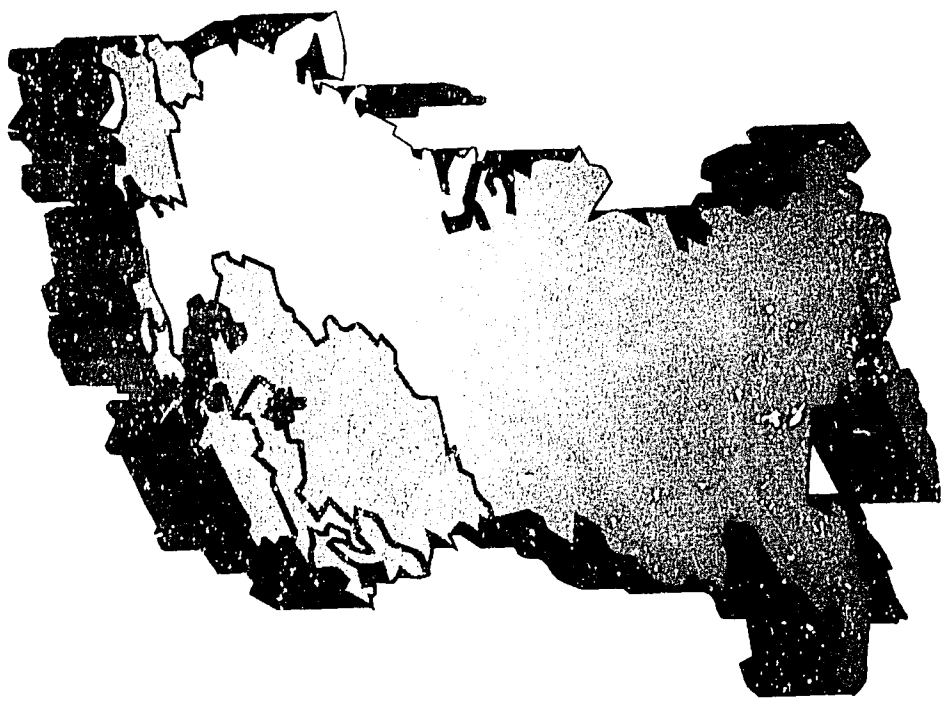
PN-ABO-671
86163

REVISED JAN. 1994

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

U.S. Agency for International Development

- New Independent States Task Force / Energy Efficiency and Market Reform Project
- Bureau of Research & Development / Office of Energy & Infrastructure



NIS Natural Gas System Rehabilitation

Final Report ▪ November 1993

Prepared by

Energy Technology Innovation Project
Contract No. DHR-5741-Q-00-1062-00
Delivery Order No. 4
Prime Contractor: Bechtel Corporation

TABLE OF CONTENTS

EXECUTIVE SUMMARY **1**

The Role of Gas 1

Natural Gas Demand Forecast 2

Gas Distribution Systems 3

District Heating Gas Conservation Projects 5

Industrial Energy Conservation Projects 6

Environmental Assessment 7

Financial Analysis of Local Gas Companies 8

Summary of Potential Investments 11

Energy Conservation Projects Funding 12

Figure 1 Master Schedule 13

TABLE OF CONTENTS

Section | Page

EXECUTIVE SUMMARY 1

1. INTRODUCTION ..... 1 - 1
   - 1.1 Background ..... 1 - 1
   - 1.2 Study Objectives ..... 1 - 1
   - 1.3 Scope of Work ..... 1 - 1
   - 1.4 Approach ..... 1 - 2
   - 1.5 Tasks To Be Completed ..... 1 - 2

2. THE ROLE OF GAS ..... 2 - 1
   - 2.1 Background ..... 2 - 1
   - 2.2 District vs. Localized Central Heating ..... 2 - 1
   - 2.3 Gas vs. Electric Stoves ..... 2 - 2
   - 2.4 Conversion of LP to MP system ..... 2 - 3
   - 2.5 Gas Use Scenarios ..... 2 - 5
   - 2.6 Use Of Polyethylene Pipe ..... 2 - 5
   - 2.7 Gas Pipeline Extensions ..... 2 - 6
   - 2.8 Apartment Building Design Review ..... 2 - 6
   - 2.9 Design Standards Review ..... 2 - 9

