ESMAP

Energy Sector Management Assistance Programme

Poland

Energy Sector Restructuring Program
Volume 3: The Natural Gas Subsector

Report No. 153/93

JOINT UNDP / WORLD BANK
ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

PURPOSE

The Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP) was launched in 1983 to complement the Energy Assessment Programme, established three years earlier. ESMAP's original purpose was to implement key recommendations of the Energy Assessment reports and ensure that proposed investments in the energy sector represented the most efficient use of scarce domestic and external resources. In 1990, an international Commission addressed ESMAP's role for the 1990s and, noting the vital role of adequate and affordable energy in economic growth, concluded that the Programme should intensify its efforts to assist developing countries to manage their energy sectors more effectively. The Commission also recommended that ESMAP concentrate on making long-term efforts in a smaller number of countries. The Commission's report was endorsed at ESMAP's November 1990 Annual Meeting and prompted an extensive reorganization and reorientation of the Programme. Today, ESMAP is conducting Energy Assessments, performing preinvestment and prefeasibility work, and providing institutional and policy advice in selected developing countries. Through these efforts, ESMAP aims to assist governments, donors, and potential investors in identifying, funding, and implementing economically and environmentally sound energy strategies.

GOVERNANCE AND OPERATIONS

ESMAP is governed by a Consultative Group (ESMAP CG), composed of representatives of the UNDP and World Bank, the governments and institutions providing financial support, and representatives of the recipients of ESMAP's assistance. The ESMAP CG is chaired by the World Bank's Vice President, Finance and Private Sector Development, and advised by a Technical Advisory Group (TAG) of independent energy experts that reviews the Programme's strategic agenda, its work program, and other issues. ESMAP is staffed by a cadre of engineers, energy planners and economists from the Industry and Energy Department of the World Bank. The Director of this Department is also the Manager of ESMAP, responsible for administering the Programme.

FUNDING

ESMAP is a cooperative effort supported by the World Bank, UNDP and other United Nations agencies, the European Community, Organization of American States (OAS), Latin American Energy Organization (OLADE) and countries including Australia, Belgium, Canada, Denmark, Germany, Finland, France, Iceland, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Sweden, Switzerland, the United Kingdom, and the United States.

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ENERGY SECTOR RESTRUCTURING PROGRAM

Volume 3

Natural Gas Subsector

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Industry and Energy Department
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PREFACE

This report—the third volume of a five-volume series of studies of restructuring in the Polish energy sector—is based on several consultants' reports completed between 1990 and 1991 that deal with restructuring and environment (Coopers & Lybrand Deloitte), gas pricing and tariffs (NERA), gas development (SOFREGAS), and legal matters (individual consultants). This work benefited from the collaboration of different groups in Poland, government officers, public enterprise managers, unions' representatives, the Polish Academy of Sciences, and Polish consultants who met regularly to discuss the progress and results of this work. The results of these studies were examined in various seminars that included representatives of the natural gas industry and the Ministry of Energy and Industry as well as the Bank of Poland and Ministry of Finance, Ministry of Privatization, unions, Polish experts, consultants, the World Bank, and ESMAP. This report provides an opportunity to bring the analysis of the restructuring issues and lessons learned in Poland into a wider perspective, allowing other countries pursuing similar restructuring needs to benefit from this work.

Substantial change has occurred in the Polish gas industry since 1990 that is not fully reflected in this report. The analysis in this report basically pertains to the situation as it was two years ago. It does not necessarily represent the views of ESMAP and the Bank today. For instance, in 1990 the issues of "a LNG terminal in northern Poland as a viable import option" and "the assumption of a future permanent price discrepancy between Russian and non-Russian gas imports" were considered interesting, but today command little attention. There are now several pressing issues which will need to be tackled, specially the best type of industrial structure for the subsector and the diversification of supply. With the establishment of the Energy Restructuring Group (ERG), these and other issues will need to be examined in a timely manner to adopt the best policy choices for Poland.

Work on energy restructuring is the responsibility of the Ministry of Industry and Trade (MoI). Given the complexities of sector restructuring and the importance of the energy sector in the economy, an Assistance Program for Energy Sector Restructuring has been designed to support MoI in this activity. This Program relies on four groups (see Annex C in Volume 1 of this report): The ERG, the counterpart group, the coordinating group and *ESMAP*.

The ERG consists of a team of international and Polish experts—that began work in December 1992 in Warsaw and will have a continuous presence there for approximately eighteen months. This Group, funded jointly by the European Community, the USAID and the UK Know-How Fund, will be closely supported by *ESMAP*. To carry out rehabilitation and restructuring proposals, a coordinating group in each subsector headed by higher management has been established. To assist MoI and the ERG, a Counterpart Group has also been established, staffed by secondees from the energy industries themselves. This group will assist the ERG in the collection and understanding of data, gaining access to industry executives as appropriate and offering comment on the implementation options. The Counterpart Group will assist the Ministry of Industry and Trade by identifying important matters for consideration and by ensuring that consequential actions which involve the coordinating groups and other parts of Government are also pursued in a timely manner. *ESMAP* will support the work of the ERG through (a) the proposed activities to be carried under the *ESMAP* program, and (b) the active involvement in ERG activities.

The *type of structure* recommended in the report is based on the creation of an open, competitive and commercial gas industry. The report recomends the separation of the vertically integrated monopoly into horizontally independent activities: (1) create two independent separate companies in exploration and production from existing units within PGNG and allow open entry to new investors; (2) create a single common carrier type of company in gas transmission selling to regional distributors and large users, and (3) create independent regional distribution franchises. However, little progress has been made in this direction. Instead, an alternative structure, currently under active consideration in Poland, is based on a strong, commercially oriented and vertically integrated state holding company. Proponents of this structure assert that since it reflects better Polish reality —the gas subsector, the market and the industrial environment in Poland—, it has better chance of success. However, this structure is very close to the old system, and would likely lead to the old inefficiencies. Experience in several countries suggests that economic efficiency would be better served by breaking up the vertically integrated monopoly and allow more competition in the sector.

In carrying out its tasks, the Energy Restructuring Group (ERG) will need to establish what stage has been reached in the continuing dialogue between PGNG and the Ministry of Industry and Trade (MoI) on the precise form of the restructuring of the subsector. It will then be necessary to settle finally the best structure for Poland. This will almost certainly involve some disaggregation of the existing company. The next step will be to examine the progress made to achieve more independent operational arrangements within PGNG.

The ERG should then establish the stage which has been reached in establishing a competitive exploration and production activity, open to foreign company participation. This will involve an examination of the relevant law and the status and effectiveness of bidding arrangements for new areas. The extent of encouragement to the formation of joint ventures must also be assessed. These matters will bear on the best way to establish the Polish upstream sector—particularly whether one or more companies should be created.

The transmission and distribution activities raise different issues. It will be necessary to examine the cost and pricing implications of a common carrier and the disaggregated structure in distribution and recommend the Government the arrangement which will produce the most efficient, viable and equitable results. Close liaison with the regulatory framework will be necesary in this stage.

A particularly important issue is the responsibility for buying gas from foreign suppliers and the strategic question of diversity of supplies. The transmission company must have the appropriate resources and skills to carry out this function on a continuing basis.

It is important that ***different gas supply options*** are examined in order to select the best one for Poland. If this is not done, there is the danger that only one supply alternative will actively be considered, one that might not be the best for the country. The available options include:: (1) UK gas via Polpipe, a pipeline from the UK continental shelf through Denmark to Poland with a capacity of about 10 BCM per year; (2) Norwegian gas via a pipeline from the Norwey's continental shelf through Denmark to Poland with a capacity of about 10 BCM per year; (3) Russian gas to Western Europe through twin pipelines via Belorus and Poland with an ultimate capacity of 40 BCM per year; (4) smaller scale schemes to access European gas via short distance pipeline connections with Germany, and (5) various potential long distance pipeline and LNG projects.

Several World Bank and ESMAP staff participated in these studies. Afsaneh Mashayekhi, Charles McPherson, and Michael Levitsky managed these studies, assisted by an ESMAP and Bank core team consisting of Christopher Brierly and John Homer (ESMAP), and David Craig and Henk Busz (EC3IE). Luis E. Gutiérrez, current ESMAP task manager for restructuring activities in Poland, was responsible for the consolidation and preparation of this report. The report benefited considerably from the comments and suggestions of several peer reviewers in and outside the Bank: Robin Bates (ENVPR), Petter Nore (ESMOD), Howard Ash (EC3IV), Robert Bacon (Consultant), and Jørn Christophersen (ERG Gas Specialist).

Funding for the work was provided by the United Kingdom's Know How Fund and by UNDP through bilateral contributions to ESMAP. The United States has also provided funding for the follow-up work since 1991.

ESMAP wishes to express its appreciation to the government of Poland and the many enterprises and organizations in the energy sector for the cooperation and assistance rendered to ESMAP staff and the various consultants during the preparation of the studies.

Currency Equivalents

Currency Unit = Zloty (Zl)
Calendar 1991 US$1 = Zl 10,559 (Average)

Weights and Measures

bcm	billion cubic meters
Btu	British thermal unit
CM	cubic meter
Gcal	Giga calorie (one million kilo calories)
GJ	Giga Joule
GW	Giga Watt (1,000,000 kW)
GWh	Giga Watt hour (1,000,000 kWh)
h/y	Hours per year
kcal	kilo calorie (4,187 Joule)
kW	kilo Watt
kWh	kilo Watt hour
MBtu	Million British thermal units
mcm	Million Cubic Meters
Mt	Million tons
Mtce	Million tons of coal equivalent
Mtoe	Million tons of oil equivalent
Mtpa	Million tons per annum
MW	Mega Watt (1,000 kW)
MWh	Mega Watt hour (1,000 kWh)
PJ	Peta Joule (34,129 tons of oil equivalent)
toe	tons of oil equivalent
TW	Tera Watt (1,000 GW)
TWh	Tera Watt hour (1,000 GWh)

Abbreviations and Acronyms

BST	bulk supply yariff
CMEA	Council for Mutual Economic Assistance
CHP	combined heat and power
DHE	District Heating Enterprise
FGD	flue-gas desulfurisation
GDP	gross domestic product
GUS	(Polish Central Statistical Office)
HOB	heat-only boiler
HV	high voltage
IBRD	International Bank for Reconstruction and Development

ITB	invitation to bid
LV	low voltage
MoI	Ministry of Industry and Trade
MV	medium voltage
NERB	National Energy Regulatory Body
PDM	(Polish National Load Dispatch Center)
PGNG	(Polish Oil and Gas Company)
PPA	power purchasing agreement
PSE	(Joint Stock Polish Grid Company)
PSENN	(Polish Grid Company)
WEWB	(Polish Power and Lignite Board)
WWK	(Polish Hard Coal Board)
ZE	*Zalad Energetyczne* (Polish electricity distribution companies)

Polish Fiscal Year

January 1 to December 31

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EXECUTIVE SUMMARY

Overview

1. The gas industry in Poland will undergo major changes whatever policy is adopted by the government. To date the industry has been characterized by prices unrelated to costs, by investment decisions unrelated to the true benefits of the investment, by management structures that severely restrict goals, and by disregard for the effects of pollution on the environment. A shift toward a market system—which will alter ownership, control, and objectives—is bound to have large effects on prices, outputs, and investments.

2. In the context of such significant changes, a study of the gas industry must provide insight into the effects that would be brought about by the adoption of market principles, and it must identify areas where the state may need to intervene to moderate the impact of pure free market forces.

3. An important feedback between policymaking and forecasting is manifested through prices. Only when prices are known can the amount demanded by industry and consumers and the amount supplied by the producers be assessed accurately. At the same time, to determine an optimal price, from the perspective of both the profit maximizing firm and from the regulatory authority, the size of the market in relation to the costs of production must be known. The detailed work undertaken attempted to identify the price that is consistent in matching supply to demand while taking into account any government control over prices. In describing the various sectors of the market in what follows, it is necessary to discuss the development plan topic by topic. For example, it must be borne in mind when discussing demand that the prices used to project the consumption by households and industry are such that the total demand generated is consistent with the supply that would be forthcoming at those same price levels. Only by adopting this methodology is it possible to focus on individual aspects of the industry, each of which presents special points of interest and concern.

4. The report commences with a study of the demand for gas in Poland. It draws on the experience to date both inside Poland and in market economies of Western Europe to suggest what the potential is for growth. Key issues are the role of the growth of the economy (as measured by GDP) and the change in the structure of the economy (as between various industries), the price of gas, and the price of alternative fuels. Coupled with these factors are the capital requirements to allow for any increases in demand. Because considerable expansion of demand for gas is foreseen, a substantial amount of new capital will be required, and it is important to determine the nature of such capital in order to assess possible financing constraints.

5. Supply in the future depends on potential investment decisions to increase domestic supply, which in turn depend both on the geological characteristics of gas deposits and on the perceived demand at the expected price for gas. In Poland, where low-cost gas supplies are not abundant, limited investment

and increased domestic production can be anticipated. The three stages of investment—exploration, production, and distribution—all require extra funds that are to be acquired from a competitive market. The balance of supply is acquired through imports, and this involves an assessment of the possible sources and costs of imported supply—the lower the cost of imports, the lower the level of domestic investment and production that would result.

6. Issues are also raised by changes in the pattern of ownership, so it is necessary to look at the legal instruments required to permit dealings with other parties (e.g., for joint ventures in exploration and production of oil and gas). Legislation defining the interest of the state in the ownership of oil and gas and some specimen contracts have been constructed, and their salient features are commented upon. (The legal and contractual framework for upstream investment is examined in chapter 7.)

7. A related but more complex issue is that of restructuring the ownership of the existing gas industry. The move to a market economy is accompanied in general by a move to private ownership of enterprises, but in the case of a "public utility" such as gas there are strong reasons not to transfer all stages of the industry to private ownership. Even when private ownership is desirable, it might take any of several forms, and important decisions about the number of private entities to be involved in any stage of production and the associated form and method of regulation, if any, are therefore outlined. In this report, specific recommendations are made that attempt to define an ideal solution—in practice, there are constraints on the form and the extent of change in structure that the government can implement.

8. The restructuring of the industry has important implications for the way in which prices will be set in the industry. Where a sector remains in public ownership, prices will be controlled to achieve the goals that determined the form of the ownership. Where a sector is privatized, prices will either be determined by competitive forces, and hence should be intimately related to costs, or, where there is still a degree of local monopoly that requires regulation, the regulatory framework will define the prices to be set. Pricing also can be affected by the extent to which taking environmental costs into account requires subsidies or taxes on the gas industry. The pricing strategy adopted will also affect cash flow, profitability of enterprises, and the budget balance of the government. These factors will interact with the ability and willingness to finance that investment that is justified by the increasing levels of demand.

9. Decisions about the future of the gas industry in Poland are strongly linked to environmental concerns. Gas is one of the least polluting fuels, and attempts to reduce pollution by curbing the use of other fuels will inevitably require an increase in the use of gas. The costs and benefits of such a shift will play an important role in the future of the gas industry.

10. The macroeconomy is strongly linked to the future of the gas industry through the effects on aggregate growth and the changing sectoral composition of demand. At the same time the substantial changes envisaged in the gas sector will have an effect on the macroeconomy, especially through any increase in the price of gas. There is also a link through the demand for investment funds. The gas sector will likely require substantial investment if it is to fulfill its role as an efficient and less polluting fuel and will compete for funds with other sectors of the economy. These demands will be coming from the state-

will compete for funds with other sectors of the economy. These demands will be coming from the state-owned sectors, from the new privately owned sectors, and from industry and households engaged in fuel switching. The effects of this large amount of potential borrowing from one economy must affect the willingness to lend and hence the cost of funds at the margin. This in turn means that projects that would be viable at the average cost of funds would not be viable at the marginal cost of funds.

11. The gas plan involves two distinct time scales. First, some decisions that will be made in the near future will not require much time to implement (e.g., the restructuring of ownership). Second, some aspects of the plan will take a number of years to come to fruition, even in the new market structure (e.g., the amount of new capacity required to provide efficiently for the emerging economy). An important practical issue is that of transition. Both political feasibility and economic costs make it imperative that the nature of this transition receive careful attention.

12. All these aspects together form a picture of a plan for the future of Poland's gas industry. A sequence of decisions must be made, and these decisions and their effects will be the basis for subsequent decisions. Certain ideal principles are stated, but the constraints imposed by practical possibilities will limit the extent to which these ideals can be fulfilled.

Demand

13. The future demand for gas in Poland was evaluated from both the macroeconomic and sectoral standpoints, and additional checks were carried out on regional balances.

14. It was assumed that the overall level of gas demand in Poland will resemble that of Western European countries at a similar level of economic development. This in turn implies that all subsidies are phased out and that gas is priced at a competitive level.

15. The annual rate of growth of income, after the initial slowdown, was assumed to be between 4.4 and 5.9 percent for the 20-year period considered. The oil price was assumed to remain on average at $20 per barrel in real terms, and delivered coal prices to range between $50 and $140 per ton to various users. The key assumption was that of the import price for gas—a base case of $80 per 1,000 cubic meters ($2.26 per gigajoule) is assumed at the beginning of the period. By 1995 this is expected to be $85 for Russian gas and about $110 for other land imports. The real price was assumed to remain constant thereafter. It was also assumed that there will be a gradual but very substantial improvement in energy efficiency.

16. Using these assumptions, high- and low-growth scenarios for total energy use were constructed. From these scenarios, figures for total gas demand were derived by using Western European data on gas shares. Table 1 presents the estimates for the share and volume of gas, excluding that used for power generation.

17. The demand was next estimated on a sectoral level to check the plausibility of the macroeconomic figures. More precise calculations about possible profitability were also performed.

18. In the residential sector, the demand for gas by existing consumers is expected to decline because urban dwellings will be gradually replaced over the period.

Table 1: Potential Demand for Gas in 2010 (Macroeconomic basis, two secenarios)

		Economic growth	
Energy	*% Share in total use*	*Low (Mtoe)*	*High (Mtoe)*
Primary	15.0	20.0	22.0
Final	17.5	15.0	17.5

19. Regarding the market for conversion to gas, it was argued that for consumers with small coal stoves the economics of conversion do not favor gas (except for the few already connected to gas for cooking or water heating) but that experience in Western Europe suggests that consumers are willing to pay for the extra convenience of gas heating. The market for small heating plants, which use coal and cannot be fitted with pollution control devices, is one where gas appears to have a very strong commercial advantage (a break-even of up to $260 per 1,000 cubic meters) in many cases. It was assumed that conversion will take place steadily over the next 20 years. In the market for district heating plants, gas is unlikely to be able to compete with the alternative of retrofitting such plants to reduce the high levels of pollution.

20. The market for new consumers has the largest potential. Most new houses under planing or construction will use gas for at least cooking and most probably for other uses as well.

21. In the commercial sector, which is likely to grow at a rapid pace, the market for gas is likely to be small because of the dominance of district heating plants that are already established in these "community" markets.

22. In the industrial sector, gas use by the steel industry is expected to decline almost to zero, while gas use in the fertilizer and chemical industries will suffer along with other fuels as the industries contract. In the light and medium industry sector, the use of gas is expected to grow rapidly because of the anticipated rapid growth of this sector and because of the attractions of gas as a flexible input into more modern processes of industrial production.

23. The power sector is the largest user of coal and lignite in Poland and is a major contributor to pollution. Although there is a long-term prospect for an increase in electricity demand, the heavy restructuring program is likely to lead to an initial decrease in the demand for electricity.

24. Calculations suggest that for power generation, the conversion of existing coal-fired plants to gas would not be economic. Allowance for pollution costs makes gas appear more attractive, but it

may be more economical to install pollution abatement equipment on existing plants. For repowering, the addition of gas turbines appears attractive economically, whereas for new power plants combined-cycle plants that use gas appear to be the least-cost option. It is suggested that only a fraction of new plants should be gas fired (up to 30 percent) for security-of-supply considerations.

25. Combining the various sectoral calculations and allowing for both a rapid (high) transition and a slow (low) transition, the demand fo. gas is shown in Table 2. These sectoral figures (excluding power generation) are closer to the higher figures obtained from the macroeconomic analysis, but they do not take into account certain constraints that may delay the introduction of gas in some sectors.

Table 2: Demand for Gas in 2010 (BCM)
(Sectoral basis, two scenarios)

Sector	*1990*	*2010 (high)*	*2010 (low)*
Residential	5.16	15.23	15.23
Industry	6.98	12.69	10.90
Power	0.00	15.50	12.20
TOTAL	12.15	43.42	38.33

26. A regional analysis, applying regional growth rates and adjusting penetration rates in accordance with the projected timing of supplies in each region, produced a forecast slightly lower than that reached by aggregate analysis. This difference is mainly caused by constraints in the region northeast of Warsaw, where the gas infrastructure is limited at present and is likely to be introduced only slowly because of the lack of industrial development.

Supply

27. At present Poland imports about two-thirds of the gas it consumes, all from the Russian republic. Domestic production in Poland consists of high-methane natural gas (HMNG), low-methane natural gas (LMNG), coalbed methane, and coke oven gas, which is being phased out.

28. Domestic production has been declining recently because of depletion of fields and because of lack of investment. A particular problem is that imports are HMNG, and domestic production includes a large proportion of LMNG, which cannot be used interchangeably with HMNG. The potential for domestic production was analyzed under three categories:

- *From existing fields, without any additional investment.* Production is expected to decline dramatically in 1992 and steadily thereafter, falling by 2010 to about 20 percent of the 1990 figure of 5 bcm a year.

- *Under a program of rehabilitating existing fields.* Under a proposed scheme costing $300 million, it would be possible to raise current production and then to halt the decline to about 50 percent of current levels by 2010. The economic viability of such a program relies on domestic costs remaining well below international levels. This may be feasible since there is considerable excess capacity in drilling and other field equipment.

- *Considering production from new fields.* If new fields were brought on line and prices were competitive with the projected import cost of gas, new production could well raise total domestic production by some 30 percent above present levels in the mid 1990s, but depletion would still mean that by the year 2010 the level of production was no higher than at present.

29. The total cost of the investment program in expanding present fields and in exploration and development of new fields would be about $675 million.

30. There is also a possibility for substantial production of coalbed methane (in addition to that already recovered from coal mines). Estimates for reserves have suggested that there may be up to eight times as much reserves as of conventional natural gas. Costs of recovery may also be competitive but more information is needed before the potential of this source can be established.

31. On the basis of the demand scenario and the estimates for domestic supply, a picture of the import requirements was built up. Power sales would be supplied from a "transit" system operating at 80 bar, which would bring imports into Poland and then be linked into the domestic system, which operates at 64 bar.

32. The anticipated change in market structure will increase the seasonal variability of demand. Part of this could be accommodated by variations in domestic production, but the limited flexibility of domestic production and import contracts means that underground storage facilities will be needed to cover winter demand adequately. Similarly, the ratio of peak to annual sales will increase, and, depending on the risk level for which the system is planned, greater flexibility will be required.

33. The fact that the two main types of gas (HMNG and LMNG) are not interchangeable means that separate balances for the two types of gas are required. Table 3 projects the gas balances for the basic and the power generation markets. The import figures include 5 bcm imports in 2000 and 8.5 bcm in 2005 for the power sector. The excess supply in 1995 reflects the assumptions that contracts currently being negotiated will result in overcoverage, given the likely collapse in demand from the steel and fertilizer industries. In 1995 it would be possible to obtain only a 50 percent risk coverage for peak demand, but by 2000 it is assumed that there would be sufficient underground storage to meet a 2 percent risk coverage.

34. The role of gas imports will be crucial, but there is considerable uncertainty about how this can be achieved. The future of supplies from Russia is increasingly uncertain and at present Poland is not connected to any other point on the European supply system. By 1995 the position of imports could become critical unless progress has been made with producing coalbed methane. Another possibility is construction of a terminal for imports of LNG.

Table 3: Projected Gas Balances for Basic and Power Markets, 1995-2005 (MCM)

Balance item	*1995*	*2000*	*2005*
Annual demand	10,893	19,845	29,156
Domestic supply			
HMNG	2,270	2,224	2,024
LMNG	3,008	2,555	2,165
COG	222	0	0
Imports			
Russia	4,800	55,005	500
Other	3,300	10,000	19,500
TOTAL SUPPLY	13,600	20,279	29,189

35. In the gas plan it was assumed that imports from Russia, which were 8.2 bcm in 1990, would fall to 4.8 bcm until 1995, rising thereafter to 5.5 bcm. To meet the immediate shortfall, Poland is seeking reexports from other East European countries.

36. In the medium term the pipeline from Bremen to Berlin could be used to obtain access to other sources of gas; it was assumed that this could provide at least 2.5 bcm from 1995 onward. In the longer term it appears that the most likely source of supply might be an extension of the pipeline from Norway to Sweden (if built) or through the continuation of the interconnection with Germany.

37. Assuming that gas prices at the border will be similar to those of Western Europe, and that oil prices are around $20 per barrel, this suggests that imports from the transit network to large users would be at about $2.8 per MBtu ($2.6 per GJ). It was also assumed that oil prices would rise to around $25 per barrel in real terms by 1995, thereafter remaining constant. The projected import bill for gas would thus rise from around $750 million in 1990 to around $4,410 million in 2010, unless there were substantial investment in coalbed methane. A decision not to use gas for power generation would also reduce the import bill significantly.

Investment

38. The basic market (residential, commercial, and industrial) will be supplied through the existing transmission system after expansion and through existing and new distribution systems. The shift in the structure of demand means that new infrastructure will be required and that this will have to be supplied in anticipation of market developments.

39. The transit power market consists of new plants connected to the gas import infrastructure. In the short run, domestic production will have to provide storage until new facilities are constructed.

40. On the import side, the existing capacity is adequate to handle the decline of imports of Russian gas, so that the interconnection with Western European supplies will be a primary concern. In addition an LNG terminal is a possible project for import supply. The cost of such a project is estimated at $650 million, with an ultimate capacity of 12 bcm per year. The transit facilities would require a total investment of $176 million.

41. At present, Poland rents underground storage in Lvov. With the increased need for storage various domestic sites are being examined. To meet the projected total requirements by the year 2010 to provide 2 percent risk coverage, additional storage capacity of 2.5 bcm will be required and the estimated total cost over the period is estimated to be around $930 million.

42. The existing transmission system in Poland is highly complex because three different types of gas are used. It is not well suited to accommodate likely future demand patterns. The main modifications will result from the phasing out of coke oven gas and its replacement by HMNG and from the introduction of new sources of supply in the western and northern parts of the country. System expansion will be required to accommodate the projected growth in demand, both in terms of volume and peak requirements.

43. The limited availability of LMNG, together with its incompatibility with imported gas, leads to the conclusion that its use should be restricted to one area of the country. The gas development plan foresees the conversion of the Lower Silesia region to LMNG and Upper Silesia to HMNG. This will require 287 kilometers of main pipeline in Lower Silesia and 85 kilometers in Upper Silesia by 1995. The total cost of conversion by 2000, including main pipelines and sidelines, delivery stations, and distribution lines, is estimated at $200 million (excluding the cost of replacing user appliances).

44. The expansion of the transmission system and the need to connect it to the Western European grid will require additional line capacity, additional delivery points, modernization of the existing system beyond that already projected, development of an adequate SCADA system, and replacement of damaged sections. The cost will be $767 million between 1995 and 2000, $951 million between 2001 and 2005, and $1,029 million between 2006 and 2010.

45. The distribution networks currently supply 5 million residential and commercial consumers (of which only 550,000 use gas for space heating). The current networks are saturated and would be unable to accommodate additional space heating demand without major reinforcement. In addition the networks are not sufficiently safe and lack a metering system, which encourages wasteful consumption.

46. To accommodate the projected increased demand for space heating, the most practical solution appears to be to increase the distribution pressure rather than the pipe diameter. New housing could be connected at fairly low cost, and modern technology, fittings, and meters could be installed as standard practice. Opportunities for modernization and improvement will come both with scheduled replacement of pipes and with conversion of coke oven gas consumers to HMNG or LMNG.

47. The strategy of undertaking the substantial costs of improvement and expansion in the distribution sector depend on the desire to convert to the use of gas for space heating, partly because of the costs of urban pollution from the existing heating. The total cost until 2010 will be $5,009 million, so that it is essential that a well-thought-out marketing plan is prepared before embarking on any such program.

48. The total costs of the investment plan are shown in Table 4. To these costs should be added the costs of gas and the operating system. Taking the basic import cost at $2.00 per MBtu (border price rising to $2.50 in 1995), the average cost of gas would be $3.10 for gas supply ex transit. The transmission cost would be $0.73 and the distribution cost $2.43, yielding a consumer delivery price of $6.26 per MBtu in 1990.

Table 4: Total Investment for Gas Development Plan (1990 prices)

Sector	*1991-1995*	*1996-2000*	*2001-2005*	*2006-2010*	*TOTAL*
Imports	75	645	142	39	901
Transmission	500	767	951	1,030	3,248
Storage	195	272	302	166	935
Distribution	551	1,293	1,464	1,505	4,815
Conversion	82	113	0	0	194
TOTAL	1,402	2,562	3,269	2,859	10,093

49. The cost-benefit analysis of the gas development plan, including power use, with different selling prices to the various categories of end user, yields a net present value (NPV) of $133 million using a 12 percent (real) discount rate.

50. The assessment of the viability of the gas plan depends crucially on certain factors and assumptions. The price of competing fuels and the availability of imported gas at the prices used are the basic assumptions. The rate of interest, although high, may not fully represent the shortage of financial capital in the Polish market. Finally, no account has been taken of the costs of converting households from coke oven gas to HMNG. This would be an additional burden on the gas sector, because it is unlikely that the consumers would be willing to pay for it themselves.

Restructuring

51. The restructuring of the Polish Gas Company (PGNG) is motivated by the factors promoting the general drive to privatization and commercialization. It had been a wholly state-owned enterprise, highly integrated both horizontally and vertically. It included not only the whole of the natural gas industry, from wellhead to burner tip, but also activities such as exploration, drilling, production, equipment manufacture, and pipeline construction. Distribution was broken down into six regional companies (cost centers) with considerable fragmentation in the exploration and production functions.

52. The current structure raises four main areas of concern:

- Fragmentation of the purchasing/transmission role
- Fragmentation of decisionmaking in exploration and production (E and P)

- Internal trading at cost plus transfer prices (which have not tracked inflation)
- Blurring of distinctions between state and enterprise.

53. In addition, for an enterprise operating in a market-oriented society, PGNG has a number of inappropriate features:

- Lack of hard budgets, which eliminates incentives
- Lack of commercial objectives for management
- Outside control of too many key financial factors
- Inefficiencies caused by outside bureaucratic forces.

54. Comparison of the scale of operations and efficiency of PGNG in 1990 with Western experience indicates some of PGNG's shortcomings:

- Up to 3 times as many seismic crews and 3 times more drilling rigs and crews in relation to the scale of operations.

- Up to 1.5 times as many production staff in relation to production volume.

- Up to 25 percent more staff in transmission and development.

55. Examining the industry's structure makes it clear that its different stages have different characteristics and potentials. Exploration and development clearly have the potential to operate on a competitive basis, as does manufacturing. Long-distance transmission, in contrast, has the characteristics of a natural monopoly, as does local gas distribution, although the latter has a much smaller minimum efficient scale.

56. Given the particular characteristics of the Polish industry and the general features of the gas industry as a whole, it would appear most appropriate for the upstream sector to be clearly separated so that a specialist management can evolve. Foreign investment, together with the associated technology, should be sought. The present number of companies should remain viable in the foreseeable future.

57. On balance, the arguments also favor separating transmission from distribution in order to gain clearer accountability of the separate managements and to open the way for "yardstick" competition for distribution at the regional level. This structure would entail the liquidation of local distribution enterprises.

58. All key transmission functions (planning, supply/demand matching, development) would be established within a single company. The associated manufacturing and service industries should be separated and allowed to operate in the normal market environment.

59. For the sales of gas by the national grid company to the regional distributors and for the sale onward by the distributors there will be monopoly power, so regulation will be required. Upstream regulation will concern licensing, royalty taxation, and depletion policy, whereas downstream regulation will be more concerned with pricing.

60. The recommended structure for regulation is to create a semi-independent government body that would have a specialized staff and whose regulatory powers would be established by legislation.

61. It is also suggested that it is important in the gas industry to establish the new structure, commercial relationships, and legislative framework before changes of ownership take place.

62. For the upstream (E and P) sector it is important to attract foreign capital, but it is also recommended that the state maintain majority ownership. In the case of the national gas transmission company it is also recommended that the state retain a majority shareholding. At the level of the regional gas supply companies, some local involvement would be useful, but this should not be at a level where cross-subsidization is possible. The need for massive amounts of capital suggests a need to draw on foreign investment in this sector also. The manufacturing and construction companies could move to early privatization, ahead of the rest of the gas sector, and no state interest should be retained.

63. Experience has shown that corporate restructuring, the development of contracts, the establishment of the regulatory framework, and the sale of assets require an enormous effort over a two- or three-year period. During this period it may be necessary to establish a holding company to oversee restructuring and privatization (not to interfere in day-to-day operations) with staff who could be seconded from the various departments of the existing company and from the Ministry of Industry. It would be dismantled once the process was complete.

Tariffs and Regulation

64. The present level of prices is not high enough to sustain the development of the gas sector in Poland. The existence of the subsidy continues to reduce incentives to achieve efficiency. The aim is to move toward marginal cost pricing in order to achieve an efficient allocation of resources.

65. In the future the imports of gas will be at "opportunity costs," but in the short term will lack quantity flexibility. Hence domestic supplies will need to be more flexible and will in effect be the marginal fields. Thus domestic producers should receive both a variable component, equivalent to the import price, and a fixed component equal to the inventory charge for holding supply ready to meet the winter peak.

66. The transport tariff must be designed to avoid monopolistic exploitation. The tariff to firms (which are already metered) should have a capacity component and a usage component—the former corresponding to the long-run marginal costs of capital expansion/replacement and the latter to short-run marginal costs of supply.

67. Because most gas will be imported, such costs should be passed on fully from the transport company to users. Retail sale of gas should have a capacity cost (to cover costs of metering, connection, and distribution) and a commodity cost.

68. A set of tariffs based on these principles has been calculated. Because these tariffs would result in large percentage increases in gas prices if implemented immediately, the question of transition needs to be considered. However, the calculation suggests prices (before tax) for industry at levels similar to those in Western Europe, and for households the prices would be substantially lower than the Western European price, despite the large percentage increase involved.

69. The tariff structure and level suggested is designed to ensure that each sector would be able to finance the costs of remaining in operation (including replacing capital). This structure does leave room for a possible source of economic rent where taxation might be needed—any domestic producer able to produce below the import price level would make an excess profit. There are several ways to tax such profits while not destroying the incentives for further exploration and development (especially by foreign companies). One scheme is to auction the rights to produce and explore on a field-by-field basis.

Environmental Aspects

70. The Gas Development Plan is intimately tied to concerns about the environment in Poland because the pollution levels are exceptionally high. Much of this is due to the nature of the fuels used and the associated technology. Where gas would not be used on a direct cost basis, an allowance for the monetary costs of pollution can make gas the most desirable fuel in some circumstances.

71. Detailed analysis shows that the power sector is the major source of all emissions in Poland, from high stacks (which spread the effects) and low stacks (which localize the effects). The emission levels of SO_2, NO_x, and particulate matter (PM) grossly exceed national air quality standards (which are lower than World Health Organisation guidelines) for the voivodships of Katowice and Krakow.

72. The potential for future pollution is assessed by forecasting likely levels in two cases. The first case is a "Do Nothing" approach, in that expected demand is met at the cheapest direct cost. The second case meets demand at lowest cost while also meeting national environmental standards. The cost of meeting the environmental standards is estimated at approximately $0.9 billion in 1990 prices.

73. Under the Gas Development Plan, as outlined above, although pollution is calculated to be reduced from the least cost approach, its level will remain high even by the year 2000, so that the costs and benefits of the use of further methods of abating pollution are evaluated.

74. Calculations based on the limited information available on the monetary costs of the different pollutants suggests that averaged over the whole country, the costs of abatement (switching fuels or technologies) will usually be greater than the damage costs.

75. For specific applications the "environmental" credit for gas could be substantial—for example in the low-stack sector (residential heating) it could be as much as $4 per GJ, which is similar in magnitude to the cost of the gas itself.

76. The implications for the Gas Development Plan are that the environmental credit for gas is large enough to justify conversion of coal stoves to gas. For power, the most attractive use of gas would be for repowering existing stations rather than for fueling new power stations. Once the environmental damage is taken into account, new power stations could justify using coal in stations fitted with flue gas desulfurisation (FGD). Overall, allowing for environmental costs, gas use should be larger than that projected on a purely direct economic cost basis.

77. The implementation of policies designed to encourage the use of gas on environmental grounds may need to start with regulation (particularly for power station technology) and then move toward more market-based approaches (emissions taxation or tradable permits) as the market system becomes better established.

Legal Arrangements

78. Beyond the economic and institutional issues discussed above lies the difficult task of implementing the necessary changes in the pattern of ownership for entities operating in the sector. This must include attracting investment from international energy companies because they alone possess the technical and financial resources to achieve—either independently or in joint ventures with Polish public or (eventually) private operators—the intensified level of exploration and exploitation activities that is required to redress Poland's dependency on petroleum fuels imported from a single supplier. Poland had no recognizable enabling environment for such investments prior to 1989, and in early 1990 the country still lacked any sector-specific legislation or regulations designed to provide the safeguards and assurances that such firms require. The 1989 Foreign Investment Law gave some guidelines for dealing with foreign investment in the economy, but did not address adequately the following key issues:

- Foreign exchange rights
- Types of investment vehicle allowed
- The identity of the licensing authority
- Level and stability of fiscality.

79. The existing enabling environment comprises sector-specific statutes and general investment laws. The former focus on the definitions and attributes of the various sectoral organizations, whereas the latter include the 1989 Foreign Investment Law, which has been modified by a new version that replaced the Agency for Foreign Investment with the Ministry of Ownership Changes.

80. Neither the sector-specific nor the general laws cover crucial issues, such as the right to carry forward exploration expenditures made in early years until a discovery has been developed and production

started. Without such clarification, private international oil and gas companies are extremely reluctant to become involved.

81. To ameliorate the situation a draft of a single Petroleum Law was produced for discussion. This law included definitions of ownership of resources, a statement of the contractual basis for oil and gas operations by all parties, a procedure for application to explore and exploit concessions, a statement on the applicability of taxes, and specific provisions on a number of issues including the environment and unitization.

82. In light of the apparent difficulties of passing such a law through Parliament a new solution through a contractual approach was explored. At the same time the Mining and Geological Laws were amended, intended partly to clarify the enabling conditions for foreign investment. These clarified the basis of ownership but did not settle the other areas of concern.

83. The contractual solution, which has been adopted in other countries, includes a draft of a model contract that provides all the basic provisions that oil companies look for when they evaluate a new investment "province." This solution covers the following areas:

- Ownership and control of petroleum and gas, designation of parties to the contract
- Duration of exploration concessions
- Details of grant of rights and automatic rights to exploit concessions once granted
- Title to assets
- Relinquishment
- Work obligations
- Establishment of a joint advisory committee
- Definition of a commercial discovery
- Fiscal provisions
- Treatment of associated gas discoveries
- Extent of government participation
- Currency and foreign exchange rights
- Training
- Dispute resolution
- Bank guarantees.

84. The contract does not, however, guarantee the position, because some of the assurances contained would be outside the power of the contracting ministry. However, the intentions expressed in the draft contract are such that some companies have already expressed interest in pursuing ventures in Poland.

1. DEMAND

1.1 A central problem in evaluating the likely future of the Polish gas industry is forecasting the demand for gas. A substantial increase in the real price of gas and a large shift in the price of gas relative to other fuels are inevitable. Because there is no experience in Poland of how supply and demand respond to price changes, the assessment is based on changes that have occurred elsewhere. The methodology used was to identify the principal uses of natural gas and to evaluate the "netback" of gas for each of those uses at prices that have been projected as likely for gas and for competing fuels. Because fuel prices will be determined by world market prices for imports, domestic demand is not expected to have a strong influence on the local price. The "netback" calculation is designed to indicate if it would be more profitable to use gas than the best competing fuel in a specific sector, taking into account both investment costs and operating costs. A positive netback value indicates that it would be sensible to use gas. The netback value for the use of natural gas in a given project is the break-even price that equates the cost of using gas to the cost of using the most attractive fuel alternative. Netback values therefore take into account not only the energy cost of the alternative fuel but also differences in equipment efficiency and other technical factors. The calculation finds the cost of producing 1 standard unit of energy (e.g., kWh) with competing fuels, allowing for new investment or replacement investment. The next step is to find the maximum price of gas the user would be willing to pay in order to produce the same amount of energy for exactly the same total cost, again including any investment costs, and then convert this (netback) to a price of gas to the producer by subtracting distribution and transmission costs. The resulting value is compared with the actual price of gas received by the producer, which is in effect the import price of gas (plus a possible margin for storage as explained below in chapter 5).

