity of 240 m^3 per minute. In 1993 the average concentration of methane in gas utilized from the Morcinek concession was 59 percent, among the highest concentration of any of the mining concessions studied.

In 1993, 8 percent of the methane recovered was drained from development areas, 42 percent was drained from working faces, and 50 percent was drained from gob areas.

Methane Resources. In-situ methane resources associated with balance reserves of coal are estimated to be 3.1-10.4 billion m^3.

PRESENT AND PLANNED UTILIZATION OF MINE METHANE

In 1993, 14.4 million m^3 of methane drained from the Morcinek mining concession were used; this represents 85 percent of the methane drained from the concession. Of this, 11.6 million m^3 were used by the mine's heat and prep plant dryer, and 2.8 million m^3 were sold to GOZG Zabrze (the POGC's Upper Silesian Gas Utility) for transport to industrial users. The Morcinek mine is connected by a 500 mm diameter pipeline to the Swierklany compression station, which is about 25 km to the north, but for reasons described in Section 3.2.3 of Part I, GOZG Zabrze ceased buying coalbed methane in October, 1993. As a result, some of this gas was vented to the atmosphere for a short period of time, but the Morcinek mine and/or neighboring mines soon began using the additional gas on-site.

Mine management plans to increase methane drainage from gob areas, and to begin drainage of methane above the 800 m level. They have also proposed increasing the capacity of the demethanization pipelines. The US Trade and Development Agency, in conjunction with the State Hard Coal Agency, is presently examining the feasibility of using vertical wells (both surface and gob) to recover coalbed methane and identify the most promising utilization options. The heating plant for the nearby of town of Cieszyn may be a potential consumer of methane from the mine in the future.

MINING ECONOMICS

In 1990, coal production costs at the Morcinek mining concession totaled 285 billion zlotys ($US 30 million), or 427 thousand zlotys ($US 45) per ton of coal mined. Coal from the concession sold for 192 thousand zlotys ($US 20) per ton, at a loss of 235 thousand zlotys ($US 25) per ton.

In July 1994, coking coal from the Jastrzebie Coal Company (to which the Morcinek mine belongs) sold for 1.25 - 1.42 million zlotys ($US 55.3 - $62.4) per ton, depending on rank. Coal prices have thus risen substantially since 1990, as a result of coal price adjustments that have been made as part of Poland's energy sector restructuring programs.

Methane drainage costs were reportedly 2.4 billion zlotys ($US 250 thousand). Methane sales recovered reportedly 745 million zlotys ($US 783 thousand). Methane thus cost 695 zlotys ($US 0.07) per m^3 to drain, and sold 146 zlotys ($US 0.02) per m^3. Ventilation cost 7.6 billion zlotys ($US 793 thousand), or 1,124 zlotys ($US 0.12 per m^3); note that drainage is less expensive than ventilation, per unit volume of methane. Total methane control costs at Morcinek mine were thus 10 billion zlotys ($US 1 million) or 1819 zlotys ($US 0.19) per cubic meter.

During the first six months of 1994, methane from the Jastrzebie Coal Company sold for an average of 478.7 zlotys ($US 0.021) per m^3. Data concerning 1994 methane control costs were unavailable.

SALINE WATER

The Morcinek mine discharges about 3,300 m^3 of water containing 70 tons of chlorides and sulfates each day. Mine water is initially held in the Olza Reservoir, which also gathers mine water from nine other coal mines, and is then discharged to a tributary of the Olza river. The purpose of the collecting reservoir is to protect the upper course of the Olza River and its tributary, the Szotkowka River. A brine desalination demonstration project is underway (see discussion under Present and Planned Utilization of Mine Methane, above).

SUMMARY DATA TABLES

COAL RESOURCES

Number of Seams	Coal Seam Thickness (m)		Overburden Thickness (m)	Balance Coal Reserves* (Million Tons)			
	Economic	Non-Economic		$A+B+C_1$	C_2	1990 Total	1993 Total
35	0.7-15.7	0.4-0.7	510-1150	295	557	852	391

COAL QUALITY

Ash Content (%)		Heating Value (kJ/kg)		Moisture (%)
As Received	ROM Average	Range	ROM Average	ROM Average
4.7-19.7	14.6	26,569-33,581	28,878	2.5

HAZARD DATA

Gas and Rock Outburst	Rock Bump Hazard	Dust Hazard	Water Hazard	Methane Hazard	Spontaneous Combustion
No Hazard	No Hazard	Present	Not Available	IV (Very High)	I (Low)

CARBON DIOXIDE EQUIVALENTS (Million Tons)

CO_2 Equivalent of Total Methane Liberated (Vented and Drained), 1993	CO_2 Equivalent of Total Methane Drained, (Used and Released), 1993
0.38	0.25

PIPELINE DATA (1995)

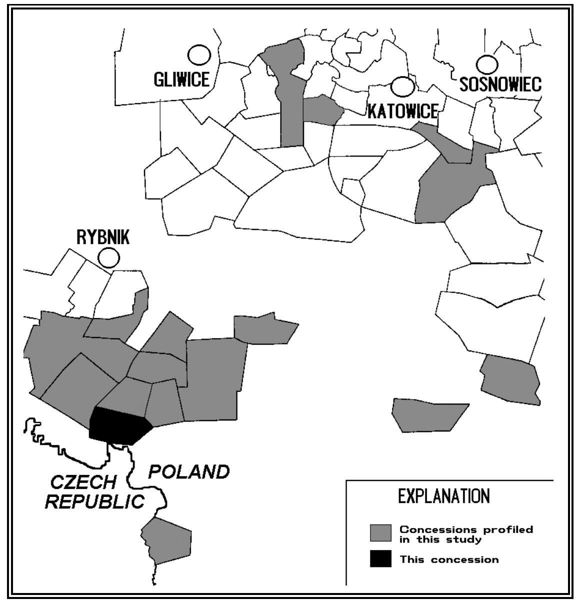
Distance to Nearest Pipeline	Owner / Manager of Pipeline
Connected by pipeline to Swierklany Compressor Station	GOZG Zabrze (subsidiary of the POGC)

MINE LIFE EXPECTANCY: More than 20 years

PREP PLANT LOCATED ON SITE?: Yes

***** $A+B+C_1$ and C_2 sub-categories reflect 1990 data; 1993 sub-categorized reserve data were unavailable

MOSZCZENICA



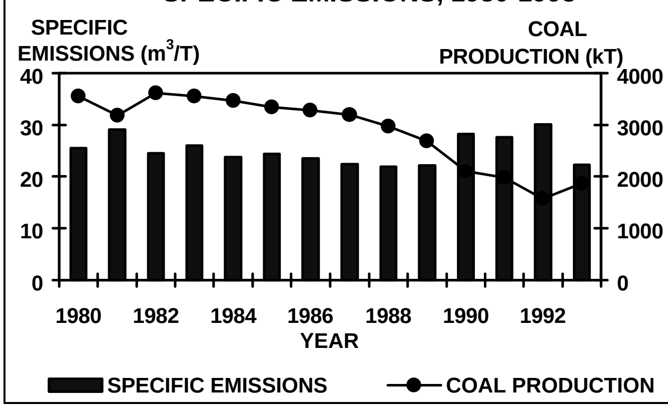
The Moszczenica mining concession is located in the southwestern portion of the Polish part of the Upper Silesian Coal Basin, approximately 16 km south of the city of Rybnik, adjacent to the border between Poland and the Czech Republic. The concession area occupies 32 km^2. Coal production started in 1966, and the mine became part of the Jastrzebie Coal Company in 1993.

Geologic Setting. The Moszczenica concession is bounded on the south by a zone of normal faulting that includes the Bzie-Czechowice fault. Strata south of this zone are downthrown as much as 260 m. The Orlowa thrust fault lies just outside of and parallel to the western boundary. Parallel to this fault is the north-south trending Zachodni normal fault, which lies just within the western boundary of the concession. The north-south trending Poludniowy fault crosses the eastern part of the concession. Carboniferous formations are unconformably overlain by Miocene strata, which thicken to the south. Overburden strata are 46-888 m thick. The average geothermal gradient is 3.33° C per 100 m.

Coal Rank. Coal rank is medium volatile bituminous through semi-anthracite (types 31 through 37, and 41) with medium and low volatile bituminous (type 35) accounting for 81 percent of the reserves.

COAL PRODUCTION AND SPECIFIC EMISSIONS

GRAPH 1. COAL PRODUCTION AND SPECIFIC EMISSIONS, 1980-1993



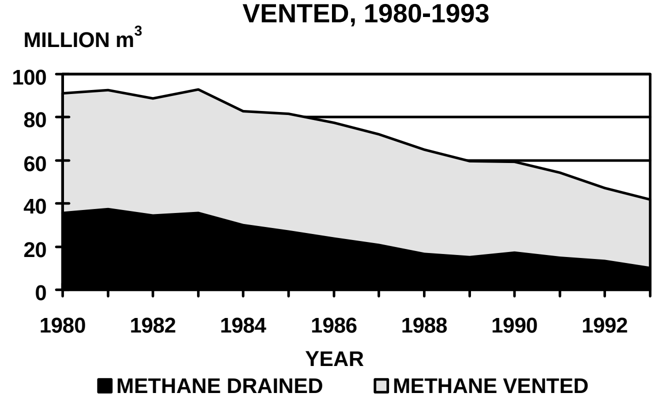
The mine has 3 working levels accessed by 8 shafts, 3 of which are ventilation shafts. Coal is mined by longwall methods from 14 working faces, with a combined length of 1,717 m. As of 1993, mining extended to a depth of 640 m. In 1990, all of the coal produced was medium and low volatile bituminous (coking coal, type 35). Clean coal production was 1,510 tons per working day based on the combined surface and underground work force, and 3,427 tons per working day based solely on the underground work force.

As shown in Graph 1, coal production has declined gradually since 1982, but rebounded slightly in 1993 to 1.9 million tons. Graph 1 also shows that specific emissions were comparatively high during the period 1990-1992. This period of high relative gassiness corresponds with rather steeply declining coal production. In 1993, 22.4 m^3 of methane were liberated per ton of coal mined from the Moszczenica concession.

METHANE LIBERATION, VENTILATION, RECOVERY, AND RESERVES

In 1993, a total of 41.8 million m^3 of methane were liberated from the Moszczenica mining concession. Of this, 10.2 million m^3 were drained, and 31.6 million m^3 were emitted via the ventilation system. Of the methane drained, 9.8 million m^3 were used, and 0.4 million m^3 were emitted.

GRAPH 2. METHANE DRAINED AND VENTED, 1980-1993



Trends in methane ventilation, drainage, and total liberation from 1980 through 1993 are shown in Graph 2. The amount of methane liberated has decreased steadily during the period 1983-1993, concomitant with an overall decrease in coal production.

Desorption tests on coal samples from the concession indicate that gas content is up to 8.1 m^3 per ton. All of the coal mined in 1990 was from methane hazard Class IV seams. The Central Mining Institute forecasts that by year 2000, this will still be the case.

Mine Ventilation. Eight ventilation shafts operate at the mine. The maximum concentration of methane in the ventilation shafts is 0.18 percent. Air flow into the ventilation shafts is 53,200 m^3 per minute, and air flows out of the shafts at the rate of 56,000 m^3 per minute (the least ventilation air intake and outflow of any of the mining concessions studied). Total power of the vent motors is 11,750 kW.

Methane Recovery. There were 2,206 drainage boreholes operating at the mine in 1991, with a total length of 198.91 km. Total length of the demethanization pipelines is 80.03 km, and their diameter ranges from 100-300 mm. Five pumps and compressors are operating, with a total capacity of 246 m^3 per minute. In 1993, the average methane concentration in gas utilized from the mine was 57 percent.

In 1993, about 91 percent of the methane drained came from development areas; none was recovered from working faces, and 9 percent was recovered from gob areas.

The Moszczenica mine is the subject of a pre-feasibility study being funded by the USAID and the USEPA. This study is being prepared by the International Coalbed Methane Group, based in Birmingham, Alabama. This study will examine the applicability of US surface gob well recovery technologies for coalbed methane production in Poland. The study is being prepared by the International Coalbed Methane Group, based in Birmingham, Alabama. It is expected that this study will be completed in early 1995.

Methane Resources. In-situ methane resources associated with balance reserves of coal are estimated to range from 3.3 - 9.2 billion m^3.

PRESENT AND PLANNED UTILIZATION OF MINE METHANE

In 1993, 9.8 million m^3 (96 percent) of the methane drained from the Moszczenica mine were used; of this, 7.7 million m^3 were consumed by the mine's electric power and heat plant, and its coal drying and preparation plant. The remaining 2.1 million m^3 were sold to GOZG Zabrze (the POGC's Upper Silesian Gas Utility). The mine is connected to the Swierklany compression station, which is about 20 km to the north, by a 500 mm diameter pipeline. However, for reasons described in Section 3.2.3 of Part I, GOZG Zabrze ceased buying mine methane in October, 1993. As a result, some mine gas was vented to the atmosphere for a short period of time, but Moszczenica and/or neighboring mines soon began using the additional gas on-site.

MINING ECONOMICS

In 1990, coal production costs at the Moszczenica mining concession totaled 531 billion zlotys ($US 56 million), or 256 thousand zlotys ($US 27) per ton of coal mined. Coal from the concession sold for 207 thousand zlotys ($US 22) per ton, at a loss of 49 thousand zlotys ($US 5) per ton.

In July 1994, coking coal from the Jastrzebie Coal Company (to which the Moszczenica mine belongs) sold for 1.25 - 1.42 million zlotys ($US 55.3 - $US 62.4) per ton, depending on rank. Coal prices have thus risen substantially since 1990, as a result of coal price adjustments that have been made as part of Poland's overall economic restructuring and its coal mining industry restructuring programs.

Methane drainage costs were 5.6 billion zlotys ($US 585 thousand). Methane sales recovered 2.5 billion zlotys ($US 261 million) Methane thus cost 324 zlotys ($US 0.034) per m^3 to drain, and sold for 145 zlotys ($US 0.015) per m^3. Ventilation cost 11.4 billion zlotys ($US 1.2 million), or 270 zlotys ($US 0.028) per m^3. Total methane control costs were thus 17 billion zlotys ($US 1.8 million) or 594 zlotys ($US 0.062) per m^3.

During the first six months of 1994, methane from the Jastrzebie Coal Company sold for an average of 478.7 zlotys ($0.021 USD) per m^3. Data concerning 1994 methane control costs were unavailable.

SALINE WATER

The mine discharges about 600 m^3 of water containing 2 tons of chlorides and sulfates each day. This is the lowest amount of salts discharged by any of the mines studied. Mine water is initially held in the Olza Reservoir, which also gathers mine water from nine other coal mines, and is then discharged to a tributary of the Olza river. The purpose of the collecting reservoir is to protect the upper course of the Olza River and its tributary, the Szotkowka River. It is not known if mine management is attempting to reduce saline water discharge.