3. NATURAL GAS DEMAND FORECAST ..... 3 - 1
   - 3.1 Introduction and Overview ..... 3 - 1
   - 3.2 Definition of Distribution Systems Geographic Boundaries ..... 3 - 2
   - 3.3 Gas Demand Data Collected ..... 3 - 3
   - 3.4 Domestic Price Evolution ..... 3 - 5
   - 3.5 Demand Model ..... 3 - 5
   - 3.6 Demand Scenarios ..... 3 - 12
   - 3.7 Conclusions ..... 3 - 16

4. GAS DISTRIBUTION SYSTEMS ..... 4 - 1
   - 4.1 Existing Conditions ..... 4 - 1
   - 4.2 Proposed Projects ..... 4 - 10
   - 4.3 Cost/Benefit Ranking of Gas Distribution Projects ..... 4 - 22

TABLE OF CONTENTS

Section Page

5. DISTRICT HEATING GAS CONSERSERVATION PROJECTS ..... 5 - 1
   5.1 Introduction ..... 5 - 1
   5.2 Existing Conditions and Recommended Projects ..... 5 - 2
   5.3 Cost/Benefit Ranking of District Heating Projects ..... 5 - 10
   5.4 Summary ..... 5 - 11

6. INDUSTRIAL ENERGY CONSERVATION PROJECTS ..... 6 - 1
   6.1 Introduction ..... 6 - 1
   6.2 Existing Conditions and Proposed Projects ..... 6 - 1
   6.3 Cost/Benefit Ranking of Industrial Projects ..... 6 - 12
   6.4 Summary ..... 6 - 13

7. ENVIRONMENTAL ASSESSMENT ..... 7 - 1
   7.1 Introduction ..... 7 - 1
   7.2 Description of the Proposed Project ..... 7 - 4
   7.3 Project Objectives ..... 7 - 10
   7.4 Baseline Data ..... 7 - 12
   7.5 Environmental Assessment Requirements ..... 7 - 22
   7.6 Significant Impacts on the Environment ..... 7 - 23
   7.7 Project Alternatives and their Impacts ..... 7 - 26
   7.8 Mitigation Measures ..... 7 - 28
   7.9 Documents Consulted ..... 7 - 36
   7.10 Ministries and Other Government Agencies Consulted ..... 7 - 36
   7.11 Environmental Assessment Preparers ..... 7 - 37

8. FINANCIAL ANALYSIS OF LOCAL GAS COMPANIES ..... 8 - 1
   8.1 Introduction ..... 8 - 1
   8.2 Financial Issues ..... 8 - 2
   8.3 Administrative Issues ..... 8 - 6
   8.4 Institutional Changes ..... 8 - 12
   8.5 Summary and Recommendations ..... 8 - 17

9. SUMMARY OF POTENTIAL INVESTMENTS ..... 9 - 1
   9. Summary ..... 9 - 1

TABLE OF CONTENTS

Section Page

APPENDICES

2-A Insertion of Polyethylene (PE) Pipe
3-A Gas Demand Model
3-B Flow Diagram
3-C Statistical Correlations
3-D Output Table
4-A Technical Data
4-B Procurement
4-C Construction and Operations Related Data
5-A District Heating System Project Profiles - Ryazan
5-B District Heating System Project Profiles - Saratov
5-C District Heating System Project Profiles - Volgograd
5-D District Heating System Project Profiles - Voronezh
6-A Industrial Energy Conservation Projects - City of Ryazan
6-B Industrial Energy Conservation Projects - City of Saratov
6-C Industrial Energy Conservation Projects - City of Volgograd
6-D Industrial Energy Conservation Projects - City of Voronezh
7-A Data Check List for Project Specific EAs for Pipeline Replacement
1. Annex A TOR for EA dated September 17, 1993
2. Annex B Major Laws, Regulations, and Programs of the Russian Federation Relevant to EA
3. Annex C Data Checklist for Project Specific EAs for Pipeline Replacement, The World Bank Technical Paper Number 154, October 1991
4. Annex D Requirements of the Committee on Federal Sanitary and Epidemiological Inspection
5. Annex E Occupational Health, General Guidelines for Industrial Projects, The World Bank, April 1984
6. Annex F Correspondence and data received from Committees for Ecology in the Cities of Ryazan, Saratov, Volgograd and Voronezh
7-B Requirements of the Committee on Federal Sanitary and Epidemiological Inspection
7-C Occupation Health, General Guidelines for Industrial Projects
8-A Questionnaire
8-B Meetings and Participants
8-C Scenario Analyses