1.2 The methodology described above is applied to all the main sectors and industries where gas is already established or where it might compete with an existing fuel. Wherever the netback value is greater than the import price there is an opportunity to make a profit by switching to gas or by using gas as the sector grows. The larger the margin between the netback value and the import price the greater the incentive to use gas, the more likely that gas will be used, and the more rapidly the change will occur.

1.3 Although this technique indicates the sectors where gas use will increase, it does not indicate how much gas use will increase. Two other factors need to be taken into account. First is the degree to which gas will penetrate an existing market. Not all of a particular market will be equally attractive for the use of gas. For example, where investment in an alternative fuel has only just taken place it will be harder to replace this by gas than in a case where the plant is old and obsolete. The second and more important factor is how the industrial and household pattern of demand will change. With the broad changes that will occur in the Polish economy in the next 20 years the structure and level of demand for inputs will change completely. Some sectors will grow in both relative and absolute importance while others will shrink. To estimate the market for gas, it is necessary not only to know which industries it will penetrate and the extent to which it will do so, but also how large these industries will be at different times during the next 20 years.

1.4 The experience of Western Europe is used to estimate the possible size and pattern of the demand for gas in Poland during the next 20 years. This estimate is made purely at the aggregate level, the next step is to examine the principal sectors and evaluate their likely use of gas in such an economy, making sure that the netback values are consistent with the pattern derived from the aggregate data. A final refinement is to repeat the analysis at the regional level where possible, and check demands against any regional supply constraints. These three calculations, taken together, present a picture of the overall level of gas demand that is similar to the gas demand observed in Western European countries at the same stage of economic development, which appear to be profitable at the prices assumed for the import of fuels, and that take special regional considerations into account.

Macroeconomic Evaluation of Potential Gas Demand

1.5 It has been assumed that Poland's concerns about environmental protection will become similar to those that are in force in the EC. The sectoral demand for gas also depends on the extent of competition and on subsidies. It is assumed that subsidies to all fuels will be gradually phased out, that restrictions on the use of gas in specific areas will be lifted, and that competition or regulation will be similar to that in Western Europe so that a similar structure of industry can evolve. Not only will prices reflect the costs of fuels (possibly including environmental costs) but there will also be significant improvements in energy efficiencies.

1.6 In order to fix the reference point for Poland some assumptions must be made about its level of income in the next 20 years. Two scenarios—high growth and low growth—are used to set plausible limits on the estimation of demand. The projected growth rates and per capita income levels are shown in Table I-1.

Table I-1: Selected Economic Growth Projections (to year 2010)

Projected index	*High growth*	*Low growth*
GDP, 2010 (bn zlotys 1988)	20,000	15,000
GDP per capita (US$, 1988)	3,800	2,900
Rate of growth (1978-2010)	3.1%	2.2%
Rate of growth (1990-2010)	5.9%	4.4%

1.7 The introduction of competition and market pricing into the energy industries will bring about large shifts in the choice of fuel and the level of fuel use. The costs of alternative fuels have been related to an assumed oil price of $20 per barrel and incorporate transport, storage, and distribution margins derived from EC experience. The figures are to be taken as constant in real terms, reflecting a view that there will be no marked increase in the trend of oil prices over the period concerned. The assumed prices for alternate fuels are shown in Table I-2.

1.8 The gas price used in the netback calculations is assumed to be the border price because of Poland's heavy reliance on imported gas. A price of $80 per 1,000 cubic meters is taken as a plausible base case ($0.08 per CM is equivalent to $2.37 per MBtu or $2.26 per GJ). It is likely that the price of Russian gas will rise over the next few years and that imports will come from other sources. It is assumed that by 1995 the price of Russian gas will be at least $85 per 1,000 cubic meters (in 1990 prices) and that the price of other land imports will be about $110 per 1,000 cubic meters. Assuming a higher initial price for Russian supplies would increase the border price to $100 per 1,000 cubic meters, but in such a case it would be less likely that the real price would increase during the next few years. After 1995 it is assumed that the real price of imported gas will remain constant.

1.9 In addition to assumptions about the level of income and the price of competing fuels, it is necessary to make an assumption about the energy intensity of the economy (i.e., the amount of energy used to produce one unit of GDP). At present the energy intensity in Poland is very high due to: the industrial structure, the efficiency of the technology employed, the fuel mix, and so on. Studies have indicated that the introduction of financial constraints on firms, of higher energy prices, of energy conservation, and of the transformation of the structure of the economy may result in a saving of up to 56 Mtoe per year, 52 percent of which would be in industry. The speed of adjustment to this final level, which is indicated as being sustainable by the desire to increase profits, will be limited by a number of factors:

- Lack of information about the technical opportunities for a more rational utilization and production of energy
- Lack of agencies, public institutions, and service companies with expertise in methods of improving energy efficiency
- Lack of local production of the required equipment
- Existing management attitudes, which may consider energy as a fixed cost
- Limited financial resources, which give low priority to improving energy efficiency.

1.10 Combining these factors results in two scenarios for energy intensity, each based

Table I-2: Alternative Energy Costs

Price	*Coal*	*Fuel oil*	*Low-sulfur fuel oil*
Production cost ($/ton)	40	89	104.2
Delivered price			
Large users	50	108	123.2
Small users	70	..	175.0
Large residential	70	108	123.2
Small residential	140	..	280.0
Calorific value (GJ/ton)	26.78	41.85	41.85

largely on international comparisons with Western European countries:

- High-growth scenario reflects a rapid growth of GDP and a major structural transformation. The ratio of final energy use to primary energy use is projected to increase from 64.7 percent in 1988 to 70 percent in 2010. Primary energy consumption would decrease from 1.86 toe per $1,000 of GDP to 0.9 toe per $1,000 of GDP reflecting an effective modernization of the economy, a radical change in the structure of industrial production, and an increase in value added per unit of output. The ratio of total to primary energy would still be higher than in Western Europe but the difference would not be as great as it is now.

- Low-growth scenario reflects a slower transformation and a slower evolution of energy intensity. The ratio of final energy to primary energy increases only to 67 percent and the primary energy intensity decreases to 1.1 toe per $1,000 of GDP.

1.11 These figures for energy intensity,combined with values for the total energy use in Poland, are summarized in Table I-3.

Table I-3: Energy Intensity, 1988 vs. Energy Intensity and Consumption, 2010

1988			
Energy intensity			
Primary	(TOE/$1,000 GDP)	1.86	
Final	(TOE/$1,000 GDP)	0.20	
2010		*High growth*	*Low growth*
Energy intensity			
Primary		1.10	0.90
Final		0.74	0.64
Energy consumption (Mtoe)			
Primary		134	144
Final		88	100

1.12 Using the above figures as guides for the total consumption of energy it is possible to arrive at a global figure for gas consumption by again using Western European experience on the share of gas in total energy use. The shares in Western Europe reflect the EC directive that restricts the use of gas for power generation so that the market for gas in Poland is potentially larger than these comparative figures would suggest. Table I-4 gives the values for the projected share and levels of gas use in Poland by 2010 without making allowance for the extra potential for the use of gas for power.

1.13 The estimates, based on the assumption that gas use in Poland in the 2010 will be similar to that in an average Western European country whose income per capita now is at the level to which Poland's is projected to grow, show a potential total demand of between 20 and 30 bcm depending on the rate of growth actually attained.

Table I-4: Gas Share in Total Energy Demand and Total Gas Demand in 2010

Energy	*Share of gas (%)*	*Use of gas (Mtoe)* Low growth	*Use of gas (Mtoe)* High growth
Primary			
High	23.0	30.0	33.0
Low	10.0	13.5	14.5
Average	15.0	20.0	22.0
Final			
High	28.0	24.6	28.0
Low	14.0	12.3	14.0
Average	17.5	15.0	17.5

1.14 Apart from the inevitable limitations of such an aggregated approach attention must be paid to two special features. First, the use of Western Europe in 1988 as a reference point for Poland, both in its use of energy relative to GDP and in the share of gas in total energy, is justified to the extent that all economies become similar when they reach the same aggregate GDP. If the nature of any such relationship changes over time due to technological progress, then, to the extent that Poland adopts this technology as it becomes available and does not continue with the average installed technology as of the reference date, the predictions about the market for energy and the market for gas in 2010 will require modification. Such changes, however, are likely to be slow and gradual in their impact so that managers will have ample time to react to the new circumstances. The second assumption, which is more important in regard to the sectoral analysis, is about the price path for oil (and for other fuels). It is assumed that there will be no change in the real price of oil and no change in relative fuel prices. Temporary price fluctuations cannot be ruled out, but the crucial assumption is that of a steady fuel price. In comparing Poland in 2010 with Western Europe as it had evolved by 1988 there is thus an implicit assumption that the real cost of each fuel will be roughly similar in the next 20 years to what it has been in the last 20 years (ignoring the markedly cyclical elements in the oil price).

Sectoral Analysis of the Market for Gas

1.15 In a sectoral analysis of the demand for gas there are three features that may cause the pattern to diverge from that envisaged in the global approach:

- Higher prices and environmental protection requirements may affect the residential sector.
- The industrial structure may evolve, and the future of the iron and steel and fertilizer industries is very uncertain.
- Gas may contribute to power generation.

1.16 These factors will be addressed in the following chapters, which present estimates of the demand for gas in the main sectors.

1.17 **Residential Sector.** The residential demand for energy is characterized at present by a lack of competition because of the dominant role of the public sector and prices that do not reflect the true costs of supply. Space heating and water heating are provided primarily by district heating systems, which are inefficient and cause pollution. The consumption per household is comparable with that in other countries, but the amount of gas used for cooking and water heating is high by Western standards, and is expected to rise further. For space heating the picture is quite different—less than 10 percent of residential consumers use gas for space heating (i.e., the penetration rate is low, largely due to restrictions imposed on the use of gas) but the unit consumption of gas for space heating is much higher than would be expected even allowing for the harsh climate. For existing consumers of gas it is assumed that demand in rural areas will remain constant as income growth is balanced by a loss of competitiveness of natural gas to its rivals (liquid fuels and LPG) for that market. In urban areas it is anticipated that the number of existing customers will decline as existing buildings are destroyed at a rate of 0.5 percent per year. The market for the conversion to natural gas consists of three different types of plants: coal stoves, small heating plants, and district heating plants. For each a netback calculation of the value of gas to the producer that would equalize the price of producing heating, including the capital costs of the conversion, has been constructed:

- Coal stoves are used in about 25 percent of the housing units in urban areas, most of which are not connected to the gas supply. They contribute heavily to pollution and cannot be equipped with emission cleaning devices. Comparing the cost of continuing to use better quality coal with the cost per year (using a 10 percent discount rate to convert capital costs to an annual equivalent basis) of converting to gas and using gas gives a netback value to coal of $210 per ton. Such a value, based on the actual price of gas, implies that consumers would not switch voluntarily from coal to gas. The situation would be more favorable for the small number of consumers who are already connected to gas for cooking or water heating and who use coal for space heating because the capital costs of conversion would be much less. Experience in Western Europe, however, has shown that consumers are willing to pay extra for the convenience of gas and the estimate is that the potential demand from households with their own heating units will be twice the current level.

- Small heating plants use coal and cannot be equipped with pollution control devices. A survey of some 4,000 such plants suggests that about 50 percent would be suitable for conversion to gas because of their proximity to the gas network and because of the age of the existing plants. The calculations suggest netbacks for gas on the order of $5.5 to $7.5 per MBtu depending on the location and size. This value, equivalent to a maximum value of $260 per 1,000 cubic meters, when compared even with the highest value of the range of prices assumed for imported gas ($100 per 1,000 cubic meters) plus a margin for storage costs, still indicates a strong economic incentive to undertake the conversion. It is assumed that this conversion would be spread over the next 20 years in parallel with improvements in the distribution network.

- District heating plants (DHPs) are coal based, generate the bulk of heat supply, and are not equipped with emission control devices. The size of these facilities makes retrofitting possible and the size of the gas market will therefore depend on the relative cost of retrofitting (assuming that this is mandatory) and the cost of conversion to gas. A detailed analysis shows that this comparison is site specific and dependent on the feasibility of connection to the gas transmission system (mainly a function of distance) and on the age and state of repair of the plant. Calculations indicate that the replacement of coal-burning facilities by gas-fueled boilers is unlikely to be economic with gas having a typical netback of $80 per 1,000 cubic meters (which is the lowest possible cost for the price of gas).

1.18 The market for gas with new consumers has the largest potential in the urban areas because of the scale of the construction program expected over the next 20 years in response to the growth in the urban population (estimated at an annual 1.4 percent) as well as the rebuilding required. It is assumed that most new houses will be connected to gas for cooking because the only alternative fuel is electricity, which is relatively less economic in this use. It is also likely that construction will shift to smaller size projects in that gas would compete with DHPs based on alternative fuels. Netback calculations for gas against coal reveal a value of $190 per 1,000 cubic meters for gas on a typical project, suggesting that gas will be an attractive fuel in this market. Over the longer term (after the year 2000) the choice between alternative fuels will increase and gas penetration in new housing will slow down. It is assumed that this gas penetration will stabilize at about 50 percent, which is in line with experience elsewhere. Table I-5 shows the potential residential demand.

Table I-5: Residential Demand for Gas by Area, 1990 and Projected for 2010 (PJ)

	Gas demand (PJ)	
Area	*1990*	*2010*
Urban (PJ)		
Existing consumers	100.30	82.7
Conversion	39.43	115.76
New consumers	0.00	193.30
TOTAL	139.73	391.76
Gas penetration rate (%)	19.11	40.84
Rural (PJ)	24.50	24.50
Total residential	164.23	416.26
in BCM	4.79	12.13
of which:		
Cooking and water heating	1.61	2.23
Space heating	3.18	9.90

1.19 **Commercial Sector.** Demand in the commercial sector is linked to residential demand and consists largely of use by laundries, bakeries, restaurants, and the space and water heating for community buildings such as schools and hospitals. Although it is estimated that the service sector will grow rapidly in Poland and that gas demand will grow rapidly from a low base, the importance of district heating plants in areas that are already urbanized will reduce the opportunities for penetrating the "community" markets (Table I-6).

Table I-6: Commercial Demand for Gas, 1990 and Projected for 2010

Area of demand	*1990*	*2010*
Urban (BCM)	0.30	3.02
Rural (BCM)	0.07	0.07
TOTAL	0.38	3.09

1.20 **Industrial Sector.** The main energy input in the industrial sector is coal (62 percent); the consumption of natural gas is concentrated in the chemical and steel industries. The share and total amount of gas used is expected to drop significantly in these two industries as a result of modernization and restructuring. The effect of new economic policies is likely to promote a more diversified industrial sector (especially light and medium industries) and this will lead to a growing demand for more flexible and efficient sources of energy, which could be met in part by natural gas, as has been the case in other countries.

1.21 In the past 40 years the iron and steel industry has been completely restructured in Western economies, and as a result energy consumption per ton of crude steel has been almost halved in a 30-year period. The number of integrated plants, which use almost entirely coal and by-product gas, has declined to a point where they represent 60 to 75 percent of total production. Mini-mills, using scrap in electric steelmaking processes, have only a small demand for other forms of energy. These current trends do not present any opportunity for natural gas. In Poland a major restructuring of the industry is needed to restore competition and to reduce pollution. This restructuring will require a large amount of capital and will need to be spread over a 10- to 15-year period, as in other countries. During this period, it has been assumed, the Polish industry will become similar to those of the Organization for Economic Cooperation and Development (OECD), and the industry's demand per capita for steel will decrease and then stabilize at the levels observed in those countries. Total demand will eventually increase, driven by the growth in population. This process will be accompanied by a drastic reduction in energy consumption and by the use of the lowest cost fuels; the substantial projected decrease in demand for gas is shown in Table I-7.

Table I-7: Production Levels and Sources of Energy in the Polish Steel Industry, 1989 and Projected for 2010

Production/energy	*1989*	*2010*
Steel production (M tons)	14.8	15.4
Total energy (TJ)	334,668.0	221,742.0
Coal	219,984.0	182,903.0
Natural Gas	68,746.0	9,710.0
Oil	16,972.0	0.0
Electricity	28,668.0	29,129.0

1.22 The fertilizer industry worldwide is likely to continue to suffer from excess capacity, and new plants cannot be justified given the price of gas that will rule in Poland; in fact, fertilizer plants are likely to be closed progressively. The sulfur market, too, is suffering from excess supply (Poland is one of the world's main producers), and the situation is likely to worsen with the implementation of more stringent pollution standards, which require higher sulfur recovery from fuel oil and coal. This industry is likely to show a slow decline also. Other chemical industries are likely to grow at a moderate rate. Potential gas demand by the chemical industries is shown in Table I-8.

Table I-8: Potential Demand for Natural Gas by Polish Chemical Industries, 1990, and Projected for 2010 (MCM)

Industry subsector	*1990*	*2010*
Nitrogen fertilizers	2.53	1.40
Sulfur	0.49	0.30
Other	0.26	0.50

1.23 The sector of light and medium industries is expected to contribute substantially to the economic recovery in Poland while its structure is expected to change considerably. To estimate the potential for gas in this sector two approaches have been used. The first is based on the contribution of the sector to GDP, the second on the consumption of energy per person employed in the sector. Both approaches use international comparisons to predict the likely path of the Polish economy. A general assumption is that the activity in this sector will become more diversified and that energy inefficiencies will be gradually reduced.

1.24 It is assumed that this sector will grow faster than the average for the economy, 4.5 percent in the high-growth scenario and 3.3 percent in the low-growth scenario. The share of this sector will rise from 38.3 percent in 1988 to about 40 percent in 2010. This is comparable to what has occurred in other countries that have experienced rapid economic growth together with deep industrial restructuring (e.g., South Korea and Spain during the past 20 years). Assuming that energy inefficiencies are reduced over the same period, which is one of the conditions required for success, the total energy demand in this sector would be between 1,424 PJ and 1,068 PJ in the high- and low-growth scenarios, respectively.

1.25 This approach assumes that by 2010 all structural problems will have been resolved so that Polish industry will be competitive with other European industries. In particular it is assumed that existing energy efficiencies will have been improved so that the energy use per person employed will be the same as that observed today in Western industrialized countries. In the industrial sector of Western European economies current unit consumption of energy is about 520 GJ per person employed (this figure appears to be fairly robust), which is about 25 to 30 percent lower than the figure for Poland. On the basis of the European unit consumption and of employment trends forecast for the sector, the energy demand for the total industrial sector in 2010 is projected to be about 1,750 PJ, of which 1,150 PJ would be for light and medium industries after the reduction of the projected demand for the steel and chemical industries.

Table I-9: Gas Netbacks in Light and Medium Industries ($/CM)

	Converted facilities		*New facilities*	
Facility size	*Boilers*	*Heat process*	*Boilers*	*Heat process*
Large	0.12	0.22	0.11	0.19
Small	0.14	0.23	0.13	0.22

1.26 Using the same international comparisons it is estimated that the share of gas in total energy supplies to this sector would reach about 25 percent by the year 2010. This reflects the comparative advantage of gas over other fuels, in particular liquid fuels, since these fuels are most suitable for these industries because of the flexibility of use demanded by new technologies that use automation and regulation. Two calculations have been used to verify this. The first calculates netback values for gas for conversion and for new facilities against liquid fuels. The results are shown in Table I-9 and indicate that, with an import price of between $0.08 and $0.10 per cubic meter, there is substantial economic potential for gas in this sector. Second, for a series of light and medium industries in the United Kingdom and in France, the penetration rates are shown to be substantial even though gas is more expensive than competing fuels.

1.27 Hence, the two scenarios—which depend on the rate of growth of GDP— indicate a potential for gas of between approximately 1,400 PJ and 1,100 PJ by the year 2010. Table I-10 shows the expected industrial demand for gas.

Table I-10: Total Polish Industrial Demand for Gas, 1990 and Projected for 2010 (BCM)

		2010	
Industry	*1990*	*High*	*Low*
Iron/steel	2.04	0.28	0.28
Chemicals	3.28	2.20	2.20
Other	1.66	10.20	8.41
TOTAL	6.98	12.69	10.90

1.28 **Power Generation Sector.** The power sector is the largest single user of coal and lignite in Poland and, because of the poor quality of coal and the lack of emission control equipment, it is also one of the largest contributors to environmental pollution. The long-term prospects for the economy are for an increase in the consumption of electricity per capita. In the short run the recession brought about by the implementation of the economic restructuring program has resulted in a sharp drop in electricity consumption and it is not known if demand will fall further before it starts to grow. To deal with this uncertainty two scenarios have been constructed:

- A "low-growth" scenario, which assumes that the 1990 level of power generation (130 TWH) will remain constant for some years and then will recover to 145 TWH in 2000 and thereafter grow at about 3.3 percent per annum

- A "base-case" scenario, which assumes that the growth in power demand will resume at the end of 1990 at the rate of 3.3 percent per annum.

1.29 The prospects for gas in the power sector depend both on the overall growth rate and on the relative advantages of gas as compared with other fuels. The use of gas, because of its cost and environmental aspects, may possibly expand in three distinct markets: in the conversion of coal-based plants, as a supplement to existing capacity (repowering), and as a fuel for new plants (including combined-cycle plants). The economics of these three cases are considered below and the netback values are given in Table I-11.

Table I-11: Gas Netback Values in the Power Sector ($/CM)

Type of power plant	*Load factor (h/y)*	*Netback*
New units		
Combined cycle	5,000	0.17
Repowering	5,000	0.16
Combined cycle	6,000	0.15
Repowering	6,000	0.15
Conversion		
Recent plant	3,000	0.11
Recent plant	5,000	0.09
Old plant	3,000	0.08
Old plant	5,000	0.07

- *Conversion of coal-fired plants to natural gas.* Netback calculations indicate that the conversion of existing plants is not justified on the basis of capital and fuel costs alone. If an allowance is made for the reduction in pollution, then conversion looks more favorable, but it may be more economical to retrofit existing plants with emission control devices (at about $250 to 300 per kW).

- *Repowering of existing plants.* The addition of gas turbines to existing coal-fired power plants can increase net efficiency (from about 34 percent to 39 percent) at a cost lower than that of new power plants. The netback values do indicate a role for gas.

- *New power plants.* Numerous studies have concluded that the use of gas in combined-cycle plants represents the least cost solution for power expansion due to lower investment costs and higher efficiency. This solution also favors environmental concerns since the level of emissions is greatly reduced.

1.30 With the minimum import price of gas at $0.08 per cubic meter the economic advantage for gas lies only with repowering and new plants. At the limit all new additions could be gas fired, but this would be neither prudent nor practical and so it has been assumed that only a fraction of the new capacity would be gas fired; thus, gas would supply on average between 20 and 30 percent of total generation. The projected gas demand from the power sector is shown in Table I-12. The relatively small difference between the high and low scenarios conceals larger differences in the intermediate years. In the low scenario no gas is required for power generation until 2005, while in the base case the gas could be required as soon as 1996.

Table I-12: Potential Demand for Gas from Power Sector in 2010 (PJ)

Type of power plant	*Base case*	*Low case*
Gas turbine (peak)	36.0	19.0
Gas turbine (repowering)	106.0	113.0
Combined cycle (base)	314.0	241.0
Combined cycle (H&P)	77.0	47.0
TOTAL (BCM)	15.5	12.2

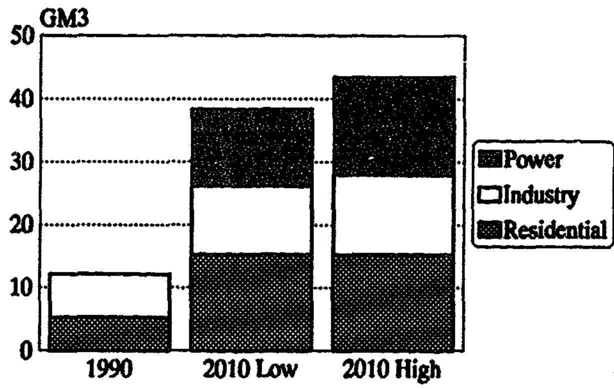


Figure I-1: Potential Gas Demand

1.31 The results of the sectoral approach have been consolidated into two scenarios. A "high" scenario assumes a rapid recovery of the economy and a rapid transition to a new economic structure. It includes higher estimates of industrial demand and of power generation. A "low" scenario assumes that the initial adjustment will be spread over a longer period, which reflects physical and financial constraints. It has correspondingly lower estimates for sales to industry and to power generation. The results are summarized in Figure I-1 and Table I-12, Table I-13.

1.32 The projected potential demand derived from the sectoral analysis is between 27 and 30 bcm, excluding power generation. These figures are closer to the higher values derived from the macroeconomic approach. Moreover they do not take into account certain constraints that may delay the introduction of gas in some sectors.

Gas Demand in Regional Context

1.33 The macroeconomic and sectoral approaches do not take into account the variations between the regions and in particular ignore any regional constraints on supply that may exist despite the rise in prices. The analysis is carried out for six regional zones, each selected as having common economic and infrastructure features. Energy requirements are assessed for each zone on the basis of regional variations from the national features used in the first two approaches. Given the greater difficulty of forecasting regional growth rates and changes in industrial structure this exercise can be regarded only as a first approximation. It is valuable, however, in that it allows known physical constraints on production, transmission, and distribution to be incorporated into the projections.

1.34 The six zones chosen for analysis are as follows:

- Zone 1 includes Upper and Lower Silesia and contains about 41 percent of Poland's industrial activities, including 78 percent of the steel industry and a large share of coal production. Katowice, Krakow, and Opole are the main cities. Industrial pollution is high, and medium-term economic prospects for the region are poor. Industrial activity is likely to decline until the completion of restructuring, and economic and urban population growth will be lower than in other regions. The widespread gas infrastructure, the closure of coke oven plants, and the high pollution do make the region prime for introduction of natural gas in the residential sector.

- Zone 2 is south of Warsaw. It is the largest industrial area excluding the steel industry. Because of its location, current activities, and population growth the region is expected to develop faster than the national average. The availability of gas transmission infrastructure should enable an early increase in the use of gas.

Table I-13: Gas Demand Based on Sector Analysis, 1990 and Projected for 2010 (BCM)

		2010	
Sector	*1990*	*High*	*Low*
Residential			
Space heating	3.25	10.52	10.52
Others	1.91	4.71	4.71
Total	5.16	15.23	15.23
Industry			
Iron and Steel	2.04	0.28	0.28
Chemicals	3.28	2.20	2.20
Others	1.66	10.20	8.41
Total	6.98	12.69	10.90
Power	0.0	15.50	12.20
TOTAL	12.15	43.42	38.33

Table I-14: Regional Variables

	Zone		
Variables	1	2, 4, 5, 6	3
Population growth (% p.a.)	0.6	1.6	2.2
New housing growth (%)	1.1	2.1	2.7
Climate factor	1.0	1.05	1.15
Industrial growth (%)	3.5	4.5	4.0

- Zone 3 is northeast of Warsaw and is mainly agricultural. The gas infrastructure is limited, and little industrial development is likely because the area will be environmentally protected. Thus, potential for gas will be mainly in the residential sector.

- Zone 4 is in the southeast, around Tarnow. Prospects here are similar to those in Zone 1, in particular because of the decline expected in the chemical industries. For gas the main potential is in the residential and commercial sector because industrial sales are not expected to regain the level of the 1980s after the decline in the chemical sector.

- Zones 5 and 6 have considerable potential for growth because of their location along the Baltic Sea and the German border. They are expected to benefit from international trade and from the availability of gas because import facilities may be located in these regions.

1.35 Regional demands have been projected by applying regional growth rates and adjusting penetration rates in accordance with the projected timing of supplies in each region. The specific regional factors are shown in Table I-14. Power demand does not need to be reanalyzed because the power projections would be unaffected by these regional concerns.

1.36 A summary of the projected total demand by sector based on a regional analysis for residential and commercial sectors is shown in Table I-15 and for the industrial sector in Table I-16.

1.37 For the residential and commercial sectors, the demands projected for 2010 are lower than those derived from the aggregate sectoral analysis. This is caused by regional constraints in zone 3, where gas cannot be used in the early part of the period because of the lack of additional infrastructure.

Table I-15: Residential and Commercial Demand based on Regional Analysis (BCM/Year)

Demand	*1995*	*2000*	*2005*	*2010*
Residential	4.36	6.19	8.15	9.80
Commercial	0.56	1.00	1.70	2.78
TOTAL	4.92	7.20	9.85	12.57
Cooking & water heating	2.64	3.22	3.98	5.01
Space heating	2.29	3.97	5.87	7.56
Projected Peak (MCM/hr)				
Temperature risk coverage				
175	2.28	3.50	4.90	6.27
176	2.06	3.10	4.31	5.52

1.38 The results for the industrial sector are within the range of the higher and lower estimates derived from the aggregate sectoral analysis.

1.39 Although the aggregate figures using the two methodologies are similar, the regional disaggregation has the advantage in that it also shows the variations in growth rates between the regions, which may be important for planning purposes. Table I-17 and Figure I-2 give a regional breakdown for the main uses of gas until the year 2010. Note that gas demand in the industrial sector is expected to grow steadily in zones 2, 5, and 6 reflecting the availability of gas in the early years and the potential of these areas. Industrial demand growth in zone 3 will start later due to the nature of the demand and the lack of infrastructure. In zones 1 and 4, industrial demand is expected to decrease in the early years because of the recession in the iron and steel and fertilizer industries and is expected to reattain the 1988 level toward the end of the period.

Table I-16: Industrial Demand Based on Regional Analysis

Demand	*1995*	*2000*	*2005*	*2010*
Base load (BCM)				
Iron and steel	0.3	0.2	0.2	0.3
Chemicals	2.9	2.5	2.2	2.2
Small and medium	1.7	3.4	6.0	9.4
TOTAL	5.0	6.1	8.5	11.9
Peak demand (MCM/hour)				
Iron and steel	0.05	0.03	0.04	0.04
Chemicals	0.40	0.40	0.40	0.40
Small and medium	0.38	0.75	1.34	2.09
TOTAL	0.83	1.18	1.77	2.52
Less interruptible	0.23	0.45	0.80	1.25

1.40 The regional analysis confirms the conclusions of the macroeconomic and sectoral approaches. The levels of demand are slightly lower in the regional approach, and these values are used to formulate a base case that is incorporated into the Gas Development Plan. Table I-18 allocates the total demand in this base case to the various components of the gas system.

Table I-17: Gas Demand Projections by Zone, 1990-2010 (BCM)

Zone	*1990*	*1995*	*2000*	*2005*	2010
Zone 1					
Commercial	0.10	0.16	0.25	0.39	0.59
Residential	1.05	1.16	1.48	1.81	2.07
Industry	2.73	1.45	1.56	2.32	2.99
Total	3.89	2.77	3.29	4.52	5.64
Zone 2					
Commercial	0.05	0.11	0.23	0.45	0.80
Residential	0.67	0.92	1.49	2.09	2.62
Industry	2.17	2.27	2.84	3.62	4.53
Total	2.89	3.30	4.56	6.16	7.95
Zone 3					
Commercial	0.01	0.02	0.05	0.11	0.22
Residential	0.06	0.16	0.36	0.59	0.78
Industry	0.05	0.05	0.19	0.39	0.75
Total	0.12	0.22	0.60	1.08	1.75
Zone 4					
Commercial	0.08	0.09	0.12	0.16	0.23
Residential	0.85	0.88	0.96	1.05	1.12
Industry	0.76	0.27	0.38	0.55	0.70
Total	1.69	1.24	1.46	1.76	2.06
Zone 5					
Commercial	0.04	0.08	0.16	0.27	0.44
Residential	0.41	0.56	0.89	1.24	1.53
Industry	0.44	0.44	0.56	0.84	1.48
Total	0.90	1.08	1.61	2.36	3.45
Zone 6					
Commercial	0.06	0.10	0.19	0.32	0.51
Residential	0.53	0.68	1.02	1.38	1.68
Industry	0.53	0.53	0.60	0.79	1.45
Total	1.11	1.30	1.81	2.49	3.64
POLAND					
Commercial	0.34	0.57	1.00	1.70	2.78
Residential	3.57	4.36	6.19	8.15	9.80
Industry	6.64	4.96	6.14	8.51	11.90
TOTAL	10.55	9.89	13.34	18.36	24.48

Table I-18: Summary Total Potential Gas Demand (BCM)

Demand	*1990*	*2000*	*2005*	*2010*
Total (excluding power)	9.910	13.330	18.350	24.500
Power (base case)	0.545	6.515	10.806	15.521
Peak demand (MCM/hour)				
Residential/commercial				
185 risk coverage	2.28	3.50	4.90	6.27
186 risk coverage	2.06	3.10	4.31	5.52
Industrial	0.83	1.18	1.77	2.52
Power				
Transmission	0.16	0.33	0.33	0.33
Transit	0.33	6.32	9.53	10.55
Total peak at 2%				
Transmission	3.27	5.01	7.00	9.12
Distribution	2.51	3.95	5.70	7.52
Transit	0.33	6.32	9.53	10.55
Total peak at 50%				
Transmission	2.45	3.88	5.44	7.09
Distribution	2.28	3.55	5.12	6.77
Transit	0.33	6.32	9.53	10.55

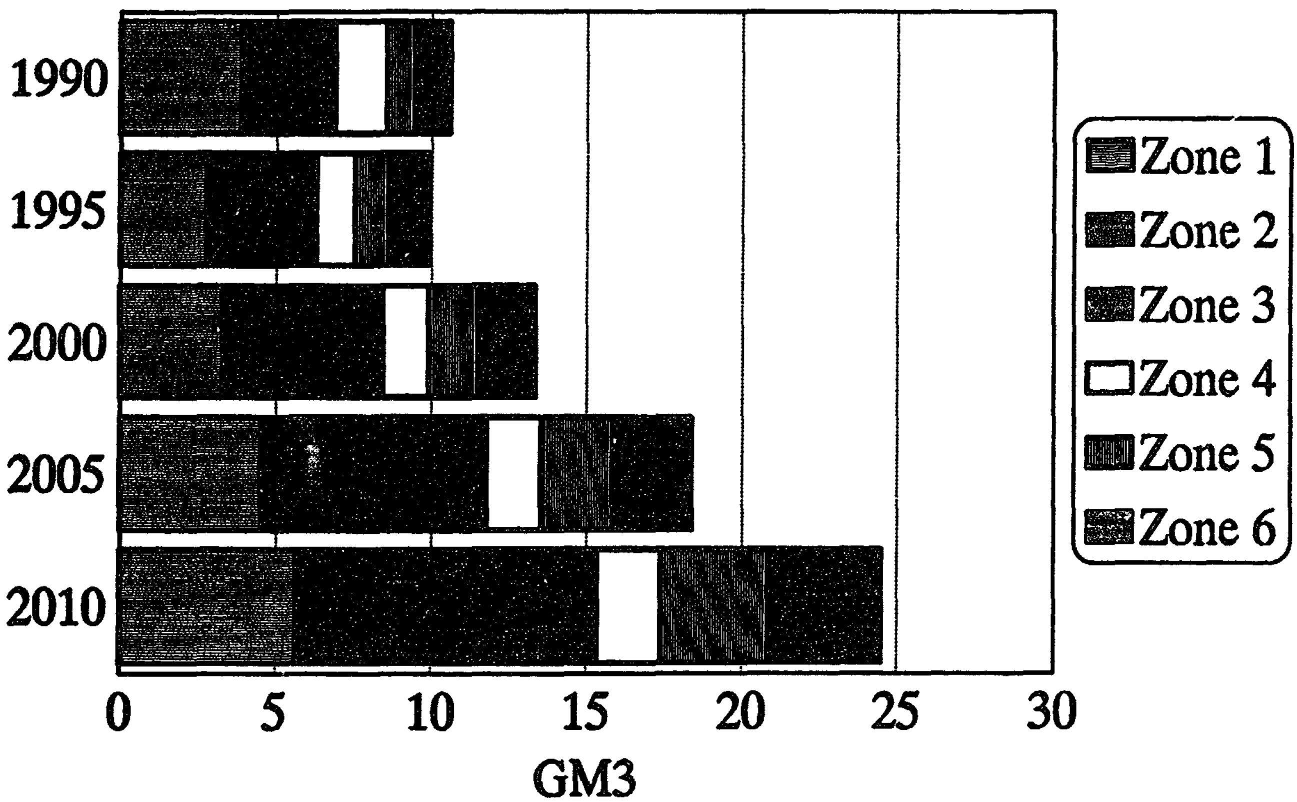


Figure I-2: Gas Demand Forecasts by Zone

2. SUPPLY

2.1 Poland imports about two-thirds of the gas it consumes from Russia. Although dependence on imports is not unusual, such heavy reliance on a single source and the lack of a long-term contract are neither typical nor desirable, especially when supplies from Russia may become less available and more expensive. Gas production in Poland consists of high-methane natural gas (HMNG), low-methane natural gas (LMNG), coke oven gas, and methane recovered from mines. Coke oven gas is likely to be phased out in the next few years, but gas from mines may become a substantial source of supply.

2.2 Domestic production has been declining recently because of the normal depletion of fields and because of inadequate funding for production and exploration. An important part of the Gas Development Plan is to increase domestic production by rehabilitating existing facilities and increasing the effectiveness of exploration.

2.3 Given the estimated domestic production and the estimated total demand as described in chapter 1, an estimate of total import demand can be constructed. The increase in demand for imports, coupled with a likely limited availability of Russian supplies, means that imports will need to be diversified.

2.4 An important feature of the demand for gas is the strong seasonal peak in the winter months, a peak that will intensify as demand shifts away from industrial use and toward residential and commercial use. To meet this peak demand at the lowest cost, when it is unlikely that the quantity of imports will be seasonally variable, clearly will require an increase in domestic storage capacity.

2.5 Another important aspect of the balance of supply and demand in Poland is that a substantial proportion of the existing domestic production is LMNG, whereas all imports will be HMNG. These two forms of gas cannot be used

Table II-1: Production from Existing Fields without Additional Investment (Base Case) (MCM)

Year	*South Poland*	*Northwest Poland*	*Total gas*
1990	1,655	3,254	4,909
1991	1,571	2,906	4,477
1992	1,499	1,201	2,689
1993	1,419	1,120	2,539
1994	1,353	1,047	2,400
1995	1,292	979	2,271
1996	1,235	967	2,202
1997	1,180	906	2,086
1998	1,129	850	1,979
1999	1,079	788	1,867
2000	1,034	743	1,777
2001	990	701	1,691
2002	949	544	1,493
2003	911	514	1,425
2004	874	485	1,359
2005	838	457	1,295
2006	806	434	1,240
2007	776	411	1,187
2008	746	369	1,115
2009	718	350	1,068

interchangeably, and therefore it is necessary to determine which demands should be linked to the limited supply of LMNG, particularly since the supply of LMNG will gradually become depleted.

Domestic Production

2.6 The composition of gas produced in Poland varies with location. In southern Poland the gas is very rich in methane (99 percent) with a Btu of 8,200 Kcal/cubic meter. In northwest Poland the gas has an average nitrogen content of 36 percent and an average Btu of 5,855 Kcal/cubic meter. Some fields also produce gas with a very high H_2S content (on the order of 1 percent), which, coupled with the high nitrogen content, reduces the calorific value further. Total estimated gas production in 1990 was 4,909 mcm, of which only 3,978 mcm was pipeline-quality gas.

2.7 PGNG conducted extensive surveys of the gas fields, and three levels of potential production have been calculated for each year until 2009:

- A base case includes production from existing fields without any additional investment.
- A second case includes additional investments for the rehabilitation of existing fields and the development of "stand-by" fields.
- A third case includes additional investment in new production.

Table II-2: Production of Pipeline-quality Gas from Existing Fields Without Additional Investment (MCM)

Year	*South Poland*	*Northwest Poland*	*Total gas*
1990	1,665	2,323	3,978
1991	1,571	2,075	3,646
1992	1,488	858	2,346
1993	1,419	800	2,219
1994	1,353	748	2,101
1995	1,292	699	1,991
1996	1,235	690	1,925
1997	1,180	647	1,827
1998	1,129	607	1,736
1999	1,079	563	1,642
2000	1,034	531	1,565
2001	990	501	1,491
2002	949	388	1,337
2003	911	367	1,278
2004	874	346	1,220
2005	838	326	1,164
2006	806	310	1,116
2007	776	293	1,069
2008	746	263	1,009
2009	718	250	968

2.8 From existing fields without any additional investment both the total production and the production of pipeline-quality gas are expected to decline dramatically in 1992 and steadily thereafter as shown in Table II-1 and Table II-2 (this excludes the effect of the small increment in 1990 due to new investment). Although the figures are initially quite different, as northwest Poland's gas fields (which produce gas with low methane content) approach depletion, the figures will be fairly similar. The data in these tables highlight the need for investment both to maintain production where possible and to increase production by increasing exploration and development.