SUMMARY DATA TABLES

COAL RESOURCES

Number of Seams	Coal Seam Thickness (m)		Overburden Thickness (m)	Balance Coal Reserves* (Million Tons)			
	Economic	Non-Economic		$A+B+C_1$	C_2	1990 Total	1993 Total
45	0.7-10.3	0.4-0.7	46-888	199	253	452	412

COAL QUALITY

Ash Content (%)		Heating Value (kJ/kg)		Moisture (%)
As Received	ROM Average	Range	ROM Average	ROM Average
4-35	10	16,894-33,444	32,611	7

HAZARD DATA

Gas and Rock Outburst	Rock Bump Hazard	Dust Hazard	Water Hazard	Methane Hazard	Spontaneous Combustion
Hazardous	I (Low)	Present	I (Low) and II (Moderate)	IV (Very High)	I (Low)

CARBON DIOXIDE EQUIVALENTS (Million Tons)

CO_2 Equivalent of Total Methane Liberated (Vented and Drained), 1993	CO_2 Equivalent of Total Methane Drained, (Used and Released), 1993
0.62	0.15

PIPELINE DATA (1995)

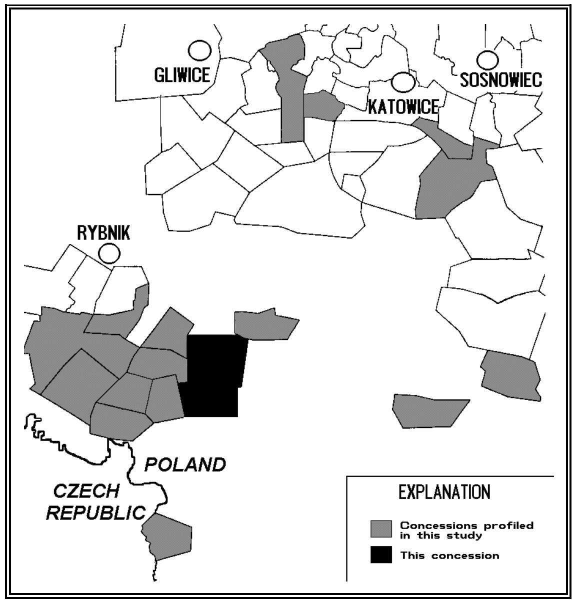
Distance to Nearest Pipeline	Owner / Manager of Pipeline
Connected by pipeline to Swierklany Compressor Station	GOZG Zabrze (subsidiary of the POGC)

MINE LIFE EXPECTANCY: More than 20 years

PREP PLANT LOCATED ON SITE?: Yes

***** $A+B+C_1$ and C_2 sub-categories reflect 1990 data; 1993 sub-categorized reserve data were unavailable

The Pniowek mining concession is located in the southwestern portion of the Polish part of the Upper Silesian Coal Basin, approximately 16 km southeast of the city of Rybnik. The concession area occupies 55.4 km^2. Coal production started in 1974, and the mine became part of the Jastrzebie Coal Company in 1993.



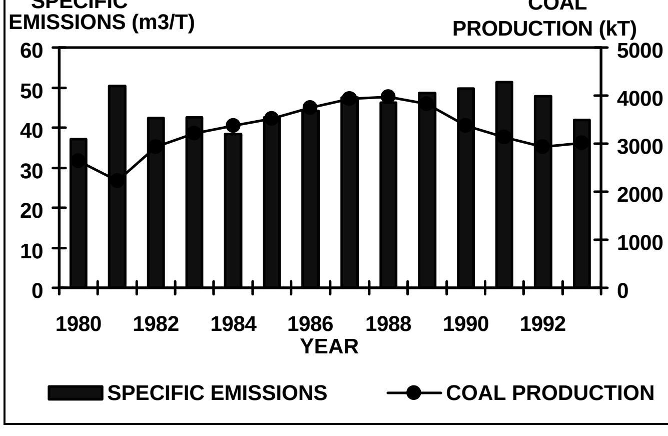
Geologic Setting. The Pniowek concession is bounded on the south by east-west trending normal faults. Strata south of this boundary are downthrown as much as 300 m relative to those north of the boundary. A zone of east-west trending normal faults is also present in the northernmost part of the concession. These faults displace strata to the south as much as 250 m. Just outside the northeast boundary of the concession, a normal fault displaces strata to the south by up to 500 m. Faults in the southern part of the concession do not reach the surface (a geologic cross section of the northern part of the concession was not available). Carboniferous formations are unconformably overlain by Miocene strata in the southern part of the concession, and presumably in the northern part as well. The average geothermal gradient is 4.0° C per 100 m.

Coal Rank. Coal rank is sub-bituminous to low volatile bituminous (types 31 through 36) with medium and low volatile bituminous (type 35) accounting for 65 percent of the reserves.

COAL PRODUCTION AND SPECIFIC EMISSIONS

The mine has 3 working levels accessed by 5 shafts, 3 of which are ventilation shafts. Coal is mined by longwall methods from 15 working faces, with a combined length of 2,409 m. As of 1993, mining extended to a depth of 830 m. In 1990, all of the coal produced was medium and low volatile bituminous (type 35). Clean coal production was 2,007 tons per working day based on the combined surface and underground work force, and 4,768 tons per working day based solely on the underground work force.

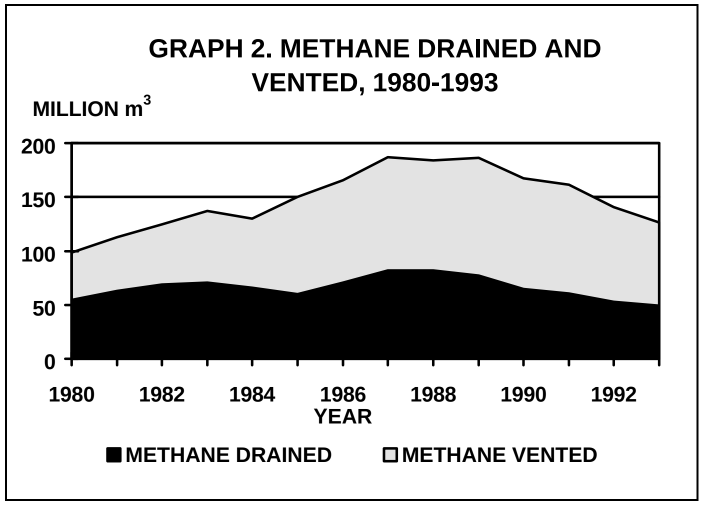
GRAPH 1. COAL PRODUCTION AND SPECIFIC EMISSIONS, 1980-1993



As shown in Graph I, coal production peaked in 1988 and has since declined. Production rose slightly in 1993, to 3.0 million tons. Graph 1 also shows that specific emissions peaked in 1991, and 41.9 m^3 of methane were liberated per ton of coal mined from the Pniowek concession.

METHANE LIBERATION, VENTILATION, RECOVERY, AND RESERVES

In 1993, a total of 126.5 million m^3 of methane were liberated from the Pniowek mining concession. Of this, 49.2 million m^3 were drained, and 77.3 million m^3 were emitted via the ventilation system. Of the methane drained, 43.4 million m^3 were used, and 5.8 million m^3 were emitted.



From 1982 through 1993, more methane was liberated at Pniowek than any other concession studied. Trends in methane ventilation, drainage, and total liberation at Pniowek during the period 1980 through 1991 are shown in Graph 2. Methane liberation began to decrease in 1990, concomitant with a decrease in coal production. The amount of methane drained exceeded the amount vented until 1985; Pniowek continues to maintain a relatively high level of recovery efficiency.

Desorption tests on coal samples from the concession indicate that gas content is up to 15 m^3 per ton. All of the coal mined in 1990 was from methane hazard Class IV seams. The Central Mining Institute forecasts that by year 2000, this will still be the case.

Mine Ventilation. Three ventilation shafts operate at the Pniowek mining concession. The average concentration of methane in the ventilation shafts is 0.38 percent, and the maximum is 0.48 percent. Air flow into the ventilation shafts is 45,836 m^3 per minute, and air flows out of the shafts at the rate of 51,235 m^3 per minute. studied). Total power of the vent motors is 8,200 kW.

Methane Recovery. The Pniowek mining concession has the largest methane drainage system of any mine studied. There were 3,511 drainage boreholes operating at Pniowek in 1991, with a total length of 340.5 km. Total length of the demethanization pipelines is 124.78 km, and their diameter ranges from 100-400 mm. Five pumps and compressors are operating, with a total capacity of 627 m^3 per minute. In 1993, the average concentration of methane in gas utilized from the mine was 62 percent, the highest of any of the mines studied.

In 1993, 16 percent of all methane recovered was drained from development areas; 47 percent was from working faces; and 37 percent was from gob areas.

Methane Resources. In-situ methane resources associated with balance reserves of coal are estimated to range from 15.6-43.5 billion m^3.

PRESENT AND PLANNED UTILIZATION OF MINE METHANE

In 1993, 43.4 million m^3 (88 percent of the total methane drained) were used. Of this, approximately 12.9 million m^3 were used in the mine's boiler or were sold to the Moszczenica and Zofiowka combined heat and power plants. The remaining 30.5 million m^3 were sold to GOZG Zabrze (the POGC's Upper Silesian Gas Utility). A 12.1 km, 500 mm diameter pipeline connects the Pniowek mine with the Swierklany compressor station, which is northwest of the mine; however, for reasons explained in Section 3.2.3 of Part I, GOZG Zabrze is not currently buying any coalbed methane at present. As a result, some of this gas was vented to the atmosphere for a short period of time, but the 1 Maja mine and/or neighboring mines soon began using the additional gas on-site.

The US Trade and Development Agency, in conjunction with the State Hard Coal Agency, is presently examining the feasibility of using vertical wells (both surface and gob) to recover coalbed methane and is identifying the most promising utilization options. A pre-feasibility study of power generation potential has already been prepared by the Polish Coalbed Methane Clearinghouse for the Pniowek mine. Coalbed methane could also be used to fuel the mine's prep plant dryer.

MINING ECONOMICS

In 1990, coal production costs at the Pniowek mining concession totaled 685 billion zlotys ($US 72 million), or 205 thousand zlotys ($US 21) per ton of coal mined. Coal from the concession sold for 103 thousand zlotys ($US 11) per ton, at a loss of 102 thousand zlotys ($US 10) per ton.

In July 1994, coking coal from the Jastrzebie Coal Company (to which the Pniowek mine belongs) sold for 1.25 - 1.42 million zlotys ($US 55.3 - 62.4) per ton, depending on rank. Coal prices have thus risen substantially since 1990, as a result of coal price adjustments that have been made as part of Poland's energy sector restructuring programs.

Methane drainage costs were 9.8 billion zlotys ($US 1 million). Methane sales recovered 8.5 billion zlotys ($US 888 thousand). Methane thus cost 152 zlotys ($US 0.016) per m^3 to drain, and sold for 137 zlotys ($US 0.014) per m^3. Ventilation cost data were unavailable.

During the first six months of 1994, methane from the Jastrzebie Coal Company sold for an average of 478.6 zlotys ($US 0.021) per m^3. Data concerning 1994 methane control costs were unavailable, but based on 1990 drainage costs it appears that the sale of recovered methane could now be profitable.

SALINE WATER

The Pniowek mine discharges about 2400 m^3 of water containing 62 tons of chlorides and sulfates each day. Mine water is initially held in the Olza Reservoir, which also gathers mine water from nine other coal mines, and is then discharged to a tributary of the Olza river. The purpose of the collecting reservoir is to protect the upper course of the Olza River and its tributary, the Szotkowka River. It is not presently known what efforts are being made at the mine to improve saline water management.

SUMMARY DATA TABLES

COAL RESOURCES

Number of Seams	Coal Seam Thickness (m)		Overburden Thickness (m)	Balance Coal Reserves* (Million Tons)			
	Economic	Non-Economic		$A+B+C_1$	C_2	1990 Total	1993 Total
53	0.7-7.8	0.4-0.7	222-1000	663	394	1057	1000

COAL QUALITY

Ash Content (%)		Heating Value (kJ/kg)		Moisture (%)
As Received	ROM Average	Range	ROM Average	ROM Average
5-38	15.42	26,800-33,400	28,300	3

HAZARD DATA

Gas and Rock Outburst	Rock Bump Hazard	Dust Hazard	Water Hazard	Methane Hazard	Spontaneous Combustion
Hazardous	No Hazard	Present	I (Low) and II (Medium)	IV (Very High)	I (Low) and II (Medium)

CARBON DIOXIDE EQUIVALENTS (Million Tons)

CO_2 Equivalent of Total Methane Liberated (Vented and Drained), 1993	CO_2 Equivalent of Total Methane Drained, (Used and Released), 1993
1.89	0.73

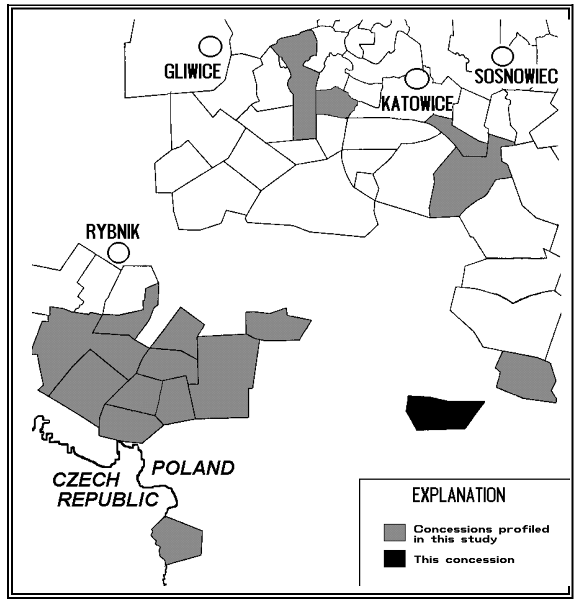
PIPELINE DATA (1995)

Distance to Nearest Pipeline	Owner / Manager of Pipeline
Connected by pipeline to Swierklany Compressor Station	GOZG Zabrze (subsidiary of the POGC)

MINE LIFE EXPECTANCY: More than 20 years

PREP PLANT LOCATED ON SITE?: Yes

***** $A+B+C_1$ and C_2 sub-categories reflect 1990 data; 1993 sub-categorized reserve data were unavailable

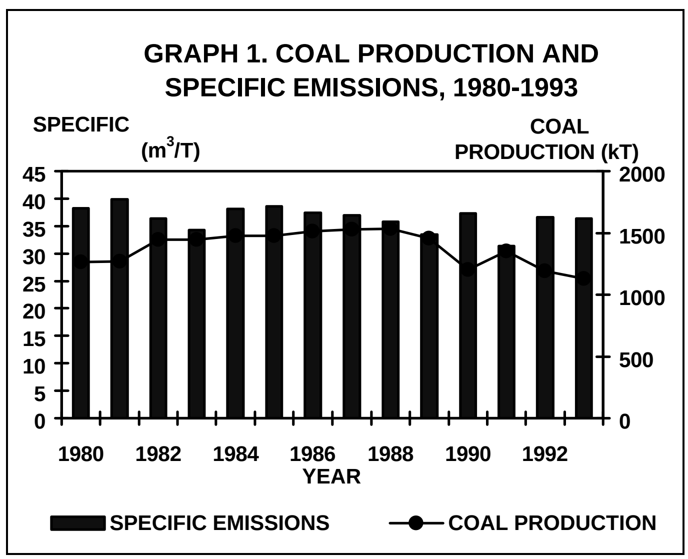


The Silesia mining concession is located in the southeastern portion of the Polish part of the Upper Silesian Coal Basin, approximately 35 km south of the city of Katowice. The concession area occupies about 27 km^2. Coal production started in 1902, and the concession became part of the Nadwislanski Coal Company in 1993.

Geologic Setting. The Silesia concession is bounded on the south by an east-west trending normal fault. Strata south of this boundary are downthrown as much as 600 m relative to those north of the boundary. Three generally north-south trending normal faults cross the concession. Two of these faults form a graben in the center of the concession, where most mining is taking place. Displacement along these faults increases to the north, reaching a maximum of about 120 m. No geologic cross section was available, but it is likely that Carboniferous formations are overlain unconformably by Miocene strata. The average geothermal gradient is 3.45° C per 100 m.

Coal Rank. Coal reserves are sub-bituminous to high volatile A bituminous (types 31 through 34) with sub-bituminous to high volatile B bituminous (Types 31 and 32) accounting for 62 percent of the reserves.