4

EXECUTIVE SUMMARY

The United States Agency for International Development (USAID) selected Bechtel Corporation to study the natural gas distribution systems in the Russian cities of Ryazan, Saratov, Volgograd, and Voronezh. The study was designed to evaluate the existing conditions of the gas distribution systems, identify investment projects that will improve their performance, and qualify for financing by the World Bank. The bank is planning to invest about $50 million in each city for projects that show high rates of return, short gestation time and result in the best natural gas utilization and long term gas distribution system development. Bechtel and its subcontractors visited the gas utility company in each city to obtain technical and financial data. In addition, energy audits were made at major industrial and district heating plants to identify energy conservation projects.

THE ROLE OF GAS

The next decade is likely to bring about changes in household energy use and district heating gas utilization, due to improvements in end-use efficiency, new developments in the industrial and commercial sectors due to changes in the Russian economy, and new technology.

Several key issues were identified in the study. Alternative actions to resolve these issues were analyzed for their effects on gas demand and gas conservation potential. The alternatives were as follows:

District Heating vs. Apartment Complex Boilers

District heating systems, which are plagued with high energy losses and other problems, currently provide the majority of multi-unit apartment buildings with space heating and hot water. Due to extensive heat losses, district heating systems become uneconomical if apartment complexes are located more than seven kilometers away from district heating plants. In such cases, it may be more economical to build smaller local boilers to supply heat and hot water to apartment complexes. The gas distribution system must be analyzed to determine the optimum gas delivery system for these new boilers.

Gas vs. Electric Cookers

The majority of apartment houses use gas for cooking purposes only. Use of electric stoves instead of gas stoves could eliminate the cost of operating and maintaining the low pressure (LP) distribution system. However, the analysis conducted for this study indicated that the cost of electricity per unit of energy is currently about sixty times that for gas. The cost of electricity is projected to be about 3 times that for gas even when the price of gas is increased to $300/1000m^3$ in order to recover the long term marginal cost of delivering gas to residential customers. Thus there will be no economic incentive for residential consumers to switch from gas to electric cookers. In addition, since only about 34 percent of heat input at the electric generating station is delivered as heat to electric stoves, there will be an overall loss of gas if all residential customers are obligated to change from gas stoves to electric stoves.

Conversion of Low Pressure to Medium Pressure System

The low pressure gas distribution system should be analyzed to determine the feasibility of converting some of it to a medium pressure system in response to demand changes caused by the installation of boilers near apartment complexes.

Upgrading from low pressure to high pressure will increase the capacity of the system to meet the future demand requirements of private homes and the boiler and cooking gas needs of apartment complexes. This can be achieved by recertification of existing pipes, by inserting polyethylene pipes, or by installing new medium pressure steel or polyethylene pipes.

End User Efficiency

End user energy efficiency can be achieved by improving the design of apartment buildings and private homes and by increasing the building insulation where feasible. After visiting many private, multi-unit and commercial buildings and reviewing their design, three major recommendations can be made. They are:

- Doubling or tripling the windows to reduce heat losses
- Thickening the walls by adding insulation
- Maintaining an attic space, even in the flat-roofed buildings

Russian Standards

Standards for the design, construction, operation and maintenance of the Russian gas distribution facilities were reviewed. The purpose of this review was to determine what recommendations could be made to increase gas use efficiency and safety. It is recommended that future regulations specify the performance standards; measures to allow more user flexibility to alter the design; and provide opportunities to optimize the design where possible. Many other recommendations were developed to improve safety and operability of the gas distribution systems.