2.9 The proposed investment program to rehabilitate existing producing fields and to develop stand-by fields includes additional drilling (253 new wells, 669 workover wells, and 159 wells to be connected to production facilities); compression in five fields; and treatment facilities for fields that produce gas with H_2S. The total incremental production is estimated to be 53 bcm (49 bcm of pipeline-quality gas) with a total investment cost of $300 million.

2.10 The economic viability of this program is very sensitive to unit costs; some of the projects would become uneconomic if costs increased to between 50 and 75 percent of the international level. Because PGNG has a considerable amount of excess capacity in drilling and other field equipment (which can be rehabilitated at low cost), PGNG's costs are substantially lower than international costs, and it is thus possible to justify the program to recover a relatively small amount of gas. This situation is only temporary, however, and PGNG's costs will rise over time.

Table II-3: Incremental Production of Pipeline-quality Gas From Existing Fields Ranked by Costs

	South Poland		*Northwest Poland*	
Tech. costs ($/MSCF)	*Prod'n (BCM)*	*Invest. (MM$)*	*Prod'n (BCM)*	*Invest. (MM$)*
0.2	6.1	23.5	15.3	28.4
0.4	10.9	72.5	20.1	78.0
0.6	11.5	83.6	28.2	210.5
1.0			28.4	216.4

2.11 Because these costs will rise over time, it is important to implement the most attractive projects first. For example, given a similar investment, the projects in northwest Poland would yield twice as much incremental production as those in southern Poland. The average incremental cost of gas recovered over the period is estimated at between $0.25 and $0.88 per GJ, well below the likely price of imported gas. Table II-3 shows the relation between production costs and the total additional amount of gas that could be obtained. As costs rise the additional gas that can be obtained economically falls sharply, showing that at a cost of $1 per 1,000 standard cubic feet ($0.92 per GJ) virtually no extra gas could be obtained from investment in the existing system. Figures for the annual incremental production of gas that would be economically viable are given in Table II-4. Although this source of additional gas is extremely important in the near future, it, too, decreases toward the end of the 1990s as depletion comes to dominate domestic supply.

2.12 The production from new fields depends both on the amount of gas present and on the amount of investment in exploration and development. PGNG's current plans call for an average of 130 exploratory wells per year for the next 20 years, and assumes new discoveries of between 40 and 100 bcm of natural gas. However, this proposed drilling program is much larger in relation to the projected seismic surveys than has been observed internationally. PGNG's exploration costs are presently low compared with international costs because of the availability of unused capacity, but here again these costs are expected to increase rapidly over time. The increase in these costs will be partially offset by the use of more modern technologies and exploration procedures (more selectivity supported by better seismic surveys, etc.). The Average Incremental Cost (AIC) was estimated based on the following assumptions:

- Potential discoveries of 40 to 100 bcm
- Reduction of PGNG's exploration program by 50 percent
- Increase of PGNG's costs to at least 50 percent of international costs.

Table II-4: Incremental Production of Pipeline-quality Gas from Existing Fields Due to Investment (MCM)

Year	*South Poland*	*Northwest Poland*	*Total gas from existing fields*
1990	0	60	4,038
1991	166	252	4,064
1992	258	1,626	4,229
1993	350	1,665	4,234
1994	694	2,008	4,802
1995	858	1,946	4,795
1996	926	1,931	4,782
1997	999	1,791	4,617
1998	938	1,649	4,323
1999	882	1,527	4,050
2000	830	1,405	3,800
2001	784	1,295	3,570
2002	738	1,274	3,349
2003	697	1,176	3,151
2004	659	1,087	2,967
2005	626	1,005	2,796
2006	593	928	2,637
2007	563	858	2,491
2008	535	808	2,353
2009	508	748	2,223

2.13 The upper and lower values for discoveries can be called the "optimistic" and "pessimistic" cases, respectively. In the optimistic case the projected AIC (at a 10- to 12 percent discount rate) ranges from \$2.5 to \$2.8 per MBtu if PGNG's costs are restricted to about 75 percent of international costs. In the pessimistic case the amount of reserves to be discovered is too low to justify the program put forward by PGNG for the next 20 years. The projected AIC rapidly exceeds the projected Russian import prices of \$2.0 per MBtu in 1990 and \$2.5 per MBtu (in constant 1990 prices) by 1995 (other land imports are projected to have higher costs but this is not certain). Because the results of exploration are so speculative, it will be necessary to monitor PGNG's program both in terms of costs and results to ensure that the marginal cost of gas discovered remains within the limits set by alternative sources of supply. The figures for the time profile of total gas supply from existing fields and from new discoveries (including fields with H_2S) are given for the optimistic and pessimistic cases in Table II-5 and Table II-6. The figures for the pessimistic case should be regarded as a conservative estimate of what can be ob'ained under economic conditions rather than as an acceptance that the high levels of expenditure proposed in the PGNG program will be viable in all cases.

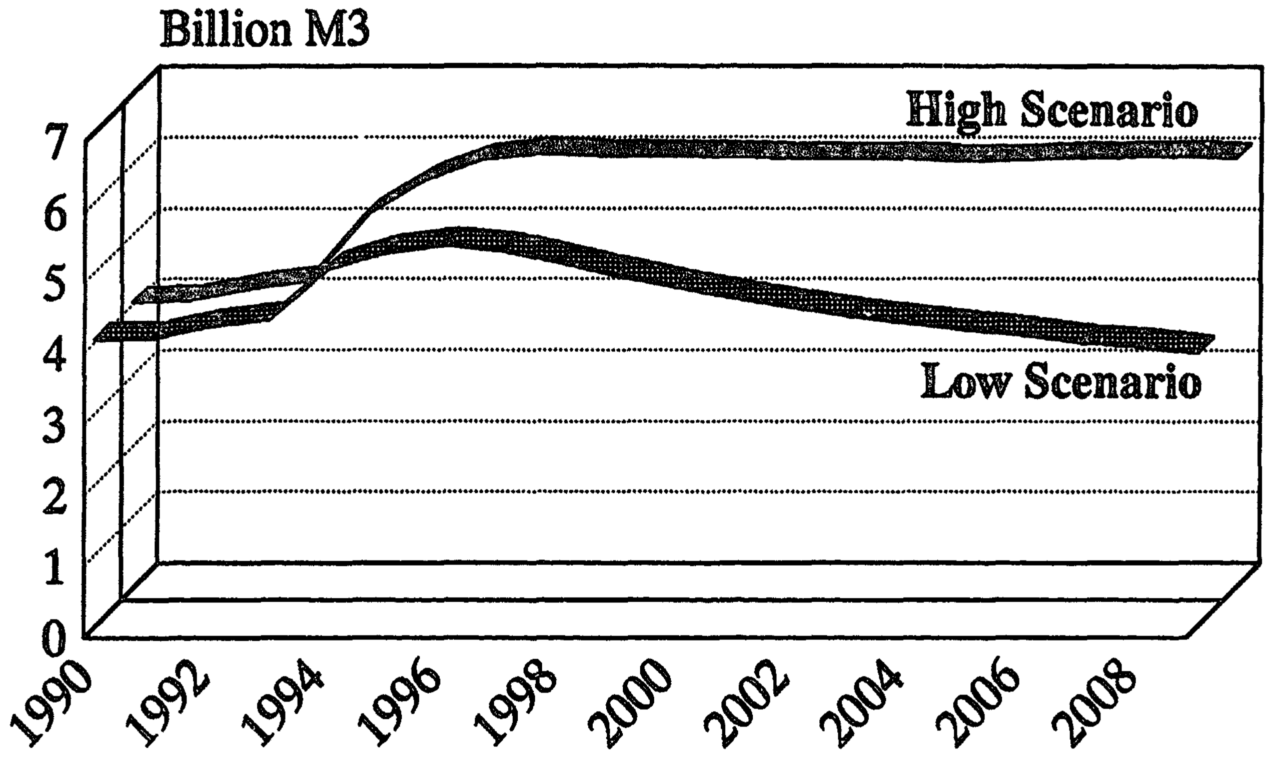
Table II-5: Total Pipeline-quality Gas From Existing Fields and New Discoveries (MCM). Optimistic Case

Year	*South Poland*	*Northwest Poland*	*Total Gas*
1990	1,655	2,383	4,038
1991	1,737	2,327	4,064
1992	1,746	2,483	4,229
1993	1,827	2,501	4,328
1994	2,295	2,980	5,275
1995	2,574	3,184	5,758
1996	2,733	3,319	6,051
1997	2,875	3,268	6,143
1998	2,891	3,223	6,114
1999	2,909	3,189	6,098
2000	2,936	3,169	6,104
2001	2,946	3,136	6,082
2002	2,959	3,109	6,068
2003	2,980	3,097	6,077
2004	2,981	3,069	6,050
2005	2,988	3,049	6,036
2006	3,023	3,062	6,085
2007	3,035	3,053	6,088
2008	3,053	3,054	6,107
2009	3,050	3,036	6,086
TOTAL	53,193	59,689	112,882

Table II-6: Total Pipeline-quality Gas From Existing Fields and New Discoveries (MCM). Pessimistic Case

Year	*South Poland*	*Northwest Poland*	*Total Gas*
1990	1,655	2,383	4,038
1991	1,737	2,327	4,064
1992	1,746	2,483	4,229
1993	1,827	2,501	4,328
1994	2,179	2,856	5,034
1995	2,342	2,936	5,278
1996	2,413	2,976	5,389
1997	2,471	2,835	5,306
1998	2,419	2,717	5,136
1999	2,353	2,594	4,947
2000	2,296	2,483	4,779
2001	2,246	2,386	4,632
2002	2,199	2,295	4,494
2003	2,166	2,219	4,379
2004	2,125	2,153	4,277
2005	2,096	2,093	4,189
2006	2,071	2,043	4,113
2007	2,031	1,978	4,008
2008	2,013	1,941	3,953
2009	1,978	1,888	3,866
TOTAL	42,357	48,084	90,440

2.14 Figure II-1 shows a substantial range in the total amount of gas domestically produced over the next 20 years according to the forecast scenario. Comparison with the data in Table II-4, which exclude production from new fields, shows that even in the pessimistic case the effect of new investment will be increasingly important after 2000. If the optimistic scenario is realized then during the decade from 2000 to 2009, an additional 2 bcm per year should become available from domestic sources.



2.15 The gas plan uses the pessimistic case as its central case for domestic supply. Because the crucial new production will take several years to come on stream, however, there will be ample time to reduce import contracts (since these are likely to be determined successively rather than all at the outset) if domestic production is greater than anticipated.

2.16 Total investment costs, both to increase production from existing fields and to explore and develop new fields, are estimated at about $675 million, of which about 50 percent will require foreign exchange. The timing of the production stream was calculated assuming that the project implementation period will be about five years.

2.17 The potential production of methane from coal mines must also be considered. It was estimated that in 1989 about 1 bcm of gas was liberated from coal mines, of which only 0.2 bcm was used—the rest was vented (there is a distinct possibility that the figures for venting were underestimated). In addition to the large amount of vented gas available, for which improved recovery might be possible, an even larger amount of gas could be available from direct recovery of coalbed methane. Coalbed methane resources have been estimated at 1,300 bcm (380 bcm are already documented), highly significant reserves when compared with estimates for natural gas in place (168 to 173 bcm). Cost estimates for the various methods of recovery have not yet been calculated, but the suggested cost (capital and operating) at the wellhead using pre-mine drainage (for which the recovery rate is highest) would be between $8.84 and $26.50 per 1,000 cubic meters, which is well below the anticipated import cost of $80 per 1,000 cubic meters. The recovery and use of coalbed methane would not only provide direct economic benefits by replacing fuel imports but also would provide several important indirect benefits such as enhancing mine safety and productivity by removing the methane from coal mines and reducing environmental damage by preventing the release of methane into the atmosphere.

2.18 At this stage it is not possible to evaluate the contribution that coalbed methane can make to the total domestic gas supply of Poland, but it appears likely, given the conservative figures for reserves and the present costs, that it could yield more gas than exploration for new gas fields. Because the increase in demand is not expected to occur until later in the decade there is still time to carry out background feasibility studies. The nature of the gas also dictates how it would need to be used. Low-quality mine ventilation air can be used economically as the combustion fuel for steam boilers or gas turbine generators only when the plants are very close to the mine (less than 2 kilometers). High-quality gas from wells drilled into unmined coal seams, however, can be used for power or linked to the transmission and distribution system. Use of this high-quality gas for power generation may be particularly attractive because coal mines typically are situated near power plants, and thus some of the required infrastructure is already in place.

Balance of Supply and Demand

2.19 Projected gas demand has been calculated based on the estimates presented in chapter 1. A central demand scenario (see Table II-7) was used to assess the need for imports and the relative contribution of HMNG and LMNG. The projected demand for each region (see chapter 1 for definitions) indicates that the volume of sales to the "basic" market (residential, commercial, and industrial sectors) will more than double from 1995 to 2010. This increase, although large, is similar to what was observed in other countries over a similar period. The projected sales to the power generation market could reach 15 bcm by 2010, although such an increase has not been observed in Western Europe because the use of gas for power generation is restricted.

Table II-7: Projected Gas Demand (MCM/year)

Region	*1995*	*2000*	*2005*	*2010*
Region 1	2,770	3,290	4,520	5,650
Region 2	3,300	4,560	6,160	7,950
Region 3	220	600	1,080	1,750
Region 4	1,240	1,460	1,760	2,060
Region 5	1,080	1,610	2,340	3,450
Region 6	1,300	1,810	2,490	3,640
TOTAL	9,910	13,330	18,350	24,500
Power	545	6,515	10,806	15,521

2.20 Sales to the "basic" market are expected to be supplied through the existing transmission and distribution systems after expansion. Sales to the power generation market would be supplied directly from a "transit" system, which would carry imports into Poland and be linked to the domestic transmission system. The reason for this distinction is that the two systems—the transit system and the domestic transmission sytem—have different technical specifications and operating parameters. The "transit" system will operate at 80 bar, but the domestic transmission system will remain at 64 bar (See Figure).

2.21 The anticipated change in the market structure, particularly for space heating, will increase the seasonal variability of demand. Currently 47 percent of demand is used during the five winter months; it is estimated that this will rise to 60 percent by 2010. This seasonal fluctuation in demand can be partially compensated for by variations in domestic production and offtake flexibility with import contracts, but both of these are rather limited (pipeline contracts generally have a flexibility of only 10 percent). Thus, PGNG must develop underground storage capacity and negotiate interruptible contracts to ensure that the winter demand is adequately covered.

2.22 A related point is that these peak requirements will increase as a multiple of annual sales. Peak demand has been estimated for 2 percent and 50 percent risk levels (a 2 percent risk coverage means that the gas company should be able just to meet the extreme peak demand that could be expected to occur twice in 100 years). Such a planning constraint does not yet exist in Poland, but it is calculated in this report because this type of objective should become part of the planning process. The projected peak requirements are shown in Table II-8.

2.23 In addition to seasonal and peak demands, supply constraints must be considered:

- The different natures of the gas used (HMNG and LMNG)
- The possible flexibility in the rate of production from domestic fields
- The flexibility of import contracts.

2.24 The facts that HMNG and LMNG are not interchangeable and that the supply will become increasingly dominated by HMNG means that separate balances for the two types of gas need to be constructed. This issue will be further complicated if coalbed methane is developed because the gas quality varies with the different techniques, which have different costs.

2.25 Although there is some flexibility in the rate of production from domestic fields, this flexibility will be limited by economic considerations and by operational constraints. The peak production of LMNG will limit the total volume that can be supplied to the residential sector and to that part of the industrial sector that cannot install dual fuel equipment.

2.26 Import contracts are limited in flexibility to about 10 percent of the daily contracted volume. Furthermore, the timing of successive contracts needs to be reconciled with the gradually increasing demand, which may require the introduction of large-scale temporary users (e.g., power generation) and interruptible contracts capable of absorbing large quantities of gas in the early years.

Table II-8: Projected Peak Requirements (MCM/hour)

Sector	*1995*	*2000*	*2005*	*2010*
Residential/ Commercial				
236	2.28	3.50	4.90	6.27
237	2.06	3.10	4.31	5.52
Industrial	0.83	1.18	1.77	2.52
Less interruptible	0.23	0.45	0.80	1.25
Power				
Transmission	0.16	0.33	0.33	0.33
Transit				
Low case	0.00	0.00	6.99	9.32
Base case	0.33	6.32	9.53	10.55
Total peak (2%)				
Transmission	3.27	5.01	7.00	9.12
Distribution	2.51	3.95	5.70	7.52
Total peak (50%)				
Transmission	2.45	3.88	5.44	7.09
Distribution	2.28	3.55	5.12	6.77

2.27 Priority was assigned to supply of the basic market (residential, commercial, and industrial) because of the need for continuity, particularly for sectors with no alternative sources of supply. The power generation market, which has alternative sources, is treated as an option that can be exercised according to the availability and price of gas. In the central scenario it was assumed that PGNG's objectives are to cover the 2 percent temperature risk by the year 2000, with minimal use of interruptible contracts. The calculated demand for LMNG was limited to the peak supply capacity of domestic sources, which means that only a fraction will be commercialized in the basic sectors. The excess LMNG could be used for a gas-based power station or, if denitrified, to supplement HMNG.

2.28 The results of the analysis are summarized in Table II-9. This is the worst case for imports because (a) it does not consider recovery of mine-vented methane or direct recovery from coalbeds, which could bolster domestic supply and reduce imports; and (b) it assumes use of gas for power generation, but if gas is not used for power generation, then demand and imports both would be reduced.

2.29 Because of the need to meet peak demand, total supply of LMNG to the basic market will decline to below production potential; excess LMNG will be used in a power plant. This strategy comports with the policy of a long-term phase-out of production of LMNG to reduce interface problems. Coordination with HMNG producers and conversion of distribution systems in south and southwest Poland will be required. HMNG is assumed to be interchangeable with imports, and in the early years additional HMNG imports will be needed to compensate for the reduction in supply from Russia. This is compatible with the projected interconnection of the Polish gas system with that of Western Europe. The volume of imports would depend on the speed of adjustment in demand by the steel and fertilizer industries.

Table II-9: Projected Gas Balances for Basic and Power Markets (MCM)

Balance item	*1995*	*2000*	*2005*
Annual demand	10,893	19,845	29,156
Domestic supply			
HMNG	2,270	2,224	2,024
LMNG	3,008	2,555	2,165
Coke oven gas	222	0	0
Imports			
USSR	4,800	5,500	5,500
Other	3,300	10,000	19,500
TOTAL SUPPLY	13,600	20,279	29,189

Table II-10: Gas Balances for Peak Demand (MCM/hour)

Balance item	*1995*	*2000*	*2005*
Demand			
248	3,274	5,010	7,001
249	2,446	3,882	5,444
Source			
Domestic	688	597	524
Existing storage	443	930	1,418
New storage	588	1,703	25,113
Imports from USSR	600	688	688
Imports from others	413	1,251	2,338

2.30 For 1995, the gas balance reflects the gas commitments currently being negotiated by PGNG to replace supplies from Russia and thus shows an excess of supply because of the assumptions about the rapid decline of the steel and fertilizer industries and of an "overcoverage" of the shortfall from Russia. By 2000, about 10.3 bcm would be required to meet demand for the basic sector. Meeting projected power demand would increase imports by 5.0 bcm. In 2005, import requirements for the basic market would be 16.5 bcm, plus 8.5 bcm for power.

2.31 In addition to annual totals for demand, peak load balances have been constructed for 1995, 2000, and 2005 (see Table II-10).

2.32 In 1995, it would be possible to obtain only 50 percent risk coverage, obtainable only by the maximal use of imports and the use of domestic production as additional storage capacity. By 2000, sufficient additional underground storage should be available to provide 2 percent risk coverage.

Imports

2.33 Although imports will become increasingly important in supplementing domestic supply to meet demand, they are uncertain at this time. The future of supplies from Russia is particularly uncertain, and in the short term Poland is not connected to any other supply point on the European system, nor does it have facilities to import LNG. The ability to expand the use of gas therefore depends crucially on the ability to expand domestic production and storage (for meeting peak demand) and on the ability to find ways to import supplies from new sources. In these circumstances it is particularly important that Poland reduce its reliance on Russia as its single supplier.

2.34 The uncertainties are likely to be greatest from 1990 to 1995. PGNG strategy should be to negotiate supply agreements, possibly short-term ones that could be implemented within the European gas system. This may mean that domestic production, particularly of HMNG, would have to be phased in and out to compensate for supply/demand imbalances. At the same time it is necessary to plan further ahead and make strategic decisions on how to diversify the source of supply. The use of LNG is one possibility, although this would involve construction of an LNG import terminal. By 1995 the reliance on imports will become critical unless investment has been made in the recovery of coalbed methane. By that time, however, Poland should have established its creditworthiness and should be in a position to import gas on the basis of long-term contracts. By the end of the century, trading relationships should be well established, and the path of domestic supply and demand should be more predictable. Thus, although more imports would be needed, they should not be difficult to obtain.

2.35 The supplies from Russia will be crucial in the next few years. The latest information indicates that these are likely to decline sharply in the short run and then perhaps stabilize. It is assumed that following the supply of 8.2 bcm in 1990 there will be 6.2 bcm in 1991 and 4.8 bcm until 1992. Thereafter it is assumed that Russian exports to Poland will rise to 5.5 bcm. To meet the immediate shortfall, PGNG is negotiating for the possible re-export of Russian gas from Germany, Yugoslavia, and Hungary, which could amount to between 2 and 3 bcm per year until 1993-94.

2.36 In the medium term the pipeline connecting Bremen to Berlin could provide access to other sources of gas. It is assumed that this could provide at least 2.5 bcm from 1994 onward. Poland's increase in demand for gas will be part of a general increase in demand for gas in Europe, which is a result of the following factors:

- Eastern European countries switching to importing from Western European sources
- Greater-than-forecast increase in use of gas for power in combined-cycle plants
- Concerns about environmental pollution, which are likely to switch demand toward gas.

2.37 This general increase in demand is shifting the market in favor of the sellers and exporters, who, not pressed for new contracts, will only take clearly profitable projects. Concerns have been expressed about the ability of Eastern European countries to bear the cost of imports and to agree to "consortium purchases" of gas.

2.38 Outside Russia the main source of supply is Norway. That country has large reserves but is in the process of reconsidering its gas export policy to take advantage of the market changes mentioned above. Norwegian exports could come directly to Poland, through other systems with spare capacity, or through systems built to supply several customers (similar to the Wintershall MIDAL proposal). The situation is likely to be unclear for some time and other sources should be sought.

2.39 Another possible source is Algeria (either through direct supply or swaps), which has recently entered an agreement to supply Yugoslavia. Algerian gas could be imported via the Transmed pipeline or via a new link through Spain. In addition, LNG could be imported if the costs of building a terminal were economically justified.

2.40 Poland's gas supply system is currently isolated, and the first priority should be to ensure interconnection with other Western and Eastern European systems. Such a connection would provide more flexibility in dealing with load fluctuations and would provide opportunities for staged increases in supply. Since the interconnection would be from the southwest or the northwest, it reinforces the recommendation that LMNG should be used only for power generation. The initial five to ten years would be covered adequately if the interconnection was established.

2.41 In the longer term it appears that a system dedicated to Eastern Europe to supply Poland and its neighbors might be justified. The most likely source of supply would be Norway through an extension of the pipeline to Sweden (if it is built) or through the continuation of the interconnection with Germany, since the projected pipeline could deliver up to 15 bcm.

2.42 Assuming that deliveries of gas to Poland arrive in the northwest, with transit to neighboring countries and delivery "en route" to power plants and to the transmission system, the cost of transport of imported gas within Poland would be $0.25 to $0.30 per GJ.

2.43 Assuming that gas prices at the border will be similar to those in Western Europe (since the geographical conditions for supply are not drastically different from those elsewhere) and that the price of oil is $18 to $20 per barrel, the gas delivered to the domestic transmission system and to large users supplied directly from the transit network would be about $2.8 per MMBtu ($2.6 per GJ). A recent range of import prices is shown in Table II-11.

Table II-11: Import Prices for Pipeline Gas ($/MBtu, January 1990 Border Prices)

Import direction	*Price ($/MBTU)*
Netherlands to Western Europe	1.83
Norway to Western Europe	1.68
Russia to Western Europe	1.80
Algeria to Italy	2.30

2.44 If it is assumed that the real price of oil will rise to $25 (1990 prices) by 1995 and will stay constant thereafter (ignoring short-term fluctuations), the CIF gas prices will be as shown in Table II-12.

2.45 Using these assumptions about the quantity and cost of imports, it is estimated that the total import bill in real terms will rise steadily from $750 million in 1990 to around $4,400 million in 2010. This sum could be substantially reduced if decisions were made to invest in domestic coalbed methane recovery and to limit the use of gas for power generation. These decisions will depend on the costs, on attitudes toward pollution, and on the availability of foreign currency.

Table II-12: Projected Gas Prices ($/MBTU in $1990)

	Price ($/MBTU)	
Imports	*1990*	*1995*
Oil prices $(1990)/bl	18.00	25.00
Domestic gas ex field	2.00	2.50
Russian imports CIF border	2.00	2.50
Other imports CIF ex transit	2.80	3.30

3. INVESTMENT

3.1 In the Gas Development Plan, the assessed levels of supply and demand, as shown in chapters 1 and 2, are related to the amount and type of investment that will be needed to balance supply and demand over the next 20-year period.

3.2 The demand is split between two markets—the basic market and the transit power market. The former covers the use of gas in the residential, commercial, and industrial sectors, and includes one power plant to balance the supply and demand of LMNG. This market should be supplied through the existing transmission system after expansion and through new distribution systems. The structure of the demand is expected to change dramatically: there will be a decline in the number of existing customers, which will be offset by an increase in the demand in the residential and commercial sectors. An increased penetration of the space heating market and the creation of a more diversified industrial sector will cause an eventual increase in the importance of the market. A particular problem for the marketing of gas is that the infrastructure must be in place before the market can be captured, so that PGNG will need to invest in anticipation of market developments.

3.3 The transit power market consists of new plants (combined cycle and conventional) connected directly to the gas import infrastructure to take advantage of higher operating pressures. These plants will play an important part in the phasing of import contracts and the balancing of supply and demand. Some conventional plants would need to be dual fuel and would have to be switched in and out of the system to ensure that contractual commitments are met.

3.4 On the supply side the assessment is that domestic production will not be able to contribute much to future supplies (excepting the possibilities offered by coalbed methane) and that this contribution will be limited further for LMNG by the need to cover peak demand. The number of supply sources will increase and their location will move to the southwest and northwest parts of the country. This implies a change in the direction of the transit of gas and the use of shorter distances to reach markets, particularly those in the north and northwest. This new pattern also shows that existing storage sites are not well located in relation to future supplies.

3.5 Given that most supply will be imported, flexibility will be minimal, and thus domestic production will have to be used to provide storage in the short to medium term until adequate storage capacity is installed. The amount of storage required will have to be substantially increased, with priority given to meeting peak demand.

3.6 The Gas Development Plan has been designed to meet the objectives described in the demand and supply assessments and reflects the constraints referred to above. Investment costs reflect conditions prevailing at the end of 1990, while operating costs have been estimated on the basis of modern gas utilities' practices and current labor costs in Poland. The program has been evaluated for the "base" case.

3.7 The proposed investment program covers import facilities (pipeline), transmission and storage facilities, and distribution and conversion.

Investment for Imports

3.8 The previous chapters have suggested that imports are likely to come from two sources: The first is Russia, whose imports are projected to decline from their present level and hence existing capacity will be adequate to handle this source of supply (no additional funds are required). The second is Western Europe, through interconnection with the European gas system and one or more "transit" projects currently under consideration. Provision has been made for investment in a link between these systems and the PGNG gas transmission system. In addition provision has been made for other connections that may be required between 1991 and 1995 until long-term supply contracts are established.

3.9 In addition, there is a possibility of importing LNG if an import terminal is constructed. The earliest that such a scheme might be required, if gas is used in the power market, is 2000. Without such a large demand for gas the scheme would be delayed. The potential for increased domestic supplies of coalbed methane and the restricted availability of resources for construction of an LNG import terminal mean that such a project need not be considered until the supply/demand picture becomes clearer. The cost of a terminal, which is based on a pre-feasibility study of a project located at Gdansk and constructed in two stages, is about $450 million for the first stage and $120 million for the second stage, with an ultimate import capacity of 10 to 12 bcm per year.

3.10 The investment costs for the import (transit) facilities are shown in Table III-1.

- *Distribution and conversion.*
- *Import facilities (pipeline).*
- *Russia.* Imports are projected to decline from their present level. Hence, existing capacity will be adequate to handle this source of supply. No additional funds are required.
- *Transmission and storage facilities.*
- *Western Europe.* Imports through interconnection with the European gas system and one or more "transit" projects currently under consideration will require investment, and provision has been made for investment in a link between these systems and the PGNG gas transmission system. In addition provision has been made for other connections that may be required between 1991 and 1995 until long-term supply contracts are established.

Table III-1: Transit System Investment ($ million)

Component	*1991-1995*	*1995-2000*	*2000-2005*	*2005-2010*	*Total*
Interconnection	75.0	..	..	..	75.0
Pipeline (Frankfurt/ Oder-Odolanov)					
Line	..	90.0	..	..	90.0
Compression	..	15.0	20.0	35.0	70.0
Other	..	10.5	2.0	3.5	16.0
Total	..	115.5	22.0	38.5	176.0
LNG Terminal					
Plant	..	450.0	120.0	..	570.0
Pipeline	..	80.0	..	..	80.0
Total	0.0	530.0	120.0	0.0	650.0
TOTAL	75.0	645.5	142.0	38.5	901.0

Investment for Storage

3.11 Most of the gas supply will be imported, and thus there will be little flexibility in delivery (about 10 percent). To compensate for this lack of flexibility, additional storage capacity will be required for the following purposes:

- To deal with seasonal fluctuations created by the residential and commercial demand for space heating

- To deal with short run adjustments on a weekly and daily basis

- To provide the means of covering the risks associated with the "maximum expected demand": in many countries gas companies are contractually bound to cover the exceptional demand that may materialize every 50 years (2 percent risk)

- To provide security of supply, which is especially important when so much is to be imported.

These operational problems can be met by other solutions such as peak-shaving plants and interruptible supply contracts, but the Gas Development Plan has been drawn up on the basis that it will be able to cover the 2 percent temperature risk, without recourse to interruptible supplies, by 2000.

3.12 In using storage facilities only a portion of the gas (working gas) is used to meet the functions outlined above. The rest (cushion gas) is used to maintain a minimum pressure within the reservoir. The cost of the cushion gas is an important element in the total costs of gas storage. The main operational parameters of storage are the working storage volume and the maximum send-out volume, which is a measure of the maximum hourly contribution to supply.

3.13 The ratio of these two parameters represents the maximum time contribution (in terms of days) of the storage to supply during peak periods. Normally two types of storage sites are distinguished: (a) short-term storage (10 to 20 days), which is usually in salt cavities or unused mines; and (b) long-term storage (50 to 100 days), which is generally in depleted fields or aquifers.

3.14 The use of depleted fields is particularly attractive because there are no exploration costs and the field is already connected to the transmission system (nor is there a separate need for cushion gas). The cost is generally the lowest (about $55 per 1,000 cubic meters of working capacity). Aquifer storage is much more expensive ($365 per 1,000 cubic meters) but offers the possibilities of large storage volumes. The offsetting problems are those of the need for exploration and new infrastructure, which are reflected in the costs. Salt cavities are the most expensive method of storage ($550 per 1,000 cubic meters) and involve problems with the disposal of brine. Their advantage is that they are suitable for high extraction rates.

3.15 In Poland during the past few years, underground storage capacity has been inadequate to meet the peak demand in cold winters. In addition, during mild winters it has been inadequate to absorb the excess supplies of Russian gas that has been contracted for. As a result PGNG has been forced to rent storage capacity in Russia and to reduce domestic production in order to ensure the full utilization of imports (in the first quarter of 1990 the production of HMNG was only about 35 percent of potential output). Other ways to balance supply and demand include conversion of LMNG into HMNG in a nitrogen removal plant, interruptible sales contracts, and variations in domestic production.

3.16 At present, total storage capacity (excluding that rented in Lvov) is about 500 mcm in three depleted fields located in the southeast. A fourth field is being studied but there are serious technical difficulties associated with this field. These storage facilities are operating in a satisfactory manner but their location is not ideal because they are close to the source of imports. Another storage site in a salt cavity is being developed at Mogilno and the first cavities should be operational by 1994. Full development will not be achieved until 2000, however, because of construction problems relating to constraints on brine disposal. The final capacity will be about 200 mcm.

3.17 Total storage requirements were estimated only for HMNG, since fluctuations in LMNG demand will be met by varying production, and during the off-peak season excess LMNG could be used in a power plant, as assumed in the base-case scenario. Storage requirements for HMNG were estimated on the basis of ability to meet the 2 percent temperature risk demand by 2000. Capacity required to meet peak demand was checked against the volume required to balance winter and summer demand; the higher of the two was taken. In the early years (1990-2000) the capacity increase is limited by the physical constraints associated with each type of storage. Meeting the 2 percent risk peak requires larger volumes of storage than balancing the summer and winter load, and this implies that additional short-term storage (salt cavities) would be required. This would account for about 50 percent of the peak send-out from storage, whereas only 15 percent of the stored volume would be stored in depleted fields and aquifers. The projected increase in storage capacity and the related investment program for a five-year period are shown in Table III-2 and Table III-3.

Table III-2: Investment in Underground Storage

Capacity	*1990*	*1995*	*2000*	*2005*	*2010*
Peak required (K CM/hr)	868	1686	2633	3929	5208
Existing/planned	280	443	930	1418	1905
Balance	(588)	(1244)	(1703)	(2511)	(3303)
Additional Capacity					
Salt cavities	0	0	355	914	1574
Depleted fields	0	588	1037	1037	1037
Aquifer	0	0	311	560	691
Total	0	588	1703	2511	3303
Volume Required (MCM)	406	443	942	1703	2827
Existing/planned	450	490	610	730	850
Balance	44	47	(332)	(973)	(1977)
Additional Capacity					
Salt cavities	0	0	89	229	394
Depleted fields	0	411	830	1245	1245
Aquifer	0	0	218	504	830
Total	0	411	1136	1977	2488
Total Capacity (MCM)	450	901	1748	2707	3318

3.18 The actual location of additional storage facilities will be determined by a number of factors. Three regions have sufficient potential to justify immediate further work to create the additional capacity in the required time frame:

- *Lowlands.* Depleted gas fields in this region could be used for storage. The fields are well situated with respect to future supply (interconnection to the European system) and demand (conversion of COG and possibly LMNG to HMNG) and storage facilities could use existing equipment and connections to the transmission system. Most of the fields were LMNG producers, however, so a danger of gas contamination exists. Further work is needed to ascertain whether that problem can be solved and at what cost.

Table III-3: Costs of Investment in Storage ($ million)

Year	*Cost ($ million)*
1990-1995	195
1996-2000	272
2001-2005	302
2006-2010	166

- *Mogilno area.* Salt deposits in this area are suitable for storage. Disposal of the brine, which may be in excess of what can be processed by the chemical industry, may be a problem, as may be the availability of water. The area is well located with respect to both supply and demand.

- *Western Poland.* A large number of sites in this region are suitable for potential aquifer storage. PGNG has identified about 250 possible sites and has preselected 25. Further work is needed to evaluate the sites both for geological risk and for economic viability.

Investment for Transmission

3.19 The principal feature of the Polish transmission system is its complexity. There are three separate subsystems and each carries a different type of gas:

- Coke oven gas (COG) in Lower and Upper Silesia

- High-nitrogen, low-methane natural gas (LMNG) produced in western Poland

- High-methane natural gas (HMNG) produced in the Carpathian fields and also imported from Russia. This system covers the majority of the country.

3.20 The three subsystems are connected at some points (mixing stations). Some areas, such as Katowice, receive two or three types of gas at once. The transmission system, as defined by PGNG, includes all lines operated at above 4 bar absolute. Compression facilites include compressor stations for imported Russian gas and coke oven gas; field compressors for produced gas that is to be injected into the transmission system; and compressors for the underground storage system. Delivery stations transfer gas from the transmission system to the distribution networks and to large industrial customers.

3.21 The gas pipelines in Poland differ from Western technology in some important respects:

- Official regulations for quality of delivered gas are far less stringent than in the West

- Safety regulations defining the maximum allowable operating pressure (MAOP) have led to a complex configuration with a wide range of values in the system, leading to a loss of transmission capacity when some sections of a line must operate at a lower MAOP

- Safety regulations prevent the use of pressures higher than 4 bar absolute in cities and also impose excessive safety distances from existing habitations, roads, and railways

- Gas pipelines are not designed for cleaning with pigging devices (except for one or two recent lines), leading to high friction factors for gas flow and added costs for compression.

3.22 All the facilities in the system are operated in local mode manually by the continuous attendance of personnel. There is no telemetry system between site facilities and the regional dispatching centers; operational data are transmitted by local personnel via radio or telephone to the regional DC to be entered into the computer system. On the national level data are collected in Warsaw by a telemetry system between the regional and national DC (computer to computer).

3.23 The existing system was originally designed to ensure the utilization of domestic sources and subsequently to transport gas imported from Russia. Thus, it is not well designed to accommodate the likely future structure of supply and demand and will hence need to be modified and expanded. The main modifications will result from the phasing out of COG and its replacement by HMNG and from the introduction of new supplies located in the western and northern parts of the country.

3.24 System expansion will be required to accommodate the projected growth in demand, both in terms of total volume and of peak requirements, and the projected increase in the number of delivery points to the distribution systems and industrial customers, which will require expansion of the regional system. Part of the modification program is already under way (conversion of Upper and Lower Silesia) and will continue over the next five to ten years.

3.25 The need to convert from the COG system, together with the limited availability of LMNG and its incompatibility with imported gas, leads to the restriction of LMNG to a tightly defined geographical area, Upper and Lower Silesia. There may be a power plant to absorb seasonal fluctuations. The use of COG was stimulated by the large amount of coal locally available, but since the late 1970s a program to replace COG with natural gas has been undertaken and, because of environmental pressure, is being implemented faster than was originally planned.

3.26 The Gas Development Plan foresees the conversion of the Lower Silesia region to LMNG and Upper Silesia to HMNG. New transmission lines will be needed to achieve this. The conversion of such a large distribution network must be performed in stages, and thus it will be necessary to supply both COG and natural gas until the conversion is completed. In addition extra transmission capacity will be needed because the existing coke oven gas lines operate at low pressures, resulting in limited transmission capacity. The technical aspects of the conversion of COG pipelines to natural gas pipelines (the formation of hydrates in the pressure-reducing station and the drying of the pipelines resulting in the recovery of dust) have been encountered before by PGNG and should not present special difficulties.

3.27 The total length of main lines to be constructed within the next five-year period is expected to be 287 kilometers in Lower Silesia and 85 kilometers in Upper Silesia. The conversion cost for coke oven gas estimated by PGNG is about $200 million over the period 1990 to 2000, of which some $65 million is for transmission. This cost includes the following:

- About 750 kilometers of new pipelines, including the main and smaller lines
- 200 new delivery stations with transmission pressure of 4 bar absolute
- The replacement of 1,200 kilometers of distribution lines.

3.28 These costs do not include replacement of users' appliances, a cost that will have to be borne fully or partly by PGNG. The unit costs used in the PGNG calculations are about 30 percent lower than Western European costs, largely because of the difference in manpower costs for construction.

3.29 The transmission network will be affected not only by the impact of the conversion of the coke oven gas system but by the shifting demand and supply envisaged in the development plan. The main and regional transmission systems will require expansion. The expansion required to meet demand has been estimated based on past expansion of the European gas system with similar supply characteristics (dependence on imports, share of space heating, and multiple supply points) and adjusted to reflect the different operating pressures of the PGNG system. The main parameter is the growth of the annual volume of gas transported in each geographic area and the density of demand (length of line per mcm per year). The projected capacity increases for the transmission system by region are shown in Table III-4. The table shows that the length of the transmission line is expected to increase rapidly over the next 20 years and that there will be considerable differences in regional rates of expansion.

3.30 The characteristics of each of the three phases of expansion are somewhat different:

- *Phase 1 (1990-1995).* During this period supplies from Russia are projected to decline and be replaced by imports from the West, and local production will remain at present levels. The phase-out of coke plants will continue, probably more rapidly than originally planned. Total gas demand will be fairly stable at its 1990 level, but demand will shift away from industry and toward the residential sector. The significant investment features will be the completion of the interconnection with Western Europe by the Emden-Berlin line or the Wintershall (MIDAL) project plus connection to the Russia-Czechoslovakia pipeline. In addition, restructuring of the LMNG system is likely to commence parallel to the conversion of the COG system to balance market developments in south and southwest Poland.

- *Phase 2 (1995-2000).* During this period additional gas imports from land sources will be needed and will acquired from the West. Gas demand is expected to increase rapidly, particularly in regions 4, 5, and 6, requiring expansion of the HMNG system. The segregation of the LMNG system is expected to be completed during this period.