COAL PRODUCTION AND SPECIFIC EMISSIONS



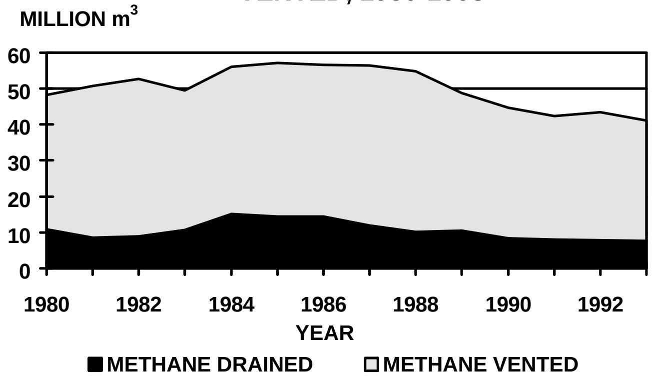
The mine has 5 working levels accessed by 5 shafts, 2 of which are ventilation shafts. Coal is mined by longwall methods from 4 working faces, with a combined length of 538 m. As of 1993, mining extended to a depth of 500 m. In 1990, all of the coal produced was sub-bituminous through high volatile B bituminous (types 31 and 32). Clean coal production was 1,800 tons per working day based on the combined surface and underground work force, and 3,700 tons per working day based solely on the underground work force.

As shown in Graph 1, coal production remained fairly steady from 1982 through 1989, decreased in 1990, and, following a rebound in 1991, declined again. In 1993, the mine produced 1.1 million tons of coal. Graph 1 also shows that the amount of methane liberated per ton of coal mined from the Silesia concession has remained fairly steady since 1980. During the past decade, the Silesia mine has consistently ranked among the top concessions studied in terms of specific emissions. In 1993, 36.4 m^3 of methane were liberated per ton of coal mined from the Silesia concession.

METHANE LIBERATION, VENTILATION, RECOVERY, AND RESERVES

In 1993, a total of 41.1 million m^3 of methane were liberated from the Silesia mining concession. Of this, 7.7 million m^3 were drained, and 33.4 million m^3 were emitted via the ventilation system. Of the methane drained, 7.6 million m^3 were used, and the remaining 0.1 million m^3 were emitted.

GRAPH 2. METHANE DRAINED AND VENTED, 1980-1993



Trends in methane ventilation, drainage, and total liberation during the period 1980 through 1993 are shown in Graph 2. In 1988, methane liberation began an overall decline, due, at least in part, to generally declining coal production.

Desorption tests on coal samples from the concession indicate that gas content is up to 10.5 m^3 per ton. All of the coal mined in 1990 was from methane hazard Class IV seams. The Central Mining Institute forecasts that by the year 2000, this will still be the case.

Mine Ventilation. Two ventilation shafts operate at the Silesia mining concession. The average concentration of methane in the ventilation shafts is 0.32 percent, and the maximum is 0.48 percent. Air flow into the ventilation shafts is 19,856 m^3 per minute, and air flows out of the shafts at the rate of 20,198 m^3 per minute. studied). Total power of the vent motors is 2,300 kW.

Methane Recovery. There were 117 drainage boreholes operating at the Silesia mining concession in 1991, with a total length of 7.8 km. Total length of the demethanization pipelines is 52.43 km, and their diameter ranges from 100-400 mm. Five pumps and compressors are operating, with a total capacity of 150 m^3 per minute. In 1993, the average concentration of methane in gas utilized from the mine was 48 percent.

In 1993, 7 percent of the methane recovered from the mine was drained from development areas; 22 percent was from working faces; and 71 percent was from gob areas.

Methane Resources. In-situ methane resources associated with balance reserves of coal are estimated to range from 7.6 - 26.5 billion m^3.

PRESENT AND PLANNED UTILIZATION OF MINE METHANE

In 1993, 7.6 million m^3 of methane drained from the Silesia concession were used; this represents 99 percent of the methane drained from the concession. Methane was consumed by the Silesia mine heat plant and the oil refinery at Czechowice-Dziedzice.

The Nadwislanska Coal Company (to which the Silesia mine belongs) has partnered with Metanel S.A., a Polish coalbed methane extraction enterprise. Metanel has received a concession to produce coalbed methane in coal reserve areas in addition to its cooperation with the Silesia mine. Methane will be produced via surface wells, and Metanel estimates initial production levels of 200 million m^3/year (EEE, 1994). Possible customers for the gas include the oil refinery at Czechowice-Dziedzice, and the CHP plant serving the town of Bielsko-Biala. The former can take up to 300 million m^3/year, and the latter 50 million m^3/year. Metanel started test drillings in July, 1994.

MINING ECONOMICS

In 1990, coal production costs at the Silesia mining concession totaled 229 billion zlotys ($US 24 million), or 190 thousand zlotys ($US 20) per ton of coal mined. Coal from the concession sold for 102 thousand zlotys ($US 11) per ton, at a loss of 88 thousand zlotys ($US 9) per ton.

Methane drainage costs were 3.6 billion zlotys ($US 376 thousand). Methane sales recovered 479 million zlotys ($US 50 thousand). Methane thus cost 428 zlotys ($US 0.05) per m^3 to drain, and sold for 165 zlotys ($US 0.02) per m^3. Ventilation costs were 3.9 billion zlotys ($US 403 thousand), or 106 zlotys ($US 0.01) per m^3. Total methane control costs were thus 7.4 billion zlotys ($US 779 thousand), or 534 zlotys ($US 0.06) per m^3.

More recent data concerning mining economics were not available.

SALINE WATER

The Silesia mine discharges about 9,400 m^3 of water containing 300 tons of chlorides and sulfates each day. It discharges more salts to Polish rivers than any of the other mines studied. The Silesia Reservoir collects water from the mine; it was designed many years ago to hold mine water for subsequent discharge to the Vistula River during periods of high flow. However, the storage capacity of the reservoir is only 1.7 million m^3, too small for the amount of water discharged from the mine. Saline water is thus discharged from the reservoir to the river regardless of the river flow rate.

Mine management is attempting to solve its saline water management problems by proper abandonment of face-dewatering boreholes (better sealing of pipes), and also by isolating selected mine workings that produce highly saline water.

SUMMARY DATA TABLES

COAL RESOURCES

Number of Seams	Coal Seam Thickness (m)		Overburden Thickness (m)	Balance Coal Reserves* (Million Tons)			
	Economic	Non-Economic		$A+B+C_1$	C_2	1990 Total	1993 Total
56	0.8-6.3	Not Available	100-700	352	377	729	727

COAL QUALITY

Ash Content (%)		Heating Value (kJ/kg)		Moisture (%)
As Received	ROM Average	Range	ROM Average	ROM Average
7-35	19.3	19,000-28,000	23,800	5

HAZARD DATA

Gas and Rock Outburst	Rock Bump Hazard	Dust Hazard	Water Hazard	Methane Hazard	Spontaneous Combustion
No Hazard	No Hazard	Present	I (Low)	I (Low) - IV (Very High)	IV (Very High)

CARBON DIOXIDE EQUIVALENTS (Million Tons)

CO_2 Equivalent of Total Methane Liberated (Vented and Drained), 1993	CO_2 Equivalent of Total Methane Drained, (Used and Released), 1993
0.61	0.11

PIPELINE DATA (1995)

Distance to Nearest Pipeline	Owner / Manager of Pipeline
Connected by pipeline to Czechowice Refinery	GOZG Zabrze (subsidiary of the POGC)

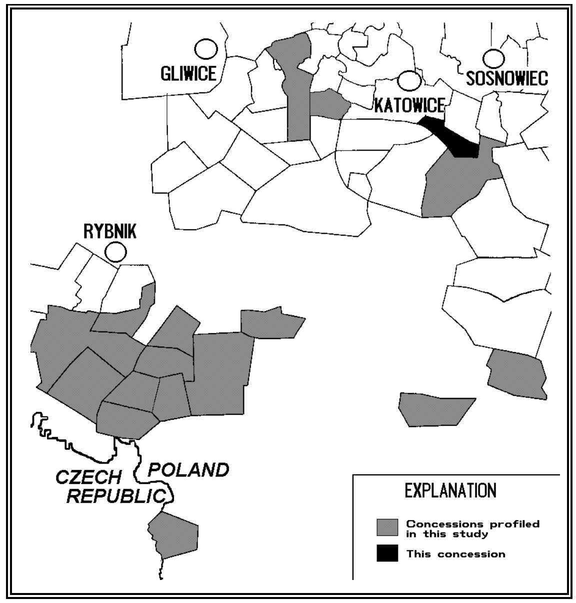
MINE LIFE EXPECTANCY: More than 20 years

PREP PLANT LOCATED ON SITE?: Yes

***** $A+B+C_1$ and C_2 sub-categories reflect 1990 data; 1993 sub-categorized reserve data were unavailable

STASZIC

The Staszic mining concession is located in the northeastern portion of the Polish part of the Upper Silesian Coal Basin, in the southeastern part of Katowice. The concession area occupies about 21 km^2. Coal production started in 1964, and the mine presently belongs to the Katowice Holding Company.

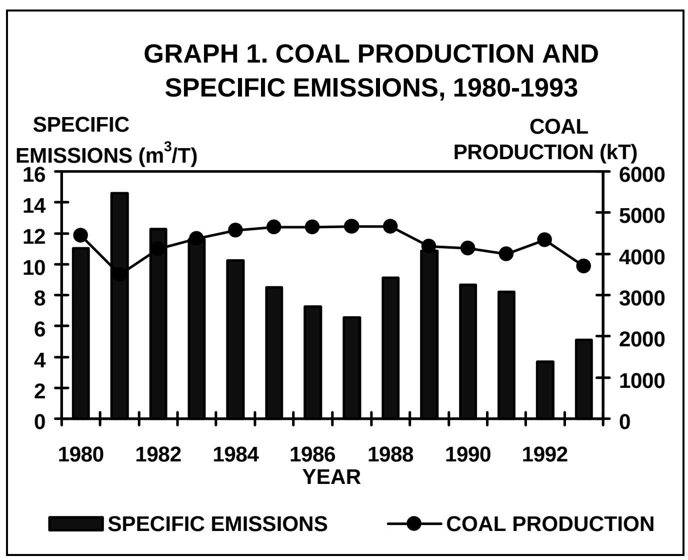


Geologic Setting. The Staszic concession is crossed by several east-southeast/west-northwest trending normal faults. The greatest displacement occurs along the Klodnicki fault; strata south of this fault are downthrown by as much as 100 m. Most of the mining occurs north of this fault, in the central part of the Staszic concession. It is not clear from the geologic cross section whether or not Miocene strata unconformably overlie the Carboniferous formations. If indeed the Miocene is present, it is a relatively thin layer, and apparently does not cover the entire concession. The average geothermal gradient is 3.28° C per 100 m.

Coal Rank. Coal rank is sub-bituminous to high volatile A bituminous (types 31 through 34) with sub-bituminous to high volatile B bituminous (Types 31 and 32) accounting for 83 percent of the reserves.

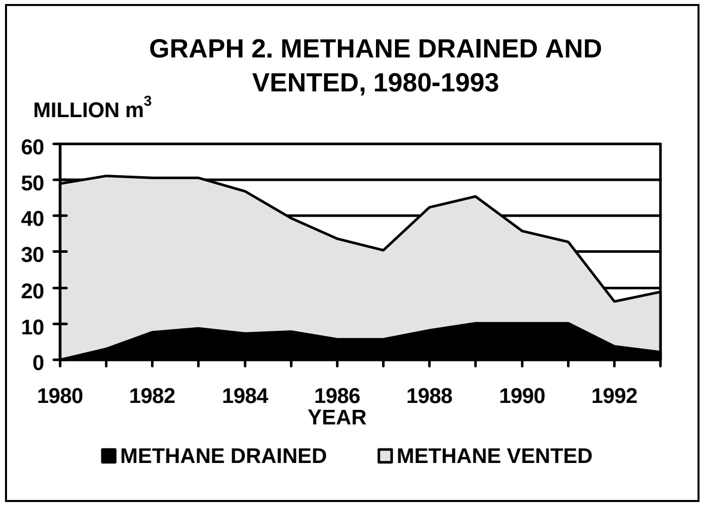
COAL PRODUCTION AND SPECIFIC EMISSIONS

The mine has 2 working levels accessed by 5 shafts, 3 of which are ventilation shafts. Coal is mined by longwall methods from 11 working faces, with a combined length of 2,103 m; 2 working levels; and 5 shafts, 3 of which are ventilation shafts. As of 1993, mining extended to a depth of 720 m. Coal production according to rank (type) was not available. Clean coal production was 2,735 tons per working day based on the combined surface and underground work force, and 5,330 tons per working day based solely on the underground work force.



As shown in Graph 1, coal production remained steady during the period 1984-1988, began declining in 1989, and following a rebound in 1992, decreased to 3.7 million tons in 1993. Graph 1 also shows that specific emissions were substantially lower in 1992 and 1993; in 1993, 5.1 m^3 of methane were liberated per ton of coal mined.

METHANE LIBERATION, VENTILATION, RECOVERY, AND RESERVES



In 1993, a total of 18.9 million m^3 of methane were liberated from the Staszic mining concession. Of this, 2.1 million m^3 were drained, and 16.8 million m^3 were emitted via the ventilation system. Of the methane drained, 2.0 million m^3 were used, and the remaining 0.1 million m^3 were emitted.

Trends in methane ventilation, drainage, and total liberation during the period 1980 through 1993 are shown in Graph 2. No data was available concerning the amount of methane drained in 1980, so all methane liberated that year is assumed to result from ventilation. Both the amount of methane drained and the amount liberated dropped sharply in 1992, and while ventilation recovered somewhat in 1993, drainage continued to decline.

Desorption tests on coal samples from the concession indicate that gas content is up to 8.0 m^3 per ton. In 1990, 75 percent of the coal mined was from methane hazard Class IV seams, and the remaining 25 percent was from methane hazard Class II seams. The Central Mining Institute forecasts that by the year 2000, 50 percent will be from Class IV seams, and the remainder will be from Class II seams.

Mine Ventilation. Three ventilation shafts operate at the Staszic mining concession. The average concentration of methane in the ventilation shafts is 0.4 percent. Air flow into the ventilation shafts is 41,890 m^3 per minute, and air flows out of the shafts at the same rate. Total power of the vent motors is 4,050 kW.

Methane Recovery. There were 300 drainage boreholes operating at the Staszic mining concession in 1991, with a total length of 35 km. Total length of the demethanization pipelines is 7.21 km, and their diameter ranges from 200-300 mm. Four pumps and compressors are operating, with a total capacity of 60 m^3 per minute. In 1993, the average concentration of methane in gas used from the mine was 48 percent.

All of the methane recovered in 1993 was drained from gob areas; none was from development areas or working faces.

Methane Resources. In-situ methane resources associated with balance reserves of coal are estimated to range from 3.2 - 5.1 billion m^3.

PRESENT AND PLANNED UTILIZATION OF MINE METHANE

In 1993, 2 million m^3 of methane drained from the Staszic concession were used; this represents 95 percent of the methane drained from the concession. The methane was consumed by the Ferrum steel complex, located near the mine.

Mine management plans to construct a new pipeline from Shaft IV to the East Field 501, and to add 4 compressors to the demethanization station, which will increase methane recovery. Potential additional consumers of methane include the Staszic mine power plant, and residences in the surrounding community.

MINING ECONOMICS

In 1990, coal production costs at the Staszic mining concession totaled 702 billion zlotys ($US 73 million), or 170 thousand zlotys ($US 18) per ton of coal mined. Coal from the concession sold for 280 thousand zlotys ($US 29) per ton, at a profit of 110 thousand zlotys ($US 11) per ton.