NATURAL GAS DEMAND FORECAST

Benjamin Schlesinger and Associates, Inc. (BSA) independently developed a forecasting model to estimate the current and projected levels of natural gas demand under alternative development scenarios for local gas distribution systems in the four cities of Saratov, Volgograd, Ryazan, and the oblast of Voronezh. Because of the unique settings and the lack of useful price history, BSA's challenge was to preserve as much of the underlying framework of sophisticated econometric models without overreaching the limitations of the available data. The result was a simplified model that forecasts demand based on those factors for which enough valid data were available.

Five primary demand scenarios were considered which illustrate the impact on gas demand of:

- The implementation of gas efficiency projects by specific industrial plants and district heating facilities
- Replacement of gas cookers with electric cookers in those areas of the low pressure gas distribution system where gas is used exclusively for cooking and the cost of rehabilitating the low pressure system may be prohibitive
- Retirement of the central heating and hot water system in those areas where conversion to a gas based system is more cost effective than upgrading the central heating and hot water system.

Projected natural gas demand for each of the four selected cities follows a similar pattern:

- Initially overall gas demand declines as industrial output falls. Industrial output is the primary factor affecting gas demand throughout the forecast period
- Decreased use in the commercial and residential sectors attributable to conservation and more efficient equipment has only a limited impact on gas demand because of the relatively small amount of gas consumed in those sectors
- Over the long term, gas demand rebounds with a revitalized Russian economy led by strong growth in industrial production and growth in the consumer sector for goods and services

GAS DISTRIBUTION SYSTEMS

Each gas utility company (usually named Gorgas) receives gas from transmission systems at the city gate stations that are owned and operated by the transmission system. The pressure is reduced at the city gate station to correspond to the operating pressure of the utility company's distribution system. The gas flow is also measured at the city gate station. The city gate stations lack modern equipment and controls.

The distribution system in each town consists of low pressure (LP) piping used to deliver gas to residential and small commercial establishments, medium pressure (MP) piping to supply gas to small industrial and major commercial enterprises, and high pressure (HP) piping used to supply gas to major industries. In addition, the HP and MP system is used to feed gas to the LP system.

The following table summarizes the main features of the four utility companies.

City	Ryazan	Saratov	Volgograd	Voronezh
Population	530,000	1,000,000	1,050,000	930,000
1992 Gas Consumption, million m^3				
Industrial	1,915	2,685	2,968	3,538
Commercial	72	299	482	456
Residential	90	198	192	436
Pipe Length, km				
Aboveground	148	896	160	235
Below ground	692	738	1,805	1,399

In each city industrial customers are metered. Commercial customers are metered in Volgograd and Voronezh but not in Ryazan and Saratov. Residential customers are not metered in any of the four cities. Most of the meters used by the customers are outdated and relatively inaccurate.

Supervisory control and data acquisition system (SCADA) is not used by any of the utility companies. Similarly, network analysis capability is not present in any city. Pipeline additions, upgrading or removal are not properly analyzed to establish the best configuration for the distribution system.

The cathodic protection system in each city was found to be outdated and many sections of pipe were not adequately protected. The leak detection and cathodic protection test equipment was found to be outdated and inadequate.

From an evaluation of the existing conditions, many areas of improvement in the construction, maintenance and operation of the distribution system were identified. The potential benefits, costs, schedule and implementation requirements are outlined in Section 4 of the report. A master schedule for these projects is shown in Figure 1 of this Section. The following projects are proposed for each city.