- *Phase 3 (2000-2010).* The main issues for the transmission system during this period will be the need to acquire extra sources of supply, either through the installation of an LNG terminal in Gdansk together with the associated trunk lines, or through the development of local coalbed methane resources. Further expansion of the system to meet increasing space heating peak demand will be required.

3.31 Projected investment costs for the transmission sector are summarized in Table III-5. This excludes investment in the transit system but does include addition of line capacity, additional delivery points, costs of modernization of the existing system (over and above projected investments in the World Bank Project), the development of an adequate SCADA system, and the replacement of damaged sections.

Table III-4: Projected Transmission System Capacity Increases, 1990-2010

Region	*1990*	*1995*	*2000*	*2005*	*2010*
Main system (km)	3,310	3,310	3,642	4,165	4,824
Main system density (km/MM CM/yr)	0.27	0.33	0.27	0.23	0.20
Regional networks (km)					
Region 1	3,070	3,070	3,174	3,420	3,646
Region 2	1,870	1,870	2,122	2,442	2,800
Region 3	750	750	826	922	1,056
Region 4	1,660	1,660	1,704	1,764	1,824
Region 5	1,175	1,175	1,281	1,427	1,649
Region 6	2,265	2,265	2,367	2,503	2,733
Total (km)	10,790	10,790	11,474	12,478	13,708
Regional networks density (km/MM CM/yr)					
Region 1	0.91	1.11	0.96	0.76	0.65
Region 2	0.46	0.57	0.47	0.40	0.35
Region 3	2.79	3.41	1.38	0.85	0.60
Region 4	1.10	1.34	1.17	1.00	0.89
Region 5	0.89	1.09	0.80	0.61	0.48
Region 6	1.43	1.74	1.31	1.01	0.75
Total (km/MM CM/yr)	0.89	1.09	0.86	0.68	0.56
TOTAL (km)	14,100	14,100	15,116	16,643	18,532
TOTAL DENSITY (km/MM CM/yr)	1.17	1.42	1.13	0.91	0.76

Distribution

3.32 Distribution networks supply about 5 million residential and commercial consumers (of which only 550,000 use gas for space heating), primarily in urban areas. The length of the networks is about 38,000 kilometers spread rather unevenly through the country. In the recent past the gas industry has followed a policy of systematic connection of new houses, resulting in a penetration rate of 68 percent (which is high by Western European standards). The municipalities and cooperatives have been the investors in the facilities that connect the new buildings to the gas supply, but upon completion these facilities have been handed over to the gas company for operation and maintenance.

Table III-5: Transmission System Investment Costs ($ million)

Cost item	*1995-2000*	*2001-2005*	*2006-2010*
New connections			
Distribution	114.0	132.5	136.0
Industry	218.0	254.0	286.0
Investment			
Transmission	141.8	214.7	241.7
Connection	107.0	124.6	137.0
SCADA	30.0	30.0	30.0
Other equipment	120.0	150.0	150.0
Replacements	36.5	45.3	49.0
TOTAL	767.3	951.1	1029.6

3.33 The distribution of gas sales by type is shown in Table III-6. "Commercial" sales are low relative to residential sales mainly because of the importance of district heating in urban areas.

3.34 Over the years the distribution of HMNG and LMNG has increased at the expense of COG and manufactured gas, both through extension of the system and by conversion of existing customers (which has now reached a rate of about 90,000 per year). Although only about 10 percent of the consumers use gas for space heating, they account for about 40 percent of total consumption. There are no precise statistics on domestic sales and their distribution among specific uses, however, because most domestic consumption is not metered individually (meters are in short supply and therefore are supplied only for customers whose consumption exceeds 3,000 CM/Y).

3.35 The technical characteristics of the distribution networks are shown in Table III-7. The networks have been designed to supply gas for cooking and water heating only and not for space heating, which in urban areas has been provided to new housing developments by district heating. The main difference from modern distribution networks is the lack of subtransmission systems in urban areas. Such systems are normally operated at a pressure of 4 to 20 bar; such pressures are not allowed in cities in Poland, where all urban networks operate at a pressure of less than 4 bar. Regarding materials, the system still has considerable lengths of expensive-to-maintain pig iron pipes. The steel pipes are not cathodically protected, and the frequency of replacement is higher than in comparable protected systems. Pipe fittings are in short supply, which increases the cost of repairs. Although several construction companies can perform the repair work, they do not compete. Use of polyethylene pipes, now common in Western Europe, is limited and substandard because of inadequate procedures and equipment.

Table III-6: Distribution of Gas Sales (MCM)

Type of Gas	*Residential*	*Commercial*	*Total*
HMNG	2,525	268	2,793
LMNG	734	40	774
COG	862	81	943
Manufactured gas	201	29	230
Propane air	12	2	14

3.36 The main conclusions of the audit of the present distribution system are as follows:

- The current networks are saturated and would be unable to accommodate additional space heating demand without major reinforcement.

- The networks are not sufficiently safe because of the lack of protection of the pipes and the rather crude technology used.

- The conversion work that has already started should be coordinated, whenever possible, with network reinforcements and restructuring.

- The absence of meters both encourages wasteful consumption and makes monitoring and planning demand very difficult.

Table III-7: Length of Distribution Networks (kilometers)

Characteristic	*Length (km)*
Urban	27,595
Rural	10,731
By pressure	
Low	26,446
Medium	11,881
By material	
Steel	32,195
Pig iron	3,449
Polyethylene	2,683
By age	
> 30 years	15,330
> 10 years	24,912
< 10 years	13,414

3.37 Safety problems and the lack of meters must be addressed whatever the nature of the Gas Development Plan, and the extent of expansion of the distribution network will depend on the overall plan for developing gas.

3.38 The development strategy outlined here is based on the analysis of potential demand given in chapter 1, which indicated that most of the potential in the residential sector lies with new housing construction because the potential in existing housing is relatively low due to widespread connection to gas for cooking and to district heating for water and space heating. The main consequence of this dichotomy is that for existing consumers the peak flow is expected to grow moderately from 9.7 MJ per hour in 1988 to about 12 MJ per hour in 2010, while for new customers the increase will be from 9.7 MJ per hour in 1988 to about 48.7 MJ per hour in 2010 as a result of the use of gas for space heating. To cope with this increased demand three strategies are possible:

- Increase the number of injection points by adding medium- to low-pressure regulators
- Increase the diameters of pipes
- Increase the distribution pressure.

3.39 Detailed analysis suggests that the most practical and economical solution would be to increase the distribution pressure.

3.40 New housing construction is likely to occur in the suburbs and the costs of connection should be fairly low, particularly if the gas network is planned and constructed at the same time as other utility networks. These new networks would be extensions of existing systems so that modern technology (polyethylene pipes and fittings) as well as higher service pressure could be used to reduce the cost. This would require changes in the existing regulations to allow higher operating pressures in urban areas and to reduce safety distances. All new consumers should be equipped with adequate safety equipment (regulators) and meters.

3.41 The two main opportunities for modernization and improvement of the existing system involve (a) introducing new technology during maintenance and repair operations and when pipes are replaced and (b) converting the associated distribution facilities and installing meters when consumers of coke oven gas and manufactured gas are converted to HMNG or LMNG.

3.42 The preliminary conclusions of the economic assessment of the market suggests that the continuation of gas distribution to villages is not justified on strict economic grounds (excessive length of network per consumer) except in special circumstances (e.g., proximity of pipeline). Each investment decision should take into account the full costs of gas supply including the distribution infrastructure, and not just the cost of the connection to the transmission line as has been the case until now.

Table III-8: Investment Costs for Expansion of Distribution

Sector	*Units*	*Amount*
New consumer		
Residential	**$**	487
Commercial	**$/GJ**	1.6
District heating plant	**$/GJ**	0.3
Reinforcement	**$/meter**	157
Conversion per consumer	**$**	204

3.43 The strategy outlined above requires substantial investment spread over a long period as network reinforcement and replacement proceed in parallel with market development. The parameters used for calculating total investment costs are shown in Table III-8.

3.44 The details of the associated investment costs are shown in Table III-9. The main issue in the plan for distribution is to ensure the capture of the potential space heating market so that gas will contribute to reducing urban pollution. Most European countries have gone through this process in the last 20 years; although well understood, it is expensive and justified only if the expected consumption materializes. It is therefore essential that extension and modernization of the existing system are carried out within an overall marketing strategy.

Table III-9: Investment Plan for Distribution ($ million)

Cost item	*1995*	*2000*	*2005*	*2010*	*Total*
Extensions					
New consumers	138.2	267.9	254.2	234.2	895.1
Conversion (coal stoves)	3.2	15.7	15.8	15.8	50.5
Commercial	10.1	23.9	38.4	60.6	133.0
Small district heating	1.4	4.2	5.6	2.8	14.0
Reinforcements	31.7	78.4	91.8	94.9	296.8
Conversions (COG)	81.6	112.8	0.0	0.0	194.4
Renewals	366.0	9,034.8	1,058.7	1,097.1	3,425.6
TOTAL	632.7	1,406.7	1,464.4	1,505.5	5,009.3

Total Investment Plan

3.45 Combining all the figures for investment costs for the base case, and allowing for an LNG plant in the period 2000-2005, yields the figures shown in Table III-10. These costs can be added to the costs of gas and the operating costs to give a total cost of gas at the outlet of the distribution system. Taking the basic import costs as starting at $2.0 per MBtu, rising to $2.5 in 1995, the average cost of gas in the base case of the development plan would be $3.10 for gas supply ex transit, plus $0.73 for transmission costs. The distribution cost would be $2.43, yielding an average cost to supply the consumer of $6.26 per MBtu.

3.46 Table III-11 shows the total demand for gas, the total costs, and the total valuation of sales at netback values for the different classes of user. The value to residential users is taken as $6.5 per MBtu, which for commercial users is $4.0, for small and medium industry $4.48, for large industry $2.5, for power $4.5, and for transit power $3.5 per MBtu. Aggregating the value of sales and comparing this with costs gives a net cash flow. The present value of this cash flow is determined using a discount rate of 12 percent and for the gas industry as a whole this turns out to be positive at $133 million. In addition an incremental cost analysis is carried out by allocating to incremental supply and sales the investments required for the expansion of the system. All other

Table III-10: Total Investment for the Gas Development Plan

Sector	*1991-1995*	*1996-2000*	*2001-2005*	*2006-2010*	*Total*
Imports	75.0	645.5	142.0	38.5	901.0
Transmission	500.0	767.3	951.1	1,029.6	3,248.0
Storage	194.8	272.4	301.9	165.8	935.0
Distribution	551.1	1,293.9	1,462.4	1,505.5	4,814.9
Conversion	81.6	112.8	0.0	0.0	194.4
TOTAL	1,402.5	2,562.0	3,269.4	2,859.4	10,093.3

investment and operating costs, which would have to be incurred to ensure the safe operation of the system, have been eliminated. On this basis the net present value of the incremental aspects of the system would be $1,120 million. This very large difference reflects the previous lack of investment, which has resulted in the need for a very large expenditure just to bring the system to an adequate level. Much of this investment will need to be started in the next five years, in parallel with the restructuring of supply and demand, at a time when total gas sales will be fairly static. The incremental analysis also highlights the importance of the power market, which could account for more than 50 percent of incremental sales. The decisions of the future of power development and the share of gas will be crucial for the gas industry.

Table III-11: Costs of Gas Development Plan ($ million)

Year	*System Costs*	*Gas Costs*	*Residential Value*	*Commercial Value*	*Individual Value*	*Power Value*	*Transit Value*	*Net Cash*
1990	674	753	1,014	52	649	0	0	288
1991	678	941	995	56	645	0	0	77
1992	681	897	977	61	632	0	0	91
1993	681	912	958	65	619	0	0	50
1994	684	1,044	940	69	607	0	0	(112)
1995	911	1,206	921	73	512	147	0	(464)
1996	918	1,409	998	85	553	175	115	(400)
1997	939	1,448	1,076	96	594	203	231	187
1998	956	1,513	1,153	108	635	231	346	4
1999	972	1,734	1,230	119	676	259	461	40
2000	1,042	1,967	1,308	131	717	287	577	10
2001	1,057	2,199	1,391	149	789	267	685	45
2002	1,073	2,391	1,473	167	862	287	794	119
2003	1,088	2,701	1,556	185	934	287	903	76
2004	1,103	2,930	1,639	203	1,006	287	1,012	112
2005	1,119	3,172	1,722	221	1,079	287	1,120	138
2006	1,136	3,445	1,805	239	1,151	320	1,240	174
2007	1,157	3,703	1,887	257	1,223	353	1,359	221
2008	1,174	3,969	1,970	275	1,296	386	1,479	263
2009	1,191	4,185	2,053	293	1,368	419	1,599	355
2010	1,209	4,400	2,069	361	1,570	292	1,718	403

Net present value at 12 percent = $133 million

3.47 The economic assessment of the viability of the Gas Development Plan depends crucially not only on allowing gas prices to rise to cover costs but also on the fact that the prices of competing fuels will have been allowed to rise to cover their costs. Further, although a high real rate of interest (12 percent) has been used in the project evaluation, no account has been taken of the effects of possible shortages of financial capital, which could raise the marginal cost of funds to a higher level. It should also be noted that these calculations exclude the costs of the conversion from COG to HMNG that will be incurred by households, and that may have to be totally or partially subsidized by PGNG. Finally no credit has been given for reducing pollution, although some conversion that would be unattractive without such an allowance has been included in the demand forecast. If the economic benefits of pollution reduction were included, then the return would be larger. Also, were environmental credits to be allocated, then the investment plan itself could be changed (see chapter 6 for a discussion of the environmental aspects of the Gas Development Plan).

4. RESTRUCTURING

4.1 The present status of the natural gas industry in Poland dates back only to 1982, when the various local and regional companies were separate state-owned enterprises. At that time the Polish Oil and Gas Company (PGNG) was established as a single legal entity reporting to the Ministry of Industry.

4.2 Until the end of 1987 PGNG operated within very tightly prescribed planning parameters that determined all key aspects of its activity, such as the choice of gas sources, the amount of investment, the allocation of supplies among customers, the prices charged, and the size of the work force.

4.3 At the beginning of 1990 the Polish government embarked on a program of radical macroeconomic reform designed to make the transition to a market economy. A Department of Privatization was created and an antimonopoly law was enacted along with other reforms.

4.4 Energy industries are so important within the economy that restructuring them will make an important contribution to the process of adjustment. The objectives of the restructuring will be to facilitate the goals of expanding gas production and use, to ensure the financial viability of the gas sector, and to improve the overall efficiency of the sector.

4.5 The first part of this chapter is organized around three main topics that relate to the present status:

- A review of PGNG's existing organization and structures
- A review of overall sector management and regulation
- An assessment of the potential for efficiency improvement.

The second part of this chapter provides a review of the options for change under four headings:

- Structure of the industry
- Trading relationships
- Regulation
- Ownership.

4.6 Finally, a strategy for implementation is outlined. Both regulation and ownership also are discussed in chapter 5, where the principal focus is on the pricing system to be adopted.

PGNG Organization

4.7 PGNG is a wholly state-owned enterprise that is highly integrated both vertically and horizontally. It embraces not only the whole of the natural gas industry from wellhead to burner tip but also upstream services such as seismic and drilling activities as well as equipment manufacturing, installation, repairs, and pipeline construction. It also handles exploration and production of relatively small quantities of crude oil.

4.8 PGNG comprises a head office in Warsaw and 22 main operating entities—these are not separate companies or subsidiaries of the market economy type; they are distinct operational units with functionally or regionally defined responsibilities, and are in effect cost centers. They have no separate legal status, do not produce separate accounts, and have limited autonomy in approving or financing investment decisions.

4.9 PGNG's Board of Directors includes a number of government representatives as well as senior enterprise managers. The presence on the Board of representatives of three national finance and planning institutions, as well as those of the parent Ministry, indicates the importance of centralized decision making.

4.10 The role of the PGNG Employees' Council is very important and goes far beyond that of workers' or trade union representatives in industrialized market economies. Wide ranging powers are established by law and include discussion of PGNG operating and development plans, as well as approval of working conditions, disposition of profit (reinvestment versus bonuses), and management appointments.

4.11 The Exploration Program Council includes representatives from outside specialist bodies as well as senior management from the exploration function within PGNG. The interests of this body are not entirely commercial (the outside members can have interests in the advancement of geological knowledge) and this high-level body is rather remote from operating conditions in the field.

4.12 The Warsaw Headquarters consists of three main units, other than the Board and the two Councils already described.

4.13 First there is PGNG's Head Office, which performs the usual central management functions. Its main role is in the planning, coordination, and financing of both operations and investments across the whole enterprise. Under the central planning system it was subordinated to overall investment plans and budget allocations developed through the national planning process. The Head Office also incorporates the central computing function (ETOG).

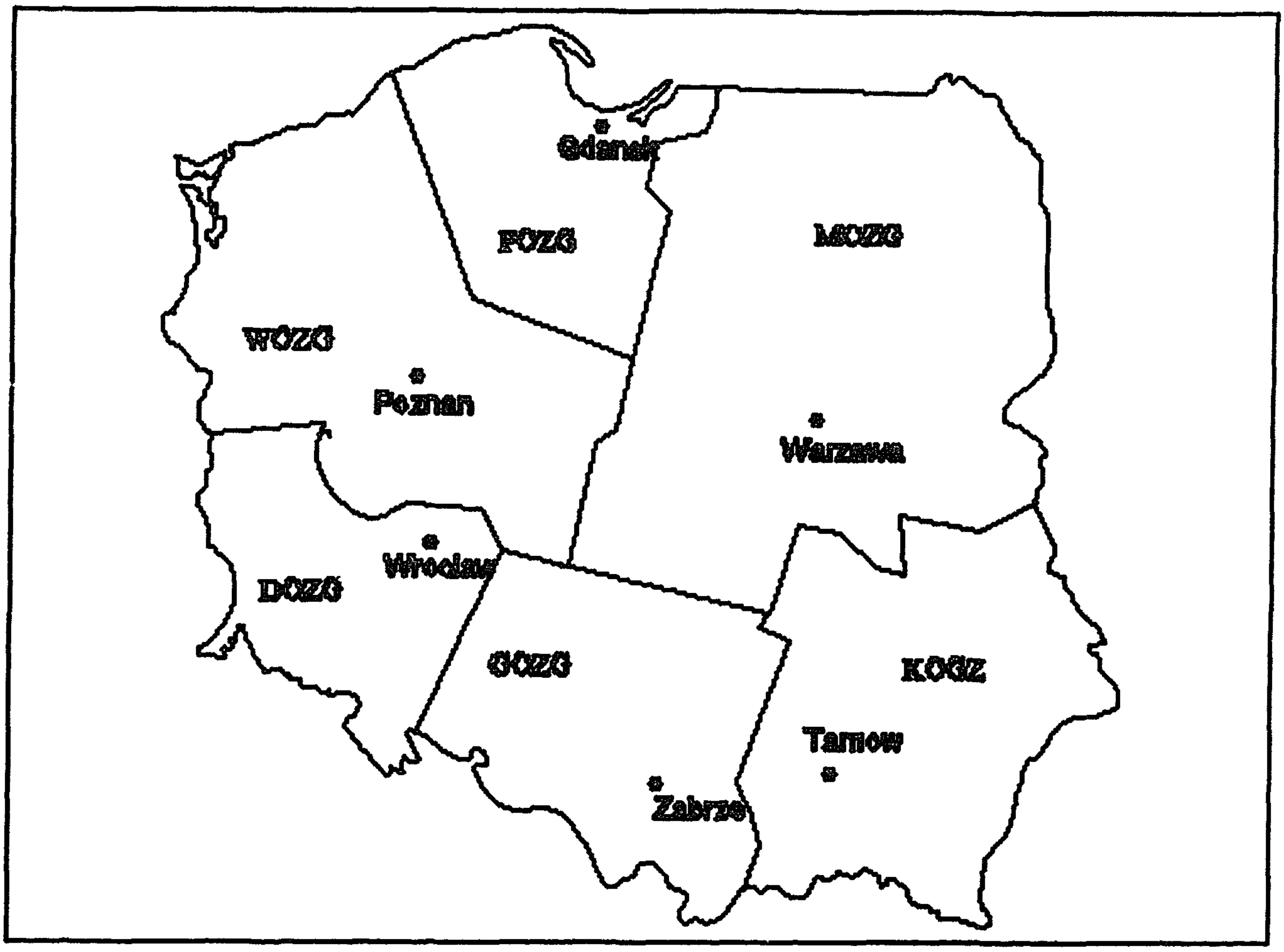


Figure IV-1: Regional Boundaries of Distribution Companies

4.14 The second HQ branch is KDG, the central planning and dispatch unit for the national transmission and storage system. It is responsible for planning the annual and seasonal supply/demand match, for "buying" indigenous gas from PGNG production companies at an internal transfer price, and dispatching supplies across the system on a daily basis. It does not negotiate the terms of natural gas imports from Russia, which are instead handled by a State external trading company, which on-sells the imported gas to PGNG. The gas purchasing/transmission function does not exist as a single entity within PGNG, and indeed is highly fragmented with supplies and dispatch in KDG, physical system planning in the Planning/Design unit, operations in the regional transmission and distribution companies, and import purchases outside PGNG altogether. Given the emphasis that market economies place on the natural gas sector, PGNG's organizational structure can be seen as a major weakness.

4.15 The third branch of the HQ is Geonafta, the main center of geological expertise, which is responsible for coordinating exploration drilling and the development of new gas projects. It also "pays" for the seismic, well logging, and analysis work of the two PGNG geophysical companies. While it has a high technical reputation, Geonafta is somewhat remote from field operations, which results in duplication of expertise in the operating companies. Its decisions are also insulated from the commercial appraisal process in that it does not have to compete for resources in an open market situation.

4.16 The 22 main Operating Companies outside the HQ comprise the following:

- A system planning and design office.

- Six regional transmission and distribution (T&D) companies (their boundaries are shown in Figure IV-1), which in turn supply gas via their local distribution subsidiaries (numbering 20 in total). These subsidiaries deliver gas in accordance with a detailed annual plan that is much influenced by central fuel allocations at the national level. They are cost centers, and are reimbursed by the Head Office on a cost plus basis.

- Two geophysical companies, providing services to Geonafta.

- Four drilling and exploration companies, which are paid on a cost-plus basis by the production companies.

- Three regional production companies, which produce gas on a seasonally flexible "swing" basis, supply gas to KDG at costs-plus internal transfer price, and also drill some in-field development wells.

- Six equipment manufacturing and repair companies.

4.17 This complex structure has left exploration and production functions highly fragmented.

4.18 By the standards of most Western gas industries, PGNG's organizational structure is highly integrated, and this raises the issue of whether such a high degree of vertical and horizontal integration is conducive to efficiency.

4.19 There are four areas of concern regarding the current structure of PGNG:

- The fragmentation of the key gas purchasing/transmission role

- The fragmentation of commercial decisionmaking in exploration and production (E&P)

- The fact that internal trading at cost-plus transfer prices reduces incentives for efficiency, and that the transfer prices have not tracked inflation, thus giving rise to revenue shortfalls and cash flow problems in parts of the enterprise

- The blurring of distinctions between the enterprise and national state institutions in terms of planning, financing, and management decision making.

Sector Management and Regulation

4.20 The institutional framework within which PGNG operates gives an important role to three main government ministries. The role of the Central Planning Office has diminished since the abolition of detailed central planning, and it no longer compares in importance with the Ministry of Industry, the Ministry of Finance, and the Ministry of Environmental Protection and Natural Resources.

4.21 The Ministry of Industry is the parent ministry of PGNG under the terms of the 1982 statutes. Through its Department of Energy and Fuel Management, the ministry is responsible for overall energy policy. In the past it gave priority to the coal industry as a major source of indigenous energy, employment, and foreign exchange. It approves operating and development plans as well as financing arrangements, comments on proposed price changes, and monitors the financial and operating performance of PGNG. It also approves development drilling, but not exploration drilling, which is covered by another ministry.

4.22 The Ministry of Finance sets financial targets for PGNG and monitors its financial performance, approves investment and operating budgets, approves prices for gas, and manages the flow of funds between PGNG and the government.

4.23 The Ministry of Environmental Protection and Natural Resources is mainly concerned with aspects of PGNG's upstream activities and approves plans for geophysical testing and exploration drilling.

4.24 PGNG has institutional relationships with other public bodies. For example, the Mining Supervision Office monitors drilling and production activities (including safety regulations).

4.25 The extensive powers of government authorities in relation to PGNG, combined with the workings of a centrally planned system, have impinged on fundamental elements of PGNG's objectives and performance. For example, PGNG has a statutory obligation to meet all demands for gas at minimum cost, and it was originally to be judged on rate of return criteria. In practice, this legal framework was overtaken by the central allocation of energy resources (e.g., an effective restriction on the use of gas for residential heating) and rigid price controls, which maintained domestic and commercial prices well below the cost of supply. Wages and salaries have also been controlled by the government to help combat inflation.

4.26 In effect the management of PGNG has not been involved with the range of tasks usually associated with running a business. Decisions about selling prices, gas import purchase costs, wages and salaries, and the availability of finance have all been made by other bodies. The main role of management has instead been in investment planning, the internal control of funds, and day-to-day operation of the industry.

4.27 The sector management and regulation framework reflect the priorities and operation of a centrally planned system and as such are inappropriate for an enterprise operating in a market-oriented economy. The following shortcomings are notable:

- The lack of a "hard budget" for the enterprise takes away management freedom, incentives (to accumulate and to reinvest), and accountability.

- Incentives for efficiency are not built into the pricing and regulatory framework.

- Management is not judged on performance because no firm commercial objectives are set.

- Too many key elements affecting financial performance are outside management's control.

- There does not appear to be a clear policy on gas development, and different agencies have different priorities.

- Government approval of plans and financing is unduly time consuming and leads to delays in decisionmaking.

- The institutional framework is complex, with multiple PGNG-government relationships, and this further weakens accountability for performance.

4.28 The aims of restructuring should be to simplify relationships with the government, to strengthen management accountability, and to create a framework that is conducive to enterprise efficiency and management effectiveness.

Scale of Operations and Efficiency

4.29 **Scale of Operations.** Total sales of about 13 bcm in 1989 are relatively low for a country of Poland's size. This reflects gas supply constraints, the predominance of coal-fired district heating in urban areas, the absence of gas-fired power generation, and the poor economics of supplying gas to a large rural population. In terms of volume, PGNG's sales are dominated by a small number of industrial users, especially the steel and chemical industries.

4.30 PGNG employs a total of 44,000 people. Almost 40 percent work in the upstream operating companies, more than 40 percent work in transmission, and a little over 15 percent work in equipment manufacturing and repair.

4.31 PGNG operates three interconnected pipeline systems for different types of gas. The distribution grid of over 41,000 kilometers is quite small for an industry with over 5.7 million customers; this probably reflects high housing densities and multiple-household connections.

4.32 For 1989 the PGNG estimates are that it supplied 63 percent of total volume to industrial customers with a revenue of 613 thousand billion zlotys (zl) and an operating "profit" of 263 thousand billion zl; the domestic sector received 34 percent of the total volume generating 48.5 thousand billion zl of revenue and an operating "loss" of 138.5 thousand billion zl. These estimates of PGNG's financial results, however, are distorted by the consumer tariffs. In fact the figures imply similar supply costs per cubic meter for both sectors, which is almost certainly not the case, because large industrial users are supplied directly from the transmission grid and domestic sales require greater winter peak capacity on average for the same volume of sales. If this overestimation of industrial cost and underestimation of domestic cost had been taken into account the difference between the two sectors' performance would be even more pronounced.

4.33 **Efficiency Comparisons.** Physical productivity comparisons between countries are difficult to make because of variations in national circumstances. In the upstream sector the main difficulties are caused by variations in geological formations and the use of different exploration and production technologies. In the downstream sector a number of external factors can affect measures of relative productivity:

- The nature of the gas supply company
- The composition of gas sales
- Different levels of consumption by type of consumer
- Different configurations of customer location on the grid
- Different ancillary activities (e.g., appliance installation), which can vary in labor intensity
- Different degrees of contracting out to third parties.

4.34 Generally, Polish state enterprises often undertake nonoperational activities of a service nature (e.g., transport, repairs, social facilities) that are not provided to the same extent by Western commercial companies.

4.35 Given the limitations of productivity comparisons detailed above, it is still useful to use Western Europe as a benchmark because of its geographical proximity and because of its potential competition with Polish energy products.

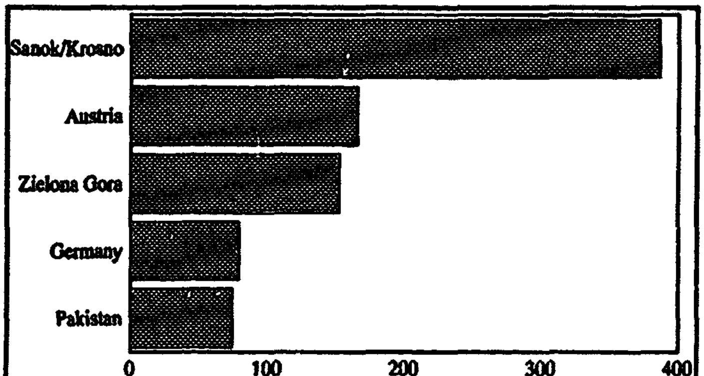
4.36 PGNG's two geophysical companies completed a total of some 4,800 kilometers of seismic lines in 1989, a steady increase over the previous few years. Each subsidiary has 7 crews comprising

5 explosive and 2 vibroseis crews, and the crew size is about the same as for Western companies. During the period 1987-89, the companies ran an average of around 30 kilometers of seismic line per crew month. By contrast, international data for onshore seismic activity shows a range of between 80 kilometers per crew month in Europe and the Americas and 110 kilometers per crew month in the eastern hemisphere.

4.37 Some of this difference may be the result of Poland's shorter working hours and severe winter weather, but the difference is so dramatic that it suggests a fundamental difference in productivity. PGNG appears to have too many crews in relation to the work load and that the interpretation activity is also overmanned. The seismic equipment is not up-to-date and the level of computerization is low; both factors contribute to the high ratio of wells drilled to kilometers of seismic run.

4.38 Exploration drilling is undertaken mainly by the four drilling companies as subcontractors to the regional production companies or to Geonafta. Most of the work is carried out on a regional basis and the volume of drilling is split almost equally between the two main production areas. This allocation of resources may need to be revised since geophysical surveys indicate that most of the potential lies in the western lowlands rather than in the south of the country.

4.39 The total output of the four drilling subsidiaries has been reasonably steady in the range 330,000 to 350,000 meters drilled per year since 1985. In 1989 the drilling companies employed a total of 8,200 staff and 93 rigs; the crew size is about the same as in Western companies. Two comparisons of relative drilling productivity have been examined. First, a typical U.K. drilling company drills about 400 to 500 meters per employee per year, whereas the PGNG subsidiaries typically achieve around 35 to 45 meters. Second, European data for onshore drilling suggests an average rig performance of about 60 to 70 meters per day, while PGNG's average is about 20 meters per day. This evidence suggests two principal conclusions:



	Sanok/Krosno	Austria	Zielona Gora	Germany	Pakistan
boe	386.3	165.5	152	79.2	74.1

Figure IV-2: Employees per Barrel of Oil (boe)

- A surplus of manned rigs in relation to actual drilling activity means fewer days of drilling per employee.

- Inferior rig technology and quality of drilling bits results in lower effective drilling times and lower drilling speeds.

4.40 Gas production is carried out by three companies, Zielona Gora in the west and Sanok and Krosno in the southeast—Krosno is by far the smallest producer. A comparison of the relationship between the number of employees per barrel of oil equivalent (boe) with countries with similar relatively small onshore accumulations is shown in Figure IV-2.

4.41 The most relevant Western comparator in terms of production conditions is Austria, and Zielona Gora's performance is very similar to the Austrian level. By contrast, the geology is less favorable in the southeast and Sanok and Krosno together require over twice as many staff per boe. Much of this can be explained by the fact that the Krosno company, with a staff of almost 1,600, is now able to produce very little. Overall, PGNG's production companies seem to have too many staff in relation to output and have too many marginal, low productivity wells, which may in turn reflect the fact that no rigorous economic evaluation is carried out before new wells are drilled.

4.42 Regarding the transmission and distribution companies, productivity comparisons need to recognize that, in general, transmission is typically a capital intensive operation that is engineering driven and staff numbers relate most directly to the size of the transmission system. In addition, staff numbers in distribution are typically influenced most by the number of customers to be served and by a lesser extent to the size of the grid.

4.43 In neither case is sales per employee a very helpful indicator for cross-country comparisons.

4.44 Since PGNG is currently vertically integrated between transmission and distribution the staffing of high-pressure networks is not separately identified. Comparisons can be made at three levels , and the comparison for the whole system is given in Table IV-1.

- PGNG transmission and distribution (T&D) compared with other downstream gas industries as a whole

- PGNG regional T&D companies compared with British Gas regions, which perform a rather similar function

- PGNG city distribution subsidiaries compared with local distribution companies in Western Europe.

Table IV-1: Length of Grid (km) and Number of Customers per Employee

Country	*Grid km/ employee*	*Customers/ employee*
Holland	8.6	435
Belgium	7.2	422
Western Germany	5.1	263
Britain	4.9	350
France	4.5	304
Poland	2.9	293

4.45 Poland has a short distribution grid per customer but this is probably due to high housing density, so that this does not of itself suggest inefficiency. Using customers per employee as an indicator, PGNG fares somewhat worse than the United Kingdom but is better than western Germany, with its many local distribution companies.

4.46 At the regional level, the number of customers per employee ranges from around 215-220 (POZG Gdansk and WOZG Posnan) to 350 (GOZG Zabrze) and 414 (MOZG Warsaw). In comparison, the British Gas regions (handling regional transmission and local distribution) range from around 290 to 360 customers per employee. On this basis the PGNG companies show a wider range of variation but the staffing per customer is only modestly greater on average.

4.47 At the local distribution level information was obtained on three "city gate" subsidiaries. ZG Krakow had 400 customers per employee, ZG Zabrze 550 customers per employee, and ZG Warsaw 900 customers per employee. By comparison the average for Dutch and Belgian companies is 510-520 customers per employee, while many western German companies have much poorer productivity on this measure than the first two Polish companies mentioned.

4.48 On the single most meaningful measure of T&D productivity, customers per employee, PGNG is somewhat below the average standard in Western Europe, and hence there is some room for improvement in T&D efficiency. Although Poland lags behind internationally in T&D efficiency, the gap is much less dramatic than it is in the E&P functions. This is not surprising, in that E&P is a high technology business where the impact of inferior equipment is much more severe.

4.49 The equipment manufacturing companies are diversified in their activities and markets, while the construction companies are substantially single activity and work for in-house PGNG customers. This has implications for the ability of PGNG to spin off these ancillary activities, if desired. With such a diverse group of companies it is difficult to find appropriate measures of productivity. Field visits to the manufacturing subsidiaries showed that the equipment is often outdated, levels of mechanization are low, the number of products is excessively high, and production runs are too short to achieve economies of scale, while factory layout and materials flows are good by international standards.

4.50 In summary, compared with Western European experience, PGNG appears to have the following characteristics:

- Three times more seismic crews in relation to the scale of operations
- Three times more drilling rigs and crews in relation to the exploration workload, even allowing for the older technology
- Up to one-and-a-half times as many production staff in relation to production volume, with productivity lowest in the southeast but comparable with Austria in the western lowlands
- Up to 25 percent more staff in T&D in relation to the most meaningful indicators of activity
- An apparent need for modernization in construction and (especially) manufacturing, with the possibility of divesting peripheral activities.

4.51 In broad terms, it appears that PGNG's staffing level may be up to twice that found in a Western country with a similar mix of activities.

Industry Structure

4.52 As has already been emphasized, the present structure of the industry provides no real incentives for developing gas production or the market in the most effective manner. It is also prone to bureaucratic interventions in internal transfer pricing and investment decisions that distort the allocation and use of resources. Significant overmanning in certain areas could jeopardize long-term financial viability, while the "soft budgets" and blurring of accountability means that management has not viewed planning for long-term financial viability as a primary task. For all of these reasons structural reform as well as pricing reform must be undertaken if the industry is to make is fullest contribution to the welfare of its customers and the economy as a whole.

4.53 A number of subsidiary or "tactical" objectives for restructuring can be identified that will contribute to the overall goals of gas development, financial viability, and efficiency. Structural change is likely to be helpful if the following conditions are met:

- It provides a clear focus on the core gas business (exploration, production, transmission, and distribution) and meeting customer needs.
- It streamlines the mechanisms for sector management and establishes clear management accountability for performance.
- It strengthens incentives to re-invest in the industry, negotiates the most favorable terms with outside suppliers, and develops the Polish gas market through effective marketing.
- It creates a framework for arm's length trading relationships that will allow market forces and competition to exert an influence on decision making.
- It facilitates regulation to protect consumers in areas of significant market power
- It reduces institutional or organizational barriers to desired changes in ownership
- It is sufficiently flexible to permit evolutionary change.
- It can be implemented without undue disruption to gas industry operations or unacceptably high costs of change.

4.54 In practice, it is unlikely that any one structure would satisfy all these objectives, and there will be trade-offs. A particularly important trade-off will be between the long-term benefits of structural change and the short-term costs of implementation.

4.55 Five key issues should be explored with regard to the future structure of PGNG:

- Relations between the upstream (E&P) and downstream (T&D) components of the industry
- The upstream structure, including geophysical operations, exploration, and production
- The relation of transmission and distribution activities
- The relation of peripheral (manufacturing and construction) activities to the core gas business
- Horizontal integration—the number of companies operating at each level in the industry.

4.56 The decisions made on these issues must take into account the very different economic and commercial characteristics of the various activities, their potential for competition, and the minimum efficient scale.

4.57 Exploration and production has the potential to be competitive, subject to the size and profitability of the specific province. For example, western Germany, which produces about three times as much gas as Poland, supports six or seven main E&P companies.

4.58 Long-distance transmission has the characteristics of a natural monopoly. There are economies of scale in pipeline operation, and international experience suggests that the existence of parallel pipelines (as in the northeast and midwest United States) is not cost effective. However, a monopoly in grid construction and operation does not imply that there must be a monopoly of grid access. "Open access" regulation, in that pipeline owners are obliged to transport gas for third parties for a reasonable fee, is now being used in both the United States and the United Kingdom in order to encourage competition in gas supply.

4.59 Local distribution of gas is also a clear natural monopoly—it makes sense for only one company to be laying gas mains and connecting households in a particular area. Distribution, however, does have a much smaller minimum efficient scale than transmission.

4.60 Most manufacturing activities within PGNG would seem to have the potential to operate on a competitive basis.

4.61 **Upstream/Downstream Integration.** The present integration of upstream and downstream activities, although common in Eastern Europe, is unusual in market economies, where E&P interests are usually operated as separate businesses at arm's length from the transmission business. Gas is sold from producers to transmission companies under freely negotiated contracts, with producers competing to meet market requirements on price, seasonal flexibility, and security of supply. If the company is integrated, as it is in Italy, there is a strong temptation to cross-subsidize with wellhead prices that are below the market value of indigenous gas. This results in underinvestment in the production sector.

4.62 It is also important to recognize that E&P is a very different kind of business from T&D. It is a relatively high risk/high margin activity, tends to be characterized by sophisticated technology, has few customers, and is frequently international in character.

4.63 It appears that restructuring should establish a clear separation of the upstream (E&P) gas business to allow the specialist management to evolve. It is also likely that foreign investment, together with technology and management expertise, would be more attracted if this branch were separate from the rest of the gas enterprise.

4.64 **Upstream Organization.** In the analysis of the upstream organization it is necessary to make a distinction between exploration business decision making (reserve evaluation, investment appraisal, risk taking, and financing) and the management of physical drilling activity. At present there is hardly any rigorous economic appraisal of exploration wells. From an economic point of view the logic of drilling exploration wells is based on the probability that recoverable reserves can be identified in sufficient commercial quantities to justify investment. It therefore makes sense to ensure that exploration and production are integrated. Under this approach, the E&P companies would be responsible for the key business decisions in the exploitation of Poland's gas reserves.

4.65 E&P activity also requires a number of services, including seismic, drilling, equipment construction, and equipment repair. In market economies the overwhelming tendency is for services to be bought in at arm's length. The following reasons support a similar structure in Poland:

- Upstream services are often specialized and it may be better to allow them to take place within specialized industries.
- Some upstream services can be provided by relatively small companies and some of the less technical areas may be suitable for sale to the private sector.
- The separation of upstream services from the core E&P functions is likely to encourage competition among the providers of these services.
- Smaller service companies may be more flexible and committed to customer satisfaction than the service departments of an integrated business.

4.66 **Transmission/Distribution Interface.** The current structure of PGNG in the downstream is based around six regional T&D companies, each of which has some local "city gate" distribution subsidiaries. There are also some separate centralized transmission functions such as supplies planning and dispatch (KDG), purchase of indigenous supplies (Head Office), and systems engineering planning (Design/Planning Office). This structure has a great weakness in that the key transmission/purchasing role is highly fragmented. A further issue is whether or not transmission and distribution should be vertically integrated.