Methane drainage costs were 6 billion zlotys ($US 627 thousand). Methane sales recovered 2 billion zlotys ($US 209 thousand). Methane thus cost 600 zlotys ($US 0.06) per m^3 to drain, and sold for 200 zlotys ($US 0.02) per m^3. Methane ventilation costs were unavailable.

SALINE WATER

The Staszic mine discharges about 3500 m^3 of water containing 57 tons of chlorides and sulfates to the Wisla River drainage each day. It is not known what plans exist to improve saline water management at the mine.

SUMMARY DATA TABLES

COAL RESOURCES

Number of Seams	Coal Seam Thickness (m)		Overburden Thickness (m)	Balance Coal Reserves* (Million Tons)			
	Economic	Non-Economic		$A+B+C_1$	C_2	1990 Total	1993 Total
56	0.8-10.8	0.6-9.8	0-95	559	86	645	637

COAL QUALITY

Ash Content (%)		Heating Value (kJ/kg)		Moisture (%)
As Received	ROM Average	Range	ROM Average	ROM Average
2.5-19.8	28,600	23,570-31,610	28,600	5.5

HAZARD DATA

Gas and Rock Outburst	Rock Bump Hazard	Dust Hazard	Water Hazard	Methane Hazard	Spontaneous Combustion
No Hazard	I (Low) and III (High)	Present	I (Low) and III (High)	II (Medium) - IV (Very High)	II (Medium)- IV (Very High)

CARBON DIOXIDE EQUIVALENTS (Million Tons)

CO_2 Equivalent of Total Methane Liberated (Vented and Drained), 1993	CO_2 Equivalent of Total Methane Drained, (Used and Released), 1993
0.28	0.03

PIPELINE DATA (1995)

Distance to Nearest Pipeline	Owner / Manager of Pipeline
Surrounding community contains gas network	GOZG Zabrze (subsidiary of the POGC)

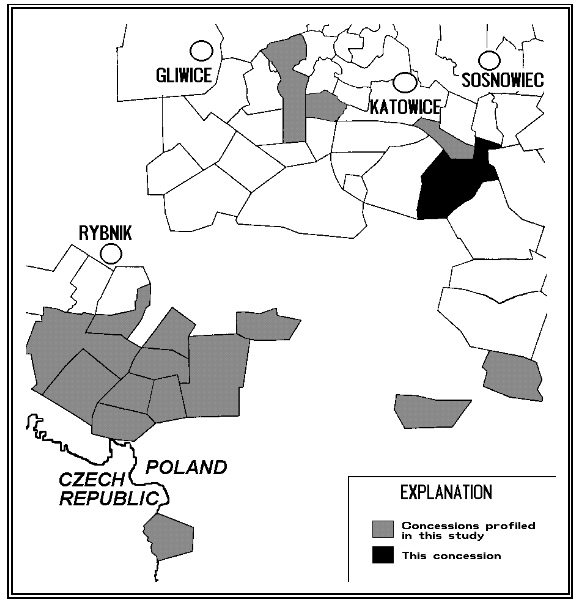
MINE LIFE EXPECTANCY: More than 20 years

PREP PLANT LOCATED ON SITE?: No

***** $A+B+C_1$ and C_2 sub-categories reflect 1990 data; 1993 sub-categorized reserve data were unavailable

WESOLA

The Wesola mining concession is located in the northeastern portion of the Polish part of the Upper Silesian Coal Basin, in the town of Myslowice, south of Katowice. Wesola is one of 11 mines that comprise the Katowice Coal Holding Company. The concession area occupies about 57 km^2. Coal production started in 1952.



Geologic Setting. The east-west trending Ksiazecego normal fault zone crosses the center of the Wesola concession. Strata south of this zone are downthrown as much as 420 m. Several faults are present in the eastern part of the concession; the largest of these is the north-south trending Wanda normal fault. Strata east of this fault are downthrown by as much as 220 m. On the western side of the concession, smaller faults form horst and graben features, but displacement is relatively low.

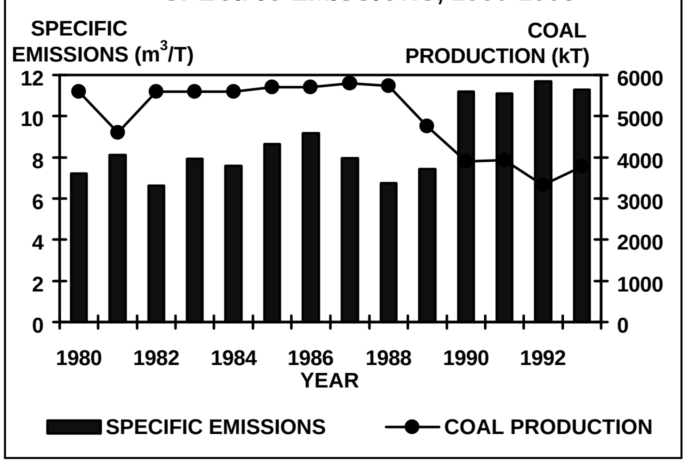
Mining is presently occurring on the structurally highest fault block. From the geologic cross section, it is not clear whether a Miocene sequence unconformably overlies the Carboniferous formations. If a Miocene layer does exist, it is probably thin and does not cover the entire concession. The average geothermal gradient is 3.53° C per 100 m.

Coal Rank. Coal rank is sub-bituminous to high volatile B bituminous (types 31-33).

COAL PRODUCTION AND SPECIFIC EMISSIONS

The mine has 5 working levels accessed by 6 shafts, 2 of which are ventilation shafts. Coal is mined by longwall methods from 12 working faces, with a combined length of 2,106 m. As of 1993, mining extended to a depth of 860 m. In 1990, all of the coal produced was sub-bituminous to high volatile B bituminous (types 31-33). Clean coal production was 2,759 tons per working day based on the combined surface and underground work force, and 5,000 tons per working day based solely on the underground work force.

GRAPH 1. COAL PRODUCTION AND SPECIFIC EMISSIONS, 1980-1993



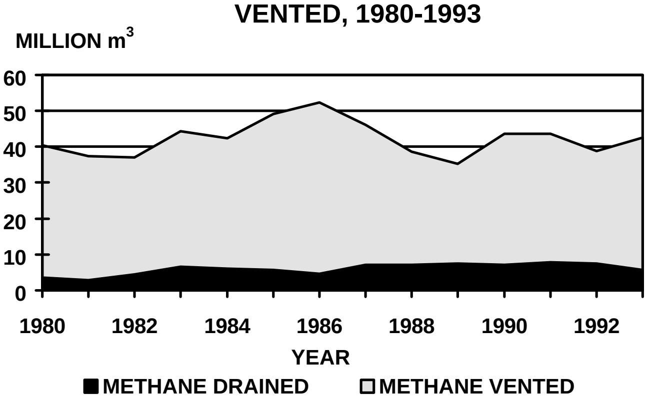
As shown in Graph 1, coal production was steady from 1982 through 1988, declined sharply in 1989 and has remained relatively low. In 1993, 3.8 million tons of coal were produced. Graph 1 also shows that specific emissions have been relatively high since 1990, perhaps reflecting new development at the mine. In 1993, 11.3 m^3 of methane were liberated per ton of coal mined.

METHANE LIBERATION, VENTILATION, RECOVERY, AND RESERVES

In 1993, a total of 42.5 million m^3 of methane were liberated from the Wesola mining concession. Of this, 5.7 million m^3 were drained, and 36.8 million m^3 were via the ventilation system. Of the methane drained, 2.6 million m^3 were used, and 3.1 million m^3 were emitted.

Trends in methane ventilation, drainage, and total liberation from 1980 through 1993 are shown in Graph 2. Note that recovery efficiency has been low throughout the period; in 1993, it was only 13 percent.

GRAPH 2. METHANE DRAINED AND VENTED, 1980-1993



Desorption tests on coal samples from the concession indicate that gas content is up to 11.6 m^3 per ton. In 1990, 50.7 percent of the of the coal mined at Wesola was from methane hazard Class IV seams, 33.3 percent was from seams rated below Class I, 12.3 percent was from Class II seams, and 3.7 percent was from Class III seams. The Central Mining Institute forecasts that by year 2000, the mine will be gassier, with 76.1 percent from Class IV seams, 13.1 percent from Class II seams, 6.9 percent from Class III seams, and 3.5 percent from Class I seams.

Mine Ventilation. Two ventilation shafts operate at the Wesola mining concession. The average concentration of methane in the ventilation shafts is 0.15 percent, and the maximum concentration is 0.22 percent. Air flow into the ventilation shafts is 38,884 m^3 per minute, and air flows out of the shafts at the rate of 41,030 m^3 per minute. Total power of the vent motors is 2,430 kW.

Methane Recovery. There were 156 drainage boreholes operating at the Wesola mining concession in 1991, with a total length of 17 km. Total length of the demethanization pipelines is 16.4 km, and their diameter ranges from 150-300 mm. Seven pumps and compressors are operating, with a total capacity of 175 m^3 per minute. In 1993, the average concentration of methane in gas utilized from the mine was 54 percent.

Of the methane drained in 1993, 98 percent was drained from working faces, and 2 percent was drained from gob areas.

Methane Resources. In-situ methane resources associated with balance reserves of coal are estimated to range from 11.6 - 11.9 billion m^3.

PRESENT AND PLANNED UTILIZATION OF MINE METHANE

In 1993, 2.6 million m^3 of methane drained from the Wesola concession were used; this represents 46 percent of the total amount drained. The methane was consumed by the heat plant that serves the Wesola mine and provides district heating for the nearby community. In 1994, all of the methane drained from the concession was used.

Potential consumers of methane in the future include: a proposed additional heat plant serving the mine; a coal prep plant that is being developed; and residential gas consumers in the surrounding community of Myslowice.

MINING ECONOMICS

In 1990, coal production costs at the Wesola mining concession totaled 538 billion zlotys ($US 56 million) or 139 thousand zlotys ($US 15) per ton of coal mined. Coal from the concession sold for 92 thousand zlotys ($US 10) per ton, at a loss of 47 thousand zlotys ($US 5) per ton.

Methane drainage costs were 1.9 billion zlotys ($US 201 thousand), or 267 zlotys ($US 0.028) per m^3. No information was available regarding methane sales. Ventilation costs in 1990 were 9.6 billion zlotys ($US 1 million), or 264 zlotys ($US 0.028) per m^3. Total methane control costs were thus 11.5 billion zlotys ($US 1.2 million), or 531 zlotys ($US 0.056) per m^3. More recent data concerning mining economics were unavailable.

SALINE WATER

About 3,300 m^3 of saline water containing 145 tons of chlorides and sulfates are discharged from the Wesola mine to the Wisla River drainage each day. It is not clear what measures are being taken to reduce this high discharge of salts. However, it is likely that mine management will attempt to improve its saline water management methods, as increasing fees and fines for salt water discharge are being imposed.

SUMMARY DATA TABLES

COAL RESOURCES

Number of Seams	Coal Seam Thickness (m)		Overburden Thickness (m)	Balance Coal Reserves* (Million Tons)			
	Economic	Non-Economic		$A+B+C_1$	C_2	1990 Total	1993 Total
42	0.8-14	0.6-1	0-234	735	271	1,006	1,025

COAL QUALITY

Ash Content (%)		Heating Value (kJ/kg)		Moisture (%)
As Received	ROM Average	Range	ROM Average	ROM Average
4.4-47	19.1	16,959-31,360	23,545	7

HAZARD DATA

Gas and Rock Outburst	Rock Bump Hazard	Dust Hazard	Water Hazard	Methane Hazard	Spontaneous Combustion
No Hazard	III (High)	None to Present	I (Low) - III (High)	0 (Very Low) - IV (Very High)	II (Medium)- IV (Very High)

CARBON DIOXIDE EQUIVALENTS (Million Tons)

CO_2 Equivalent of Total Methane Liberated (Vented and Drained), 1993	CO_2 Equivalent of Total Methane Drained, (Used and Released), 1993
0.63	0.05

PIPELINE DATA (1995)

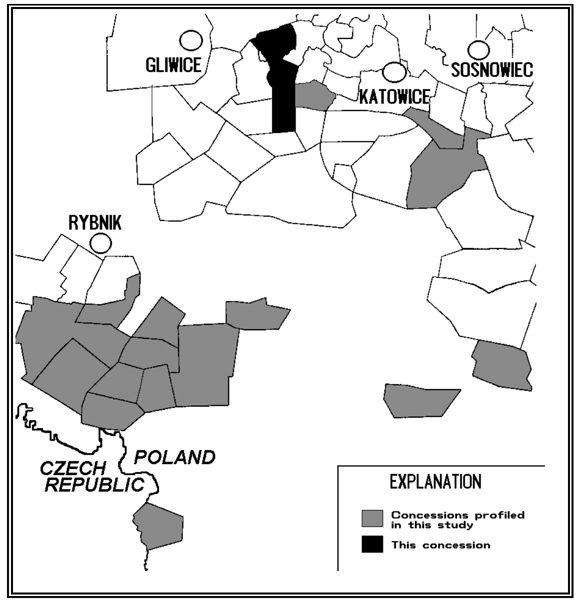
Distance to Nearest Pipeline	Owner / Manager of Pipeline
Surrounding community contains gas network	GOZG Zabrze (subsidiary of the POGC)

MINE LIFE EXPECTANCY: More than 20 years

PREP PLANT LOCATED ON SITE?: No; under development

***** $A+B+C_1$ and C_2 sub-categories reflect 1990 data; 1993 sub-categorized reserve data were unavailable

ZABRZE-BIELSZOWICE



The Zabrze-Bielszowice mining concession is located in the northwestern portion of the Polish part of the Upper Silesian Coal Basin, approximately 14 km west of the city of Katowice in the towns of Ruda-Slaska-Bielszowice and Zabrze. The Zabrze-Bielszowice mine is one of 9 mines that comprise the Rudzka Coal Company. The concession area occupies about 41 km^2. Coal production started in 1891.

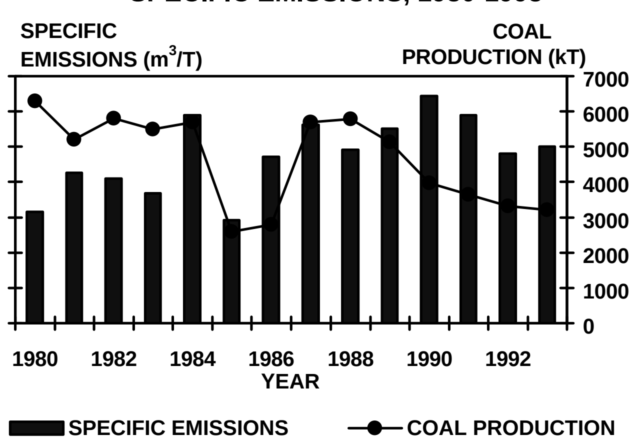
Geologic Setting. Two main east-west trending fault zones divide the concession into three blocks. The largest fault in northern fault zone is the Soara normal fault. The largest fault in the southern fault zone is the Klodnicki normal fault. Most of the mining in this concession has occurred between these two fault zones, on a structurally isolated block. A geologic cross section was not available, but it is probable that in at least part of the concession, a Miocene sequence unconformably overlies the Carboniferous formations. The average geothermal gradient is 3.7° C per 100 m.

Coal Reserves and Rank. Coal rank is sub-bituminous to low volatile bituminous (types 31 through 35), with high volatile A and B bituminous (type 34) accounting for 63 percent of the reserves.