- SCADA

  These projects include providing a system control center with computers and communications facilities for:

  - Monitoring and controlling distribution operating pressures and flow rates
  - Detecting illegal entry and unsafe conditions at City Gate Stations and other controlled access locations
  - Analyzing the distribution system performance and forecasting load and operating conditions based on weather forecasts

- Protection Systems

  These projects upgrade the existing cathodic protection (CP) systems to state-of-the-art standards for operating, maintaining, and preserving the present distribution system piping. The elements of these projects are:

  - A detailed office study of the layout of the distribution mains, and connected facilities. This study will include leak history, locations of interfering facilities such as electrified trolley tracks, and similar installations.
  - Sectionalizing the mains into units for field surveys to determine electrical isolation requirements.
  - Progressively electrically isolating the sections by installing insulating fittings or fittings in all service risers and other connected facilities.
  - Performing required pipe-to-soil potential and electric current drain surveys.
  - Installing CP rectifier stations, anodes, and ground beds as required.

- Construction Equipment

  These projects provide the cities with new tools and equipment for operations, maintenance, and personnel safety to conform with present-day standards and practices. Items included for two crews for each city are truck-mounted equipment for emergency response, excavating equipment, X-ray equipment for inspecting welds, pipe bending machines, and miscellaneous tools and safety equipment for personnel. These items are listed in paragraph 4.2.3.5 - Cost.

- Test Equipment

  These projects provide essential, modern leak detectors, gas analyzers, and calibration equipment to replace old equipment of uncertain reliability that is difficult to maintain because of age and origin from various foreign and domestic manufacturers.

- Gas Meters

  These projects will install gas meters in phases as follows:

  - Phase 1 - Commercial establishments
  - Phase 2 - Private homes with space heating
  - Phase 3 - Upgrade industrial customers
  - Phase 4 - Apartment blocks

- Gas Meter Testing

  These projects provide gas meter testing facilities with state-of-the-art electronic measurement of gas flow through meters for providing accuracy of calibration. Meters are assumed to be shop-tested on a 10-year basis, and have internal moving parts replaced to restore the meter to new condition.

DISTRICT HEATING GAS CONSERVATION PROJECTS

Joseph Technology Corporation (JTC) performed energy audits in the four cities. In each city, the local gas utility company supplies customers with gas and maintenance and metering is their responsibility.

Typically, each city has two to five cogeneration plants owned by the energy utility, which generate electricity and heat. In addition to cogeneration plants, there are also several district heating (DH) companies which either belong to the energy utility or city, or are independent. These district heating companies buy heat from power plants, produce additional heat in their own hot water boilers and supply the customers with the heat (usually hot water). The hot water from power plants is pumped through the transmission piping to the intermediate substations. The substations and distribution piping is typically owned by DH companies, while transmission piping is usually owned by the energy utility. The power plants do not usually sell heat directly to the customers, although there are exceptions. Many industrial enterprises possessing large boiler rooms with excess heating capacity provide heating to the adjacent districts. Theoretically, the water is supplied at a temperature of 150°C and returned at 70°C.

The most common problems identified were as follows:

- In practice, the temperature of supply water is lower while return water exceeds 70°C.
- Heat is not metered–the customers do not have BTU meters.
- Power plants and municipal boiler plants have flow meters but often they are not accurate or not functioning.
- The condition of transmission and distribution piping is very poor with heat loss due to leaks and poor insulation.
- Heat only boilers owned by the municipality are very inefficient (45 to 50%)

The gas conservation measures recommended include:

- Replacement of burners at municipal boilers

- Utilization of portable control instrumentation sets for leak detection, emission control, diagnostics at power plants and municipal boilers
- Installation of heat recovery at power plants and municipal boilers
- Reduction of air infiltration to the boilers by sealing the boilers
- Installation of automated control systems at boiler plants
- Installation of control valves and BTU meters in buildings

The most feasible projects with less than two years payback period are as follows:

- Utilization of portable sets of express control instrumentation for leak detection, flue gas analysis and diagnostics of the equipment at municipal boiler plants and power plants.
- Replacement of burners at the municipality owned boilers

The short and mid-term projects with the payback period from two to six years include:

- Burner replacement for boilers and furnaces
- Reduction of air infiltration by sealing ovens and boilers allowing to improve the combustion process
- Installation of heat recovery systems

And finally, long-term projects include:

- Installation of BTU meters and control valves in buildings served by municipal heat only boilers
- Installation of controls at distribution substations
- Installation of new boilers
- Installation of variable speed controls at district heating pump motors at power plants

The implementation cost of the selected projects for all four cities is estimated at $42 million with the reduction in the total gas consumption of 280 million m^3.