4.67 Although transmission and distribution both involve the supply of gas through pipes, the two activities also differ markedly. Transmission is typically capital intensive with relatively low manpower needs, few customers, and relatively low margins, often involving long-term planning to meet the level, seasonal variability, and quality requirements of gas demand. Local distribution, in contrast, is generally less capital intensive with greater manpower needs, a very substantial customer interface and higher value added. Whereas purchasing, planning, and engineering skills are at a premium for transmission, distribution requires customer service, marketing, and customer accounting, as well as distribution engineering. On this analysis of business activities there is no overwhelming case for vertical integration.

4.68 The relationship between transmission and distribution can be described by four main "structural models":

- *Vertical integration.* Typical of the United Kingdom and France, this system usually involves one transmission department and several regional distribution departments.

- *Single transmission company and several separate local distribution companies.* This arrangement is typical of Belgium, Denmark, Italy, and the Netherlands.

- *"Three-tier" system.* Typical of western Germany, this system involves a few transregional transmission companies, a large number of regional transmission companies, and a very large number of local distribution companies.

- *Competing transmission companies and a much larger number of local distributors.* This is the arrangement in the United States.

4.69 PGNG's structure lies somewhere between that of the United Kingdom and France and that of western Germany, since there are effectively three levels within the integrated company. The international evidence on the relative efficiency of these models is inconclusive, but there is some evidence that Belgium and the Netherlands, which are not vertically integrated, are the most efficient, while western Germany is low in productivity due to excessive disaggregation.

4.70 The arguments in favor of integrated T&D are as follows:

- Ease of investment planning and coordination because management has a view of the industry as a whole

- Ease of coordination between gas purchasing and marketing to final consumers (separate transmission companies may find it difficult to gain an unbiased estimate of a distributor's future sales)

- A direct incentive for purchasing gas at the lowest cost because the company reaps the full benefits of increased margins and/or higher sales

- The opportunity to pursue coordinated national marketing campaigns and to ensure nationally consistent pricing and supply policies.

4.71 In practice, purchasing and marketing are not always as well coordinated as they might be. British Gas, for example, is trying to streamline management by eliminating the intermediate layers of management that are common in integrated utilities.

4.72 The major arguments in favor of the two-tier structure are as follows:

- Increased focus on the different management needs of the two businesses
- Clear emphasis in the transmission company on "commodity trading," with the same negotiators buying and selling to ensure "back-to-back" arrangements with a positive margin
- Greater incentives for the management of the separate companies to maximize profit, as compared with the difficulty of establishing "profit centers" within an integrated company
- More responsiveness to local market conditions on the part of the regional/local distributors
- An opportunity to compare the efficiency and effectiveness of the various distribution companies through "yardstick" competition, thus providing a spur to improved performance
- The opportunity to pursue ownership policies at the distribution level that are different from those at the transmission level
- In the longer term, providing greater scope for introducing more competition in direct supply by moving to an open access system, and allowing distribution companies to purchase directly from producers.

4.73 The three-tier structure is perhaps the one that PGNG could most easily move to, but the arguments against it are the additional complexity of trading relationships with an extra set of transactions, the extra overhead costs, and the sub-economic size of very small local distribution entities.

4.74 The multiple-pipeline company structure is not a viable option in Poland and is unlikely to be cost efficient, even though it has provided a vehicle for intense competition in the United States.

4.75 On balance it may be best to separate transmission from distribution within a two-tier structure in order to gain the advantages of clearer accountability of separate managements, yardstick competition at the distribution level, increased flexibility with respect to ownership, and the greater potential for increasing competition in the long run. This restructuring would entail the liquidation of the third tier of local distribution enterprises and the preservation of PGNG's regional gas supply subsidiaries as regional transmission and distribution enterprises.

4.76 The responsibility for the national (high-pressure) grid should be removed from the regional companies. It would be more efficient to bring together all the key transmission functions—supplies planning and supply/demand matching, gas purchasing, system planning, high-pressure grid development and operation—within a single national transmission company.

4.77 **Manufacturing and Construction.** The relationship between PGNG's peripheral (manufacturing and construction) companies and the core gas business is of two types. Those companies (e.g., ZUG and ZNTS Gazomet) that work mainly for organizations other than PGNG could easily be established as entirely separate enterprises. Companies that work almost exclusively for PGNG (e.g., in construction) are in a more difficult position because there may be enough work on long-distance transmission lines in Poland for only one company. Separated off, BUG Gazobudowa might not be able to survive in the face of foreign competition and it would in any case be facing the national transmission company as a monopoly purchaser of its services. In such a case it may well be better to integrate the construction company with the transmission company.

4.78 **Number of Enterprises.** A key issue is the number of companies that should exist at each level of the industry. For upstream (E&P) it is necessary to distinguish between seismic (geophysical) and drilling companies. It is uncertain whether the volume of new seismic work in Poland will be sufficient to support two viable companies, but there is a clear need for competition in order to improve efficiency. One solution would be to maintain both companies but to recognize that one or both should seek some relations with an international seismic company in order to obtain access to a larger market outside Poland as well as to improve technology to international levels.

4.79 As the minimum economic scale of a drilling service company is small, there is no reason why the four companies should not continue to survive. However, each will need to reduce its size in order to provide a basis for financial viability. Access to Western technology will also be required.

4.80 At present, Poland has three E&P companies, but the company at Krosno is by far the smallest and now produces very little oil and gas. It should certainly be merged with the Sanok company. Although Sanok itself could be merged with the Zielona Gora business to form a single Polish E&P firm with greater strength in dealing with third parties (foreign companies or the national transmission grid), some strong arguments could be brought to bear against such a merger:

- Benefits of introducing greater competition in production
- Opportunities for yardstick comparisons of efficiency
- Opportunities to introduce competitive bidding for licenses between the Polish companies
- Avoidance of distorting investment patterns through cross-subsidies
- Avoidance of another layer of management above the two regional offices
- Avoidance of complete monopoly in purchase of upstream services from Polish companies.

4.81 There are also several options with regard to the number of regional transmission and distribution companies. Since the six regional companies vary a good deal in size and customer mix it is reasonable to consider whether they will all continue to be viable or whether there should be some consolidation. The move to a less distorted pricing pattern, as discussed in chapter 5, will tend to raise domestic prices more than industrial prices, so that regions with a greater mix of residential sales will fare best, whereas regions with a larger share going to industry will do less well. Without a detailed study of cost and demand conditions it is impossible to make firm predictions on future viability.

4.82 International comparisons of size, measured both by customers per company and sales per company, show that even the smallest company in Poland is substantially larger in these terms than viable and efficient companies in Belgium and the Netherlands. Provided there is economic consumer pricing and a reasonable level of efficiency there is no reason to suggest that the present companies will not be viable in the future. Indeed, the number of regional transmission and distribution companies could be increased to allow a greater sensitivity to local needs and priorities. In the Polish situation, strong arguments militate against moving rapidly toward a situation with many small distribution companies:

- It would introduce excessive fragmentation of the regional transmission function or the preservation of a "three-tier" structure in the downstream gas industry.
- Transmission needs to be coordinated across large geographical areas.
- The local companies would be in a very weak bargaining position with the centralized national transmission company.
- If they were moved under municipal control, local companies could be used as a source of cross-subsidy, as appears to be the case in some other countries.

4.83 The present structure seems most able to provide a commercial counterweight to the national transmission company and most able to attract the levels of finance envisaged in the Gas Development Plan as outlined.

Trading Relationships

4.84 If the structural change in the Polish gas sector is to yield the expected benefits, much will depend on the nature of the trading relationships that are established within the new industry structure. The six key sets of trading relationships are as follows:

- The provision of manufacturing, construction, and equipment repair services to the industry
- Seismic and drilling services provided by upstream companies to the E&P companies
- Sales of gas at the wellhead from E&P companies to the national transmission company
- Bulk supply of gas from the national transmission company to the regional transmission and distribution companies

- Sales from the national transmission company to large consumers (power stations) directly connected to the national grid

- Sales from regional T&D companies to all other consumers on medium-pressure transmission or low-pressure distribution systems.

4.85 If the E&P companies retain ownership of underground storage there will also be a need for storage contracts between them and the national transmission company. In addition the transmission company is likely to be negotiating on a commercial basis for imported gas.

4.86 Consistent with the goals of gas market development, efficiency and financial viability, the trading relationships should be designed to do the following:

- Phase out direct government intervention in pricing

- Allow market forces and commercial incentives to operate, while protecting the public interest from abuse of monopoly power

- Supplement commercial pricing arrangements with other arm's length contract term obligations to deliver, penalties for failure to perform, etc.

- Allow the maximum scope for the emergence of competition in the provision of services and, where appropriate, in gas supply.

4.87 The provision of manufacturing, construction, and repair services should be on commercially negotiated terms and market prices; these activities follow naturally within a market economy.

4.88 For seismic and drilling services similar remarks can be made. Day rates would be negotiated between the service industries and the E&P companies.

4.89 Producer prices should reflect the commodity value of the output, in comparison with high load factor import prices, and the capacity value in terms of seasonal supply flexibility, which reduces the need for underground storage. The mechanisms for setting the price are discussed in chapter 5; the key point being that flexible indigenous gas should be sold at a premium over high load factor imports, rather than being sold for a fraction of the price. Maintenance of excessively low producer prices will lead to underinvestment in E&P, which will result in excessive gas imports and storage or a failure to develop the gas market. A rapid transition to economic prices could result in windfall profits in respect of older, low cost developments so that a system of upstream revenue taxation might be required.

4.90 In addition to new prices between the E&P companies and the national transmission company, there will be a need for contracts to cover such items as delivery and offtake obligations, gas quality, metering, billing and payment, penalties for failure to perform, and force majeure relief. These should be freely negotiated terms although there may be some need for initial government involvement given the limited commercial experience of the companies and the degree of public interest.

4.91 Bulk gas supplies from the national transmission company to the six regional companies will also require a contract, although the pricing arrangements will probably comprise a published Bulk Supply Tariff. Details of such pricing proposals are included in chapter 5.

4.92 The direct customers of the national transmission company are likely to be very large, such as fertilizer plants, steel mills, or power stations. As such they either have, or are capable of having, alternative fuel options, such as dual firing. For seasonal load balancing, it is desirable for Poland to develop seasonally interruptible sales contracts, similar to those in the West, with these customers who can easily switch to other fuels. In general such contracts should be negotiated between the parties and are likely to be simple and standardized.

4.93 Regional sales to customers should probably be on a published tariff basis, particularly because of the strong monopoly element in this supply link, which requires a greater degree of transparency than is normally required.

4.94 A general question of trading relationships that cuts across the specific issues discussed above, is that of the national transmission company's role and, in particular, the option of moving toward open access to the grid. The arguments for open access (breaking of monopoly of gas supply) and against (increased risk and uncertainty) are still controversial in Western Europe. However, the practical experience of the difficulty of introducing such systems (with transport tariffs for use of the grid as well as a gas tariff) is such that it would be premature to move to this system in Poland at the present time.

Key Features of Recommended Structure

4.95 Figure IV-2, Figure IV-3 presents the recommended structure of the natural gas subsector. In what follows, each of the stages of the production-distribution chain is examined.

4.96 **Exploration and Production.** Two integrated oil and gas exploration and production (E&P) companies should be created from various parts of PGNG including the three existing production units currently within PGNG. It is recommended that the number of E&P companies be reduced from three to two as it is unlikely that one of the existing production units (Krosno) will be financially viable as an independent company. The two new companies would be vested with operating and production licenses for the areas in which they currently operate. All new licenses would be open to competitive tender. It should be noted, however, that legislation currently in preparation requires successful foreign tenderers to take one of the new Polish E&P companies as a partner. This would provide the Polish companies access to foreign expertise and technology through participation in new field developments.

4.97 **Transmission.** It is recommended that a single joint stock transmission company own the high-pressure gas network and act (at least initially) as the sole buyer and seller of gas transported on the high-pressure transmission network. This structure will retain the benefits of network coordination and dispatch and ease the transition to fully commercial gas trading, including the possibility of open access to the transmission network. To ensure that the company does not abuse its monopoly position, its activities would be subject to regulatory supervision. In the longer term, when the necessary expertise in bulk gas purchasing and sales has developed sufficiently in Poland, other companies could be permitted to negotiate for bulk supplies and sell them to large consumers, paying the transmission company charges for the use of its high-pressure grid.

4.98 **Distribution.** Six joint stock regional companies should be formed from the six existing businesses owned by PGNG. In common with the electricity subsector, the existence of fixed local transmission and distribution networks will mean that these companies will have a monopoly in their local areas. In contrast, however, it is recommended that relatively few distribution companies are created in the gas subsector (in the electricity subsector at least 15 are recommended). This is a reflection of a number of factors, in particular the following:

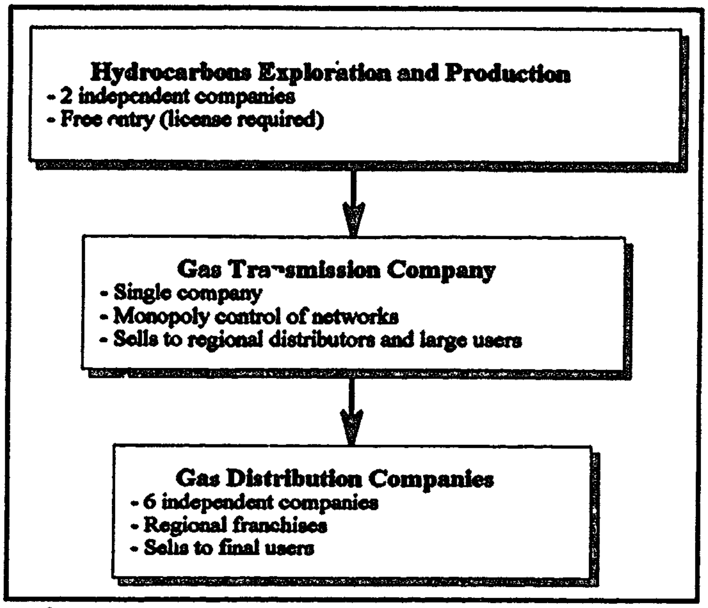


Figure IV-3: Recommended Structure of the Gas Subsector

- The need to coordinate regional gas transmission networks across large geographical areas.

- The projected major expansion in gas sales, which is likely to require the new gas distribution companies to make significant investments. It is possible that companies smaller than those proposed could not generate sufficient funds to finance these projects internally.

- There are likely to be significant benefits from retaining the six regional companies in terms of continuity and ease of implementation.

The final decision to proceed with six regional companies will need to be supported by more detailed projections of their future financial performance.

4.99 **Ancillary Companies/Common Bodies.** Independent upstream service companies, providing contract services (seismic, drilling, etc.) competitively to the E&P companies should be established at an early date. The activities of the other existing ancillary enterprises (including manufacturing and construction work) should be reviewed to establish which, if any, would provide essential (noncontractible) services to the new companies, and that it may therefore be appropriate to integrate into the new gas companies. This is only likely to be an issue with construction activity; there is a strong case for establishing the manufacturing units as independent companies. Where the enterprises are not reintegrated and where there is a reasonable expectation of them being financially viable, they should be transformed into joint stock companies and privatized.

Regulation

4.100 As Poland moves toward a market economy and creates incentives for managers to act in the commercial interest of their own firms, there will be instances when the operation of market forces will lead to an abuse of monopoly power contrary to the public interest. The Polish government has already recognized this by passing a general law in February 1990 to counter monopoly practices.

4.101 A number of gas sector organizations will be placed in monopoly positions in the restructured industry. The national transmission company will initially be a monopoly supplier at the Bulk Supply Tariff to the regional T&D companies. In addition, the regional T&D companies will be monopoly suppliers to customers who do not have dual firing.

4.102 In each case some form of price regulation will be required and this is discussed in detail in chapter 4. Two short-term aspects that will require regulation are the monopoly of the Zielona Gora production company to supply low-methane gas to the national transmission company, and the market power of the E&P companies in their roles as sources of seasonal supply.

4.103 Apart from the issue of price regulation, moves to a more independent and competitive gas sector are likely to create a need to define other means by which the government can monitor or influence key aspects of the sector both in the upstream (E&P) and in the downstream (T&D) sectors.

4.104 **Upstream.** Regulation can differ considerably from one country to another in the upstream sector. Common activities include licensing, taxation, safety, and environmental issues, but other elements may be discretionary (e.g., depletion policy, approval of field development plans).

4.105 Regulatory intervention may have several forms:

- Direct regulation by government departments (e.g., as in the U.K. and the United States)
- Regulation through a state agency (e.g., the Norwegian Petroleum Directorate)
- Indirect control by a strong national gas/oil company (e.g., AGIP, Italy; Statoil, Norway).

4.106 The first form of regulatory control is the most prevalent and gives the government a clear link between upstream policy and other political objectives. However, it can create conflicts of interest that remain hidden from public view. One clear potential conflict is between the maximization of upstream output and safety, as is evidenced by the recent Cullen Inquiry into the Piper Alpha disaster in the United Kingdom, which exposed the inadequacy of safety monitoring by the Department of Energy. In order to avoid such direct conflicts, if upstream development policy is to be handled by a ministry, then health, safety, and environmental policy could be passed to a separate agency.

4.107 The principal advantages of a separate agency, such as the Norwegian Petroleum Directorate, is that it has the opportunity to build a specialized team of gas experts, outside the mainstream civil service, who can take a more independent view of safety, environmental, and resource management issues. The agency can report to different ministries on the various issues involved.

4.108 The approach of exerting indirect policy control through a state gas (and oil) company has the advantage that the preferential treatment for national enterprises will maintain employment and output, but there is the danger that the lack of incentives will lead to inefficiency, and, as argued above, this is a serious concern in Poland.

4.109 It appears on balance that the best solution would be the creation of a semi-independent upstream regulatory authority reporting to the Ministry of the Environment and Natural Resources. The likely creation of an entirely separate national agency for all health and safety matters would remove one potential area of conflict with the ministry. There may be a shortage of suitably qualified staff but some of the existing Geonafta staff could take on a new role in upstream regulation, for which their skills and expertise would be very appropriate.

4.110 **Downstream.** Regulation here is quite different from the practice upstream. The key function is the monitoring and regulation of gas prices. Four principal models can be used to describe the institutional framework for carrying out this function:

- *Direct determination or approval of prices by a ministry.* This is the case in France and the Netherlands.

- *Regulation by an independent government agency.* An example is OFGAS in the United Kingdom.

- *Regulation by a representative body.* This is the case with the Supervisory Committee for Electricity and Gas in Belgium, which includes representatives from the manufacturing industry and trade unions, as well as from the government.

- *Regulation by competition authorities.* In some cases regulation, rather than being carried out by sector-specific bodies, is done by competition authorities in accordance with antimonopoly legislation. This is the case in western Germany.

4.111 Direct price control by a ministry is common in countries where the gas industry is owned by the state. It ensures that gas pricing is handled with due regard for political sensitivities (e.g., the impact on low-income groups). However, these closed-door negotiations are rarely based on clear principles, and concern for efficiency and financial viability are often subordinated to macroeconomic concerns, such as counterinflation policy. Because the aim in Poland is to remove the gas industry from state ownership, this model would be completely inappropriate.

4.112 The creation of a separate government agency, responsible to Parliament rather than to the Ministry, removes gas pricing from the directly political arena and provides stability of pricing policy, which is attractive to investors. There is a need to ensure that the body is not of an excessive size and that senior appointments are not politicized.

4.113 The Belgian tripartite body, although designed to achieve a consensus between three interest groups, is very cumbersome, although it does achieve a high degree of transparency of both costs and prices. In Poland, such a body is likely to become caught up in differences of view regarding the pace of economic reform.

4.114 The German approach of avoiding formal regulation altogether, while allowing the competition authorities to intervene in the event that companies' pricing breaches antimonopoly legislation, has meant that in practice there is very little regulation. Gas prices are almost universally negotiated and not published, so that it is very difficult to identify abuses.

4.115 It appears that the best solution in Poland would be the creation of a semi-independent government agency that could regulate prices and other relevant matters in the downstream. Legislation would be needed to establish its powers. The Ministry of Industry is likely to have to play a key role in drafting the legislation and establishing the mechanism for the regulation of gas prices, as is discussed in chapter 5.

Ownership

4.116 It is important to implement the new industry structure, commercial relationships, and regulatory framework before changes of ownership occur, because this pattern is likely to be more effective than changing ownership before these other changes are made. Once the restructured PGNG has been transformed into a set of independent joint stock companies, then a number of ownership options can be considered:

- Sale of assets or equity into private hands
- Formation of new joint venture companies with a private investor
- Transfer of part ownership into municipal hands
- Direct sale of shares to the public (through a bond or voucher system)
- Employee or customer share ownership.

4.117 Ownership patterns in the gas sector are varied. Some trends do emerge, however, for the three main levels in the sector.

4.118 **Upstream Sector (E&P).** In the upstream sector there is a need to acquire international technology, improve productivity, and, where possible, to gain access to markets outside Poland. These goals are more likely to be achieved by joint ventures with private foreign investors than by remaining in the hands of the government.

4.119 The proposed licensing scheme is an important factor in the decision on the form of ownership. If foreign bidders for new licenses are obliged to do so in partnership with a Polish E&P company, then the latter (as nonoperator) will benefit from the foreign investment and will have the opportunity to learn from the international operating company's management expertise and use of technology. However, significant investment in the equity capital of the Polish E&P companies by any single foreign company might be prejudicial to attracting a wide range of foreign bidders for new licenses, since the Polish companies would no longer be independent. A model in which private Polish and foreign investors could participate in the equity capital, while maintaining majority state ownership and limiting any single corporate investor to a maximum of 10-20 percent, might achieve the best balance of interests.

4.120 **National Transmission Company.** The transmission part of the gas sector will be of considerable strategic importance in the restructured gas industry since it will have the primary responsibility for importing gas, planning and operating the national grid, and for providing gas supply security at reasonable cost. It has a "natural monopoly" position as network owner and its commercial behavior will have a significant impact on the balance of payments, the prospects for expanded gas production in Poland, and the viability of its customers (the regional gas supply companies).

4.121 For the reasons mentioned above, it is common even in market economies for the state to maintain a substantial ownership interest (often 50 percent or more). However, British Gas is 100 percent privately owned but heavily regulated, with most of its shares in the hands of financial institutions and small shareholders. Both British Gas and Ruhrgas, which is largely privately owned, typically earn a much higher return than the Western European transmission companies with greater public ownership. This illustrates the general point that private investors have higher profit expectations than the state itself.

4.122 One model that does not seem to work well is where potential gas suppliers are allowed to take equity holdings. This policy was tried and then reversed by Swedegas because it created conflicts of interest when the board met to make key gas purchasing decisions of a commercially sensitive nature.

4.123 Perhaps the best system for Poland would be to retain majority state ownership with the minority private stake bringing in greater commercial expertise, best practice engineering, and improved management practices, as well as reinforcing the separation of the company from the state itself.

4.124 **Regional Gas Supply Companies.** Central government ownership of distribution companies is rare in Western Europe, but municipal or private/municipal joint venture companies are common. The establishment of arm's length trading relationships between the national transmission company and the regional companies is likely to be better established if the pattern of ownership is different at the two levels. However, in the short term the financial viability of some the regional companies with predominantly domestic/commercial sales may require some form of cross-subsidy at the bulk supply tariff (BST) level. Any early move to establish different ownership structures could make it difficult to operate a cross-subsidy arrangement, so a cautious approach to ownership change will be required until the level and structure of gas tariffs has been established.

4.125 After the period of price transition, there does not seem to be any case for maintaining 100-percent central government ownership in this part of the gas industry. The most important government objectives (e.g., consumer protection or preference for natural gas on environmental grounds) can be achieved through other means such as regulation and taxation.

4.126 Some local government (voivod or municipal) interest could be useful in that it distinguishes regional ownership from that of the national transmission company while it increases local control and reinforces links between gas distribution planning and urban land use planning. There are, however, dangers in allowing a substantial degree of local ownership in terms of limited commercial understanding, overriding political objectives, and the risk of cross-subsidy from gas to other loss-making municipal enterprises.

4.127 There is likely to be a long-term need for massive investment in gas distribution networks (see chapter 3) and this suggests a need to draw on external sources of capital. The current interest in bidding for distribution concessions in Portugal suggests that there are a number of potential investors interested in this part of the industry, as well as in E&P. Part ownership may be an effective way to gain access to marketing, engineering, and financial expertise.

4.128 Some customer shareholding may also help to strengthen commitment to customers, but there would be little direct benefit to the company. An eclectic approach to regional company ownership, in which central and local government, domestic and foreign capital, and some customer shareholding are all involved, is a reasonable approach. The approach need not be standardized across all six regional transmission and distribution companies.

4.129 **Manufacturing and Construction Companies.** For companies that it does not make sense to retain in the gas sector, there could be advantages to early privatization ahead of the rest of the gas sector. There are no new regulatory mechanisms or institutional arrangements that need to be established. Part ownership or joint venture arrangements with foreign companies could bring advantages in terms of access to foreign markets, capital, management, and technology.

4.130 **Employee Share Ownership.** There could be a useful role for a modest scale of employee share ownership in many of the successor enterprises to PGNG because of the benefits of increased employee identification with the business interest of their enterprise. However, considerable disadvantages may result if employee ownership constitutes more than a small stake:

- There is a current shortage of capital in private hands
- Inequity between employees who were working for a profitable enterprise and those who were not

- The possibility, confirmed by recent Yugoslavian experience, that inexperienced employee owners may take a short-term view and favor increased dividends at the expense of sufficient reinvestment to safeguard the long-term future of the enterprise

- Inadequate commercial and management expertise.

Implementation Strategy

4.131 Following the preliminary phase of agreement on the fundamental restructuring plans and timescales, the restructuring priorities suggest three phases of implementation:

- Phase 1—restructuring and commercialization
- Phase 2—corporatization (with 100 percent government ownership)
- Phase 3—ownership change.

4.132 **Phases 1 and 2: Restructuring, Commercialization, and Corporatization.** The principal changes involved in the Phase 1 restructuring involve the following steps:

- The separation of upstream (E&P) from downstream (T&D) activities

- The integration of exploration and production as a single business activity, with upstream services bought in from independent companies

- The integration of the key national transmission functions, together with the separation of national transmission from regional distribution to final customers.

4.133 If PGNG is to be transformed as a whole to a joint-stock company, in order to facilitate restructuring of a more thoroughgoing kind and to overcome rigidities within the framework of the existing state enterprise system, then this should happen early in phase 1.

4.134 For restructuring to achieve its objectives, it will need to be accompanied by:

- A program for achieving material efficiency improvements
- The creation of a new regulatory framework and regulatory bodies with clearly defined tasks
- The replacement of administered internal sales prices by arm's length commercial contracts
- Definition of investment priorities for each enterprise
- A move toward economic levels of gas prices.

4.135 To meet the Polish government's restructuring aims most effectively, this package of changes should be implemented as a whole, since each element depends on the other for its efficacy.

4.136 The question of staffing and manpower changes is discussed further below. At the transmission and distribution level, some manpower reductions appear to be required but these could probably be handled through "natural wastage." PGNG's upstream businesses employ about twice as many as would be needed if they had access to efficient technology, so that there will need to be a radical down-sizing in order to increase the prospects for survival in an open and competitive economy.

4.137 It appears that it would be best to make substantial progress with phases 1 and 2 before embarking on ownership changes. Unless the industry is restructured and commercialized, it will be unattractive to private investors and, once it is privatized, it would be much more difficult to implement restructuring and regulatory changes.

4.138 Recent experience elsewhere suggests that corporate restructuring, the development of contracts for commercial trading relationships, the establishment of new regulatory frameworks, and the sale of assets require an enormous amount of concentrated effort over a period of 2-3 years. While the industry itself can play a part, there is a clear need for some central "steering" of the change implementation program. As PGNG's parent ministry, the Ministry of Industry will play an important role. However, its energy sector is relatively small and has to face the restructuring of several major energy enterprises at the same time.

4.139 Elsewhere in Eastern Europe holding companies have been created to oversee restructuring and privatization and to push forward the industrial as well as the governmental aspects of the process. The creation of a specific holding company for the Polish gas sector would be one possible solution. The role of the holding company would be as follows:

- To steer and facilitate the PGNG restructuring, including the allocation and movement of key staff and the drafting of trading contracts
- To own the gas sector enterprises created out of PGNG as subsidiaries on behalf of the government, pending their complete or partial sale
- To set specific (high-level) financial objectives for each gas sector enterprise while it remains in state ownership
- To collect dividends from its subsidiaries and pay dividends to the government as shareholder
- To manage the sale of subsidiaries into private ownership and the formation of joint ventures, by verifying company valuations and ensuring that such arrangements yield the maximum possible value to the government
- To act as a buffer between the government and the enterprises during the transitional phase of restructuring.

4.140 The holding company is to facilitate change and not to coordinate day-to-day operations—it must not act as a surrogate PGNG headquarters. It should have quite a small staff with a narrow range of strategic functions. It is also essentially temporary and, once the process of restructuring and organizational change is complete, it should be dismantled, passing any remaining central government gas sector interests back to direct state ownership.

4.141 It would also be desirable to establish two holding companies—one for the upstream and one for the downstream in order to reinforce their separation at the earliest stage. With a need for a small staff of 30 to 50 (including secretarial and administrative support) for each holding company, the creation of two rather than one company should not be constrained by a lack of suitably skilled manpower. Secondments from government administration (e.g., Ministries of Industry, Finance, Environmental Protection and Natural Resources) as well as appropriate senior management from PGNG itself should provide the needed manpower.

4.142 The first major step in the restructuring strategy would be to "cap badge" PGNG staff in order to identify them with their new organizational units. In some cases there would be little change (e.g., geophysics, regional transmission and distribution, manufacturing and construction); the major staff movements are likely to be as follows:

- From Warsaw head office (e.g., KDG), the Design/Planning office in Wroclaw, the regional supply companies and possibly BUG Gazobudowa into a new national transmission company
- From Geonafta and the drilling companies (as well as the existing production companies) to the new E&P enterprises
- From various sources into the new holding companies and regulatory bodies.

4.143 There may also be selective movement of individuals out of the Head Office to strengthen senior management at the operating company level. At the same time measures will need to be taken to address the most serious cases of overmanning.

4.144 Once the new staffing patterns have been established, work can begin to produce new contracts for trading between the new units, even prior to corporatization. The principal "internal" contracts will need to cover:

- Sales of gas from the E&P companies to the national transmission company
- Sales of gas from the national transmission company to the regional gas supply companies (at the Bulk Supply Tariff)
- The provision of services (seismic, well logging, drilling, equipment manufacturing and repair, etc.) from the ancillary companies to the core E&P and T&D.

4.145 The first two categories are likely to be covered by long-term agreements with appropriate mechanisms for quantity and price adjustments. Trading for the third category w uld ultimately take place under case-by-case contracts, probably involving competitive bidding in some instances. In the short term it may be appropriate to develop one-year "framework" agreements that provide general guidance on commercial terms until management of both sets of companies gain experience negotiating individual deals.

4.146 The next step will be to establish the new regulatory institutions, their terms of reference, reporting mechanisms, and regulatory mechanisms. This will require legislation; the key elements will be as follows:

- Downstream price regulation, covering both the BST and final consumer prices
- Downstream safety, gas quality, and customer service standards
- Upstream licensing and development approvals
- Upstream taxation
- Specific application of health, safety, and environmental standards to the gas industry.

4.147 Once the new staffing, trading and regulatory arrangements are in place then restructuring can move to corporatization. This would involve the transformation of the restructured enterprises within PGNG into autonomous joint stock companies operating under company law but owned 100 percent by the government through the relevant holding company. The recent Law on Privatization would be one method of effecting this transformation.

4.148 There should then be a period of operation of the new trading and regulatory relationships, while under government ownership. At this stage it would still be relatively easy to adjust the trading and regulatory regime in the light of experience while no nongovernmental interests are involved.

4.149 **Phase 3: Ownership Change.** It may well be that interest will be expressed by private investors before phase 2 is completed. Once corporatization has taken place, the respective holding companies will be free to become more proactive with regard to ownership change within the framework of government policy on this issue. The scope for different kinds of new ownership will depend on the financial and operational strengths of particular gas sector enterprises and the development, in the meantime, of legal and institutional mechanisms (e.g., capital markets) appropriate to Polish private sector investment.

5. PRICING

5.1 The recommended pricing strategy is based upon the following observations: present gas prices are not high enough to sustain the development of the gas sector in Poland and do not reflect the resource costs of obtaining and supplying gas; continuation of the present prices would require the continuation of the present central government subsidy, the presence of which would reduce the badly needed incentives to increase efficiency; existence of a long-term subsidy would not be consistent with the pattern of economic reforms envisaged by the government or with the objective of improving the central government's own finances.

5.2 The institutional structure proposed for the gas industry determines what commercial arrangements will be required for the purchase, sale, and transport of gas. Given the restructuring proposals discussed in chapter 4 it follows that there must be separate tariffs for the purchase of gas from producers, a tariff for the bulk supply or resale of gas, a transport tariff, and retail tariffs for the final users. A key point in this structure is that there should be a separate transport tariff that does not conceal the cost of transporting the gas within a single retail tariff. This separation is designed to encourage the efficient allocation of resources by indicating the price for transport. In addition, it facilitates the regulation of the natural monopoly position of the transport company.

5.3 The central principle of the recommended pricing strategy is that of marginal cost pricing. There are of course financial and practical constraints that would make it impossible to set all prices exactly equal to marginal costs, but the general approach of charging the marginal customer the extra cost that their supply imposes on the gas system provides the correct signals for investment not only within the gas industry, but also between industries where all industries follow competitive pricing strategies.

5.4 The structure of this chapter of the report is that the general principles of efficient pricing are first discussed together with considerations of the methodology of applying such principles. The next section examines the costs and other factors that are needed to construct an actual set of tariffs. The recommended prices thus calculated are then compared with the values in other countries, and the effects on individual and macroeconomic behavior are examined. The effect of the proposed tariffs on the financial viability of the gas sector and the treatment of excess profits are then discussed. The problems of transitional pricing, which are discussed in more detail in chapter 5 of this report, are considered along with the implications of the pricing rules for the regulation of the industry.

Principles of Efficient Pricing

5.5 Prices play a crucial role in the allocation of resources (i.e., in determining the use of resources for one purpose rather than another). In a market economy prices tend to move toward market clearing levels and reflect the cost of producing the last unit of output and the price that the marginal consumer is willing to pay. This coincidence ensures that the industry is the correct size (i.e., that it does not leave output too low at a level where some consumer would be willing to pay more for some extra item than it costs, nor too high where the price paid does not cover the cost of providing the last unit). Application of this principle across all industries ensures that it is not possible to reallocate resources and produce an increase in national output and welfare.

5.6 This "first best" pricing rule requires that certain conditions exist throughout the economy. There must be competition in all markets so that no company can make excess profits—if a company could make excess profits, then other companies would enter that market and eliminate such profits through competition. This assumption in turn requires that no natural monopolies exist whose cost advantage is such that no rival could threaten their excess profit. Were there to be such natural monopolies, then for marginal cost pricing to be efficient, it would be necessary for the monopolies to be regulated so that they set prices equal to their marginal costs, even though this does not maximize their profits.

5.7 In addition to the requirement that all markets be priced at marginal costs, the optimum competitive solution requires that no externalities be involved in the production or consumption of goods. In addition to the standard cases of public goods and merit goods, which require government provision financed through taxes, there is also the case where there is an externality that is susceptible to the price system. Pollution is one of the most important examples—the output of an industry produces pollutants that affect individuals who are not buying the product and hence whose welfare is not reflected in the price set by the interaction of supply and demand. The market price does not take the welfare of this group into account, which results in an overlarge production by this industry and a correspondingly too small an output by other industries. Since the production and consumption of fuels are a major source of the very high levels of pollution in Poland, concern for the environment means that this must be taken into account when making plans for each fuel. Gas is generally the least polluting fuel so its use should be encouraged while use of other fuels should be discouraged or prevented to reduce pollution. The principles of optimal pricing need to be adjusted to take into account the marginal costs or benefits of pollution. This issue is examined in chapter 6 of this report but the main conclusion is that the use of subsidies to encourage the use of gas relative to other fuels is not the best way to proceed. Not only would this have a cost to the central government, it would also send the wrong message to the industries that are causing the most pollution through the use of coal and heavy fuel oil. Only by taxing the polluters, or requiring them to clean up their emissions, will the proper signals be given directly to those for whom straight market pricing would produce too high a level of output.

5.8 The gas industry has an important monopoly element in the transportation sector. It would be difficult and inefficient to attempt to introduce any competition into the transportation of gas. Duplicating pipelines would merely result in raising the cost per unit transported since there are natural economies of scale in pipelines. To satisfy the criteria for efficient pricing in the transportation of gas it is not possible to rely on competitive forces to bring about prices equal to marginal costs. Instead the sector must be regulated so that prices are set to equal the marginal costs of supplying customers. Such prices will explicitly need to take into account marginal capital costs as well as variable costs, as will be explained below. If this framework is adopted then it is possible for the sector to have both efficient prices and financial viability, which would ensure revenue sufficient to cover operating costs and the costs of investments necessary to maintain supplies.

5.9 Financial viability is a primary requirement in determining the level of gas tariffs. If the prices and tariffs based on marginal costs yield insufficient revenue to cover the actual accounting costs of enterprises in the gas sector then some tariff components would need to be increased to obtain the additional revenue (the case of excess revenue is discussed below). The choice of which element to increase should, if possible, be based on criteria that are economically efficient and hence that have the least effect on the pattern of demand. This probably can be done most simply by altering the fixed component of a tariff. There may be considerations of income distribution that affect the government's attitude toward pricing but from the point of view of industrial performance it is better if the correct price signals are maintained and help is given to target groups through income subsidies rather than through subsidized prices on certain commodities.

5.10 In choosing the optimal approach to pricing it is important to recognize that the appropriate marginal costs are the total increment in costs of increasing the supply by one more unit. Such costs will include the cost of incremental capital as well as the cost of the extra gas itself. If the system has been optimized to meet a given demand (which may involve a given degree of slack) then when demand is increased by one unit, more output would be required, which in turn would require additional investment. The industry would voluntarily supply the extra amount of investment only if the consumer is willing to pay enough to cover all these costs. If there were a shortfall the government could finance the extra investment through taxation, which would mean taking resources away from sectors where prices did cover costs in order to increase the output of an industry where prices did not cover costs. Since prices represent value to a consumer in a market economy, such a procedure would produce an output of lower total valuation. In short the marginal costs of nongas supply (the investment costs) provide the correct signals for making decisions about whether it is worthwhile to increase the capacity of the system. For the gas itself, the appropriate measure of marginal cost is the cost to the supplier of acquiring incremental quantities of gas for resale. Often, but not always, this will be the price at which the gas is purchased. The details of this are covered below. When supply is rationed so that there is unsatisfied demand at a price that covers all the costs of supply (e.g., were imports of gas at world market prices from Russia to be limited for some reason) then the price should reflect the value consumers place on the goods. Prices should be allowed to rise until there is no excess demand. The excess profit (economic rent) can be secured by the government by taxation for the benefit of society as a whole, since the industry does not need this extra amount in order to make the optimal investment decisions.

5.11 The application of strict marginal cost pricing also implies tariffs that distinguish the various aspects of supply itself. For example, the cost of supplying a consumer has three main components: the costs of metering and collecting payment, which are largely independent of the amount or nature of the supply of gas; the costs of maintaining sufficient supply in the pipes to the consumer's premises, which can be linked to the peak requirements of the consumer; and the purchase or production cost of the gas itself. Changes in the pattern of demand affect these components in different ways so that the best pricing approach would be a multipart tariff with a fixed component and a variable component.

5.12 This example also serves to show why the optimal pricing strategy should not be a cost-plus determined price. A cost-plus price, which is an average cost plus a margin, although simple to operate, does not assign costs correctly between categories of customer. Because efficient resource allocation requires that costs be correctly assigned, it is important to set the structure as well as the general level of tariffs correctly.

5.13 If an industry is competitive and there are no extensive economies of scale then competition will tend to bring about prices that are equal to marginal costs. Any firm that does not set prices so that they reflect costs will find that it is forgoing profits and that its rivals will be more successful. In such a case there would be no need to prescribe the tariffs because the market would bring them about. Moreover there would be a strong incentive to become more efficient and reduce the costs to increase profits. In the absence of competition, for example where there is a natural monopoly, not only is there less incentive to improve technical efficiency, but also the level of prices set will not reflect marginal costs unless the industry is regulated. Economic analysis shows that unregulated monopolies, seeking the maximum profit, tend to restrict output by raising prices above the marginal cost level. This results in a misallocation of resources among industries—resources could be bid away from other industries, where the price paid for the goods they produce just covers their cost, and diverted into the monopoly industry, which produces an output valued at more than the marginal cost of the same resource unit. As a result of this potential misallocation, brought about by the presence of the natural monopoly, rules for regulating the price and output of the firm must be determined, while at the same time maintaining the maximum incentive for the managers of the firm to improve its performance.