COAL PRODUCTION AND SPECIFIC EMISSIONS

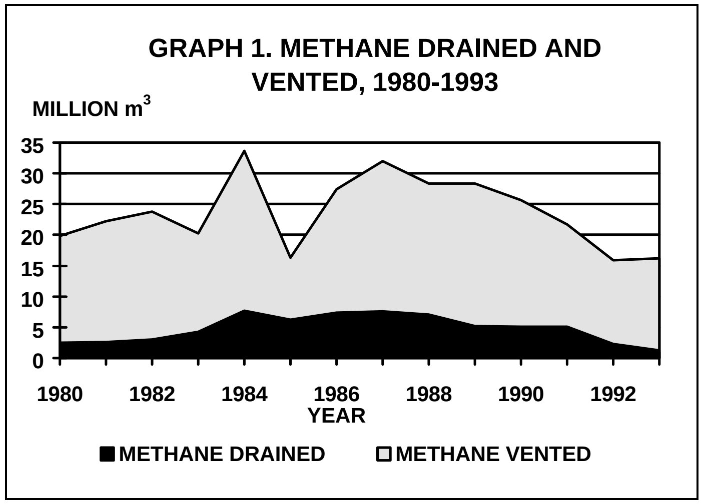
The mine has 10 working levels accessed by 11 shafts, 3 of which are ventilation shafts. Coal is mined by longwall methods from 13 working faces, with a combined length of 2,545 m. As of 1993, mining extended to a depth of 840 m. In 1990, nearly 4 million tons of coal were produced, of which 2.9 million tons were sub-bituminous (types 31 and 32), 0.8 million tons were high volatile A and B bituminous (type 34, coking coal), and 0.3 million tons were high volatile B bituminous (type 33, power coal). Clean coal production was 1,955 tons per working day based on the combined surface and underground work force, and 3,347 tons per working day based solely on the underground work force.

GRAPH 1. COAL PRODUCTION AND SPECIFIC EMISSIONS, 1980-1993



As shown in Graph 1, coal production has fluctuated considerably since 1980, reaching its lowest levels in 1985 and 1986. In 1993, 3.2 million tons were mined. Graph 1, shows that specific emissions have also fluctuated, perhaps in response to changing stages of mine development. In 1993, 5 m^3 of methane were liberated per ton of coal mined from the Zabrze-Bielszowice concession.

In 1993, a total of 16.2 million m^3 of methane were liberated from the Zabrze-Bielszowice mining concession. Of this, 1.2 million m^3 were drained, and 15 million m^3 were emitted via the ventilation system. All of the drained methane was utilized.



Trends in methane ventilation, drainage, and total liberation from 1980 through 1993 are shown in Graph 1. The amount of methane vented was especially high in 1984 and again in 1987. As shown in the graph, recovery efficiency tends to be low at this mine, and in 1993 was only 7 percent, the lowest of any of the mines studied.

Desorption tests on coal samples from the concession indicate that gas content ranges to 11.6 m^3 per ton. In 1990, 19 percent of the coal mined was from methane hazard Class 0 seams; 15 percent was from Class I seams; 9 percent was from Class II seams; 38 percent was from Class III seams; and 19 percent was from Class IV seams. The Central Mining Institute forecasts that by year 2000, 31 percent will be from Class 0 seams; 9 percent will be from Class I seams; 46 percent will be from Class III seams; and 14 percent will be from Class IV seams.

Mine Ventilation. Three ventilation shafts operate at the Zabrze-Bielszowice mining concession. The average concentration of methane in the ventilation shafts is 0.03 percent, and the maximum is 0.05 percent. Air flow into the ventilation shafts is 68,890 m^3 per minute, and air flows out of the shafts at the same rate. Total power of the vent motors is 5,200 kW.

Methane Recovery. There were 19 drainage boreholes operating at the Zabrze-Bielszowice mining concession in 1991, with a total length of 0.8 km. Total length of the demethanization pipelines is 5.3 km, and their diameter ranges from 150-300 mm. Six pumps and compressors are operating, with a total capacity of 150 m^3 per minute. In 1992, the average concentration of methane in gas utilized from the mine was 50 percent.

In 1993, 36 percent of the methane recovered was drained from working faces, and 64 percent was drained from gob areas.

Methane Resources. In-situ methane resources associated with balance reserves of coal are estimated to range from 2.2 - 6.3 billion m^3.

PRESENT AND PLANNED UTILIZATION OF MINE METHANE

In 1993, 1.2 million m^3 of methane drained from the Zabrze-Bielszowice concession were used; this represents all of the methane drained from the concession. The methane was consumed by the Zabrze-Bielszowice mine heat plant at Operation No. 2.

Mine management plans to rebuild the demethanization station, and to drain coal seam "405/1/I". Estimates of the mine's heat plant fuel consumption indicated that it could use as much as 18 million m^3 of methane annually. Other potential consumers of methane include residential users of conventional natural gas in the surrounding communities of Ruda Slaska-Bielszowice and Zabrze.

MINING ECONOMICS

In 1990, coal production costs at the Zabrze-Bielszowice mining concession totaled 718 billion zlotys ($US 75 million), or 183 thousand zlotys ($US 19) per ton of coal mined. Coal from the concession sold for 116 thousand zlotys ($US 12) per ton, at a loss of 67 thousand zlotys ($US 7) per ton.

Methane drainage costs were 2.5 billion zlotys ($US 261 thousand) or 499 zlotys ($US 0.05 USD) per m^3. Data regarding methane sales were not available. Ventilation costs in 1990 were 12.3 billion zlotys ($US 1.3 million), or 597 zlotys ($US 0.06) per cubic meter (note that ventilation costs exceeded drainage costs, per unit volume of methane). Total methane control costs were thus 14.8 billion zlotys ($US 1.5 million), or 1,096 zlotys ($US 0.11) per cubic meter. Data regarding methane sales were not available.

More current data on mining economics were not available.

SALINE WATER

The Zabrze-Bielszowice mine discharges about 9200 m^3 of water containing 34 tons of chlorides and sulfates to the Klodnica River each day. The mine is considering treating this water by reverse osmosis.

SUMMARY DATA TABLES

COAL RESOURCES

Number of Seams	Coal Seam Thickness (m)		Overburden Thickness (m)	Balance Coal Reserves* (Million Tons)			
	Economic	Non-Economic		$A+B+C_1$	C_2	1990 Total	1993 Total
65	0.7-11.0	0.4-1.0	3-236	378	170	548	545

COAL QUALITY

Ash Content (%)		Heating Value (kJ/kg)		Moisture (%)
As Received	ROM Average	Range	ROM Average	ROM Average
2-33	14	20,600-31,822	28,403	3.3

HAZARD DATA

Gas and Rock Outburst	Rock Bump Hazard	Dust Hazard	Water Hazard	Methane Hazard	Spontaneous Combustion
No Hazard	I (Low) - III (High)	None	II (Medium)	0 (Very Low) - IV (Very High)	II (Medium)- IV (Very High)

CARBON DIOXIDE EQUIVALENTS (Million Tons)

CO_2 Equivalent of Total Methane Liberated (Vented and Drained), 1993	CO_2 Equivalent of Total Methane Drained, (Used and Released), 1993
0.24	0.02

PIPELINE DATA (1995)

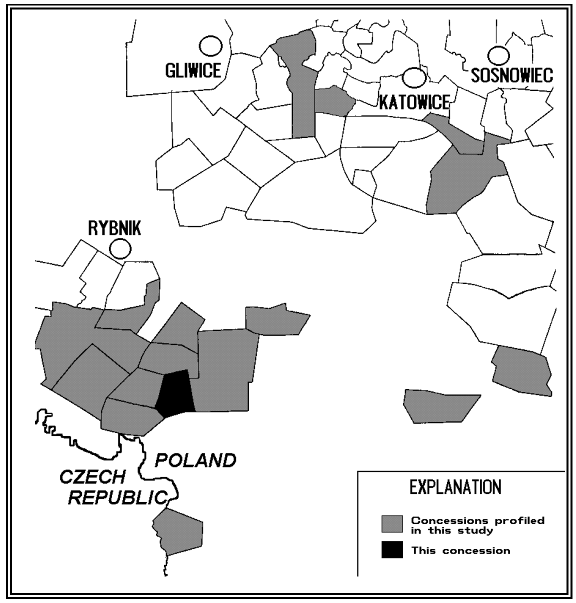
Distance to Nearest Pipeline	Owner / Manager of Pipeline
Surrounding community contains gas network	GOZG Zabrze (subsidiary of the POGC)

MINE LIFE EXPECTANCY: More than 20 years

PREP PLANT LOCATED ON SITE?: Yes, but no coal dryer

***** $A+B+C_1$ and C_2 sub-categories reflect 1990 data; 1993 sub-categorized reserve data were unavailable

The Zofiowka mining concession is located in the southwestern portion of the Polish part of the Upper Silesian Coal Basin, approximately 16 km south-southeast of the city of Rybnik. The concession area occupies 16.4 km^2. Coal productions started in 1969. The concession became part of the Jastrzebie Coal Company in 1993.



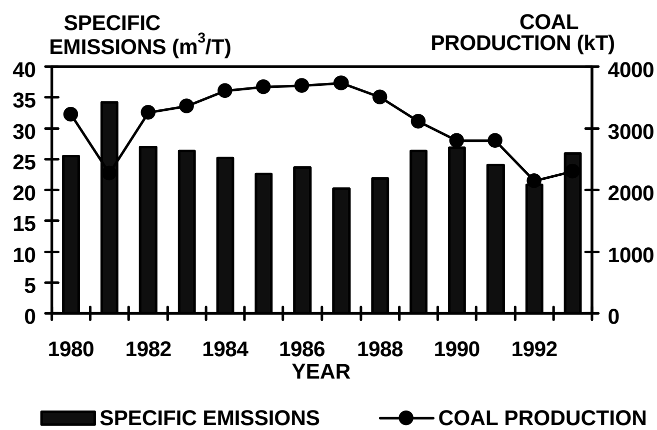
Geologic Setting. Several normal faults cross the Zofiowka mining concession. Displacement along these faults is minimal. The most prominent fault is the Jastrzebie fault, a low angle fault with only 10 m displacement. None of these faults reaches the surface. A thick Miocene sequence unconformably overlies the Carboniferous formation. The average geothermal gradient is 3.45° C per 100 m.

Coal Reserves and Rank. Coal rank is high volatile B bituminous through low volatile bituminous (types 34 through 37), with medium and low volatile bituminous (type 35) accounting for 83 percent of the reserves. In 1993, coal reserves totaled 546 millions tons.

COAL PRODUCTION AND SPECIFIC EMISSIONS

The mine has 4 working levels accessed by 5 shafts, 2 of which are ventilation shafts. Coal is mined by longwall methods from 12 working faces, with a combined length of 1,520 m. As of 1989, mining extended to a depth of 830 m. In 1990, a total of 2.8 million tons of coal were produced, 2.6 million of which were medium and low volatile bituminous (type 35), and the remaining 0.2 million of which were low volatile bituminous (types 36 and 37). Clean coal production was 1,890 tons per working day based on the combined surface and underground work force, and 4,780 tons per working day based solely on the underground work force.

GRAPH 1. COAL PRODUCTION AND SPECIFIC EMISSIONS, 1980-1993

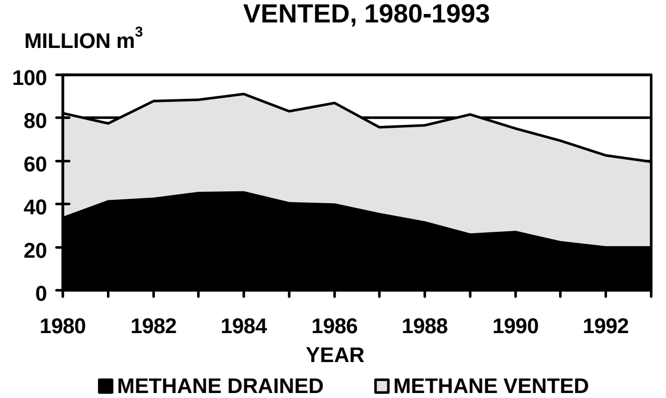


As shown in Graph I, coal production reached a peak in 1987 and then began to decline. In 1993, production rebounded slightly to 2.3 million tons. It is unlikely that future production will exceed 1993 levels. Graph 1 also shows that specific emissions have fluctuated only slightly throughout the period. In 1993, 25.9 m^3 of methane were liberated per ton of coal mined from the concession.

METHANE LIBERATION, VENTILATION, RECOVERY, AND RESERVES

In 1993, a total of 59.6 million m^3 of methane were liberated from the Zofiowka mining concession. Of this, 19.8 million m^3 were drained, and 39.8 million m^3 were emitted via the ventilation system. Of the methane drained, 5.2 million m^3 were utilized, and the remaining and 4.6 million m^3 were emitted. Of the mines studied, Zofiowka ranked third in terms of volume of methane drained.

GRAPH 2. METHANE DRAINED AND VENTED, 1980-1993



Trends in methane ventilation, drainage, and total liberation from 1980 through 1993 are shown in Graph 2. Methane liberation has generally decreased since the mid-1980's, primarily as a result of declining coal production.

Desorption tests on coal samples from the concession indicate that gas content ranges to 23 m^3/ton. In 1990, 100 percent of the coal mined was from methane hazard Class IV seams. The Central Mining Institute forecasts that in the year 2000, this will still be the case.

Mine Ventilation. Two ventilation shafts operate at the Zofiowka mining concession. The average concentration of methane in the ventilation shafts is 0.18 percent. Air flow into the ventilation shafts is 47,730 m^3 per minute, and air flows out of the shafts at the rate of 26,853 m^3 per minute. Total power of the vent motors is 5,700 kW.

Methane Recovery. There were 1,883 drainage boreholes operating at the concession in 1991, with a total length 112.75 km. Total length of the demethanization pipelines is 89.19 km, and their diameter ranges from 100-300 mm. Twelve pumps and compressors are operating, with a total capacity of 505 m^3 per minute. In 1993, the average methane concentration in gas utilized from the mine 48 percent.

In 1993, 28 percent of the methane recovered was drained from development areas, 34 percent was drained from working faces, and 38 percent was drained from gob areas.

The Zofiowka mine is the subject of a pre-feasibility study being funded by the USAID and the USEPA. This study is being prepared by the International Coalbed Methane Group, based in Birmingham, Alabama. This study will examine the applicability of US surface gob well recovery technologies for coalbed methane production in Poland. The study is being prepared by the International Coalbed Methane Group, based in Birmingham, Alabama. It is expected that this study will be completed in early 1995.

Methane Resources. In-situ methane resources associated with balance reserves of coal are estimated to range from 12.6 - 14.2 billion m^3.

PRESENT AND PLANNED UTILIZATION OF MINE METHANE

In 1990, 15.2 million m^3 of methane drained from the concession were used; this represents 77 percent of the methane drained from the concession. Of this methane, 14.9 million m3 were used on-site, at the mine's combined heat and power (CHP) plant; the remaining 0.3 million m3 were sold to GOZG Zabrze (the POGC's Upper Silesian Gas Utility). The Zofiowka mine is connected to the Swierklany compressor station by 6.9 km of 500 mm diameter pipeline, but for reasons explained in Section 3.2.3 of Part I, GOZG Zabrze ceased buying coalbed methane in 1993. As a result, some of this gas was vented to the atmosphere for a short period of time, but Zofiowka and/or neighboring mines soon began using the additional gas on-site.

This Zofiowka CHP plant used 39.9 million m^3 of mine gas in 1993. Some of this gas, whose average methane concentration was 49.9 percent, was drained from mines other than Zofiowka. About 10 percent of the fuel energy consumed by the power plant came from methane. In order to increase the amount of methane used at the plant, it would be necessary to modify the boilers (Zimny, 1994).