INDUSTRIAL ENERGY CONSERVATION PROJECTS

In every city, the utility company provided general information regarding citywide gas consumption and identified enterprises with the largest gas consumption. Six to eight of the largest gas consumers in each city were audited. At the industrial plants, process equipment and operations were assessed, schematics of energy utilization systems were reviewed, and records of natural gas use by the facility were obtained. During the audit, an assessment of gas firing equipment located at the plant including furnaces, kilns, and boilers, was performed. After the assessment, the preliminary gas saving actions were identified.

The most common problems identified were:

- Low efficiency of boilers due to inefficient burners, poor insulation and lack of automatic controls
- Low efficiency of gas fired furnaces due to the same reasons
- High temperature of flue gas due to inefficient or very often recovery systems
- No condensate return to the boiler room usually due to condensate contamination.

The most feasible projects with less than two years payback periods are as follows:

- Utilization of portable sets of express control instrumentation for leak detection, flue gas analysis and diagnostics of equipment
- Filtration of the contaminated steam condensate and installation of heat recovery equipment
- Installation of automatic controls for boilers and furnaces
- Installation of equipment for heat recovery from flue gases having a temperature of 350 to 400°C (662 to 752°F)
- Replacement of gas burner equipment for boilers and furnaces

The implementation cost of the selected short and mid-term projects for the four cities is estimated at $9.7 million with reduction in gas consumption of 133 million m^3

ENVIRONMENTAL ASSESSMENT

A World Bank category B environmental assessment (EA) was prepared, as a combined document to satisfy World Bank and Russian Federation requirements. This EA, which has been prepared according to Terms of Reference (TOR) was signed by the Ministry of Fuel and Energy and the Ministry of the Environment in September 1993. The EA provides a description of the environmental requirements and procedures, a description of the projects components and the need for them, general baseline data for the four cities, and identifies the environmental impacts which can be anticipated at this level of project definition.

No significant impacts have been identified. The Energy Conservation projects, which will have separate EAs prepared for them at a later date, would result in beneficial regional air quality and greenhouse effect impacts. Only three of the project components may have a measurable impact on the physical environment: replacement of degraded pipe, cathodic protection (including new test equipment), and new construction, maintenance, and operating equipment. Whereas the impacts of cathodic protection and new equipment would be cumulative and not site-dependent, pipe replacement impacts would be dependent on the specific characteristics of the construction sites involved. All impacts that have been considered are described, and a mitigation program has been developed. The adverse impacts which may result from the project include the following: Short-term construction impacts, including traffic circulation, air quality, odor, soil erosion, water quality, barrier to fish movement, noise, public safety risks, and economic impacts.

Beneficial impacts which may result from the reduction in methane leaks include a cumulative increase in public safety as a result of reduction of gas leaks and a cumulative beneficial impact in reducing the greenhouse effect. Also, economic benefits would result from gas conservation and potential additional sales of gas by the Russian Federation at world market prices.

The mitigation program includes an implementation plan, schedule, and costs. No additional cost is assumed for construction mitigation measures because highest and best engineering and construction practices would include all of the measures recommended. Costs for the recommended Enhancement of Environmental Capability Program are estimated to be $157,000 in year 1, $107,000 in year 2 and $20,000 yearly thereafter.

FINANCIAL ANALYSIS OF LOCAL GAS COMPANIES

Price Waterhouse (PW) conducted a financial analysis and an organizational evaluation of the four gas utility companies. This analysis included the compilation of financial statements which are included within this report. A compilation is limited to presenting in the form of a projection information that is the representation of gas utility management and does not include evaluation of the support for the assumptions underlying the projection. PW has not examined the projection and, accordingly, does not express an opinion or any other form of assurance on the projection statements or assumptions.