Application of Efficient Pricing Theory to the Polish Gas Sector

5.14 Although the ideal solution is to price at marginal costs, this is not always a practical solution if there are no data available upon which to estimate the costs of supplying extra units of gas at the level of output taken as the target for the industry. The best method is to base estimates of marginal cost on such data as is available (PGNG's recorded costs) and to check these against Western European experience. Thus, each link in the chain of the proposed restructured Polish gas industry is examined in this report.

.15 **Purchase of Gas Supplies from Producers.** PGNG, at present and in the future, will import most of its gas and will obtain some from domestic suppliers. The imported gas will be obtained at something like a world market price, the details depending on the form of future negotiations with Russia and the availability of alternative supplies. Such supplies are likely to lack quantity flexibility, judging by present contracts, so that domestic supplies are likely to be much more variable. Domestic supplies will be provided mainly in the peak season (i.e., they will be the equivalent of marginal storage fields for the support of the winter seasonal load). Domestic producers not only should receive a (variable) component equivalent to the price of the alternative supply (import price) but also a fixed margin equal to the inventory charge for holding supply ready to meet the winter peak. This scheme ensures that domestic producers have the maximum incentive, consistent with economic efficiency, to develop and maintain supplies. They will produce and sell to PGNG if the marginal cost of production is below the market price of imports. If the supply of imported gas is not rationed this provides the necessary competitive pressure to encourage the domestic private production sector to price optimally and to cut costs, provided that the private industry is attempting to maximize profits. If there were a reason why this sector did not wish to maximize profits, then the price might need to be regulated so at least the correct signal for future investment would be generated. The production sector appears to be the sector with the greatest inefficiency relative to Western standards and therefore the one where the most severe adjustment is required. The setting of alternative goals, such as a limit to the speed of adjustment in order to avoid massive redundancies early on in the restructuring, weakens the desire to maximize profits and hence may affect the tendency to set the optimal prices for investment and resource allocation.

5.16 **Transport Tariff.** Gas transport is a natural monopoly that results from the scale economies of larger pipe diameters and the geographically fixed nature of the transport technology. Hence, left to itself, this sector would not develop a competitive structure or competitive pricing. An unregulated monopoly seller has an interest to restrict output by raising prices above marginal costs. To ensure that the optimal pricing is followed it is necessary to regulate this sector and to do this effectively it must be possible to identify the price charged for the transportation of gas. For large industrial customers and the Local Distribution Companies (LDC) the economic infrastructure for separate metering is already in place and the demands are sufficiently great that it is both practical and desirable to design separate tariff schedules. The firm transport tariff should consist of two components: a capacity component and a usage component. The usage component should reflect the amount of gas purchased and would relate to short-run operating costs. The capacity component should reflect expenses such as capital expansion and/or replacement that are marginal in the long run. The determining factor is that the system is built to reflect peak usage since there is little domestic storage. In this case the principle is that where the same capacity is used by all customers, fixed transport capacity costs should be attributed to customers based on their utilization of the pipeline at the peak (peak customers should bear all the capacity costs and none should be borne by off-peak customers). The most convenient measure of peak usage is the daily equivalent of the sum of the "annual" and "seasonal" supply nominations. Following the same principle the marginal transport cost for "interruptible" customers is only the variable transport cost.

5.17 **Resale of Gas from the Transport Company to Large Industrial and LDC Users.** Most gas will be imported and the price is likely to vary, perhaps being indexed to the world oil price. PGNG should be able to pass on gas cost changes fully without altering the transport cost component. It is also desirable that if it is necessary to contract for a year at a time for gas supplies, then the large industrial companies and LDCs should also nominate (specify) their requirements for a year, in a way that corresponds to the arrangements for contracting for supplies.

5.18 **Retail Sale of Gas to Customers of LDCs.** Considerations for the retail sale of gas to customers of LDCs are similar to those for the transport of gas at the national level. Individual users face both marginal capacity costs and marginal usage costs. The capacity costs include the cost of installing and reading a meter, rendering bills for service and maintenance of the meter and customer connection, and the costs of the distribution facilities. The marginal commodity cost is the cost of providing the gas at different times of the year. Since gas costs are likely to be higher in the winter, reflecting the need to use more domestic supplies that are compensated for by the storage factor, the marginal cost is also seasonal. It has been common not to assess LDC customers for a capacity charge; instead, a declining block tariff has been used, with the second block reflecting the short-run marginal commodity cost. Here, a capacity charge is recommended because it shows most clearly the nature of the nonusage costs.

Link Between Theoretical and Practical Pricing

5.19 The gas purchase tariff must reflect the price of imported supplies and also include a storage charge for domestic supplies when these are used to meet peak winter demands. Since the Polish gas sector uses several varieties of gas, which differ substantially in calorific value, it is recommended that the tariff scheme equate prices on a calorific basis (the lower volume used by higher calorific gas is countered by the fact that such gas is shipped greater distances while no allowance is suggested for distance at present). Because there are no appropriate data available for assessing the seasonal holding charge on Polish gas, a figure, based on U.S. experience, of $15.18 per cubic meter of seasonal nominations is chosen. At the same time it is assumed, for illustrative purposes, that the import price of gas will be $80 per cubic meter. The full set of the associated tariffs for the purchase of gas from the domestic suppliers is given in Table V-1.

Table V-1: Gas Purchase Tariffs (imports at $80/m^3)

Tariff	*HMNG*	*LMNG*	*Coke*
Unit price (zlotys/1,000m^3)	760,000	481,900	380,000
Winter holding charge	170,100	107,900	85,000

5.20 The transport company should sell gas to its customers using a bulk supply tariff for the cost of the gas itself in order to recoup the costs of purchasing the gas from the exporter or the domestic production company. The key feature here is that the supplies of imported gas are not flexible, hence a system is needed that ensures that the amount purchased by the gas supply companies is taken by the users of gas. The method suggested is for firm customers to nominate (specify) the amount of gas they wish to purchase on a consistent daily basis and pay the bulk supply tariff when purchasing this annual contract quantity. In return they would be guaranteed 1/365 of this quantity every day (assuming that the import contract is on a yearly basis). Annual nominations force customers that want high-volume firm deliveries to pay for their minimum deliveries whether they take them or not, so by taking the nominated amount they receive the lowest per unit price of gas (the import price). Similarly, firm customers also nominate quantities for specific seasons—if the "winter" season is defined as six months, then they are guaranteed up to 1/180 of their seasonal quantity every day. The charge for the unit of seasonal gas would equal the import price plus the seasonal holding charge. Again, by taking the full amount nominated, the buyer minimizes the per unit cost. The bulk supply tariff is the same as the gas purchase tariff in Table V-1; it is the amount per unit nominated for firm supply. Customers that do not need firm supplies prefer to have interruptible contracts. Because there are no long-term obligations to such customers they should not be charged any capital costs, and it is recommended that sales of interruptible gas be based on individual negotiations, subject to general regulatory oversight.

Table V-2: Transport Tariff (zlotys)

	Tariff		
Type of charge	*HMNG*	*LMNG*	*Coke*
Monthly demand charge per unit of peak capacity	4,004,000	2,539,000	2,002,000
Volumetric charge per 1,000 cubic meters	31,100	19,700	15,600

5.21 It is recommended that the costs of the transport of gas be covered by a two-part tariff. The first part is a capacity charge to cover the fixed costs, and this allocates fixed costs to customers on the basis of their reserved share of peak capacity (whether or not they actually use it). The fixed transport charge is based on the annual transport expenditures contained in the proposed investment plan plus a return on existing assets plus current estimates of overhead costs such as materials and labor. The estimated figures are based on 1989 peak deliveries; in the future actual nominations will be available. The second part of the tariff is a volumetric charge that recovers the variable transport costs (e.g., compressor fuel). Again basing the calculation on 1990 costs and 1989 deliveries the transport tariff can be calculated. The estimated values are shown in Table V-2.

5.22 At this stage it is recommended that tariffs should not be related to distance of transport even though the costs of transport increase with distance. This is for reasons of simplicity because the gas flows are often complicated and at present there is no way to monitor these distances. Interruptible customers will again be charged only the volumetric part of the tariff.

5.23 It is recommended that the retail tariff structure distinguish four groups of customers: residential, commercial and small industrial, large industrial, and district heating. The industrial customers have already been taken into account through the bulk supply and transport tariffs. For the smaller retail customers a two-part firm tariff is recommended. The first part would be a monthly demand charge that varies by customer class. Every customer in the same class would pay the same monthly charge while they remain connected to the system. This charge would cover various fixed expenses: annual customer charges such as billing and meter maintenance; fixed distribution expenses and fixed transport charges incurred by the LDCs. Although setting only four separate sets of tariffs would mean that not every individual would pay their exact marginal cost, it is necessary, for the sake of simplicity, that only a few sets be used. With more information on customer types (e.g., by region) a more varied set of tariffs could emerge. The total fixed charge is calculated by adding together the sum of the proposed investments, a return on the existing assets, and 1990 estimates of overhead costs. Per customer retail demand charges were computed by dividing these expenses by weighted customer totals. The weights ensure that each customer class receives a share of total costs proportional to its utilization of the distribution system. The second part of the tariff is a variable charge based on the actual amount of gas used and would have separate winter and summer prices. The summer price would include the variable distribution cost, the variable transport cost, and the annual gas price. The winter charge would in addition include the storage-based holding charge. Residential customers should be subdivided into space-heating and non-space-heating customers. Because of the large number of meters and the infrequency of meter reading, these customers would pay the same variable charge all year. With regard to connecting potential non-space-heating customers—who would use gas only for cooking—the gas company would have to consider whether it is economically feasible to make the investment in the distribution system and to undertaking the operating expenses for the relatively small amount of gas (150 cubic meters) such customers would consume. The costs and proposed tariff for the residential sector thus must be carefully analyzed to avoid penetration into an economic environment not viable for the company. Table V-3 shows the recommended retail tariffs for LDC customers.

Table V-3: Retail Tariffs for Local Distribution Company (LDC) Customers

Sector	*Monthly fixed charge (zlotys)*	*Summer variable charge (zlotys/m³)*	*Winter variable charge (zlotys/m³)*
High Methane			
Cooking/water heating	35,900	922	922
Space heating	282,400	922	922
Commercial/small industry	212,800	864	950
District heating	9,250,300	864	950
Low Methane			
Cooking	35,900	584	584
Space heating	282,400	584	584
Commercial	212,800	548	602
District heating	9,250,300	548	602
Coke			
Cooking	35,900	461	461
Space heating	282,400	461	461
Commercial	212,800	432	475
District heating	9,250,300	432	475
Town Gas			
Cooking	35,900	427	427
Space heating	282,400	427	427
Commercial	212,800	400	440
District heating	9,250,300	400	440

5.24 These tariffs are applied to representative units to obtain the expenditure under the proposed scheme and the expenditure that would be incurred under the existing scheme. It is assumed that customers made the following purchases of gas per year: residential cooking and water heating, 800 cubic meters; residential space heating, 4,500 cubic meters; commercial and small industrial, 3,300 cubic meters; and nonlimited industrial, 549,000 cubic meters. The results are shown in Table V-4.

Table V-4: Average Total Annual Bills for High-methane Natural Gas Customers (zlotys)

Class of customer	*Fixed charge (zlotys)*	*Summer variable charge (zlotys)*	*Winter variable charge (zlotys)*	*Total tariff*
Cooking				
Existing	24,000	17,250	17,250	58,500
Proposed	430,800	69,150	69,150	569,100
Difference (%)	1,695	301	301	873
Cooking/water/heating				
Existing	24,000	92,000	92,000	208,000
Proposed	430,800	368,800	368,800	1,168,400
Difference (%)	1,695	301	301	462
Space heating				
Existing	36,000	258,750	776,250	1,071,000
Proposed	3,388,800	1,037,250	3,111,750	7,537,800
Difference (%)	9,313	301	301	604
Commercial/small industry				
Existing	50,400	777,000	1,540,000	2,360,400
Proposed	2,553,600	950,400	2,090,000	5,594,000
Difference (%)	4,967	23	36	137
Large industry				
Existing	142,135,000	76,767,480	203,842,560	420,745,040
Proposed	422,800,000	156,384,000	349,600,000	928,784,000
Difference (%)	197	109	72	121

5.25 The tariffs and average expenditure shown in Table V-3 and Table V-4 are for large limited industrial companies with meters and devices for recording hourly flow. Companies that are nonlimited and whose usage is measured solely by meters should be charged in a different way. There should be a two-part tariff with a fee for each unit of daily capacity as determined by the size of the meter. The variable charge would be the variable charge faced by residential and commercial retail customers. The retail tariff for large industrial nonlimited customers is shown in Table V-5.

5.26 The tariff scheme proposed is likely to encourage nonlimited industrial companies to request flow meters so that they can receive the lower transport and bulk supply tariff offered to limited customers. The reason for this lower charge is that existing limited customers do not utilize distribution facilities. Any retail industrial customer wishing to bypass its distribution company should pay for the interconnection with the transport pipeline.

Table V-5: Tariffs for Large Industrial LDC Customers (zlotys/m^3)

Fuel	*Monthly fixed charge (zlotys)*	*Summer variable charge (zlotys)*	*Winter variable charge (zlotys)*
High methane	2,079	864	950
Low methane	7,660	548	602
Coke	6,039	432	475
Town gas	5,598	400	440

5.27 The restructuring proposals presented in chapter 4 recommended that LDCs should operate the town gas networks. Accordingly it is proposed that town gas customers should pay the general retail price, and this has been incorporated in the above calculations.

5.28 The tariffs proposed above would produce large percentage increases in gas prices if they were introduced immediately. The issue of transition is discussed in the last section of this chapter, but it is useful to compare these prices, as possible long-run targets, with the levels of current prices in other countries. Average prices are determined by the individual tariffs and by the pattern of gas consumption. Exchange rate variations also make exact comparisons difficult. The comparisons given here are indicative rather than a precise guide.

5.29 Table V-6 shows delivered prices (1988) before tax for six European OECD countries for industrial consumers, power generation, and for households.

5.30 These tariffs are to be compared with the proposed values for Poland, which, weighted by the present structure of consumption, would produce an average price for industry of $110 per 1,000 cubic meters at an import gas price of $80 ($135 at an import price of $100). Proposed prices for households would range between $210 and $235 in these two scenarios. The proposed household price is certainly likely to be lower than that in Western Europe despite the very large percentage rise shown in Table V-4.

5.31 When compared to economic costs (usually based on border prices), energy prices in Poland are too low. Furthermore relative prices do not reflect the relative costs of the delivery of different fuels to the consumer. A comparison of relative prices for industrial and household consumers in Poland and in the OECD countries is shown in Table V-7. It shows that for industry the prices of other fuels relative to steam coal are higher than in Western Europe, with coal being underpriced. In the electricity and gas sectors the relatively high prices for industrial consumers are used to cross-subsidize prices for households with the result that the relative prices of these fuels are lower than in Western Europe. This shows why the figures reported in Table V-4 show the largest percentage rises for households. (It should be noted that these relative price figures for Poland were calculated for the situation after July 1990 when there were substantial increases in the prices of electricity and gas to households).

Table V-6: Delivered Natural Gas Prices in Selected OECD Countries before Tax (US$/1,000m³)

Country	*Industry*	*Power*	*Households*
Belgium	105	85	265
France	122	NA	331
Germany (FRG)	122	114	254
Italy	82	59	338
Netherlands	149	NA	215
United Kingdom	NA	210	230
WEIGHTED AVERAGE	116	117	272

5.32 The revised tariffs will raise the expenditure on gas, and increases in other fuel prices will produce an overall increase in the share of the household budget used to purchase fuel. However, the share of household expenditure on gas is low, around 0.5 percent, and thus the substantial increases in tariffs will have only a modest impact on the total cost of living. Households using gas only for cooking, where the current bill is 0.4 percent of the existing average wage, will not be much affected. Households that also use gas for water heating would find that their total payments for gas would rise to between 6 and 8 percent of the present average wage. This impact would be modified if they economized on the use of gas. Households that use gas for space heating would face the largest increases. The current gas heating costs of 8.5 percent of the average wage would rise to about 50 percent of the average wage. There are only 350,000 households that use gas for space heating and these are usually high-income single families with high per capita housing space, for whom the costs would be a lower proportion

Table V-7: Relative Fuel Prices in Poland and in the OECD Countries (Price of 1 GJ of Steam Coal for Power Plants = 1)

	Industry		Household	
Fuel	Poland	OECD	Poland	OECD
Steam coal	1.2	1.1	1.8	3.7
Fuel/heating oil	2.5	1.4	NA	2.9
Natural gas	3.2	1.6	1.4	3.2
Electricity	10.3	[illegible]	8.3	11.0

Note: The use of heating oil in Poland as a household fuel is negligible.

of their income. They would be able to minimize the increase in their costs by heating a smaller part of their total housing space. At present the average consumption of households with gas space heating is higher in Poland (4,000 to 4,500 cubic meters) than in Western Europe (3,200 cubic meters), which suggests that despite the climatic differences, the very low price of gas encourages an unnecessarily high use of gas for space heating.

5.33 There may be households for whom the rise in gas costs would be very severe, particularly during the period of transition of the economy. If it is necessary to protect these people, it would be best to do so either by an income subsidy or by a subsidy to help with the fixed costs of the tariff. It is important not to subsidize operating costs because such an action would send the incorrect signals for the demand and supply of gas.

5.34 Because gas is used as an input to many economic sectors, the proposed increase in gas prices will be passed on in the prices of other products. The total effect on prices can be analyzed by using the pricing impact model developed within the UNDP/World Bank Project on Energy Planning. In the short term it is assumed that the price changes do not bring about substitution between production factors or between fuels. In the longer run in a market economy firms will substitute away from higher price factors and this will reduce the impact on inflation. The possibility that wages adjust fully to the higher prices (thus forcing up labor costs and prices still further) and that the exchange rate adjusts to offset the loss of competitiveness of exports (thus increasing inflation via a higher price of imports) can also be taken into account. The results are shown in Table V-8 for the higher border price of gas.

Table V-8: Inflationary Impact of Gas Price Increases (% Change)

Wage compensation	Yes	No	Yes	No
Exchange rate adj	No	No	Yes	Yes
Consumer prices	4.2	2.4	5.1	2.8
Producer prices	5.2	3.2	9.1	6.6

5.35 The figures in Table V-8 represent the highest case—the highest likely border price of gas is used and no substitution between factors or fuels is allowed. It is also assumed that prices are fully passed on while in a competitive environment strong competition from imports will reduce this effect. Only if increases in energy prices were used as an excuse for uncontrolled price increases (as in 1988) or for a substantial increase in real wages (as in 1989) would the effect on the rate of inflation be large.

Financial Viability of the Gas Sector

5.36 The tariff proposals set out were designed to ensure that each sector is able to finance the costs of continuing in operation, including the replacement of existing capacity and investment in new capacity. Individual companies engaged in transportation and distribution may experience poorer than expected results, or even experience losses, over short periods, for at least three reasons. The first reason is that actual costs may be higher than the anticipated costs at the time the tariffs were actually set. The second reason is that prices may be subject to regulatory controls that assume cost and efficiency levels for the sector that it is unable to achieve. The third reason is that demand may fall below the level expected so that revenue suffers. It is important to organize the companies so that they can deal with these fluctuations, which are likely to become less severe as more experience is gained of the free market behavior of consumers and of the firms themselves. In the production sector, where exploration is by its nature risky, there will certainly be the possibility for losses although companies would expect to make a larger margin on capital to compensate them for the risks. The involvement of foreign companies in this sector would also help to spread such risks.

5.37 The effect on public finances begins with the presumption that initially the component parts of the Polish gas sector are publicly owned. This would be followed by a sequential privatization after restructuring has taken place. The requirement that the sector be self financing, even though the actual conditions for imports are still uncertain, means that there is unlikely to be a net transfer of funds from the treasury. On the contrary, through taxation and the sale of assets and companies, there should be a return of funds to the treasury.

5.38 The issue of taxation to acquire excess profits for the Polish people occurs only after privatization, and interacts with the success of privatization, since excessive taxation would reduce the interest of any potential buyer. There are two major sources of "economic rent" (profits greater than those needed in order to keep the business running efficiently) in the Polish gas sector. The first is the rent that would accrue to any domestic gas producer whose costs are less than the domestic gas purchase tariff. The second is that which may accrue to the LDCs or the transport company if price rationing were used to alleviate problems relating to shortages and excess demand. It is preferable to let any such rents accrue to the transport company since it avoids treating the various LDCs differently and it also gives the government a better opportunity to secure the rent.

5.39 The government can also raise large funds by committing to the gas service prices in excess of costs and then selling the assets at the higher values that would result (which is in effect an indirect tax on gas consumption). An alternative way to achieve the same end would be to burden the new company with a debt, interest on which is payable to the government. The extra cost of the debt would be reflected in higher gas prices. The offset to these possibilities, which are not justified in resource allocation or efficiency terms, would be the higher level of inflation that would result. Also, given that it is desirable to encourage the use of gas because it causes less pollution, unnecessarily high prices would have undesirable side effects on the environment.

Taxation

5.40 It is assumed that the gas sector would be subject to the same forms of general taxation on profits, income, and employment as other sectors of the Polish economy. The purpose of this section is to consider whether there are any grounds for additional taxes specific to the gas sector.

5.41 Economic rents (profits in excess of those needed to provide the incentives for production) can arise with the production and sale of a natural resource. The major example is the Polish gas deposits that the state as owner appropriates. Rents also arise due to the presence of monopoly power as in the case of the transportation and distribution networks. These rents can either be allowed to materialize through earning excess profits or else the government can suppress them through regulation. The former also would distort the efficient pricing and allocation of resources and there is also a tendency to try to conceal such profits by inflating staff and other costs. The regulation of such cases is discussed below.

5.42 There are several alternative ways to attempt to capture the economic rent from exploration and production. The simplest approach is to auction the rights to explore and produce on a field-by-field basis. Participants would estimate their costs and likely benefits and these would determine the maximum they would be prepared to bid (which would equal the rent they would expect to receive from the field). Such an arrangement would result in the government obtaining all the rent while not interfering with the incentives to produce efficiently. The effectiveness of such a scheme is reduced if the companies' expectations are incorrect (they might bid less than the actual rent) or if they use a very short time horizon to obtain quick profits (thus placing heavy weight on early production from the field). Bidders may also anticipate that the government would change the regulatory and tax system if the exploration turned out to be very successful, or if the price of gas were to rise sharply. In such a case they would underbid even if the government had no intention of altering the system. If the price did rise sharply, then the unforeseen profits earned by the company would be a target for the government.

5.43 The first alternative or supplementary approach to an auction scheme is the use of joint ventures (assuming that the public sector would be less efficient than a private firm in exploration and production). This spreads the risk and may encourage more investment, but it does not allow all of the rent to be captured. Additional financial instruments would be required to attempt to capture all the rent.

5.44 One method for capturing the rent is a revenue tax (which could be progressive to reflect the fact that rent tends to be larger on larger fields). If a field turns out to be more productive than expected or if prices rise unexpectedly, then the tax captures a share of this extra rent. The disadvantages of revenue taxes are that (a) they distort the marginal incentive to produce (and would distort the bidding if used in conjunction with an auction system), (b) they do not remove the burden of risk from the company, and (c) they ignore cost conditions and by averaging they risk the nonexploitation of reserves that could be brought to the market at lower cost than imported gas.

5.45 A more desirable form of tax would be a profit tax since this is affected by cost conditions and is targeted on the economic rent itself. However, it also suffers from the disadvantage of not being field specific and it will only capture part of the rent from an unexpected rise in prices. Finally there is an incentive for the firm to inflate its costs in order to reduce stated profits. If profits taxes are to be used to supplement the auction system then it is preferable that they be progressive with the lowest rate at zero so that the incentive to supply incremental gas is not weakened. The highest rate should not be such that when combined with the general corporate tax, incentives were severely weakened.

Regulation

5.46 The nature of the downstream gas industry is such that there is inevitably a degree of monopoly power in the transmission system and local monopoly power in the local distribution system. There is no way in which either of these markets can be made directly competitive. Hence if they are to be returned to the private sector it is necessary to ensure that their behavior does not result in a misallocation of resources. Hence a regulatory authority is needed with legal powers to control the actions of these sectors.

5.47 It is recommended that there be only a single regulatory authority for the gas sector. This would promote consistency in dealing with the various LDCs and also allow the introduction of comparative competition by some form of "yardstick" regulation if so desired. Whether the same regulatory authority should cover the entire fuel sector is more complex, although a shortage of skilled resources, particularly in the immediate future, would support such a point of view.

5.48 The object of a regulatory authority is to ensure that the regulated firm behaves as if it were operating in a competitive environment. This requires a balance between incentives for the firm to produce efficiently and the need to protect consumers from unnecessarily high prices. It is also important to make sure that the quality of service (e.g., speed of connection, customer complaint mechanisms) does not deteriorate and to prevent the firm from discriminating between different customers (e.g., buying gas at a lower price from low-cost producers than from high-cost producers).

5.49 The most important constraint preventing the regulatory authority from carrying out this program is the availability of information. Without detailed knowledge of a firm's practices, the regulatory authority cannot properly assess a firm's claim that high prices are needed to generate enough profits given the (possibly) inflated cost levels. It is also necessary, for regulation to be successful in the long run, that the actions of the regulator be set by predetermined rules. If the regulator can change the rules for intervention whenever it pleases, then the incentive for the firm would be much reduced—for example, innovation or cost-cutting plans would lose their appeal if the regulator could change the rules to absorb any resulting profits.

5.50 Legislation is required to provide the regulatory body with enough powers to carry out its duties, but first it is necessary to define what these duties are, in terms of the protection of the consumer and the ability of the regulated firm to earn enough profit to finance its business.

5.51 The principle object of the regulator will be some form of price control. However, the regulator will not have enough information to know exactly what the price should be. Knowledge of the profit level will not be adequate because managers can conceal overhigh prices by inflating their costs by, for example, paying themselves and their staff larger salaries, increasing staff benefits, and so on.

5.52 One method of price control is through "cost of service" or "rate of return" regulation. This allows firms to set prices, which for their given costs yield a specified return on investment capital. The parties can determine together acceptable levels of costs, the value of capital assets, and the appropriate rate of return. This system ensures the financial viability of the regulated firm. The main disadvantage of this approach is that it offers little incentive to the firm to cut its costs because any such gains are retained by the firm only for a short period, depending on the length of the regulatory review. It also encourages overcapitalization because it is only by increasing the capital base that a greater total profit can be sustained in the long run.

5.53 The alternative method of regulation removes the dependence of prices on costs and the size of assets by imposing a "cap" on prices. This gives the firm every incentive to innovate and to improve efficiency because it can retain the profits. The difficulty with this method is to choose a price cap that will allow the firm to earn normal, but not excess, profits. Changing circumstances also need to be taken into account. This can be allowed for by permitting the price cap to change in line with the cost of certain pre-specified items. In the context of the transport and distribution companies price caps should be adjusted in line with the general level of retail prices and changes in the input cost of gas. It is also necessary to periodically review and adjust the price cap on the basis of identifiable costs, which will inevitably involve consideration of the rate of return. Hence the price cap has some of the elements of "rate of return" regulation with a longer (and pre-specified) regulatory lag, which might be every three or five years under normal circumstances.

5.54 In the case of distribution companies, once they have been established as separate private entities, it would be possible to use "yardstick" competition (i.e., each firm would be required to match the achievements of the rest of the industry).

5.55 It is important for the regulatory body also to preserve the quality of service. Firms subject to price cap regulation have a natural tendency to lower unit costs by lowering the quality of service (since they cannot benefit from improved services by raising prices to the levels that consumers would be willing to pay), to increase profits. The regulatory authority must be able to monitor various aspects of service (e.g., the speed of connection, the number of customer complaints) and must have the power to "punish" the firm through adjustments to the price cap if there is a marked deterioration in the quality of service.

5.56 The ability of the regulatory authority to increase efficiency by encouraging competition is rather limited in the gas sector, although there may be opportunities to allow large firms to buy gas directly from the transportation company, which would put pressure on the distribution companies to keep prices low enough so that this is not an attractive option.

5.57 Discrimination by undue preference toward producers or industrial customers should be explicitly prohibited in the firms' licenses, and at the same time it should be the duty of the regulator to curb any such practice. To do so the regulator must have the powers to obtain and verify the information possessed by the companies.

5.58 Regulated firms that also carry out unregulated business present a particular difficulty because of the possibility of cross-subsidization. Overheads and other types of capital expenditure may be appropriated to the regulated business in order to justify increasing its prices. It is important that the regulator have sufficient power to check the allocation of such costs between the various parts of the firm's business.

5.59 A set of detailed proposals for the formal duties and powers of the gas regulatory authority is set out in appendix A, and a set of regulatory information requirements are set out in appendix B.

Transitional Arrangements

5.60 The pricing discussion indicates that there are two distinct phases in the transition. First there is the phase of restructuring and the move to efficient pricing by the publicly owned gas companies. The tariffs discussed above are viewed as the prices that publicly owned companies should charge in order to obtain the maximum economic efficiency. These prices will also provide a starting point for the companies once they are privatized. The shorter the period of public ownership, the less time is available to adjust prices to these ideal levels. The experience gained in using and setting these tariff structures is likely to be important because this will be carried over to the private sector and the market-oriented reasoning underlying them (e.g., ensuring that capital costs are properly taken into account) will be needed at that stage.

5.61 Once the companies have been privatized then these tariff schedules will not be operative, although the general principles of two-part pricing could be retained by legislation. The various LDCs will gradually set different prices so that an important part of the second transition during the early years of private ownership would be to ensure that regional prices did not diverge to an unacceptable degree.

5.62 More difficult issues for the first transition period, when prices are raised toward efficient levels, occur in the macroeconomic context. The price increase will have an impact on the rate of inflation, which may be reflected in higher wage claims. It is important to recognize that the alternative of not raising final gas prices, when the price of imported gas has risen, would require a government subsidy, and that the associated fiscal deficit would also stimulate inflation. The parallel case of coal will be important, since the more rapidly coal prices are allowed to rise toward border prices the easier it will be to do the same for gas.

6. ENVIRONMENTAL ASPECTS OF THE GAS DEVELOPMENT PLAN

6.1 The Gas Development Plan is intimately tied to concerns about the environment in Poland. Pollution levels in Poland are exceptionally high and much of this is due to the nature of the fuels used and their associated technologies. In planning for the future, it is important to make allowances for the positive effect the use of gas will have on pollution. Where direct economic benefits are not strong enough to use gas to replace other fuels, it may still be best to encourage the use of gas because of the reduction in pollution that would result.

6.2 To show that it is desirable to encourage the use of gas beyond the point where a direct competitive market would lead, it is necessary to establish the facts about the levels of pollutants in Poland and to link these to the output of different fuels. It is then possible to estimate the pollution levels that would occur if gas were allowed to take up its "free market" position. Although this may result in a major drop in pollution levels, the total pollution level may still be above the acceptable threshold. In such a case it is possible to find the least cost ways to reduce pollution still further by encouraging the use of gas for applications where it would not penetrate if left to market forces.

6.3 This chapter begins with a brief outline of the pattern of energy supply and use in Poland. From this pattern emerges a picture of the emissions of various pollutants. The next step is to review the likely pollution levels that will occur if the Gas Development Plan is carried out and other fuels adjust in a similar way to free market conditions. Following this a methodology to assign values to the environmental benefits associated with gas use is described so that a comparison of the direct costs of extra gas use and the extra benefits of the associated pollution reduction can be made.

Energy and Pollution in Poland

6.4 Poland has a high energy intensity but this does not represent a profligate way of life—the primary energy use per capita was comparable with that for Western Europe in 1990. However, the ratio of primary energy use to Gross Domestic Product (GDP) was exceptionally high (almost 0.8 tonnes of oil equivalent [toe] per $1,000 compared with 0.4 toe per $1,000 in Western Europe). This is largely because coal is used in energy intensive industries such as power generation, steel, and engineering and for space heating by consumers (coal accounts for approximately 75 percent of all primary energy). This coal-dominated energy supply has changed little in the last decade and Poland still has one of the world's most coal-dependent economies.

6.5 The coal used in the power and heat sectors is of poor quality, which results in emissions of large quantities of dust and gases into the atmosphere. The coal has a high ash content, is high in sulfur, and has a low calorific value (most domestically used coal is unwashed). The effects of extensive use of this coal are shown in Table VI-1.

Table VI-1: Emissions of Gases and Dust by Fuel Type (1988)

Fuel	*SO_2*	*NO_x*	*CO_2*	*Dust*
Coal (shares)	68.7	36.6	57.8	74.0
Lignite	19.1	7.7	12.3	9.9
Oil	5.4	40.8	10.2	-
Gas	-	2.9	4.6	-
Coke	2.7	-	6.1	-
Other	4.1	12.0	9.0	16.1
TOTAL (million tonnes)	3.8	1.35	460.0	2.1

6.6 The data in the table confirm that coal is the dominant source of SO_2, particulates (dust or PM), and CO_2, but show that coal is a less dominant emitter of NO_x.

6.7 The sectoral distribution of emissions is shown in Table VI-3. The power sector is the major source of emissions. Emissions of SO_2, NO_x, and large particulates from tall stacks can be transported, and their effects felt, far from the power stations. Low stacks (which account for about half the emissions) are potential hazards to local air quality.

6.8 Data on trends in emissions for the period 1980 to 1988 suggest that for SO_2, NO_x, and CO_2 there has been a slight increase over time. Only for PM, because of removal plants, has there been improvement.

Table VI-2: Emissions of Pollutants by Voivodship in 1988 (tonnes/km²)

Voivodship	*SO_2*	*PM*	*NO_x*
Warsaw	35	35	19
Jenia Gora	49	21	5
Katowice	119	57	40
Konin	32	15	5
Krakow	35	33	19
Kegbuca	22	6	2
Lodz	44	47	19
Piotrkow	56	8	14
Tarnobrzeg	30	9	8
Poland (average)	12	7	4

6.9 The concentration of emission sources varies greatly across the country. Throughout the Katowice voivodship and in the cities of Krakow, Warsaw, Lodz, and Gdansk. Table VI-2 shows average emission levels for the worst voivodships and the Polish average in 1988.

6.10 Domestic pollution is also affected by the flow of pollutants into and out of the country. Table VI-4 shows "exports" and "imports" of pollutants estimated for 1988. Local concentrations of high net imports are also problems, but detailed data on pollution deposition are lacking for Poland.

6.11 A further pollution problem is the leakage and venting of methane from the gas system during exploration, production, transmission, and handling. For 1989 total estimated losses from the gas system were about 2.3 percent of production (14 PJ) compared with a world figure of 1 percent or less.

Table VI-3: Sectoral Emissions of Gases and Dust (1988)

Sector	SO_2	NO_x	CO_2	*Dust*
PPP (shares)	36.6	30.1	33.9	36.6
IPP	17.5	11.0	17.5	23.6
Other industry	7.5	24.0	17.6	17.5
MHP	2.1	1.8	2.6	2.5
Transport	1.1	11.8	3.0	<1.0
Residential/ commercial	18.9	21.3	25.4	19.4
TOTAL (million tonnes)	3.8	1.35	460	2.1

Much of this leakage is due to the age of the pipes, which are cracked and corroded. The pipes are expected to be replaced by 2000, so methane losses should decrease substantially. There is also leakage of methane from produced coal mine gas and from coal mines. Although methane contributes to global warming, its effects compared with those of CO_2 produced by combustion are only about equivalent to a factor of two by weight. Hence emissions of methane from the natural gas system (0.3 million tonnes) are equivalent to about 0.6 million tonnes of CO_2, about 0.2 per cent of Poland's annual emissions.

6.12 Some areas of Poland have more detailed figures on the ambient concentrations of major pollutants. Average levels for sites in Katowice and Krakow voidvodships are presented in Table VI-5. These figures must be compared with the national standards in Poland (which are somewhat lower than the WHO guidelines) for SO_2 and PM, shown in Table VI-5, Table VI-6.

6.13 Comparison of the data in these two tables shows that the averages for Katowice and Krakow grossly violate national standards; individual locations show even greater extremes of pollution.

Valuation of Environmental Benefits Associated with Gas Use

6.14 It is necessary to analyze the potential benefits of using gas more extensively as a way to reduce the high pollution levels to devise a method to trade off the costs associated with higher pollution, which would result if gas were not used, against the higher direct costs of the gas itself. The concept of "value in use" has been developed for such situations. The "value in use" is the opportunity cost or the economic value added by using gas. In situations when gas is the only fuel, the value in use is the value of the product less the cost of production, including the cost of the gas itself, properly defined. When an alternative fuel actually

Table VI-4: Exports and Imports of Pollutants (1,000 tonnes)

Flow of pollutants	SO_2	NO_x
Imports	1,008	123
Exports	1,032	165

could be used, then the value in use is equal to the difference in the costs of the gas and the alternative fuel after adjusting for other cost differences (the value of the product being the same).

6.15 Because gas is more environmentally friendly than other fuels, the inclusion of environmental concerns will generally increase the value in use of gas. Where the environmental benefit is larger in one use than in another, a change may occur in the ranking of priorities of projects for which gas should be used compared with that arrived at on a straight monetary basis.

Table VI-5: Ambient Concentration of Pollutants (mg/m³)

Voivodship and pollutant	*Annual average concentration*	*Heating season average concentration*	*Maximum daily concentration*
Katowice Voidvodship (1987)			
SO_2	61	98	480
PM	200	230	683
NO_x	107	117	342
Krakow Voivodship (1989)			
a. In the city			
SO_2	75	95	381
PM	62	95	333
NO_x	56	61	254
b. Outside the city			
SO_2	45	59	288
PM	40	56	311
NO_x	53	51	229

6.16 One of the central approaches to evaluating environmental damage has used the idea of dose-response functions. These attempt to establish the sensitivity of a particular damage category to changes in a particular pollutant, and then place a monetary value on the damage caused or avoided. This approach has been used successfully to assess damage to crops by SO_2 contamination. More recently a particular dose-response function has been increasingly utilized in such studies—this postulates that there is a "critical load" of pollution below which little or no detectable damage occurs. Above the critical load the incremental damage is assumed measurable and is treated as if it increases linearly with the load. The implication of the linearity assumption is that the marginal benefit of reduction in pollution is independent of the prevailing load of pollution (provided that the latter is above the critical level).

Table VI-6: National Air Quality Standards (mg/m³)

Pollutant	*Average annual concentration*	*Average daily concentration*
SO_2	32	200
PM	50	120
NO_x	50	150

6.17 The second step in the analysis is to assign a monetary value to the benefit of marginal reductions in pollution. A variety of techniques are available and have been used in different circumstances. Empirical studies carried out for OECD countries have a number of important implications for the approach to damage estimation:

- The estimates for a particular damage category can vary widely, so results must be viewed as being subject to considerable uncertainty.

- It is difficult to apportion the relative costs of damage among different pollutants where there is more than one pollutant; hence it can be difficult to link the benefit of reducing environmental damage to the reduction in deposition of individual pollutants.

- From existing studies it is not possible to conclude that a particular damage category dominates the costs of environmental damage.

From these points it can be seen that it is not valid to simplify the analysis of environmental damage by concentrating on one or two types of damage category alone.

6.18 The analysis of critical loads must be carried out for each pollutant and for each damage category. The study focuses on the categories as shown in Table VI-7.

Table VI-7: Pollutants and Damage Categories

Pollutant	*Urban areas*	*Rural areas*
SO_2 and NO_x	Health	Forests
	Buildings	Other
		Agriculture
Particulates	Health	

6.19 For CO_2 emissions the critical load approach is not appropriate since all emissions add to a global total that is well beyond any threshold effect. The assumption is that SO_2, NO_x, and particulate concentrations are not sufficiently high to damage health or buildings in rural areas. The main damage from particulates is related to the inhalation of suspended particulate matter, which affects respiratory functions.

6.20 To derive an estimate of the change in the value of gas that results when environmental considerations are included, it is necessary to identify the change in emission of each pollutant per Btu of gas substituted for another fuel (also allowing for indirect changes in emissions further back in the fuel supply chain) and then to place an economic value on the changes in the levels of emission for each damage type. The identification of changes in emissions per Btu of gas substitution should not only account for changes at the point of fuel combustion but also for changes in the emission of SO_2, NO_x, PM, and CO_2 from further back in the supply chain (e.g., NO_x emissions from compression stations on the gas transmission network, or NO_x and PM from the transport of coal). In practice these indirect effects are small—fuel use in the supply of gas is less than 1 percent of the energy content of the gas transmitted—and they can be ignored.

6.21 For the valuation of the emissions the benefit of the reduced emission in a given application will be set by the lesser of (a) the cheapest means of reducing emissions in the specific application, other than by gas substitution or (b) the monetary value of the change in emission levels that would be caused by the substitution of gas in the application.