MINING ECONOMICS

In 1990, coal production costs at the Zofiowka mining concession totaled 595 billion zlotys ($US 62 million), or about 222 thousand zlotys ($US 23) per ton of coal mined. Coal from the concession sold for 219 thousand zlotys ($US 22) per ton, at a loss of 3 thousand zlotys ($US 1) per ton.

In 1994, coking coal from the Jastrzebie Coal Company (to which the Pniowek mine belongs) sold for 1.25 - 1.42 million zlotys ($US 55.3 - $62.4) per ton, depending on rank. Coal prices have thus risen substantially since 1990, as a result of coal price adjustments that have been made as part of Poland's overall economic restructuring and its coal mining industry programs.

Methane drainage costs were 8.7 billion zlotys ($US 909 thousand). Methane sales recovered 3.5 billion zlotys ($US 366 thousand). Methane thus cost 323 zlotys ($US 0.034) per m^3 to drain, and sold for 147 zlotys ($US 0.016) per m^3. Ventilation costs in 1990 were 32.4 billion zlotys ($US 3.4 million), or 676 zlotys ($US 0.071) per m^3 ; note that ventilation, per unit volume of methane, was more expensive than drainage. Total methane control costs were thus 41.1 billion zlotys ($US 4.3 million), or 999 zlotys ($US 0.105 USD) per m^3 .

During the first six months of 1994, methane from the Jastrzebie Coal Company sold for an average of 478.6 zlotys ($US 0.021) per m^3. Data concerning 1994 methane control costs were unavailable.

SALINE WATER

The mine discharges about 2200 m^3 of water containing 17 tons of chlorides and sulfates each day. While this is a relatively moderate amount of salts compared to most of the mines studied, it still represents a source of water pollution. Mine water is initially held in the Olza Reservoir, which also gathers mine water from nine other coal mines, and is then discharged to a tributary of the Olza river. The purpose of the collecting reservoir is to protect the upper course of the Olza River and its tributary, the Szotkowka River. It is not known what steps are being taken to improve management of saline water from the Zofiowka mine.

SUMMARY DATA TABLES

COAL RESOURCES

Number of Seams	Coal Seam Thickness (m)		Overburden Thickness (m)	Balance Coal Reserves* (Million Tons)			
	Economic	Non-Economic		$A+B+C_1$	C_2	1990 Total	1993 Total
61	0.7-9.8	0.4-0.7	224-710	349	207	556	546

COAL QUALITY

Ash Content (%)		Heating Value (kJ/kg)		Moisture (%)
As Received	ROM Average	Range	ROM Average	ROM Average
3.03	37.72	24,162-32,080	27,755	2.55

HAZARD DATA

Gas and Rock Outburst	Rock Bump Hazard	Dust Hazard	Water Hazard	Methane Hazard	Spontaneous Combustion
Hazardous	I (Low)	Present	I (Low) and II (Medium)	IV (Very High)	I (Low)

CARBON DIOXIDE EQUIVALENTS (Million Tons)

CO_2 Equivalent of Total Methane Liberated (Vented and Drained), 1993	CO_2 Equivalent of Total Methane Drained, (Used and Released), 1993
0.89	0.30

PIPELINE DATA (1995)

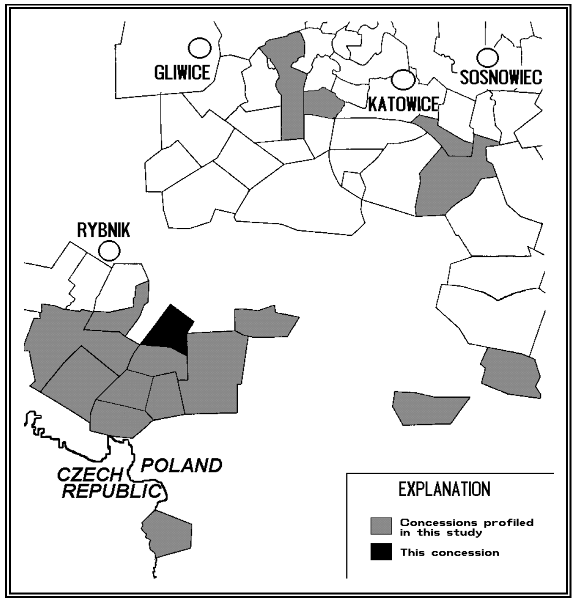
Distance to Nearest Pipeline	Owner / Manager of Pipeline
Connected by pipeline to Swierklany Compressor Station	GOZG Zabrze (subsidiary of the POGC)

MINE LIFE EXPECTANCY: More than 20 years

PREP PLANT LOCATED ON SITE?: Yes

***** $A+B+C_1$ and C_2 sub-categories reflect 1990 data; 1993 sub-categorized reserve data were unavailable

ZORY (ZMP)



The Zory mining concession is located in the southwestern portion of the Polish part of the Upper Silesian Coal Basin, approximately 10 km southeast of the city of Rybnik. Zory is independent of any coal company. The concession area occupies about 19 km^2. Coal production started in 1979.

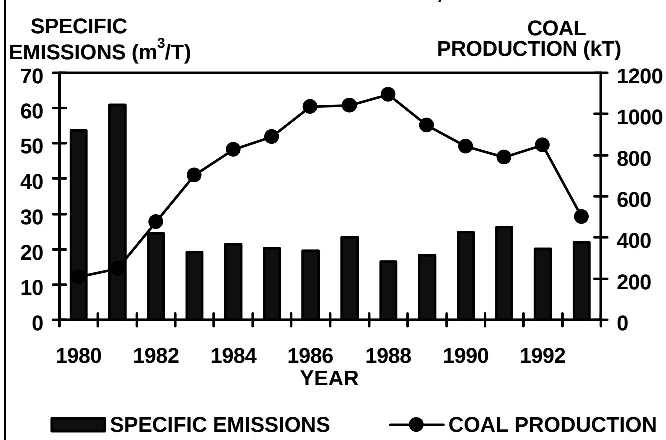
Geologic Setting. The mining concession is bounded on three sides by faults. The Orlowa-Boguszowice thrust fault forms the western boundary of the concession; strata east of this fault are downthrown by as much as 1100 m. The Graniczny normal fault forms the southern boundary of the concession; strata south of this boundary are downthrown about 270 m. The Wschodni-Graniczny zone of normal faulting forms the eastern boundary of the concession; strata east of this boundary are downthrown by as much as 240 m. The north-south trending Gogolowski normal fault and east-west trending Polnocny normal fault also cross the concession. A thick Miocene sequence unconformably overlies Carboniferous formations. The average geothermal gradient is 3.33° C per 100 m.

Coal Rank. Coal rank is sub-bituminous to low volatile bituminous (types 31 through 35), with medium and low volatile bituminous (type 35) accounting for 61 percent of the reserves.

COAL PRODUCTION AND SPECIFIC EMISSIONS

The mine has 3 working levels accessed by 2 shafts, 1 of which is a ventilation shaft. Coal is mined by longwall methods from 6 working faces with a combined length of 895 m. As of 1993, mining extended to a depth of 700 m. In 1990, a total of 841 thousand tons of coal were produced, of which 640 thousand were medium and low volatile bituminous (type 35). The rank (type) of the remaining 241 thousand tons was not specified. Clean coal production was 1,147 tons per working day based on the combined surface and underground work force, and 3,727 tons per working day based solely on the underground work force.

GRAPH 1. COAL PRODUCTION AND SPECIFIC EMISSIONS, 1980-1993



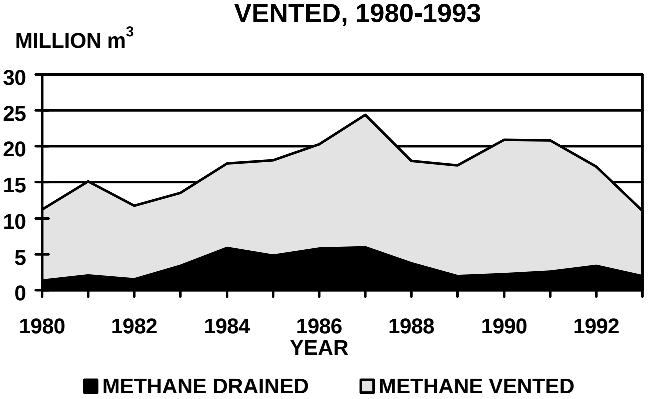
As shown in Graph 1, coal production peaked in 1988 and has since declined substantially since then. In 1993, only 500 thousand tons were produced. The mine had been scheduled for closure in the mid-1990's, but these plans have been canceled. In 1993, 22.0 m^3 of methane were liberated per ton of coal mined from the Zory concession.

METHANE LIBERATION, VENTILATION, RECOVERY, AND RESERVES

In 1993, a total of 11.0 million m^3 of methane were liberated from the Zory mining concession. Of this, 2.0 million m^3 were drained, and 9.0 million m^3 of which were emitted via the ventilation system. Of the methane drained, 1.4 million m^3 were utilized, and the remaining and 0.6 million m^3 were emitted.

Trends in methane ventilation, drainage, and total liberation from 1980 through 1993 are shown in Graph 1. Methane ventilation decreased sharply in 1993, corresponding to a sharp decrease in coal production.

GRAPH 2. METHANE DRAINED AND VENTED, 1980-1993



Desorption tests on coal samples from the concession indicate that gas content is up to 4.8 m^3 per ton. In 1990, 51 percent of the coal mined was from methane hazard Class IV seams, and the remaining 49 percent was from Class III seams. The Central Mining Institute forecasts that by year 2000, 90 percent will be from Class IV seams and 10 percent will be from Class III seams.

Mine Ventilation. One ventilation shaft operates at the Zory mining concession. The average concentration of methane in the ventilation shaft is 0.13 percent. Air flow into the ventilation shafts is 25,448 m^3 per minute, and air flows out of the shafts at the rate of 26,853 m^3 per minute. Total power of the vent motors is 4,800 kW.

Methane Recovery. There were 100 drainage boreholes operating at the Zory mining concession in 1991, with a total length of 9.76 km. Total length of the demethanization pipelines is 22.24 km, and their diameter ranges from 100-400 mm. As the demethanization station was still under construction in 1991, no data was available regarding pumps and compressors. In 1993, the average concentration of methane in gas utilized from the Zory mine was 53 percent.

In 1993, 3 percent of the methane recovered was drained from development areas, 20 percent was from working faces, and 77 percent was drained from gob areas.

Methane Resources. In-situ methane resources associated with balance reserves of coal are estimated to range from 1.4 billion to 6.4 billion m^3.

PRESENT AND PLANNED UTILIZATION OF MINE METHANE

In 1993, 1.4 million m^3 of methane drained from the Zory concession were used; this represents 70 percent of the methane drained from the concession. The methane was consumed by the power plant at the nearby Jankowice mine. The Zory mine is connected to the Swierklany compressor station by approximately 6 km of pipeline. Mine management has not identified potential additional consumers of the concession's methane. The mine does not have a coal prep plant, but other on-site utilization opportunities may exist.

MINING ECONOMICS

In 1990, coal production costs at the Zory mining concession totaled 314 billion zlotys ($US 33 million), or 374 thousand zlotys ($US 39) per ton of coal mined. Coal from the concession sold for 184 thousand zlotys ($US 19) per ton, at a loss of 190 thousand zlotys ($US 20) per ton. More recent data concerning mining economics were not available.

Methane drainage costs were 2.6 billion zlotys ($US 272 thousand) in 1990. Methane sales recovered 304 million zlotys ($US 32 thousand). Methane thus cost or 1,139 zlotys ($US 0.119) per m^3 to drain and sold for 157 zlotys ($US 0.016) per m^3. Ventilation costs were 3.4 billion zlotys ($US 356 thousand), or 183 zlotys ($US 0.019) per m^3. Total methane control costs were thus 6 billion zlotys ($US 628 thousand), or 1,322 zlotys ($US 0.138) per m^3.

More recent data concerning mining economics were not available.

SALINE WATER

Data concerning discharge of water from the Zory mine were unavailable.

SUMMARY DATA TABLES

COAL RESOURCES

Number of Seams	Coal Seam Thickness (m)		Overburden Thickness (m)	Balance Coal Reserves* (Million Tons)			
	Economic	Non-Economic		$A+B+C_1$	C_2	1990 Total	1993 Total
76	0.7-5.1	0.4-1	83-245	191	149	340	290

COAL QUALITY

Ash Content (%)		Heating Value (kJ/kg)		Moisture (%)
As Received	ROM Average	Range	ROM Average	ROM Average
3-39	16	15,357-35,997	27,974	4

HAZARD DATA

Gas and Rock Outburst	Rock Bump Hazard	Dust Hazard	Water Hazard	Methane Hazard	Spontaneous Combustion
Hazardous	No hazard	Present	I (Low) to II (Medium)	III (High) to IV(Very High)	I (Low) to II (Medium)

CARBON DIOXIDE EQUIVALENTS (Million Tons)

CO_2 Equivalent of Total Methane Liberated (Vented and Drained), 1993	CO_2 Equivalent of Total Methane Drained, (Used and Released), 1993
0.16	0.03

PIPELINE DATA (1995)

Distance to Nearest Pipeline	Owner / Manager of Pipeline
Connected by pipeline to Swierklany Compressor Station	GOZG Zabrze (subsidiary of the POGC)

MINE LIFE EXPECTANCY: More than 20 years

PREP PLANT LOCATED ON SITE?: No

* $A+B+C_1$ and C_2 sub-categories reflect 1990 data; 1993 sub-categorized reserve data were unavailable

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APPENDIX A

LIST OF CONTACTS

APPENDIX A - LIST OF CONTACTS

Dr. Michal Wilczynski
Deputy Energy Resources Minister
Ministry of Environmental Protection,
Natural Resources and Forestry
ul. Wawelska 52/54
00-922 Warsaw, Poland
tel. (48) (22) 250-001, fax 253-972

Mieczyslaw Kacmarczyk, General Manager
Polish Oil and Gas Company
Krucza 6/14
00-537, Warsaw, Poland
tel. (48) (2) 281-642, fax (22) 290-856

Andrzej Pecikiewicz, Program Assistant
Agency for International Development
Al. Ujazdowskie 29/31
Warsaw, Poland
tel. (48) (2) 628-3041, fax 628-7486

Mgr. inz. Eugeniusz Ciszak
State Hard Coal Agency
ul. Powstancow 30
40-952 Katowice, Poland
tel. (48) (32) 572-028, fax 511-986

Mgr. inz. Ryszard Wysocki, Vice President
State Higher Mining Authority
ul. Poniatowskiego 31
40-055 Katowice, Poland
tel. (48) (32) 511-471, fax 514-884

Adam Graczynski, General Director
Central Mining Institute
Plac Gworkow 1
40-951 Katowice, Poland
tel. (48) (32) 583-002, fax 596-533

Dr. Wojciech S. Beblo, Director
Ecological Department of Katowice Voivodship
ul. Jagiellonska 25
40-032 Katowice, Poland
tel./fax (48) (32) 519-561

Jan Surowka, Director
Coalbed Methane Clearinghouse
ul. Powstancow 41a, pok. 603
40-024 Katowice, Poland
tel. (48) (32) 155-6065, fax 155-27290

Dr. inz. Tadeusz Demel, President
Katowice Coal Holding Company
ul. Damrota 18
40-951 Katowice, Poland
tel./fax (48) (32) 573-105

Dr. inz. Jerzy Chowaniec, President
Nadwislanska Coal Company
ul. Grota Roweckiego 44
43-100 Tychy, Poland
tel. (48) (3) 127-3527, fax 127-5913

mgr. inz. Krystian Zajac, President
Rybnick Coal Company
ul. Jastrzebska 10
44-253 Rybnik, Poland
tel. (48) (36) 394-600, fax 20-201

mgr. inz. Michal Kwiatkowski, President
Gliwice Coal Company
ul. Jasna 31
44-101 Gliwice, Poland
tel. (48) (32) 394-600, fax (48) (32) 394-602

mgr. inz. Maciej Czernicki, President
Jastrzebie Coal Company
ul. Armii Krajowej 56
44-330 Jastrzebie, Poland
tel. (48) (36) 63-311, fax 62-671

Wladyslaw Szotrowski, President
Bytom Coal Company
ul. Strezlcow Bytomskich 207
44-914 Bytom, Poland
tel. (48) (32) 814-050, fax 810-080

Dr. inz. Jan Szlozak
Rudzka Coal Company SA
ul. Kokota 168
41-711 Ruda SL, Poland
tel. (48) (32) 420 262, fax 717-893

Voluntary Reporting of Greenhouse Gases
U.S. Department of Energy
Energy Information Administration, EI-81
1000 Independence Avenue, SW
Washington, DC 20585

APPENDIX B

EXPLANATION OF POLISH RESOURCE, COAL RANK, AND MINING HAZARD CLASSIFICATION SYSTEMS USED IN THIS REPORT

APPENDIX B - EXPLANATION OF POLISH RESOURCE, COAL RANK, AND MINING HAZARD CLASSIFICATION SYSTEMS USED IN THIS REPORT

MINERAL RESOURCE CLASSIFICATION SYSTEM

The coal resource data presented in this report pertain to **documented reserves** (sometimes translated as "geologic reserves" or "documented geologic reserves"). The Polish government defines documented reserves as "reserves documented by geologic investigations, evaluated quantitatively."