PW observed the following general conditions existing at each of the four companies:

1. Each of the companies is more concerned with revenue rather than efficiency. Purchasing gas within a monopolistic environment, the companies do not have the opportunity to set rates which would promote sales. Therefore, the financial health of each company is entirely dependent upon its captive customers and the revenues generated by their ability to pay established rates for gas service. However, in order for the companies to be transformed into consumer-oriented enterprises it is essential that the companies become merchants of a commodity rather than providers of an allocated resource.

2. Under the current system of national gas allocation, the company has no incentive to reduce gas consumption. During any year that savings may take place, the company is not permitted to redirect volumes saved and to sell them to other customers, and in subsequent years, the company's allocation of gas is reduced by the volumes saved.

3. There is an absence of meaningful investment for growth and expansion of the utility companies. Each company expenses an amount equal to current depreciation for investment; however, depreciation is calculated relative to the installed cost of the company's assets (adjusted once, in 1992, for inflation) and is, therefore, grossly inadequate for the longer term viability of the company.

4. Inflation in Russia effectively eliminates the ability of each company to retain and to accumulate earnings. Despite recent indexation of gas prices to inflation, the utility companies are virtually defenseless in relating current costs to market prices. The problem is exacerbated by each company's "billing gap," the 30 to 60 day period between the time that the bill is issued and the time that funds are received by the company. At current rates of inflation this gap can reduce revenues by 35 to 82 percent.

5. Each utility company pays its employees significantly higher salaries than are earned in the same cities by employees at other enterprises. The payment of these high salaries requires that the companies pay an excess salary tax of 39 percent on much of their payroll. In order to justify these high levels of compensation, the companies must seek to "right size" their staff.

Price Waterhouse evaluated the financial viability of each company relative to projects being proposed by the Study Team. The evaluation was based upon forecasts of demand provided by Benjamin Schlessinger & Associates, as well as pricing, economic and financial assumptions as directed by the World Bank. The basic premise underlying each of the analyses was that natural gas prices would quickly rise from current levels to US$40 per thousand cubic meters (in 1993 dollars), or a higher level which would enable refunding of the proposed investment.

The following four scenarios were considered:

Case 1: Demand Scenario #1 plus projects for SCADA, Network Analysis, Cathodic Protection, Leak Detection and Pipeline Replacement.

Case 2: Demand Scenario #1 plus metering projects only.

Case 3: Demand Scenario #1 plus projects in Cases 1 and 2.

Case 4: Demand Scenario #5 plus projects in Cases 1 and 2.

The results of these analyses are as follows:

The projects will require external funding in the approximate range of 65 to 75 per cent of total project costs. Under The World Bank's inflation and pricing assumptions—i.e. in the latter case that all gas prices would rise from August 1993 price levels to the level of US$40 (in 1993 dollars) per 1000 cubic meters by January 1996—the burden of servicing the debt associated with the proposed projects significantly reduces the ratio of each company's net income to net assets.

Profitability, when defined by The World Bank for the purposes of this study as the ratio of a company's average net income to net assets being at or above 10 per cent during the 1998-2002 period, is achieved only at Saratovgorgas with respect to cases 1 and 2, and at Volgogradgorgas with respect to case 2. Profitability, on this basis, within the range of 5 to 10 per cent of net assets is achieved at Ryazangorgas under cases 1 and 2 and at Volgogradgorgas under case 1.

The higher project costs of cases 3 and 4—i.e. the higher external funding and debt service requirements—have the effect of reducing the ratio of net income to net assets to less than 4 per cent at Saratovgorgas and less than 1 per cent at Ryazangorgas and Volgogradgorgas.

Under none of the cases is Voronezhoblgas profitable. The debt service burden lowers its ratio of net income to net assets to -1.3% in case 1, -.4% in case 2, -3.4% in case 3 and -2.4.% in case 4.

Increasing the cost of gas would improve these financial positions. However, such increases would be significantly in excess of the rate of inflation.