6.22 The benefit of reduced emissions in the given application might arise either in the form of reduced marginal damage costs or in the form of displaced expenditure on abatement of other emission sources at the margin, or a mixture of both. Gas cannot be credited with the full value of (b) if it is cheaper to reduce the emissions by another means, such as by the installation of pollution abatement technology, nor can it be credited with the benefit of avoiding the full cost of abatement if the monetary value of the damage itself were less.

6.23 To produce results it is necessary to make some simplifying assumptions:

- Emission sources are divided into high- and low-stack sources and costs of abatement are analyzed separately for each category.

- The geographical dispersion of pollution sources is separated into rural and urban so that there are four possible patterns of dispersion (e.g., from high-stack to rural).

- Such a high proportion of the pollution deposited in Poland is above the critical load that little error is introduced by assuming that all pollution abatement reduces damage.

- Monetary damage functions are linear functions of deposition above the critical load so that the marginal value of a ton of avoided deposition is the same wherever this takes place, irrespective of the severity of pollution in a particular location.

6.24 A consequence of these assumptions is that the benefit of reducing a ton of emissions from each high-stack source is identical whatever the location of the source (which does assume that an equal weight is given to the exports of pollution). A similar rule holds for low-stack sources—the different dispersion coefficients for the two sources means that the benefits from reducing pollution from them are not necessarily equal. Hence for a particular source of emissions an equation can be written:

> Value of reduced emissions from high stack = [Effects of high-stack emission on urban depositions x the lesser of {the marginal costs of abating urban depositions, urban marginal damage}] + [Effects of high-stack emission on rural depositions x the lesser of {the marginal costs of abating rural depositions, rural marginal damage}]

6.25 A critical element in the analysis involves the assumptions about the dispersion coefficients from the high- and low-stack sources to rural and urban locations. In the absence of more detailed information it is assumed that the deposition in other countries of pollutants that arise in Poland has the same rural/urban split as in Poland and that the marginal damage cause is the same as in Poland. For dispersion coefficients, see Table VI-8, which shows that 25 percent of the SO_2 from low-stack emissions is deposited in urban areas and 75 percent in rural areas.

Table VI-8: Assumed Dispersion Coefficients

Pollutant and source	*Dispersion coefficient*	
	Urban	*Rural*
SO_2 and NO_x		
High-stack sources	0.05	0.95
Low-stack sources	0.25	0.75
Particulate matter		
High-stack sources	0.05	0.95
Low-stack sources	0.45	0.55

Pollution and Environmental Targets

6.26 To evaluate the range of possibilities for air pollution, three scenarios were evaluated: (a) The Base scenario assumes that the national energy system develops to meet expected growth while optimizing the use of fuels and technologies according to costs—within the limits imposed by the need to meet national environmental targets. (b) The Do Nothing (DN) scenario imposes no environmental constraints. (c) The Gas scenario assumes that gas supply is unlimited—imports of LNG representing the marginal supply. Table VI-9 shows the total and energy industry emissions for the 1980-90 period and the three scenarios.

6.27 Unconstrained emissions of SO_2 in the DN scenario are projected to rise; NO_x levels will increase even faster (largely because of rapid growth in road transport). PM emissions should decline because of fuel switching.

6.28 To achieve the target levels of pollution emission in the Base case or the similar Gas case would require major reductions in the power sector. SO_2 emissions need to be 60 percent below the 1980 level, and PM levels need to be 74 percent down. If these targets are to be met by alternative fuel use, the additional discounted costs would be 213 billion zlotys (1984 prices) for the Base case and 188 billion zlotys for the Gas case—approximately $1 billion or $0.9 billion in 1990 prices.

Table VI-9: Pollutant Emissions: Historical Record (1980-90) and Three Scenarios (million tonnes)

Scenario/year	*SO_2*	*NO_x*	*PM*	*CO_2*
Historical record				
1980	3.6 (2.6)	1.3 (0.6)	2.9 (1.7)	460 (247)
1988	3.8 (2.9)	1.4 (0.6)	2.1 (1.4)	460 (265)
1990	3.2 (2.6)	1.1 (0.5)	2.0 (1.4)	377 (230)
Do nothing				
2000	3.3 (2.6)	1.5 (0.6)	1.7 (1.1)	430 (264)
2010	3.8 (3.1)	1.8 (0.7)	1.5 (1.0)	511 (317)
Base case				
2000	2.5 (1.8)	1.4 (0.5)	1.3 (0.8)	427 (260)
2010	1.8 (1.1)	1.6 (0.6)	0.9 (0.4)	473 (279)
Gas case				
2000	2.5 (1.8)	1.4 (0.5)	1.3 (0.8)	423 (256)
2010	1.8 (1.1)	1.6 (0.6)	0.9 (0.4)	474 (280)

Note: Figures in parentheses are for the energy industries.

Future Air Pollution and the Gas Development Plan

6.29 To quantify the environmental impact of the Gas Development Plan the net reduction in emissions as a result of displacing coal or oil by gas are estimated. The emission factors for gas (NO_x and CO_2) and those for the fuels replaced depend on the applications themselves. Small consumers generally use better-quality coal (with lower SO_2 and PM) than large consumers, gas competes with oil in industry, and it is assumed that new coal-fired power plants will be fitted with flue gas desulfurization (FGD) equipment and other equipment to reduce pollution. Table VI-10 shows the emissions of various pollutants that would be avoided by the adoption of the Gas Development Plan.

Table VI-10: Avoided Emissions Arising from Adoption of the Gas Development Plan

		Emissions Avoided (tonnes)			
Source	*Additional Gas Volume (PJ)*	*SO_2*	*PM (10^3*	*NO_x (10^3)*	*CO_2*
Residential					
Gas stoves	21	19	13	<1	1.4
New consumers	161	121	85	19	7.5
Small DH plant	47	35	24	6	2.2
Commercial	84	63	45	9	3.9
Industry	265	158	0	64	5.1
Power					
Existing	120	157	71	15	5.3
New	360	84	12	56	23
TOTAL	1060	640	250	170	48

6.30 To reach a more complete picture of the levels of pollution in Poland an allowance has to be made for the transboundary flows of SO_2 and NO_x. A simple extrapolation based on existing emission scenarios taking into account supply and demand as well as national targets for emission control suggests that by 2000 the imports of SO_2 will have fallen from 1.062 million tonnes in 1988 to 0.762 million tonnes, and that for NO_x imports will fall from 1.492 million tonnes to 1.225 million tonnes. After the year 2000 it is assumed that imports will remain constant reflecting a balance between growth of demand and pollution control. For exports it is assumed that for SO_2 there will be a continuing decline until 2010, while for NO_x there will be an initial decline followed by a return to the levels of 1988. The overall production, import, and export figures are shown in Table VI-11.

6.31 From the figures for emissions and the net trade in transboundary flows, figures are calculated for pollution loads (the amount eventually deposited in Poland). It is assumed that there is no PM flow into or out of Poland. Table VI-12 gives the projected values.

Table VI-11: Exports, Imports, and Domestic Emissions

	Sum of domestic Emissions and imports			*Exports*		
Pollutant	*1988*	*2000*	*2010*	*1988*	*2000*	*2010*
SO_2	4.83	3.28	2.56	1.02	0.69	0.54
NO_x	2.84	2.62	2.86	1.52	1.40	1.53

6.32 Estimating the regional impact of reducing pollution requires a model of the regional impact of all flows. This is not available, so it is assumed that loads are reduced pro rata across the country. Table VI-13 gives projections of concentrations of pollutants in Katowice and Krakow voivodships in 2010 on the basis of a 47 percent reduction of SO_2, a 60 percent reduction in PM, and no change in NO_x. These levels correspond to the highest- and lowest-polluting areas in the samples.

6.33 The data in the table must be compared with critical load estimates to see if pollution is likely to be reduced below the critical level in these areas, which are among the worst in Poland.

Table VI-12: Projected Pollution Loads (million tonnes)

Pollutant	*1988*	*2000*	*2010*
SO_2	3.8	2.6	2.0
NO_x	1.3	1.2	1.3
PM	2.1	1.3	0.9

6.34 Table VI-14 gives critical loads for various pollutants for the different damage categories as assessed for a series of studies in Europe. It appears that the critical loads for damage in materials and health would still be exceeded for all pollutants in both voivodships for at least part of the year. The projected levels of PM concentration are of particular concern; by comparison the current urban concentration in the UK is about 15 mg/m^3 and for SO_2 it is less than 40 mg/m^3. More detailed assessment of the pollution values for individual areas suggests that the figures are fairly accurate; certainly accurate enough that the prediction that pollution will exceed the critical load level is correct.

Alternative Methods of Emission Control

6.35 Despite the extensive substitution of gas for other fuels foreseen in the Gas Development Plan, pollution will remain high in 2000. Hence, an analysis of alternative abatement costs is used (a) to consider the cheapest alternative cost in any application; and (b) to examine the marginal cost of abatement for a given target level of reduced emissions.

6.36 The analysis includes separate estimates for the high- and low-stack sectors because the damage is different in each. The analyses are integrated once the overall strategy for pollution abatement is considered.

6.37 **High-Stack Emissions.** Substantial emissions are produced by the power and district heating industries (for which about two-thirds of sources are high-stack emissions). To set figures for environmental credits for pollution abatement it is necessary first to obtain the marginal abatement costs for a target level that is broadly consistent with reaching the critical loads. The target levels used in this report are those of current Polish policy: 30 percent for SO_2, 50 percent for PM, and 10 percent for NO_x.

6.38 For SO_2 the lowest-cost way to reduce emissions by 5 percent in the period 2000-2010 is to use high-quality hard coal instead of high-sulfur lignite for power generation. Improving energy use efficiency can lead to a reduction of SO_2 emissions. A reduction of more than 30 percent can be achieved by reducing the ratio of energy consumption to GDP to the levels in Western Europe. On the other hand, a 30 percent reduction would require coal preparation and extensive use of flue-gas desulfurisation (FGD) facilities in new and existing power and district heating plants. About 60 percent of Polish coal used in the high-stack sector is unwashed, so there is considerable scope for improvement in quality and calorific value. The methods, processes, and equipment for these procedures are well established and are already in use in some Polish plants. The waste from cleaning the coal, which is largely fine solids suspensions, will be localized and in principle is amenable to straightforward treatment. A number of FGD technologies are available for reducing SO_2 emissions. Regenerable systems, which have essentially no waste products, are environmentally attractive, but their costs are high, and they could present problems for disposal of the sulfuric acid produced. Nonregenerable systems use limestone or lime as the

Table VI-13: Projected Ambient Concentration of Pollutants, Two Voivodships, 2010 (mg/m^3)

	Concentration (milligrams per cubic meter)		
Voivodship/ Pollutant	*Annual average*	*Heating season average*	*Daily maximum*
Katowice			
SO_2	10-60	20-90	60-600
PM	60-90	80-220	210-630
NO_x	80-180	90-190	160-760
Krakow			
SO_2	10-50	20-70	60-270
PM	20-60	20-90	100-340
NO_x	50-60	50-60	230-250

Table VI-14: Critical Loads for Major Damage Categories

Damage category	*Critical load*
Lakes	
Acidic lakes	320 mg S m^{-2} y^{-1}
Susceptible lakes	800 mg S m^{-2} y^{-1}
Crops	
Rye grass (SO_2 sensitive)	10 mg SO_2 m^{-3}
Forest	
Leaf damage	50 mg SO_2 m^{-3}
Nutrient imbalance	100 mg N m^{-2} y^{-1}
Soils	
Sandy soils	240 mg S m^{-2} y^{-1}
Other soils	480 mg S m^{-2} y^{-1}
Groundwater	50 mg NO_3 m^{-2} y^{-1}
Maternity	20-30 mg SO_2 m^{-3}
Human health	40-60 mg SO_2 m^{-3}
	40-60 mg PM m^{-3}
	150 mg NO_x m^{-3}

agent to combine with the sulfur dioxide and produce a sludge from which dry gypsum can be produced for sale. For an existing plant the cost of a wet-waste FGD process is about $1,100 per ton; this is the marginal technique needed to achieve the 30 percent reduction in SO_2, so this cost is taken as the marginal cost of abatement.

6.39 For PM reduction the use of retrofitting and electrostatic precipitators at existing power and heating plants, as well as upgrading and better maintenance of existing plants, are all possible methods of improvement. However, the marginal cost of abatement to the level shown will be determined by FGD costs—and the marginal costs of abatement of PM are estimated at $250 per ton.

6.40 For NO_x it is assumed that all new plants will have low-NO_x burners and that old plants will be retrofitted by 2000. This would maintain current levels of NO_x emissions. Achieving the target reduction would require use of Fluidised Bed Boilers, which have an abatement cost of $9,000 per ton.

6.41 **Low-Stack Emissions.** Emissions from low-stack sources are the major cause of air- pollution-related damage to human health and buildings. Options for reducing emissions:

- Energy efficiency in all sectors
- Coal preparation for all coal users where coal is currently unwashed
- Modification of existing coal-burning equipment or new installations
- Switching from coal or high-sulfur fuel oil to low-sulfur fuel oil where possible
- Retrofitting boilers with pollution control equipment
- Conversion of existing boilers for fluidised bed combustion.

6.42 Measures to improve energy efficiency will also reduce emissions of SO_2, PM, and NO_x because they reduce fuel consumption. The use of clean coal technologies such as fluidised bed combustion will have similar effects. Coal preparation and switching from coal to low-sulfur fuel oil will reduce emissions of SO_2 and PM, while switching from high-sulfur fuel oil to low-sulfur fuel oil will reduce only the SO_2 emission. Of the options mentioned above, switching from coal or high-sulfur fuel oil to low-sulfur fuel oil and retrofitting boilers with pollution control equipment are not realistic options for the majority of low-stack sources located within urban centers, but they may feature in reductions from medium-size industrial sources.

6.43 Opportunities exist to improve energy efficiency in industrial processes, buildings, vehicles, domestic appliances, and so forth, and experience in Europe suggests that the economic potential for improving energy efficiency in end-use sectors is substantial. However, there are substantial barriers to improving energy efficiency, and it is likely that incentives and public programs will be needed to bring about significant improvements in Poland. A significant number of energy efficiency improvements will be cost effective, but it may be worthwhile, for the sake of pollution abatement, to undertake energy efficiency measures that are not directly financially attractive. Experience suggests that in the timescale of the Gas Development Plan only about a 20 to 30 percent improvement will be achieved and that this will not reduce pollution to the critical load, leaving the cost of marginal emissions reduction unaffected.

6.44 One relatively straightforward way to reduce SO_2 emissions is to switch from high-sulfur fuel oil (2.5 percent sulfur) to low-sulfur fuel oil (1 percent)—at current prices this implies a cost of about $500 per ton of SO_2 reduction. An additional option is to switch from coal to low-sulfur fuel oil in large boiler applications at a cost of about $4,000 per ton of SO_2 reduction. These margins are very sensitive to shifts in relative fuel prices—a 10 percent fall in the coal price and a 10 percent increase in the fuel oil price would increase the cost of SO_2 reduction by about 40 percent. Switching from coal to low-sulfur fuel oil would also virtually eliminate PM emissions from this source at a cost of about $2,000 per ton (on the basis of fuel prices used in the GDP). The key strategic question is whether it would be wise to encourage widespread switching to fuel oil given Poland's reliance on imported oil and the uncertainties of the world oil market.

Table VI-15: Marginal Costs of Abatement ($ per ton)

Source/ pollutant	*Cost ($/ton)*	*Assumptions*
High-stack		
SO_2	100	Assuming 30% reduction target
PM	250	Assuming 50% reduction target
NO_x	9,000	Assuming 10% reduction target
Low-stack		
SO_2	9,000	Ignoring assumed benefit from PM reduction
PM	6,000	Ignoring assumed benefit from SO2 reduction
NO_x	9,000	

6.45 The Gas Development Plan projects significant penetration of gas use into the residential heating sector. For coal stove conversion, driven primarily by environmental concerns and secondarily by convenience, this switch would eliminate SO_2 and PM emissions from these sources. However, significant reductions in PM, and some SO_2 reduction can also be achieved by other means:

- Upgrading the quality of coal used where relevant
- Switching to natural or manufactured smokeless fuels
- Modifying existing coal-burning equipment
- Installing new modern coal-burning equipment.

Where coal is unwashed (e.g., in parts of Krakow), washing and cleaning will reduce SO_2 and PM emissions at a relatively low cost. More significant reductions can be achieved by switching to smokeless fuels, which can reduce PM emissions by up to 90 percent and SO_2 emissions by up to 40 percent. The costs, however, are high—about $9,000 per ton of SO_2 emission reduced, about $6,000 per ton for PM. Since the two are reduced together the calculations must take into account the associated reductions in pollutants. It appears that in most cases the marginal costs of emissions reductions from the low-stack sector would be set by the costs of switching to smokeless fuel. In the low-stack sector there are few options to reduce NO_x emissions apart from those associated with increasing energy efficiency. The marginal cost of abatement is set at the costs of using catalytic converters on cars, costed at around

$9,000 per ton. The costs of abatement for high- and low-stack emissions have been calculated as one measure of the possible environmental credit for gas. The figures derived are shown in Table VI-15.

Monetary Value of Benefits of Pollution Reduction

6.46 Comparison of these estimates (derived from a variety of sources on Poland) with estimates in other countries reveals that for damage to forests, agriculture, and health, estimates appear to be reliable and may be low. The estimate for damage to buildings, one of the largest in the total, diverges from other countries' experience. Given that it was rather arbitrarily assumed that pollution damage shortened building life by 20 years, the figure for building damage has been reduced to $600 million.

Table VI-16: Pollution-related Damage Costs

Category	*Value (billion 1988 zlotys)*	*Value ($ million, 1990 prices)*
Mining damage	56	130
Soil degradation	649	1,600
Air pollution	1,022	2,530
Health	183	450
Structures	736	1,820
Agriculture	51	120
Soil acidification	13	30
Forests	38	90
Water pollution	268	660
Transport	119	300
TOTAL	2,114	5,220

Table VI-17: Production-related Damage Costs (1990 prices)

Damage area	*$ million (1990 prices)*	*% GDP*
Forests	90	0.1
Agriculture	160	0.2
Health	450	0.6
Buildings	600	0.8
TOTAL	1,300	1.8

6.47 For the purposes of the gas study the damage costs allowed amount to $1.3 billion in 1990 prices (1.8 percent of GDP). The costs included are shown in Table VI-17.

6.48 These figures make no allowance for disamenity or for damage to soil and water where the main pollutants are produced by nonenergy industries. However, these estimates are based on internal administered prices rather than on border prices, which are likely to be a better estimate of the costs in a market-driven situation. It is estimated that average prices and hence average damage costs need to be multiplied by a factor of 2.5 to raise them to border price levels.

6.49 The studies on which the above figures are based do not apportion air pollution to the specific pollutants, but it is necessary to assign such values in order to calculate environmental credits for various investments. This is done by making some simple working assumptions. The aggregate damage cost for each category (forests, agriculture, health, and materials) is divided among the three major pollutants according to the overall loads of these pollutants and their relative harmfulness. Table VI-18 shows the relative effects on a given damage category of the different pollutants at the margin. This table is based on empirical data but these are subject to some uncertainty.

6.50 Deposition of PM is assumed as below critical load damage to agriculture and forests.

6.51 These figures can be combined with the figures for overall damage costs evaluated at border prices (data in Table VI-17 multiplied by 2.5) to yield figures for the cost of damage by pollutant and damage category expressed in dollars per ton deposited as shown in Table VI-19.

6.52 The data in Table VI-19 provide a measure of average damage costs; it is derived by dividing total damage costs by total depositions. Hence marginal damage costs may be understated because damage is in fact caused only by depositions above the critical load. Furthermore the estimates also omit losses of amenity value, which would be reflected by willingness to pay measures, as opposed to the loss of production approach used by necessity in this study.

Table VI-18: Relative Harmfulness (weighted by deposits) of Various Pollutants by Damage Area

Damage area	*SO_2*	*PM*	*NO_x*
Agriculture	1	0	0.3
Forests	1	0	0.3
Health	1	1.2	0.2
Structures	1	0.3	0.3

Environmental Credit for Gas

6.53 In paragraph 6.45 the marginal costs of abatement were derived and in paragraph 6.52 the marginal costs of damage were estimated. These two costs can be combined to determine the size of the environmental credit associated with the use of gas. Marginal abatement costs are expressed as a cost per ton emitted while marginal damage costs are per ton deposited. The least cost strategy for pollution abatement should compare the marginal cost of abating a ton deposited with the cost of the damage per ton deposited. The lower of the two sets the limit on the value of reducing deposits. Although it is possible to

Table VI-19: Damage Costs From Pollution Deposits (per tonne)

Damage area	*SO_2*	*PM*	*NO_x*
Agriculture	90	0	90
Forests	50	0	50
TOTAL RURAL	140	0	140
Health	900	900	400
Materials	1,700	400	1,200
TOTAL URBAN	2,600	1,300	1,600

carry out the analysis in terms of depositions it is easier to present it in terms of emissions and this is the method adopted in this report. Under certain conditions, which are applicable to Poland, the results deduced for emissions are equivalent to those for depositions.

6.54 The estimates of marginal damage costs were expressed in terms of dollars per ton deposited in urban and rural areas. These are converted into values for the damage per ton of emission from high- and low-level sources. To derive these figures it has been assumed that depositions outside Poland cause similar damage to depositions inside Poland. Table VI-21 presents the estimates of the damage cost from emissions of the various pollutants.

Table VI-20: Abatement Costs For Emissions of Various Pollutants ($ per ton)

Source	SO_2	*PM*	NO_x
High stacks	1,100	250	9,000
Low stacks	7,900	3,880	9,000

Table VI-21: Damage Costs from Emissions of Various Pollutants ($ per ton)

Source	SO_2	*PM*	NO_x
High stacks	265	60	180
Low stacks	650	720	460

6.55 These figures are to be compared with the marginal abatement costs given in Table VI-20. In this table the figures for SO_2 and PM in the low-stack sector reflect the cost of switching to smokeless fuel, which can achieve SO_2 reductions of only 40 percent, so that for a target in excess of this it would be necessary to switch to gas. The figures for NO_x reflect the costs of catalytic converters. The figures in these tables show that in every case the costs of abatement are very much higher than the costs of pollution. It must be remembered that the damage estimates reflect only lost production rather than willingness to pay, while the estimated damage costs are average costs and not marginal costs, which would certainly be higher. There is also considerable uncertainty surrounding the actual magnitudes. For SO_2 and PM it may be that a full analysis would show that abatement was less costly than pollution, but for NO_x it appears that in Poland abatement is not cheaper than pollution.

6.56 The implication that the target levels of abatement are higher than the levels that could be justified on the basis of damage cost estimates may be questionable. In most countries emission reductions are perceived as worthwhile, although recent work in OECD countries raises similar questions on a strict economic basis. Moreover, the targets for percentage reduction set for Poland seem reasonable in that they are broadly similar to those adopted in OECD countries. Indeed, if national targets for emissions reductions are adopted then a value of damage is being imputed that at least equals the associated cost of achieving the reduction. More specifically, if the target level of reductions is taken as a fixed constraint, then the implied credit for reducing emissions must be increased to a level that reflects the marginal cost of abatement. Failure to do this when setting the environmental credit for gas would risk the adoption of more expensive measures than gas substitution in seeking to meet the targets. Hence, we propose to increase the marginal damage estimates to reflect the above observations.

6.57 For SO_2 the marginal damage estimate must be increased by a factor of around 4 to equate the marginal damage estimate with the marginal abatement cost for the high-stack sector. A similar scaling factor is applied to the SO_2 marginal damage estimate for the low-stack sector in the absence of better information (note that there is some overlap in the types of damage caused by high- and low-stack sources so that there is some justification for this approach).

6.58 In the case of PM, if the policy objective is to reduce PM deposition in urban areas, then the relevant criteria is to equate the marginal damage cost with the marginal cost of abatement for the low-stack sector. The high-stack sector would not be relevant in this context because the abatement of high-stack PM emissions could only reduce urban depositions by about 5 percent; any plausible target for reductions would be above this level and so would definitely require action on low-stack PM emission sources. The resulting scaling factor for PM marginal damage estimates would be just over 5. Note that when this scaling factor is applied to damage from high-stack sources as well, abatement of high-stack emissions becomes worthwhile; although the marginal damage associated with high-stack sources is an order of magnitude lower than the damage associated with low-stack sources, the cost of achieving high-stack abatement is also lower by an order of magnitude. A policy could be adopted that sought to reduce high-stack PM emissions since these are relatively cheap to achieve, but did not impose a "smokeless fuel" policy in urban areas. In the latter case, the marginal damage estimates would be scaled by a factor of 4 instead of 5.

6.59 The marginal abatement cost for NO_X reduction is so much higher than the marginal damage estimate that no plausible upward adjustment to damage estimates could make them equal. In essence, this result implies that the "cheap" means of NO_X abatement, such as the fitting of low NO_X burners, may be worthwhile, but that the adoption of expensive NO_X control measures, such as postcombustion control on power stations or catalytic convertors on cars, should not be given any priority in pollution abatement strategy. To set environmental credits for gas we use the marginal damage estimates for NO_X, but adopt the crude assumption that they should be scaled up by a factor of 4, as for SO_2, on the grounds that similar underestimates of damage costs might apply to NO_X as to SO_2.

6.60 Accordingly, a revised set of valuations for marginal emissions reflecting less ambitious targets is shown in Table VI-22. These values for marginal changes in emissions can be converted into limits on the environmental credits for gas, expressed in $ per GJ, by combining them with emission coefficients for different fuels and end-use sectors. These implied values place a limit on the environmental credit for gas because the credit must be the lower of the cheapest means of abatement and the monetary value of the change in emissions.

6.61 In some sectors the abatement option in specific applications will set credits below those implied by the valuation of marginal changes as given in Table VI-22. This is the case in those sectors of industry that use high-sulfur oil where emissions of SO_2 can be reduced at a cost of around $500 per ton. It is also the case in the power sector where the costs of fitting FGD to certain plants are below the marginal cost of abatement in the high-stack sector. Table VI-23 shows the environmental credits that are attributable to gas in each end-use sector.

Table VI-22: Monetary Valuation of Changes in Emissions ($ per ton)

Source	SO_2	*PM*	NO_x
High stacks	1,100	250-320	700
Low stacks	2,500	2,800-3,880	1,800

6.62 The values for PM show the implied credit for two scenarios: (a) a policy to abate emissions in the high-stack sector, and (b) a policy to enforce the use of smokeless fuel instead of coai in cities.

6.63 The main implication of Table VI-23 is that the environmental credit for gas could be substantial—it could be as high as $4 per GJ in the low-stack sector, where this credit is set by the marginal cost of abatement. The use of a lower marginal damage estimate for PM would reduce the credit to between $2 and $3 per GJ, but this is still about the same as the cost of the gas itself. The largest element of the credit relates to SO_2; the credit for NO_x can effectively be ignored. Some further observations follow:

- The total environmental credit is larger in the low-stack than in the high-stack sector, particularly for PM.

- The environmental credit is shown as being similar across end uses in the low-stack sector because the same abatement option (switching to smokeless fuel) is assumed.

Table VI-23: Environmental Credits for Gas ($/GJ)

Sector	SO_2	*PM*	NO_x
Residential			
Stoves	2.5	2 - 2.5	< 0.1
New consumers	2.0	1.5 - 2.0	< 0.2
Small DH	2.0	1.5 - 2.0	< 0.2
Commercial	2.0	1.5 - 2.0	< 0.2
Industry			
Coal use	2.0	1.5 - 2.0	< 0.2
HFO use	1.0	—	< 0.2
Gasoil use	0.5	—	< 0.2
Power and DH			
Existing: 2.3% sulfur coal	1.5	0.1	< 0.1
Existing: 1.2% sulfur coal	1.0	0.1	< 0.1
Existing: 0.6% sulfur lignite	0.5	0.1	< 0.1
New: 1.2% sulfur coal	0.2	< 0.1	< 0.1

- The environmental credit is larger for gas used in existing power stations than in new power stations, mainly because a new gas-fired power station is in competition with a new coal or lignite station, on which FGD is assumed to be required.

6.64 The table does not take into account any potential environmental credit for CO_2 abatement. The potential size of this credit can be estimated using the following assumptions:

- The carbon content of gas is about 14 tonnes per TJ, of coal about 22 tonnes per TJ.

- Where gas and coal would be used at similar levels of efficiency, the saving in CO_2 emission will be equivalent to 0.008 tonnes carbon per GJ.

- Using an estimate of $10 per ton of carbon for the shadow cost of abating CO_2 emission, the implied credit would be about $0.1 per GJ.

- Methane leakage in the gas supply system might offset up to 30 percent of the CO_2 credit.

6.65 The resulting level credit of around $0.1 per GJ is unlikely to have major implications for the Gas Development Plan.

Table VI-24: Projected Market Demands for Gas in the Gas Development Plan (PJ)

Sector	*1988*	*2000*	*2010*
Residential	124	212	337
Commercial	11	34	95
Industry	239	211	408
Power	---	0-233	426-532
TOTAL	374	460-680	1,270-1,370

Implications for the Gas Development Plan

6.66 The chapters on the future demand and supply for gas in Poland have estimated netback values for gas. In some cases these implicitly had already included an environmental credit—gas is assumed to penetrate the residential market despite low netback values because of the associated environmental benefit. This benefit must not be counted twice.

6.67 The demand analysis, based on a sectoral approach, is shown in Table VI-24. All sectors show considerable potential for growth in the demand for gas, but about half of the growth potential is in the power generation sector.

6.68 Netback values are shown for each of the markets in Table VI-25. In principle these values can be compared with the cost of gas supply.

6.69 In principle the inclusion of environmental considerations within the assessment of gas value in use could alter the priorities for allocating gas between the various end markets and alter the total volumes of gas that it is worth developing or importing.

6.70 The environmental credits implied in Table VI-23 can be compared with the netback values given in Table VI-25 to show the effects of allocation of gas to end-use sectors.

6.71 The main conclusions are as follows:

- The environmental credit for the use of gas in the conversion of coal stoves may be sufficiently large to justify supplying gas to this market segment for environmental reasons. This supports the assumption that consumers should be given the incentive to switch from coal to gas on environmental grounds. However, this part of the gas market is projected to be fairly small so that the impact on total demand will be slight.

- The size of the environmental credit is higher for the low-stack sector than for the high-stack sector; the difference, which reflects the fact that postcombustion control and switching to smokeless fuels is expensive in the low-stack sector, could be about $2 to 3 per GJ, sufficient to reverse the ranking of some high- and low-stack gas allocations and place a premium on gas use in urban areas.

- Environmental considerations are unlikely to change the ranking of gas relative to other fuels in low-stack sectors. This is because the environmental credit is similar across most applications, which in turn, results from the fact that the environmental credit is set by the benefit of the avoided damage.

- The environmental credit for existing power stations appears sufficiently large to reverse the order of allocating gas in the power sector—making it more economically attractive to use gas for repowering existing power stations than for new power stations.

6.72 In some situations the SO_2 and PM abatement required to reduce pollution to the critical load can be achieved with relatively low-cost methods, such as coarse-coal preparation. This might achieve an abatement of up to 30 percent for SO_2 and up to 80 percent for PM at a cost equivalent to $0.4 per GJ of gas. This size of credit might be insufficient to justify the promotion of gas in such instances. However, the indications are that coarse coal is used in relatively few urban centers.

Table VI-25: Netbacks for Gas in the Gas Development Plan ($/GJ)

	Netback ($/GJ)
Gas stove conversion	2.9
Small boilerhouses	7.7
Large district heating plant	2.2
Industrial processes:	
existing	6.0-6.4
new	5.3-6.1
Industrial boilers:	
existing	3.3 -3.9
new	3.0 -3.8
Power plants:	
existing (conversion)	2.0-3.0
existing (repowering)	4.1-4.4
new	4.3-4.8

6.73 Turning to the total volume of gas use, the results imply that:

- The environmental credit for most end-use sectors is a significant element that might justify further production/imports at the margin.

- The environmental credit appears sufficiently large that it could become economically worthwhile to import gas in situations where it would not be economic in their absence.

- Environmental considerations are unlikely to significantly alter the economics of gas use in new power stations where gas is competing with other fuels in new stations, which are likely to be required by regulation to have FGD.

6.74 To meet Poland's targets for emissions reduction, it is clear that gas will play a large role. Without increased gas use, the projected emissions in 2010 would be higher than otherwise by amounts equivalent to:

- 17 percent of the 1980 level of SO_2 emissions
- 9 percent of the 1980 level of PM emissions
- 13 percent of the 1980 level of NO_x emissions

6.75 These figures must be seen against the policy for a target of national reductions of 50 percent for SO_2 and 70 percent for PM by 2010.

6.76 The discussion has focused at the national rather than at the regional level. Some evidence suggests that SO_2 deposition for Poland as a whole might be similar to that for the Krakow voivodship. This reflects the fact that both high and low stack emissions are widely dispersed. As a result it would not be expected that sharp priorities for regional allocation would be obtained from a regional analysis. For urban centers, however, the position is quite different. The bulk of deposition in a town is likely to be from sources in or around the town. Thus a major reduction in urban emissions can greatly improve urban air quality. This suggests that the allocation of gas, on environmental grounds, should be significantly distorted in favor of low stack sources in or around urban centers.

6.77 Using Krakow as an example, the assumptions on dispersion suggest that the bulk of deposition in a town originates from sources in or near the town. If all the coal in Krakow were washed and graded before use, then the deposition of SO_2 might be reduced by up to 25 percent and that of PM by up to 75 percent, although this might still leave ambient concentration levels above the critical load. A wholesale switch to gas would eliminate both SO_2 and PM and reduce total deposition to a very low level, which would attract an environmental credit against the coal preparation option of around $2.5 per GJ. Against the alternative of switching to smokeless fuel, which would reduce SO_2 by 30 percent and PM by 85 to 90 percent, gas would attract a credit of as much as $4 to $5 per GJ. This would have to take into account the cost of laying the gas distribution network and the cost of retrofitting gas pipes in existing buildings.

6.78 The implications of these remarks for project appraisal will depend on individual cases since there is clearly quite a wide range of credits involved. However, two general points can be made. First, in the low-stack sector the environmental credit for gas is set by the benefit of the damage avoided, which, by its nature, is independent of the project in question so that the broad sectoral conclusion is less likely to be reversed at the individual level. Second, in the high-stack sector many of the projects will be large scale; as such it is more desirable and more feasible to require an explicit account of environmental factors that will be taken into account in decisions about gas allocation to these projects.

6.79 Turning to implementation, there are four broad options for influencing decisions on gas allocation so that environmental considerations are taken into account:

- If the state were to retain a controlling interest in POGC, then the government could require project appraisal procedures to into take account environmental factors.

- Use of environmental taxation that penalizes different fuels in accordance with the degree of associated emissions as proxy for environmental damage.

- Use of emissions taxes, or a system of tradable permits

- Regulation.

6.80 Differential taxation has the greatest attraction for those sectors where the environmental impact of fuel use is dependent largely on the choice of fuel. Differential taxation is appropriate for low stack users where the fuel-using equipment cannot be readily adapted to control emissions, but it is less appropriate for high-stack sectors where the level of emissions will depend on the plant in which the fuel is used.

6.81 As Poland moves toward a market system, approaches based on emissions taxation or tradable permits become more viable. Meanwhile regulation is likely to be the most viable form of pollution abatement with or without other measures.

7. LEGAL AND CONTRACTUAL FRAMEWORK FOR UPSTREAM INVESTMENT

7.1 Prior to 1989, there was no clear legal or contractual framework under that international companies could invest in upstream operations (oil and gas exploration, development, or production) in Poland. The 1989 Foreign Investment Law appeared to give some guidelines for foreign investment in all sectors of the economy, but did not provide any of the specific safeguards and assurances that firms operating in the international arena require. Elements that were not covered or were treated in an inadequate or unsatisfactory way were as follows:

- Foreign exchange rights, especially regarding the proceeds of export sales

- Types of investment vehicle allowed, given that oil companies prefer to operate abroad using locally registered wholly owned subsidiaries (in the case of U.S. firms, these would be Delaware corporations licensed to do business in the host country)

- Licensing authority, with regard to which there were conflicting claims of regulatory authority in this area from the Ministries of Industry and of Environmental Protection, Natural Resources and Forestry, as well as from the holding and operating entities, and POGC and Petro-Baltic

- Level and stability of fiscality, which was murky because applicability of income and other taxes to petroleum exploitation activities was not clear, and (worst of all) the authorities were given wide discretion in the imposition of differential royalty rates and other levies, with express provision for punitive rates in "unusually profitable circumstances."

7.2 The basic question of ownership of mineral resources was subject to interpretation; defined as belonging to the "Narod" or People, this was argued by some to mean that such resources belonged to the workers in the public enterprises exploiting them! In addition, there were few clear guidelines pertaining to the protection of the environment, an area that the new post-communist regime sought to make a top priority.

7.3 In 1990, one positive development occurred when a single authority (the Ministry of Natural Resources, Environmental Protection and Forestry) was designated to license activities in the mineral sector (for both exploration and exploitation/production). The ministry then created a functional unit within the ministry to oversee concession issuance and supervision, the Bureau of Geological Concessions, headed by an experienced geologist. Against this background, the consultants engaged by ESMAP to provide advice and support to the Polish government on establishing a Legal and Contractual Framework for oil and gas investment in the country began work. Collaborating closely with their Polish counterparts in the Ministry of Environmental Protection, Natural Resources and Forestry, the Ministry of Industry, and POGC, they identified the following plan of priority action:

- Identify and analyze the existing legal, regulatory, and contractual framework for operations in the sector, especially with regard to investment by foreign companies.

- Compare the resulting environment in its various constituent parts with the situation that exists in countries with which Poland must compete for the investment budgets of international companies.

- Suggest alterations to the Polish framework that would make Poland more attractive to such investors while providing appropriate safeguards to the national interests of Poland, including environmental protection.

- Draft legal and regulatory texts and a model contract that would effect the improvements suggested, and explain the reasons for any necessary and significant departures from customary Polish practice.

- Promote interest in Poland on the part of the international oil and gas industry, through the organization of a promotional campaign, which, using the newly drafted legal and contractual materials (to the extent they are accepted and put into effect), would publicize the new investment climate in Poland.

- Capitalize on interest generated through the campaign to negotiate and execute new investment agreements with reputable foreign firms.

7.4 The brief of the consultant team retained under the Legal and Contractual Study was defined to include all but the last two elements, and the Ministry of Environmental Protection, Natural Resources and Forestry engaged a consultant directly under the Environmental Loan from the World Bank to assist with the promotion and negotiation aspects. POGC had already retained a firm of experienced technical consultants to prepare the geological, geophysical, and geochemical data packages that international companies require in order to evaluate investment opportunities in a new country. The following section describes the process of carrying out the work plan described above.

Analysis of the Existing Polish Enabling Environment

7.5 **Sector-Specific Statutes.** Activities pertaining to underground resources are regulated in Poland by two basic laws (*Ustawas*), the Mining Law of May 6, 1953, and the Geological Law of November 16, 1960. The precise relationship of these two instruments is not altogether clear or consistent. As one would expect in a Marxist command system, the main function of both appears to be the definition of the attributes and authority of various overlapping and sometimes competing state sectoral organizations such as POGC, the Higher Mining Bureau, or the State Geological Enterprise. For example, the competent Minister had the right to alter royalty rates in various ill-defined circumstances, which is totally unacceptable to potential international investors. This did not constitute a problem when the only operating entity in a position to pay such royalty, POGC, was a public company with no balance sheet or financial accountability.

7.6 **General Investment Laws.** The formation and activities of companies in Poland are regulated by the Commercial Code of 1934 and the Civil Code of 1964. Companies pay various forms of income taxes and other levies in accordance with the Tax Liabilities Law. Responsibility for promoting and regulating investment in Poland by foreign companies has been attributed to various bodies over the past few years. In 1986, a law regulating the acquisition of shares in Polish companies by foreigners was passed (the Law of April 23, 1986, on Companies with Foreign Capital Participation). This foresaw that the oversight agency for such activities would be the Ministry of Foreign Trade, which has since been replaced by the Ministry of Foreign Economic Relations. The 1986 Law was superseded by the 1989 Foreign Investment Law, which named the Agency for Foreign Investment as the supervisory body; the 1989 Law was replaced in 1991 by a further version, which abolished the Agency for Foreign Investment, whose functions were to be assumed by the Ministry of Ownership Changes. The latter is currently (April 1992) in the process of being merged into a new economic superministry.

7.7 The various laws regulating, and attempting to encourage, foreign investment in Poland go some distance toward creating an enabling environment for general foreign investment, especially in the manufacturing and service sectors. However, international petroleum companies will not readily operate in a situation with no recognizable sector-specific guidelines, or where the existing guidelines are inappropriate to the special nature of energy resource extraction. This involves, among other things, the role of the risk element at the exploration stage: companies accept the fact that their initial investment may be totally unproductive; as a result, they are reluctant to compound their loss through the expense and complication of contributing capital to the formation of a local joint-stock or limited liability company, when they are normally permitted to operate through a locally registered, wholly owned subsidiary of a foreign-incorporated vehicle.