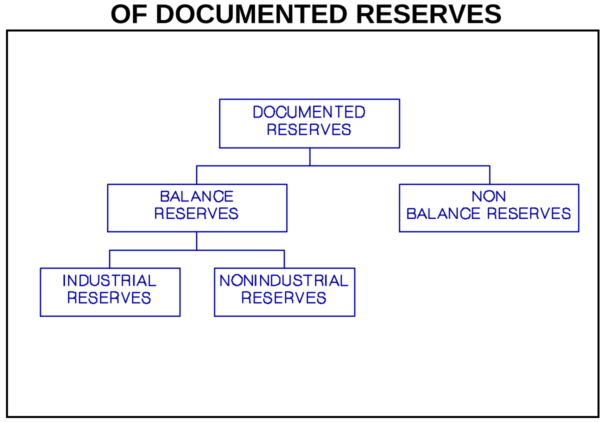
As in other countries, documented reserves are categorized according to the degree of assurance that they exist. In Poland, documented reserves comprise degrees of assurance **A,B,C_1** and **C_2**. These are equivalent to descriptive terms used in the US as shown in Table B-1.

TABLE B-1.
COMPARISON OF RESERVE CLASSIFICATION SYSTEMS

United States of America	Poland
Measured	A
Indicated	B
	C_1
Inferred	C_2

In Poland, documented reserves are further subdivided as shown in Figure B-1. Terms are defined as follows:

FIGURE B-1. POLISH CLASSIFICATION OF DOCUMENTED RESERVES



Balance reserves - documented reserves that meet balance criteria, including requirements related to quality, geologic conditions, and mining conditions. Criteria vary for separate coal mines or companies, but in general they are as follows: maximum depth = 1000 m, minimum seam thickness=1 m, maximum ash content = 40 percent.

Non-balance reserves - documented reserves that do not meet the balance criteria for one or more of the following reasons: insufficient quality, complicated geologic or mining conditions, or insufficient seam thickness.

Industrial reserves - balance reserves intended to be produced using available mining technology and production systems. These reserves are evaluated by the appropriate Ministry in charge of projects developing specific deposits.

Non-industrial reserves - balance reserves which are not intended for production using available technology and production systems.

COAL RANK

In Poland, as in other countries, coal is ranked according to various parameters including its carbon, volatile matter, and moisture content, as well as its heating value. As shown in Figure B-2, the Polish system differs from the US and German systems in that rank is expressed numerically, rather than by descriptive terminology.

MINING HAZARD CLASSIFICATIONS

Several types of mining hazards are categorized according to their severity:

Gas and Rock Outburst - Mines were reported as being either non-hazardous (**NH**) or hazardous (**H**) in terms of outbursts of methane and/or carbon dioxide, and rock. Hazardous mines are those prone to gas and rock outbursts. The methane content of their coal (dry, ash-free) is usually greater than or equal to 8 m^3 per ton, and/or the coal may be overpressured with methane or carbon dioxide.

Rock Bump Hazard - "rock bump" refers to sudden and violent destruction of rock structures around a mining excavation, with the result that rock is thrown into the excavated area. The rock accumulates elastic strain energy, which is suddenly released when the resistance of the rocks is exceeded. This can be caused by natural conditions or mining activity, or a combination of both factors.

Rock bump hazard is categorized as follows:

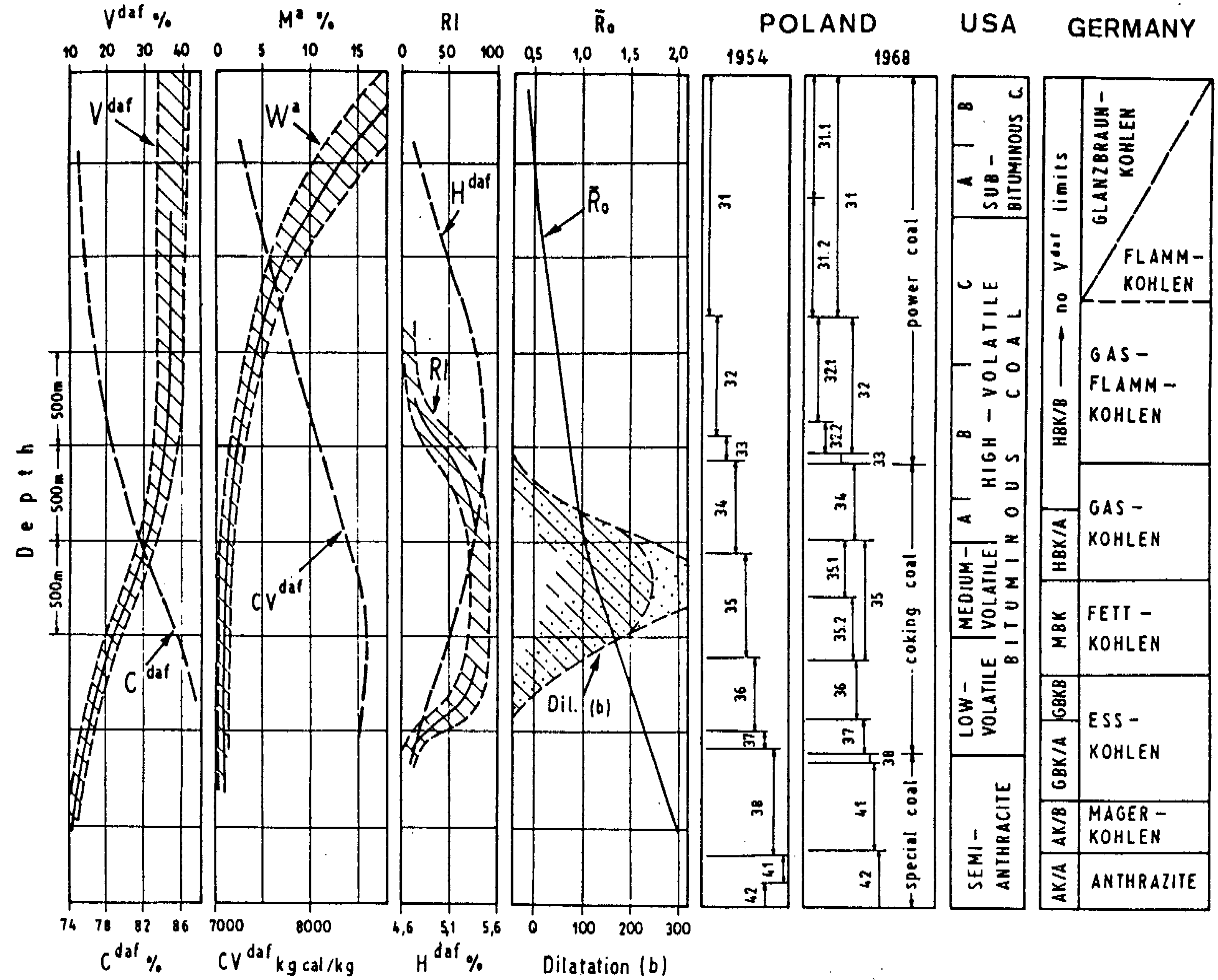
NH - coal seams are not susceptible to rock bumps

I - coal seams are susceptible to rock bumps, but no rock bumps have occurred during the past thirty years of uninterrupted exploitation under consistent conditions; or, parts of the coal seam susceptible to rock bumps are decompressed by initial excavation of the decompressing seam, in conjunction with roof collapse, but rock bumps do not occur; or, parts of the coal seam susceptible to rock bumps are decompressed by an earlier excavation with hydraulic filling of the lower seam, and the following conditions are met: a) the distance from the roof of the decompressing seam to the floor of the decompressed seam does not exceed six times the thickness of the decompressing bed; and b) after decompression, rock bumps do not occur.

II - coal seams are susceptible to rock bumps, but excavation is conducted in a way that prevents formation of concentrated stresses, and rock bumps have not occurred during the last two years of uninterrupted exploitation under consistent conditions; or, parts of the coal seam susceptible to rock bumps are decompressed by earlier excavation with hydraulic filling of the decompressing bed, and rock bumps have not occurred when one of the following conditions are met: a) the distance from the roof of the decompressing seam to the floor of the decompressed seam exceeds six times the thickness of the decompressing seam; or b) the decompressing seam occurs above the decompressed seam.

III - coal seams are susceptible to rock bumps, which occur despite the fact that mining is conducted in a way which prevents concentration of stresses; or, coal seams are not decompressed in safety and resistance pillars, and other remains of the seams susceptible to rock bumps are surrounded by gobs (regardless of their previous rock bump hazard classification); or, coal seams susceptible to rock bumps are not decompressed, and are located within the zone influenced by exploitation and remaining residues (regardless of their previous rock bump hazard classification).

FIGURE B-2. COMPARISON OF POLISH, U.S., AND GERMAN COAL RANK CLASSIFICATION SYSTEMS (From Kotas, 1994)



Dust Hazard - Coal dust is defined as coal particles which pass through a 1 X 1 mm mesh sieve. A coal seam is considered to be endangered by coal dust explosions if it has a volatile matter content greater than 12 percent (dry, ash free). Coal seams and underground workings are divided into dust hazard classes A and B:

A - no dangerous coal dust occurs, or in Zone 1[1] the sections of workings with dangerous coal dust are not longer than 30 m.

B - dangerous coal dust occurs, or in Zone 1 the sections of workings with dangerous coal dust are longer than 30 m.

Water Hazard - Intrusion of water into underground mining excavations creates a hazard for mines and for general operation of the mine. Three classes of water hazard have been established:

I - surface reservoirs or streams are present, and underground aquifers are isolated from mining operations by a layer of impermeable rock, and mining operations will not destroy the isolating properties of this rock layer; or, aquifers existing in or close to the coal deposit are isolated from mining operations by a sufficiently thick and resistant impermeable layer; or, confined aquifers are drained, and water recharge to the mining operation originates from unconfined aquifers; or, any situation that would otherwise be considered water hazard Class II, except for the fact that only a single mining excavation could be damaged.

II - surface reservoirs or streams are present, and infiltration may cause underground reservoirs to flood the mining operations; or, a layered aquifer exists in the roof or floor of the deposit, and is not isolated by a sufficiently thick and resistant impermeable layer; or, water is present in fractures but is isolated from mining operations by a sufficiently thick and resistant impermeable layer; or, improperly abandoned or inadequately documented surface boreholes exist, or boreholes create the possibility of direct contact of the mining excavation with surface or underground reservoirs; or, any situation that would otherwise be considered water hazard Class III, except for the fact that only a few mining excavations could be damaged.

III - surface reservoirs or streams create the possibility of direct flow of water into the mining excavation; or, there is a water-filled fracture in the roof or floor of a coal deposit; or, aquifers occur in the coal deposit or its roof; or, water reservoirs exist under pressure in the floor of an excavation; or, there are water-bearing faults whose location and/or water volume are insufficiently documented; or, there is a possibility of water carrying sediments into mining excavations.

Methane Hazard - coal seams are categorized in five classes depending on in-situ methane content and methane released into mine workings, as shown in Table B-2:

[1] Zone 1 refers to underground workings lying in a range of up to 300 m from the place of a possible explosion initiation in non-gassy fields, and in a range of up to 500 m in gassy fields.

TABLE B-2. POLISH CLASSIFICATION OF COAL SEAMS AND MINE WORKINGS WITH REGARD TO METHANE HAZARD

Class	Methane Content in Coal, m^3/T on a Dry, Ash-free Basis	Methane Released in the Workings, m^3/T of Daily Output
0	<0.02	N/A
I	0.02 - 2.5	<5
II	2.5 - 4.5	5-10
III	4.5 - 8.0	10-15
IV	>8.0	>15

Spontaneous Combustion - coal seams are categorized according to their rate of spontaneous combustion, as shown in Table A-3:

TABLE B-3. CLASSIFICATION OF COAL SEAMS ACCORDING TO SPONTANEOUS COMBUSTION RATE

Class	Spontaneous Combustion Index S_z (° C/min.)	Spontaneous Combustion Rate
I	below 80	low
II	80-100	medium
III	100-120	high
IV	more than 120	very high

APPENDIX C

SELECTED TABLES FROM DATABASE OF PROFILES

TABLE C-1. TOTAL METHANE LIBERATED AT PROFILED MINES (MILLION CUBIC METERS)														
MINE	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1 MAJA	68.0	64.6	60.6	56.3	47.3	40.3	42.0	39.8	43.5	45.2	48.1	41.1	37.8	32.0
BORYNIA	11.4	12.9	11.2	8.2	12.6	13.5	14.2	15.5	14.2	15.4	13.9	11.7	6.4	8.9
BRZESZCZE	129.5	120.0	114.3	108.1	114.3	119.4	119.1	134.6	120.0	159.5	148.0	123.3	120.2	124.9
HALEMBA	2.4	25.0	31.2	38.4	50.0	62.4	65.7	81.2	94.9	81.3	73.3	59.4	73.7	53.0
JANKOWICE	8.6	8.6	11.5	13.3	10.7	11.3	11.1	11.0	12.5	13.1	12.6	13.8	12.5	8.7
JASTRZEBIE	50.1	47.8	41.2	32.7	26.7	25.2	25.6	24.1	24.2	23.4	23.2	22.6	21.4	20.0
KRUPINSKI	3.1	2.6	3.5	2.7	17.8	26.4	40.1	49.7	67.6	76.1	70.6	60.5	57.6	48.7
MARCEL	14.8	14.5	14.4	12.5	12.6	12.9	11.8	11.8	14.0	13.6	14.6	11.6	10.6	10.8
MORCINEK	0.0	0.0	0.0	0.3	1.8	0.6	2.3	5.2	11.7	11.3	13.6	23.6	28.7	25.6
MOSZCZENICA	91.2	92.5	88.8	92.8	82.9	81.7	77.5	72.0	64.9	59.6	59.2	54.4	47.3	41.8
PNIOWEK	98.3	112.6	124.8	136.8	130.0	150.1	165.5	186.9	183.9	186.3	167.4	161.3	140.8	126.5
SILESIA	48.2	50.8	52.7	49.5	56.1	57.1	56.6	56.5	54.9	48.7	44.8	42.4	43.5	41.1
STASZIC	49.0	51.1	50.6	50.7	46.9	39.4	33.6	30.5	42.4	45.4	35.7	32.8	16.2	18.9
WESOLA	40.3	37.4	37.0	44.3	42.4	49.2	52.3	46.2	38.7	35.3	43.6	43.7	38.8	42.5
ZABRZE-BIEL.	19.9	22.2	23.8	20.3	33.6	16.3	27.4	32.0	28.4	28.3	25.6	21.7	15.9	16.2
ZOFIOWKA	82.1	77.4	87.8	88.3	91.0	83.1	87.0	75.6	76.6	81.6	75.1	67.1	44.6	59.6
ZORY (ZMP)	11.2	15.2	11.7	13.5	17.6	18.1	20.3	24.4	18.0	17.4	20.9	20.8	17.2	11.0
TOTAL	**728.2**	**755.0**	**755.0**	**768.6**	**794.1**	**806.9**	**852.1**	**896.8**	**910.1**	**941.5**	**890.1**	**811.8**	**733.2**	**690.2**

TABLE C-2. SPECIFIC EMISSIONS AT PROFILED MINES (CUBIC METERS PER TON MINED)

MINE	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1 MAJA	25.2	29.4	23.3	21.7	18.9	16.1	16.8	15.9	17.8	20.8	25.0	23.6	23.5	18.9
BORYNIA	4.4	5.5	3.9	2.7	4.0	4.4	4.6	4.9	4.6	5.6	5.7	5.1	3.0	3.9
BRZESZCZE	33.2	36.3	30.1	27.7	29.3	30.6	31.3	34.5	31.1	44.1	49.1	38.8	39.0	43.5
HALEMBA	0.5	6.5	7.0	8.0	10.1	11.9	11.7	14.3	16.4	15.4	17.5	15.8	25.2	19.1
JANKOWICE	2.4	2.4	2.7	2.8	2.2	2.2	2.1	2.0	2.2	2.6	3.4	4.0	3.4	2.4
JASTRZEBIE	17.9	19.1	14.2	11.3	8.9	8.1	8.2	8.9	8.9	8.9	10.1	11.1	10.4	9.8
KRUPINSKI	0.0	0.0	0.0	266.0	50.9	41.6	44.8	46.7	55.5	58.9	51.7	42.3	33.1	29.9
MARCEL	6.4	7.2	6.2	5.4	5.5	5.6	5.1	4.9	5.9	6.3	7.6	6.7	6.2	4.9
MORCINEK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.9	18.0	16.9	19.9	28.1	29.9	26.7
MOSZCZENICA	25.6	29.1	24.5	26.1	23.9	24.4	23.6	22.5	21.8	22.1	28.2	27.6	30.1	22.4
PNIOWEK	37.2	50.5	42.4	42.6	38.4	42.6	44.2	47.6	46.2	48.7	49.7	51.4	47.9	41.9
SILESIA	38.2	39.9	36.4	34.3	38.1	38.6	37.4	36.9	35.8	33.5	37.3	31.4	36.6	36.4
STASZIC	11.0	14.6	12.3	11.6	10.2	8.5	7.3	6.5	9.1	10.9	8.6	8.2	3.7	5.1
WESOLA	7.2	8.1	6.6	7.9	7.6	8.6	9.2	8.0	6.7	7.4	11.2	11.1	11.7	11.3
ZABRZE-BIEL.	3.2	4.3	4.1	3.7	5.9	2.9	4.7	5.6	4.9	5.5	6.4	5.9	4.8	5.0
ZOFIOWKA	25.5	34.2	27.0	26.3	25.2	22.6	23.6	20.3	21.9	26.3	26.8	24.0	20.8	25.9
ZORY (ZMP)	53.7	60.9	24.5	19.3	21.3	20.3	19.6	23.4	16.4	18.4	24.9	26.3	20.2	22.0
WEIGHTED AVERAGE	**14.7**	**17.9**	**14.9**	**14.8**	**14.8**	**14.8**	**15.2**	**15.8**	**17.6**	**18.2**	**20.3**	**19.3**	**18.5**	**17.4**

TABLE C-3. COAL PRODUCTION AT PROFILED MINES (THOUSAND TONS)														
MINE	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1 MAJA	2,700	2,200	2,600	2,600	2,500	2,500	2,500	2,500	2,441	2,177	1,927	1,740	1,610	1,690
BORYNIA	2,608	2,346	2,900	3,029	3,112	3,077	3,112	3,160	3,103	2,754	2,443	2,290	2,110	2,300
BRZESZCZE	3,900	3,300	3,800	3,900	3,900	3,900	3,800	3,900	3,854	3,613	3,014	3,180	3,080	2,870
HALEMBA	4,556	3,835	4,487	4,774	4,975	5,230	5,625	5,662	5,766	5,296	4,200	3,770	2,920	2,780
JANKOWICE	3,600	3,500	4,300	4,700	4,900	5,100	5,300	5,400	5,574	5,077	3,715	3,480	3,690	3,690
JASTRZEBIE	2,800	2,500	2,900	2,900	3,000	3,100	3,100	2,700	2,722	2,635	2,301	2,040	2,060	2,040
KRUPINSKI	-	-	-	10	349	635	895	1,065	1,217	1,292	1,364	1,430	1,740	1,630
MARCEL	2,300	2,000	2,300	2,300	2,300	2,300	2,300	2,400	2,380	2,158	1,916	1,720	1,720	2,190
MORCINEK	-	-	-	-	-	-	-	400	649	669	683	840	960	960
MOSZCZENICA	3,560	3,180	3,620	3,560	3,470	3,350	3,280	3,200	2,974	2,695	2,098	1,970	1,570	1,870
PNIOWEK	2,642	2,232	2,940	3,212	3,380	3,524	3,748	3,929	3,977	3,824	3,368	3,140	2,940	3,020
SILESIA	1,263	1,272	1,448	1,444	1,475	1,479	1,511	1,530	1,535	1,457	1,201	1,350	1,190	1,130
STASZIC	4,447	3,498	4,120	4,362	4,577	4,640	4,640	4,658	4,661	4,174	4,130	4,000	4,330	3,700
WESOLA	5,600	4,600	5,600	5,600	5,600	5,700	5,700	5,800	5,733	4,755	3,900	3,940	3,330	3,770
ZABRZE-BIEL.	6,300	5,200	5,800	5,500	5,700	5,600	5,800	5,700	5,777	5,132	3,979	3,650	3,310	3,210
ZOFIOWKA	3,221	2,267	3,255	3,362	3,608	3,672	3,684	3,731	3,504	3,105	2,796	2,800	2,140	2,300
ZORY (ZMP)	209	249	477	703	826	888	1,036	1,043	1,095	946	841	790	850	500
TOTAL	**49,706**	**42,179**	**50,547**	**51,956**	**53,672**	**54,695**	**56,031**	**56,778**	**56,962**	**51,759**	**43,876**	**42,130**	**39,550**	**39,650**

TABLE C-4. METHANE LIBERATED BY VENTILATION AT PROFILED MINES (THOUSAND CUBIC METERS)

MINE	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1 MAJA	38,421	39,399	37,980	33,244	29,539	25,860	28,025	26,264	30,590	33,859	36,308	30,300	28,300	23,500
BORYNIA	11,240	12,120	10,820	8,129	12,446	13,478	13,996	15,522	13,476	15,033	12,960	10,400	5,600	8,000
BRZESZCZE	99,738	93,551	87,966	83,455	88,006	92,192	88,210	93,691	88,436	114,344	101,000	82,500	83,300	80,400
HALEMBA	2,327	20,347	27,028	33,454	43,346	54,383	58,593	68,460	70,755	56,952	57,652	39,500	48,700	37,400
JANKOWICE	3,783	3,725	4,683	5,275	5,258	5,917	6,542	6,983	8,225	8,642	9,017	11,200	9,900	6,400
JASTRZEBIE	41,500	41,000	35,053	24,600	20,865	20,138	20,256	19,300	19,600	18,974	19,700	18,800	17,500	16,500
KRUPINSKI	-	-	-	-	7,568	13,634	23,748	29,659	38,710	45,895	46,200	41,900	40,400	32,900
MARCEL	6,843	6,532	6,791	6,626	6,428	6,687	6,584	6,324	6,324	6,376	6,226	6,300	6,100	5,900
MORCINEK	-	-	-	278	1,792	636	2,265	4,702	10,031	7,124	6,750	8,400	8,800	8,700
MOSZCZENICA	55,684	55,227	54,419	57,128	52,878	54,748	53,672	51,192	48,283	44,478	42,062	39,700	33,800	31,600
PNIOWEK	43,950	49,837	55,770	66,136	64,143	90,005	94,633	105,000	102,000	109,275	103,000	100,600	88,200	77,300
SILESIA	37,423	42,153	43,783	38,789	40,997	42,731	42,153	44,571	44,781	38,264	36,444	34,400	35,600	33,400
STASZIC	49,000	48,000	43,000	42,000	39,600	31,500	28,000	24,800	34,200	35,300	25,500	22,700	12,400	16,800
WESOLA	36,697	34,432	32,542	37,800	36,414	43,528	47,570	39,097	31,520	27,745	36,444	35,900	31,400	36,800
ZABRZE-BIEL.	17,400	19,625	20,793	16,008	25,960	10,096	20,012	24,499	21,340	23,130	20,553	16,600	13,600	15,000
ZOFIOWKA	48,470	36,235	45,503	43,323	45,650	42,567	47,216	40,300	45,088	15,369	47,939	47,100	42,600	39,800
ZORY (ZMP)	9,871	13,151	10,192	10,167	11,746	13,244	14,516	18,353	14,280	55,652	18,672	18,200	13,800	9,000
TOTAL	**502,347**	**515,334**	**516,323**	**506,412**	**532,636**	**561,344**	**595,991**	**618,717**	**627,639**	**656,412**	**626,427**	**564,500**	**520,000**	**479,400**

TABLE C-5. METHANE DRAINED (THOUSAND CUBIC METERS)

MINE	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1 MAJA	29,612	25,213	22,592	23,064	17,714	14,431	13,991	13,527	12,953	11,384	11,794	10,800	9,500	8,500
BORYNIA	157	738	418	62	125	-	192	-	690	382	899	1,300	800	900
BRZESZCZE	29,744	26,397	26,366	24,620	26,239	27,158	30,902	40,880	31,572	45,145	47,019	40,800	36,900	44,500
HALEMBA	109	4,695	4,184	4,944	6,679	8,043	7,151	12,728	24,094	24,384	15,650	19,900	25,000	15,600
JANKOWICE	4,830	4,849	6,789	8,036	5,400	5,400	4,529	4,010	4,253	4,448	3,578	2,600	2,600	2,300
JASTRZEBIE	8,604	6,845	6,175	8,066	5,845	5,026	5,293	4,838	4,555	4,399	3,450	3,800	3,900	3,500
KRUPINSKI	3,132	2,582	3,483	2,657	10,212	12,772	16,383	20,070	28,892	30,208	24,371	18,600	17,200	15,800
MARCEL	7,943	7,962	7,582	5,874	6,206	6,245	5,184	5,434	7,645	7,240	8,391	5,300	4,500	4,900
MORCINEK	-	-	-	-	-	-	-	455	1,632	4,166	6,815	15,200	19,900	16,900
MOSZCZENICA	35,483	37,301	34,344	35,654	29,983	26,955	23,845	20,817	16,634	15,075	17,164	14,700	13,500	10,200
PNIOWEK	54,316	62,770	68,979	70,665	65,809	60,102	70,873	81,925	81,907	76,989	64,751	60,700	52,600	49,200
SILESIA	10,776	8,598	8,899	10,745	15,139	14,347	14,400	11,907	10,140	10,474	8,313	8,000	7,900	7,700
STASZIC	-	3,050	7,612	8,647	7,270	7,891	5,641	5,685	8,201	10,107	10,218	10,100	3,800	2,100
WESOLA	3,646	2,932	4,467	6,524	6,010	5,652	4,699	7,062	7,152	7,535	7,199	7,800	7,400	5,700
ZABRZE-BIEL.	2,485	2,571	2,986	4,246	7,642	6,229	7,385	7,532	7,034	5,214	5,053	5,100	2,300	1,200
ZOFIOWKA	33,665	41,207	42,316	44,997	45,323	40,503	39,798	35,268	31,483	25,912	27,132	20,000	22,000	20,000
ZORY (ZMP)	1,348	2,013	1,518	3,370	5,885	4,809	5,789	6,005	3,713	1,993	2,266	2,600	3,400	2,000
TOTAL	**225,850**	**239,723**	**248,710**	**262,171**	**261,481**	**245,563**	**256,055**	**278,143**	**282,550**	**285,055**	**264,063**	**247,300**	**233,200**	**211,000**

TABLE C-6. METHANE UTILIZATION AND EMISSION DATA FROM PROFILED MINES (MILLION CUBIC METERS)

	UTILIZED				DRAINED BUT NOT UTILIZED				TOTAL EMITTED			
	1990	1991	1992	1993	1990	1991	1992	1993	1990	1991	1992	1993
1 MAJA	10.0	8.9	8.3	7.3	1.8	1.9	1.2	1.2	38.1	32.2	29.5	24.7
BORYNIA	-	-	-	-	0.9	1.3	0.8	0.9	13.9	11.7	6.4	8.9
BRZESZCZE	31.5	37.3	35.4	44.1	15.5	3.5	1.5	0.4	116.5	86.0	84.8	80.8
HALEMBA	6.2	6.2	5.0	3.0	9.5	13.7	20.0	12.6	67.1	53.2	68.7	50.0
JANKOWICE	3.0	2.0	2.0	1.7	0.6	0.6	0.6	0.6	9.6	11.8	10.5	7.0
JASTRZEBIE	3.3	3.5	3.7	3.1	0.1	0.3	0.2	0.4	19.8	19.1	17.7	16.9
KRUPINSKI	5.4	5.4	6.8	6.7	19.0	13.2	10.4	9.1	65.2	55.1	50.8	42.0
MARCEL	6.3	5.0	4.3	4.2	2.1	0.3	0.2	0.7	8.3	6.6	6.3	6.6
MORCINEK	6.7	13.9	16.9	14.4	0.1	1.3	3.0	2.5	6.9	9.7	11.8	11.2
MOSZCZENICA	17.2	13.9	11.5	9.8	-	0.8	2.0	0.4	42.0	40.5	35.8	32.0
PNIOWEK	64.7	52.1	42.3	43.4	-	8.6	10.3	5.8	102.7	109.2	98.5	83.1
SILESIA	8.0	7.7	7.8	7.6	0.3	0.3	0.1	0.1	36.7	34.7	35.7	33.5
STASZIC	6.7	7.0	3.7	2.0	3.6	3.1	0.1	0.1	29.1	25.8	12.5	16.9
WESOLA	3.1	5.1	7.4	2.6	4.1	2.7	-	3.1	40.6	38.6	31.4	39.9
ZABRZE-BIEL.	4.3	4.9	2.2	1.2	0.7	0.2	0.1	-	21.3	16.8	13.7	15.0
ZOFIOWKA	24.0	16.3	16.8	15.2	3.1	3.7	5.2	4.8	51.0	50.8	27.8	44.4
ZORY (ZMP)	1.9	1.9	2.1	1.4	0.3	0.7	1.3	0.6	19.0	18.9	15.1	9.6
TOTAL	**202.3**	**191.1**	**176.2**	**167.7**	**61.8**	**56.2**	**57.0**	**43.3**	**746.1**	**620.7**	**557.0**	**522.5**