7.8 Oil companies are very reluctant to enter situations where the repatriation of foreign currency is linked to profits (or worse still, to the share capital of the company); the various versions of Foreign Investment Laws in Poland have included both of these stipulations. As a specific, but crucial, example, such firms absolutely require the right to carry forward exploration expenditures made in early years until a discovery has been developed and production begins; many general tax codes treat such investment as losses in the year incurred and limit the maximum period of carry-forward (in Poland, to three years). Neither the sector-specific nor the general legislation address such concerns, and on many issues of importance to investors the texts are either inappropriate, silent, or confusing.

The Draft Unified Petroleum (Exploration and Production) Law

7.9 The ESMAP team therefore advised their Polish counterparts that a radical solution was required, and the draft of a single Petroleum Law was produced and provided to the Ministry of

Environmental Protection, Natural Resources and Forestry for discussion. The draft was intended to be the basic legal feature in a package of elements that would eventually include the Model Petroleum Exploration and Production Contract described below. As the detailed rules and regulations governing oil and gas operations would be set out in the specific licenses and concession agreements based on the Model Contract, the Law could be a brief enabling instrument. This is consistent with good recent international practice and is the preferred route of most serious investors. The tenets of the draft law included the following:

- Clear definition of the key questions of ownership of petroleum resources and authority to license and supervise activities in the sector

- Statement of the legal and contractual basis for oil and gas operations by all parties, Polish public and private as well as foreign

- Principal qualifications required of prospective applicants for rights as well as the main rights and obligations conferred by virtue of the licensing process

- Basic procedure for submission of applications for exploration and exploitation concessions

- Statement of applicability of taxes, duties, and levies giving the details of such imposts that apply to foreign companies engaged in petroleum extraction as well as applicable exemptions

- Specific provisions regarding natural gas, training obligations of rightholders, the environment, and unitization.

The draft law further provided for the subsequent issuance of more comprehensive regulations, which set forth the detailed procedures and rules for operations. This is the preferred course as the intent is to provide a framework enabling law that would not require frequent amendment or replacement, as changes in the international environment or investment criteria could be reflected at the level of the regulations rather than in the law.

7.10 The Polish reaction to the draft Petroleum Law was not enthusiastic: legal experts pointed out at length that such a step went counter to existing Polish legal practice. Officials familiar with the political process expressed deep pessimism about the prospects for replacing the disparate and largely inappropriate corpus of legislation that applies to petroleum operations with a single comprehensive Petroleum Law. There were many reasons given, but perhaps the main one is this: Getting any new law passed through both houses of the fledgling Parliament is a difficult proposition at best. Even if a separate law were passed for petroleum, however, the sectoral protagonists concerned with the extraction of other substances classified as mines under Polish law, notably coal, which by virtue of its importance to the economy has a substantial lobby in Poland, would clamor for separate treatment as well. Whatever the full reasons, the lack of a recognizable Petroleum Law in Poland must be seen as a continuing disincentive to investment in the country by international oil and gas companies. As the government's stated objective is to encourage such investment, the enactment of a modern statutory basis for activities in this area must remain a priority.

7.11 **1991 Amendments.** The ESMAP team made it clear to the government that the enabling environment disincentives would limit the level of oil industry interest in consummating investment ventures in Poland; several potentially interested firms provided similar comments, some in dramatic language, directly to the Concessions Bureau. In April 1991, both the Mining Law and the Geological Law were amended, with part of the stated intention being to clarify the enabling conditions for foreign investment. The Amendments for the first time set forth clearly the question of State ownership of mineral resources, and resolved the formerly vexing question of sharing royalty income between the State Treasury and local authorities (*Woyewodas* and *Gminas*). On a more pragmatic level, the Amendments designated the Ministry of Environmental Protection, Natural Resources and Forestry as the sole focus of authority for mineral licensing and supervision. Unfortunately, none of the other main industry concerns was effectively put to rest. Of most concern was the retention of the Minister's discretion as Concession Authority to raise royalty rates, and other ambiguous or inappropriate stipulations. The basic purpose of the Amendments may, as with the Mining Law and Geological Law before them, have been to clarify bureaucratic turf boundaries. While this is not unimportant—especially in the light of the internecine tug-of-war that had characterized administration of the sector in the past—oil companies to whom the amended laws were shown commented that they would have great difficulty operating in such an environment.

7.12 **Contractual Solution.** In the light of the current bottleneck regarding enactment of a comprehensive legal framework, the ESMAP team and their Polish counterparts concentrated on devising a contractual solution. This would attempt to adapt to the existing overall framework by creating a strong and comprehensive agreement including as many as possible of the elements that were to have been included in the new law. The efficacy of such a solution, which is used successfully in a number of countries (Egypt is one example), depends on the possibility of achieving a sufficient status in law of the executed agreement that it overrides any conflicting provisions in the statutes or regulations affecting operations in the sector. It was thought that this could be achieved by a ratification process whereby the Council of Ministers, or possibly even the Parliament, would approve the signed contract and thus confer the needed status in law upon it.

7.13 The team proceeded to draft a Model Contract that would provide all the basic provisions that oil companies look for when they evaluate a new investment "province." This was the intent all along, but the original outline was made substantially more comprehensive; among subjects covered in detail in the draft, and that would have (in the opinion of the ESMAP team) been more efficiently dealt with in a unified law, were foreign exchange, tax exemptions, a detailed description of the Minister's authority to contract, and procedures for moving from an exploration concession to an exploitation concession (production lease) in the event of a commercial discovery.

7.14 The following section describes the draft Model Contract submitted to the government in May, 1991, which was distributed to the oil industry at a series of promotional seminars held in July and

December 1991, in London, Houston, and Calgary. In it the term *contractor* has its usual meaning in such documents, namely the private party to the contract with the State. The contractor may thus be one company or a number of firms allied in an unincorporated joint venture association common in the international oil industry. *Petroleum* means both crude oil and natural gas.

The Model Petroleum Exploration and Production Contract

7.15 The draft Model Contract was submitted to the government for comments on May 28, 1991. The ESMAP team at first began work on a type of contract that has been used successfully in many countries to attract investment in exploration and production activities, the production-sharing contract. These contracts are generally favored by oil companies because, while leaving the ultimate ownership of resources with the government, they give the company an ownership right on oil produced under the contract, which after all is what they are interested in. However, the Polish reviewers of the preliminary version of the contract pointed out that Polish legal and tax tradition would fit in much better with a tax-and-royalty or "concession" arrangement. The drafters then converted their early work into a draft tax-and-royalty arrangement. It dealt with the main issues usually covered by such instruments in a way consistent with recent international documents that have been successfully used for the dual purposes involved: (a) promoting interest in the host country on the part of the international industry and serving as a basis for negotiations, and (b) protecting the reasonable interests of all parties, first of all the State party, in executed agreements based on the Model.

7.16 As a major international energy company had already tabled a draft exploration and production contract, selected provisions of this document were used as the basis for treatment given the relevant issues in the draft Model, although most clauses were either replaced or extensively revised to reflect the fact that the Model is the government's initial negotiating position rather than that of a potential investor. As with the ESMAP team, the company had originally tabled a production-sharing agreement, which was replaced with a tax-and-royalty draft after the Polish legal experts gave their unfavorable opinion about production-sharing. The following is a summary of the key issues and a reasoned description of the treatment given them in the Model:

7.17 **Ownership and Control of Petroleum and Parties to the Contract.** The ownership question, mentioned above, was settled by stating that the ownership and control of all petroleum (oil and gas) existing in Poland or under its territorial waters belongs to the Polish Nation, while control of petroleum resources being vested in the State Treasury of the Republic. The delegation of concession-granting and other authority in the sector to the Ministry of Environmental Protection, Natural Resources and Forestry by the Parliament acting on behalf of the State Treasury is then recited, so that the foreign investor will clearly see where his interlocutor's authority to negotiate, license, and administer derives from. It had originally been thought that POGC would be a party to the contract, with the Minister of Industry representing the State but with POGC being the contractor's main interlocutor. This situation changed radically with the designation of the Ministry of Environmental Protection, Natural Resources and Forestry rather than the Ministry of Industry as the Concession Authority and the decision to review POGC's future in extenso, and the new situation was reflected in the Model. This would be between the

Minister of Environmental Protection, Natural Resources and Forestry and the contractor directly; if the Minister elected to acquire a working interest in the concession, POGC or some future operating entity might have a role to play, but this was left to future determination.

7.18 **Duration.** Because of rigid limitations on exploration terms set forth in the Amendments to the Mining Law and the Geological Law, exploration concessions must have a maximum term of six years (three years initial period with a further three years optional extension). It would have been preferable for the Concessions Bureau to have more flexibility than that, in order to more efficiently adapt to the variable regional geology and investor intentions. Exploitation concessions, the term of which is left to the Minister's discretion, are set at 20 years from the start of production under the contract.

7.19 **Grant of Rights.** The May 1991 Model stated that the Ministry "hereby grants Contractor and Exploration Concession covering the entire Contract Area". While the concept of simultaneous contractual grant of rights without further bureaucratic procedure is attractive to industry, it was pointed out that Polish practice will require a separate administrative act issuing concessions. The next draft of the Model will therefore state that the Minister will issue the appropriate Exploration Concessions on the effective date of the contract.

7.20 **Automatic Right to Exploitation Concession.** Modern practice dictates that companies should be able to develop and produce resources discovered through exploration operations they have funded without being subject to further administrative discretion. This is difficult in Poland as the Exploitation Concession can only be applied for once an exploitable discovery has been made, and various award criteria are set forth in the statutes. While the 1991 Amendments to the Mining and Geological Laws state in somewhat ambiguous terms that the holder of an Exploration Concession who has made a discovery has the right to an Exploitation Concession, Polish practice is such that issuance of the production right cannot be made automatic or included in the rights granted in the contract. In the Model, therefore, the Minister undertakes to issue an Exploitation Concession "as of right" provided the Contractor has fulfilled all his obligations under the contract and Polish law as of that date.

7.21 **Title to Assets.** Title to any land purchased by the contractor under the Model passes to the State Treasury as soon as it is purchased. The Model states that other fixed and movable assets acquired for the purpose of operations under the contract will become the property of the State progressively as those assets are subjected to depreciation against Polish Income Tax. This sort of provision is common under production-sharing regimes, and is considered to be theoretically equitable in that the government effectively pays for the depreciated assets by means of tax not received, and in the oil business the residual value of facilities can be considerable even after they are fully amortized. However, this is one of a number of points that were included in the Model on the understanding that the government could readily concede them if a potential partner objected to them (and was willing to provide a quid pro quo of more importance to Poland).

7.22 **Relinquishment.** After the initial three-year exploration period, the company would have the right to surrender its rights under the contract without further obligation (provided all commitments up to that point had been satisfied). If it elected to continue into the (maximum) three-year extension period, a portion of the original area of the contract would be relinquished. The Model left the percentage blank as a formally negotiable item.

7.23 **Work Obligations.** While the detailed exploration or other work obligations undertaken by the contractor were left blank to be filled in during negotiations, the structure is such that the work commitments are defined in accordance with accepted criteria such as line-kilometers of seismic survey to be acquired and processed, or wells drilled to a minimum geological target horizon. Work is considered to be of more importance than expenditure as such, given that the purpose of such agreements is to efficiently find petroleum resources rather than to encourage spending per se; the State ends up reimbursing such costs anyway in the success case through cost recovery or depreciation against income tax. The majority of exploration expenditures usually goes to international service contractors and expatriate employees and is thus of limited direct benefit to the local economy. Therefore, no formal expenditure commitment is envisaged.

7.24 **Joint Advisory Committee.** To ensure effective communication between the contractor and the government during the exploration phase, a Joint Advisory Committee is established that would have equal representation from the Ministry on the one hand and from the company or companies comprising the contractor on the other. To reassure companies that there will be no undue interference with what they see as their right to make technical and operational decisions on their own (especially while they are providing 100 percent of all funds), many of the key decisions are excluded from the Committee's purview, such as areal relinquishment, the location of wells, extensions, appraisal wells, commercial discovery, the design or submission of a development plan for a discovery, the application for an exploitation concession, or abandonment. In the event a discovery is made and the State elects to acquire a participating interest in the field (see below, paragraph 7.30), the Joint Advisory Committee would be replaced by the Joint Operating Committee structure, which is standard in the oil industry and which would be provided for in the form of Operating Agreement appended to the Model.

7.25 **Commercial Discovery.** The contractor has the basic right to determine whether or not a discovery made under the contract constitutes a commercially producible resource or not. If he deems it to be commercial, he then proceeds to elaborate and present an Overall Development Plan for extracting and transporting the petroleum to market. The Minister reserves the right to appraise and to develop discoveries that the contractor does not consider to be commercially viable, at the State's sole cost and risk. Such situations can theoretically occur given the fact that the State normally receives more of the rent from a field than the contractor, or when a discovery is too small to be of interest to the investor with a global portfolio of opportunities to invest in. This "sole risk" clause is worded so as to ensure that the contractor's ability to operate is not interfered with, and giving him the right to "back in" to a participating interest in such developments.

7.26 **Fiscal Provisions.** Polish Mining law provides that a **royalty** be paid to the State, and this is reflected in the Model. Because the Minister as Concession Authority has a certain amount of discretion to vary royalty rates, it is made clear in the Model Contract that a fixed level of royalty will be due throughout the validity of the contract. This provides a degree of fiscal stability that investors require, and constitutes a contractual undertaking by the Minister not to exercise his statutory authority to vary the rate. The rate in the May 1991 Model was 10 percent; since then, an Ordinance from the Council of Ministers was issued fixing the rate for oil and gas at 6 percent, with the Minister retaining the discretion to raise the rate by up to 50 percent. As this would make the maximum royalty payable 9 percent, future drafts of the Model (and the contract under negotiation) will provide a fixed royalty rate of 9 percent.

7.27 Corporate income tax is stated to be payable at the usual rate applicable to a foreign corporation doing business in Poland, and certain clarification of depreciation rules and other technical procedures was given. Consideration is reportedly being given to lowering the rate of corporate income tax (currently 40 percent), and possibly to providing other fiscal incentives to foreign investors such as tax holidays; it was felt important to provide in the Model Contract a stable and predictable level of State fiscal take. Investors in extractive industries have shown a global tendency to prefer stability over generally lower but fluctuating tax rates (Chile is a good example). The Model therefore provided for a Special Charge that would be payable in addition to Corporate Income Tax. This charge would only be payable if the contractor achieved a prenegotiated level of real after-tax rate of return on his investment, which is consistent with threshold levels in the international oil business, thus favoring the development of small or otherwise marginal fields while assuring the State of an equitable share in an extremely profitable venture.

7.28 Several of the oil companies to which the draft Model was distributed complained about what they called a "ceiling" on their profits. While such complaints tended to come from the smaller and less sophisticated firms, and most of the more experienced international operators in fact prefer a profit-based taxation instrument rather than a more rigid system, a few more significant firms also expressed a preference for a different rent-sharing scheme. This latter group included the company already in negotiation for exploration rights, and in the contract negotiated with that firm and in future drafts of the Model, the contractor is given the choice of the rate-of-return based Charge described above, and one calculated for all intents and purposes like an additional level of "off the top" proportional mining royalty, which is due once the quotient of the contractor's cumulative gross income under the contract divided by his cumulative gross outpays including all other taxes has become a prenegotiated number greater than one.

7.29 **Natural Gas.** Poland is known in the industry as primarily a gas province, and the Model included a comprehensive treatment of gas discoveries, both associated with crude oil and nonassociated. Basically, the contractor has the right to develop gas reserves as he chooses, as is the case for crude oil; however, if he does not elect to exploit associated gas, it will be provided free of charge to the State, which must finance all costs of exploitation if it chooses to exploit it. The Polish domestic market has first call on nonassociated gas, provided the commercial terms obtained are no less favorable than those under which the gas could be exported. If it is exported, the actual realized price holds, while domestic sales are priced in accordance with a formula based on a basket of fuel oils (before tax). In the event an international border price for gas imports into Poland is established, this price may be substituted for the fuel-linked formula.

7.30 **Government Participation.** The State has the right to acquire a participating interest in the rights and obligations of the contractor under the contract in the event a discovery is declared to be commercial and an Exploitation Concession is awarded for this purpose. The level of such participation is flexible, but cannot be less than 10 percent nor more than 40 percent (it can be 0). While the State makes no reimbursement for its share of past exploration expenses leading up to the commercial discovery, it bears its full percentage interest share of all future expenses under the contract. This limited participation right is considered to afford the government the opportunity to participate more extensively in a profitable discovery while achieving more effective transfer of technology and training benefits than is possible when the State role is restricted to licensing and taxation.

7.31 **Currency and Exchange.** International oil companies seek the unfettered right to hold foreign currency and move it freely in and out of the host country, as well as to receive abroad the proceeds of oil export sales and remit to the host country only such sums as are required for local costs and payments to the government. As in any bargaining situation, they will accept limitations on these requirements to the extent the other party has a strong bargaining position, such as significant oil producers, or countries with long track records of successful operations, for example. As Poland is in neither category, the Model provided all the rights and assurances normally found in incentive environments internationally. Polish counsel and the Ministry of Finance pointed out, however, that in the light of the impracticality of raising the legal status of the contract, the Minister of Environmental Protection, Natural Resources and Forestry would be exceeding his authority if he made such undertakings. At this writing, the Ministry of Finance is considering the issuance of Regulations by Ministerial Decree, which would provide assurances in this regard as well as certain specific tax-related ones described elsewhere.

7.32 **Training.** The contractor is required to contribute US$50,000 per contract year during the exploration phase for training of Polish employees, rising to US$100,000 per year after the award of the first Exploitation Concession.

7.33 **Dispute Resolution.** In the event disputes of a basically technical nature arise between the Minister and the contractor, the Model provides that in specific instances such differences will be referred to expert determination. If the dispute is more serious or concerns the interpretation of or compliance with the contract, it is settled through binding international arbitration under the Rules of the London Court of Arbitration.

7.34 **Legal Issues.** The Model treats most issues of a primarily legal nature in a manner consistent with most international practice: thus the contract is to be governed by Polish Law and the decisions of international tribunals; appropriate provision for Force Majeure is made; and the Minister has the right to terminate the contract in certain well-defined instances of breach or failure by the contractor.

7.35 **Bank Guarantee.** In the light of the emphasis on work obligations rather than expenditure and the absence of a formal expenditure commitment, it was considered important to require all contractors to post an irrevocable bank guarantee or letter of credit for the nominal value of the minimum work obligations. This could be called by the government in case the contractor failed to fulfill his commitments, and would ensure that the State received some consideration for granting the rights and entering into the contract even if the contractor became bankrupt or otherwise failed to comply with his obligations. The face value of the Guarantee would be reduced progressively as work was carried out, thus reducing the cost of the Guarantee to the contractor.

Problems with the Draft Model

7.36 The current Polish legal system regarding contracts, belonging as it does to the continental law system and based on a Civil Code enacted in 1964, gives a specific legal status to a contract entered into between two parties. Even if one party is a Ministry of the central government and the other a foreign company, the status in law of the contract is clearly defined in the Code and it is not possible to improvise further actions that would elevate the contract to the level required to accomplish the comprehensive aims embodied in the draft Model Contract. In short, a contract obligates the State only to the extent that the commitments entered into by the official party to the contract are within the official attributes and authority of that party. This could be effective regarding certain problems presented by the statutory situation; for example, the Minister's discretion to raise royalty rates can be limited through his committing in the contract to impose a stated level of royalty on the investor signing the contract (for the duration of the contract and regarding substances extracted by virtue thereof).

7.37 However, the status of contracts under Polish Law meant that a number of important topics covered in the draft were outside the attributes of the Minister of Environmental Protection, Natural Resources and Forestry who alone had authority to sign such an agreement. While the Model released to interested companies presented the intentions of the Polish parties regarding effect of the various clarifications and reassurances expected by companies, those assurances that were beyond the explicit competence of the Minister of Environmental Protection, Natural Resources and Forestry must be dealt with otherwise than in a contract signed by him.

7.38 Despite the difficulties in adapting the Polish legal system to the requirements of international investors in oil and gas projects, a number of reputable international companies with the requisite technical and financial resources to make a positive contribution to Poland's needs in this respect expressed interest in pursuing ventures in the country. While most of these expressions of interest came from companies that had attended one of the promotional seminars, a few firms had developed an early interest in Polish exploration and one had begun to study Polish geological data with a view to entering into serious negotiations for exploration rights. The firm began discussions with POGC and in July 1989, signed a Study Agreement giving them access to geological data and the right to enter into negotiations toward concessionary rights if the study results were positive.

7.39 Upon transfer of licensing and negotiations authority to the Ministry of Environmental Protection, Natural Resources and Forestry, the company transferred the focus of its previously ad hoc negotiations from POGC to representatives of the Bureau of Geological Concessions, now assisted by the consultant engaged under the World Bank Environment Loan. From that point on, the draft Model Contract was used as the basic negotiating framework. When it became apparent that key safeguards and clarifications required by the company would need to be dealt with outside the context of the contract with the Ministry of Environmental Protection, Natural Resources and Forestry, the Bureau organized meetings with the Ministry of Finance and other relevant authorities within whose authority it was to grant the assurances, exceptions, and clarifications needed to complete the enabling environment and make it acceptable to investors. At the time of this writing, the Ministry of Finance had agreed in principle to issue a Ministerial Decree setting forth the needed assurances and undertakings, and the company had indicated that it would proceed to sign a contract on the basis of such Regulations provided they reflected the company's stated position on the issues.

Completion of the Legal and Contractual Study

7.40 The ESMAP team that had produced the draft Petroleum Law and Model Contract were asked to produce a follow-up study that would include critical review of proposed new legislation. This new draft, the Mining and Geological and Laws, prepared entirely by Polish experts, would combine the subjects covered by the current amended Geological and Mining Laws into a single ordinance. The Polish authorities felt this would solve some of the inadequacies of the amended Mining and Geological Laws. The team was also asked to present a further draft of the Model Contract that would include only matters within the competence of the Minister of Environmental Protection, Natural Resources and Forestry, and to advise the Bureau on training matters, especially with regard to the economic evaluation of projects. Issues not addressed in the revised Model would be covered through the Regulations to be issued by the Minister of Finance, who it was determined had the requisite authority regarding all major issues not within the competence of the Minister of Environmental Protection, Natural Resources and Forestry. While the preferred course was for the latter to issue a single Decree providing the needed safeguards and guidelines of general application to all companies that might acquire exploration or production rights under the new procedures, it appeared likely that a once-off solution addressing only the situation of the company furthest along in negotiations would be used, and that an overall series of general regulations would follow in due course.

Joint UNDP/World Bank
ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

LIST OF REPORTS ON COMPLETED ACTIVITIES

Region/Country	*Activity/Report Title*	*Date*	*Number*
	SUB-SAHARAN AFRICA (AFR)		
Africa Regional	Anglophone Africa Household Energy Workshop (English)	07/88	085/88
	Regional Power Seminar on Reducing Electric Power S Losses in Africa (English)	08/88	087/88
	Institutional Evaluation of EGL (English)	02/89	098/89
	Biomass Mapping Regional Workshops (English - Out of Print)	05/89	--
	Francophone Household Energy Workshop (French)	08/89	103/89
	Interafrican Electrical Engineering College: Proposals for Short- and Long-Term Development (English)	03/90	112/90
	Biomass Assessment and Mapping (English - Out of Print)	03/90	--
Angola	Energy Assessment (English and Portuguese)	05/89	4708-ANG
	Power Rehabilitation and Technical Assistance (English)	10/91	142/91
Benin	Energy Assessment (English and French)	06/85	5222-BEN
Botswana	Energy Assessment (English)	09/84	4998-BT
	Pump Electrification Prefeasibility Study (English)	01/86	047/86
	Review of Electricity Service Connection Policy (English)	07/87	071/87
	Tuli Block Farms Electrification Study (English)	07/87	072/87
	Household Energy Issues Study (English - Out of Print)	02/88	--
	Urban Household Energy Strategy Study (English)	05/91	132/91
Burkina Faso	Energy Assessment (English and French)	01/86	5730-BUR
	Technical Assistance Program (English)	03/86	052/86
	Urban Household Energy Strategy Study (English and French)	06/91	134/91
Burundi	Energy Assessment (English)	06/82	3778-BU
	Petroleum Supply Management (English)	01/84	012/84
	Status Report (English and French)	02/84	011/84
	Presentation of Energy Projects for the Fourth Five-Year Plan (1983-1987) (English and French)	05/85	036/85
	Improved Charcoal Cookstove Strategy (English and French)	09/85	042/85
	Peat Utilization Project (English)	11/85	046/85
	Energy Assessment (English and French)	01/92	9215-BU
Cape Verde	Energy Assessment (English and Portuguese)	08/84	5073-CV
	Household Energy Strategy Study (English)	02/90	110/90
Central African Republic	Energy Assessement (French)	08/92	9898-CAR
Comoros	Energy Assessment (English and French)	01/88	7104-COM
Congo	Energy Assessment (English)	01/88	6420-COB
	Power Development Plan (English and French)	03/90	106/90
Côte d'Ivoire	Energy Assessment (English and French)	04/85	5250-IVC
	Improved Biomass Utilization (English and French)	04/87	069/87
	Power System Efficiency Study (Out of Print)	12/87	--
	Power Sector Efficiency Study (French)	02/92	140/91
Ethiopia	Energy Assessment (English)	07/84	4741-ET
	Power System Efficiency Study (English)	10/85	045/85

Region/Country	*Activity/Report Title*	*Date*	*Number*
Ethiopia	Agricultural Residue Briquetting Pilot Project (English)	12/86	062/86
	Bagasse Study (English)	12/86	063/86
	Cooking Efficiency Project (English)	12/87	--
Gabon	Energy Assessment (English)	07/88	6915-GA
The Gambia	Energy Assessment (English)	11/83	4743-GM
	Solar Water Heating Retrofit Project (English)	02/85	030/85
	Solar Photovoltaic Applications (English)	03/85	032/85
	Petroleum Supply Management Assistance (English)	04/85	035/85
Ghana	Energy Assessment (English)	11/86	6234-GH
	Energy Rationalization in the Industrial Sector (English)	06/88	084/88
	Sawmill Residues Utilization Study (English)	11/88	074/87
Guinea	Energy Assessment (Out of Print)	11/86	6137-GUI
Guinea-Bissau	Energy Assessment (English and Portuguese)	08/84	5083-GUB
	Recommended Technical Assistance Projects (English & Portuguese)	04/85	033/85
	Management Options for the Electric Power and Water Supply Subsectors (English)	02/90	100/90
	Power and Water Institutional Restructuring (French)	04/91	118/91
Kenya	Energy Assessment (English)	05/82	3800-KE
	Power System Efficiency Study (English)	03/84	014/84
	Status Report (English)	05/84	016/84
	Coal Conversion Action Plan (English - Out of Print)	02/87	--
	Solar Water Heating Study (English)	02/87	066/87
	Peri-Urban Woodfuel Development (English)	10/87	076/87
	Power Master Plan (English - Out of Print)	11/87	--
Lesotho	Energy Assessment (English)	01/84	4676-LSO
Liberia	Energy Assessment (English)	12/84	5279-LBR
	Recommended Technical Assistance Projects (English)	06/85	038/85
	Power System Efficiency Study (English)	12/87	081/87
Madagascar	Energy Assessment (English)	01/87	5700-MAG
	Power System Efficiency Study (English and French)	12/87	075/87
Malawi	Energy Assessment (English)	08/82	3903-MAL
	Technical Assistance to Improve the Efficiency of Fuelwood Use in the Tobacco Industry (English)	11/83	009/83
	Status Report (English)	01/84	013/84
Mali	Energy Assessment (English and French)	11/91	8423-MLI
	Household Energy Strategy (English and French)	03/92	147/92
Islamic Republic of Mauritania	Energy Assessment (English and French)	04/85	5224-MAU
	Household Energy Strategy Study (English and French)	07/90	123/90
Mauritius	Energy Assessment (English)	12/81	3510-MAS
	Status Report (English)	10/83	008/83
	Power System Efficiency Audit (English)	05/87	070/87
	Bagasse Power Potential (English)	10/87	077/87
Mozambique	Energy Assessment (English)	01/87	6128-MOZ
	Household Electricity Utilization Study (English)	03/90	113/90
Niger	Energy Assessment (French)	05/84	4642-NIR
	Status Report (English and French)	02/86	051/86
	Improved Stoves Project (English and French)	12/87	080/87

Region/Country	*Activity/Report Title*	*Date*	*Number*
Niger	Household Energy Conservation and Substitution (English and French)	01/88	082/88
Nigeria	Energy Assessment (English)	08/83	4440-UNI
Rwanda	Energy Assessment (English)	06/82	3779-RW
	Energy Assessment (English and French)	07/91	8017-RW
	Status Report (English and French)	05/84	017/84
	Improved Charcoal Cookstove Strategy (English and French)	08/86	059/86
	Improved Charcoal Production Techniques (English and French)	02/87	065/87
	Commercialization of Improved Charcoal Stoves and Carbonization Techniques Mid-Term Progress Report (English and French)	12/91	141/91
SADCC	SADCC Regional Sector: Regional Capacity-Building Program for Energy Surveys and Policy Analysis (English)	11/91	--
Sao Tome and Principe	Energy Assessment (English)	10/85	5803-STP
Senegal	Energy Assessment (English)	07/83	4182-SE
	Status Report (English and French)	10/84	025/84
	Industrial Energy Conservation Study (English)	05/85	037/85
	Preparatory Assistance for Donor Meeting (English and French)	04/86	056/86
	Urban Household Energy Strategy (English)	02/89	096/89
Seychelles	Energy Assessment (English)	01/84	4693-SEY
	Electric Power System Efficiency Study (English)	08/84	021/84
Sierra Leone	Energy Assessment (English)	10/87	6597-SL
Somalia	Energy Assessment (English)	12/85	5796-SO
Sudan	Management Assistance to the Ministry of Energy and Mining	05/83	003/83
	Energy Assessment (English)	07/83	4511-SU
	Power System Efficiency Study (English)	06/84	018/84
	Status Report (English)	11/84	026/84
	Wood Energy/Forestry Feasibility (English - Out of Print)	07/87	073/87
Swaziland	Energy Assessment (English)	02/87	6262-SW
Tanzania	Energy Assessment (English)	11/84	4969-TA
	Peri-Urban Woodfuels Feasibility Study (English)	08/88	086/88
	Tobacco Curing Efficiency Study (English)	05/89	102/89
	Remote Sensing and Mapping of Woodlands (English)	06/90	--
	Industrial Energy Efficiency Technical Assistance (English - Out of Print)	08/90	122/90
Togo	Energy Assessment (English)	06/85	5221-TO
	Wood Recovery in the Nangbeto Lake (English and French)	04/86	055/86
	Power Efficiency Improvement (English and French)	12/87	078/87
Uganda	Energy Assessment (English)	07/83	4453-UG
	Status Report (English)	08/84	020/84
	Institutional Review of the Energy Sector (English)	01/85	029/85
	Energy Efficiency in Tobacco Curing Industry (English)	02/86	049/86
	Fuelwood/Forestry Feasibility Study (English)	03/86	053/86
	Power System Efficiency Study (English)	12/88	092/88
	Energy Efficiency Improvement in the Brick and Tile Industry (English)	02/89	097/89
	Tobacco Curing Pilot Project (English - Out of Print)	03/89	UNDP Terminal Report

Region/Country	*Activity/Report Title*	*Date*	*Number*
Zaire	Energy Assessment (English)	05/86	5837-ZR
Zambia	Energy Assessment (English)	01/83	4110-ZA
	Status Report (English)	08/85	039/85
	Energy Sector Institutional Review (English)	11/86	060/86
Zambia	Power Subsector Efficiency Study (English)	02/89	093/88
	Energy Strategy Study (English)	02/89	094/88
	Urban Household Energy Strategy Study (English)	08/90	121/90
Zimbabwe	Energy Assessment (English)	06/82	3765-ZIM
	Power System Efficiency Study (English)	06/83	005/83
	Status Report (English)	08/84	019/84
	Power Sector Management Assistance Project (English)	04/85	034/85
	Petroleum Management Assistance (English)	12/89	109/89
	Power Sector Management Institution Building (English - Out of Print)	09/89	--
	Charcoal Utilization Prefeasibility Study (English)	06/90	119/90
	Integrated Energy Strategy Evaluation (English)	01/92	8768-ZIM

EAST ASIA AND PACIFIC (EAP)

Asia Regional	Pacific Household and Rural Energy Seminar (English)	11/90	--
China	County-Level Rural Energy Assessments (English)	05/89	101/89
	Fuelwood Forestry Preinvestment Study (English)	12/89	105/89
Fiji	Energy Assessment (English)	06/83	4462-FIJ
Indonesia	Energy Assessment (English)	11/81	3543-IND
	Status Report (English)	09/84	022/84
	Power Generation Efficiency Study (English)	02/86	050/86
	Energy Efficiency in the Brick, Tile and Lime Industries (English)	04/87	067/87
	Diesel Generating Plant Efficiency Study (English)	12/88	095/88
	Urban Household Energy Strategy Study (English)	02/90	107/90
	Biomass Gasifier Preinvestment Study Vols. I & II (English)	12/90	124/90
Malaysia	Sabah Power System Efficiency Study (English)	03/87	068/87
	Gas Utilization Study (English)	09/91	9645-MA
Myanmar	Energy Assessment (English)	06/85	5416-BA
Papua New Guinea	Energy Assessment (English)	06/82	3882-PNG
	Status Report (English)	07/83	006/83
	Energy Strategy Paper (English - Out of Print)	--	--
	Institutional Review in the Energy Sector (English)	10/84	023/84
	Power Tariff Study (English)	10/84	024/84
Solomon Islands	Energy Assessment (English)	06/83	4404-SOL
	Energy Assessment (English)	01/92	979/SOL
South Pacific	Petroleum Transport in the South Pacific (English-Out of Print)	05/86	--
Thailand	Energy Assessment (English)	09/85	5793-TH
	Rural Energy Issues and Options (English - Out of Print)	09/85	044/85
	Accelerated Dissemination of Improved Stoves and Charcoal Kilns (English - Out of Print)	09/87	079/87

Region/Country	*Activity/Report Title*	*Date*	*Number*
Thailand	Northeast Region Village Forestry and Woodfuels Preinvestment Study (English)	02/88	083/88
	Impact of Lower Oil Prices (English)	08/88	--
	Coal Development and Utilization Study (English)	10/89	--
Tonga	Energy Assessment (English)	06/85	5498-TON
Vanuatu	Energy Assessment (English)	06/85	5577-VA
Western Samoa	Energy Assessment (English)	06/85	5497-WSO

SOUTH ASIA (SAS)

Bangladesh	Energy Assessment (English)	10/82	3873-BD
	Priority Investment Program	05/83	002/83
	Status Report (English)	04/84	015/84
	Power System Efficiency Study (English)	02/85	031/85
	Small Scale Uses of Gas Prefeasibility Study (English - (Out of Print)	12/88	--
India	Opportunities for Commercialization of Nonconventional Energy Systems (English)	11/88	091/88
	Maharashtra Bagasse Energy Efficiency Project (English)	05/91	120/91
	Mini-Hydro Development on Irrigation Dams and Canal Drops Vols. I, II and III (English)	07/91	139/91
	WindFarm Pre-Investment Study (English)	12/92	150/92
Nepal	Energy Assessment (English)	08/83	4474-NEP
	Status Report (English)	01/85	028/84
Pakistan	Household Energy Assessment (English - Out of Print)	05/88	--
	Assessment of Photovoltaic Programs, Applications, and Markets (English)	10/89	103/89
Sri Lanka	Energy Assessment (English)	05/82	3792-CE
	Power System Loss Reduction Study (English)	07/83	007/83
	Status Report (English)	01/84	010/84
	Industrial Energy Conservation Study (English)	03/86	054/86

EUROPE AND CENTRAL ASIA (ECA)

Eastern Europe	The Future of Natural Gas in Eastern Europe (English)	08/92	149/92
Poland	Energy Sector Restructuring Vols. I-V (English)	01/93	153/93
Portugal	Energy Assessment (English)	04/84	4824-PO
Turkey	Energy Assessment (English)	03/83	3877-TU

MIDDLE EAST AND NORTH AFRICA (MNA)

Morocco	Energy Assessment (English and French)	03/84	4157-MOR
	Status Report (English and French)	01/86	048/86
Syria	Energy Assessment (English)	05/86	5822-SYR
	Electric Power Efficiency Study (English)	09/88	089/88
	Energy Efficiency Improvement in the Cement Sector (English)	04/89	099/89

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Syria	Energy Efficiency Improvement in the Fertilizer Sector(English)	06/90	115/90
Tunisia	Fuel Substitution (English and French)	03/90	--
	Power Efficiency Study (English and French)	02/92	136/91
	Energy Management Strategy in the Residential and Tertiary Sectors (English)	04/92	146/92
Yemen	Energy Assessment (English)	12/84	4892-YAR
	Energy Investment Priorities (English - Out of Print)	02/87	6376-YAR
	Household Energy Strategy Study Phase I (English)	03/91	126/91

LATIN AMERICA AND THE CARIBBEAN (LAC)

LAC Regional	Regional Seminar on Electric Power System Loss Reduction in the Caribbean (English)	07/89	--
Bolivia	Energy Assessment (English)	04/83	4213-BO
	National Energy Plan (English)	12/87	--
	National Energy Plan (Spanish)	08/91	131/91
	La Paz Private Power Technical Assistance (English)	11/90	111/90
	Natural Gas Distribution: Economics and Regulation (English)	03/92	125/92
	Prefeasibility Evaluation Rural Electrification and Demand Assessment (English and Spanish)	04/91	129/91
	Private Power Generation and Transmission (English)	01/92	137/91
Chile	Energy Sector Review (English - Out of Print)	08/88	7129-CH
Colombia	Energy Strategy Paper (English)	12/86	--
Costa Rica	Energy Assessment (English and Spanish)	01/84	4655-CR
	Recommended Technical Assistance Projects (English)	11/84	027/84
	Forest Residues Utilization Study (English and Spanish)	02/90	108/90
Dominican Republic	Energy Assessment (English)	05/91	8234-DO
Ecuador	Energy Assessment (Spanish)	12/85	5865-EC
	Energy Strategy Phase I (Spanish)	07/88	--
	Energy Strategy (English)	04/91	--
	Private Minihydropower Development Study (English)	11/92	--
Haiti	Energy Assessment (English and French)	06/82	3672-HA
	Status Report (English and French)	08/85	041/85
	Household Energy Strategy (English and French)	12/91	143/91
Honduras	Energy Assessment (English)	08/87	6476-HO
	Petroleum Supply Management (English)	03/91	128/91
Jamaica	Energy Assessment (English)	04/85	5466-JM
	Petroleum Procurement, Refining, and Distribution Study (English)	11/86	061/86
	Energy Efficiency Building Code Phase I (English-Out of Print)	03/88	--
	Energy Efficiency Standards and Labels Phase I (English - Out of Print)	03/88	--
	Management Information System Phase I (English - Out of PRint)	03/88	--
	Charcoal Production Project (English)	09/88	090/88
	FIDCO Sawmill Residues Utilization Study (English)	09/88	088/88

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Jamaica	Energy Sector Strategy and Investment Planning Study (English)	07/92	135/92
Mexico	Improved Charcoal Production Within Forest Management for the State of Veracruz (English and Spanish)	08/91	138/91
Panama	Power System Efficiency Study (English - Out of Print)	06/83	004/83
Paraguay	Energy Assessment (English)	10/84	5145-PA
	Recommended Technical Assistance Projects (English- (Out of Print)	09/85	--
	Status Report (English and Spanish)	09/85	043/85
Peru	Energy Assessment (English)	01/84	4677-PE
	Status Report (English - Out of Print)	08/85	040/85
	Proposal for a Stove Dissemination Program in the Sierra (English and Spanish)	02/87	064/87
	Energy Strategy (Spanish)	12/90	--
Saint Lucia	Energy Assessment (English)	09/84	5111-SLU
St. Vincent and the Grenadines	Energy Assessment (English)	09/84	5103-STV
Trinidad and Tobago	Energy Assessment (English - Out of Print)	12/85	5930-TR

GLOBAL

	Energy End Use Efficiency: Research and Strategy (English - Out of Print)	11/89	--
	Guidelines for Utility Customer Management and Metering (English and Spanish)	07/91	--
	Women and Energy--A Resource Guide The International Network: Policies and Experience (English)	04/90	--
	Assessment of Personal Computer Models for Energy Planning in Developing Countries (English)	10/91	--
	Long-Term Gas Contracts Principles and Applications (English)	12/92	152/92

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