Administrative Issues

Although each of the companies has been a successful enterprise within the context of its charter, five significant administrative deficiencies were noted at each company. These deficiencies adversely impact the performance of the companies and will likely prevent them from operating successfully in a market-oriented environment.

1. The absence of a business-oriented focus. Within the controlled society, the role of the natural gas distribution company was to distribute an allocated resource. The

focus of the enterprise was management of an infrastructure without regard to the consequence of profit and loss. The companies must now re-shape their organizational focus such that their decisions will reflect the goal of being merchants of an economic commodity rather than as distributors of an allocated resource.

2. The absence of a marketing function. Although each company has a "sales" department, this function—which is primarily a coordinative unit responsible for preparing necessary contracts and documentation—needs to take a more active role in soliciting new customer service.

3. Inadequate procedures to reconcile sales volumes and revenues. Accounting for the cash flow associated with sales and for the volumes of gas purchased and sold are well defined functions. Regardless, they exist separately without opportunity for internal audit below the senior management level. A system of reconciliation needs to be implemented.

4. Excessive reliance upon manual procedures. Bookkeeping practices are labor-intensive and heavily dependent upon manual calculations. The introduction of personal computers would expedite these procedures, and provide a more secure environment for the retention of important documents and support needed forecasts and analyses. Bookkeeping employees may be retrained in the use of computers for these purposes.

5. The absence of management and financial analysis. The broader introduction of computer technology will facilitate the conduct of these important analyses and should be a high priority at each company.

Correction of these deficiencies will require the development and implementation of business and management training at all levels throughout the organizations. Specific observations with regard to each company's operation and management are also provided.

Institutional Issues

Under the Ministry of Energy there are two major gas companies: A.O. Gasprom and A.O. Rostroigazifkatsiya. Both have recently been reorganized as joint stock companies.

Gasprom is responsible for all aspects of the Russian gas industry except for distribution. Its broad span of control includes the transmission grid within Russia as well as the network which serves export markets. The company is highly influential in the setting of gas industry policy including pricing.

Rosgas is an intermediary between Gasprom and end users. It operates through a system of 71 "Oblgases" or regional gas companies. In turn each, Oblgas operates through a number of city and district gas companies ("Gorgas" and "Mejraygas", respectively). Some of these companies are jurisdictionally independent gas companies; most of the companies located in small towns and rural areas are, however, simply departments of the Oblgas.

Rosgas is responsible for gas supply allocation and pricing. Currently each Gorgas prepares an annual request for service which is forwarded to the Oblgas which, in turn, combines the requests into a single regional request is forwarded to Rosgas. Rosgas presents these applications to the Ministry of Fuel and Energy. In parallel, the Gorgases and Oblgases send their applications to Gasprom. Negotiations among the Ministry of Fuel and Energy, Gasprom and Rosgas result in the actual allocation of gas service for the year. All gas which is allocated is paid for by the customers to whom it is allocated. There are penalty provisions for taking more than the

allocation with penalties going largely to the local governments rather than the utility company. If less than the allocated volume is taken, the subsequent year's allocation will be reduced accordingly. The utility company is not permitted to redirect an unused allocation to other customers except within the industry of the initial allocation.

Prices are determined by the State Pricing Committee of the Russian Federation and are established at the same levels for customers throughout Russia. Recent decrees have called for these prices to increase with the rate of inflation. There is, however, political pressure to keep residential prices at subsidized levels relative to the price of gas for industrial customers. The utility companies are required to sell gas at these prices. Sales at higher prices are prohibited. Even if they are to sell gas at lower prices, their tax base is the volume of their allocation priced at the governmentally approved level.

There are two models by which companies in Russia may be privatized. Each model allows employees and management the opportunity to buy shares in the utility company, with the remainder going to local and state governments. Neither form is intended to bring capital to the company. The proceeds will be low because the assets are evaluated at original cost (adjusted once for inflation, in 1992). Also approximately 50% of the value will be exchanged for vouchers which have been distributed throughout Russia free of charge.

It has not been determined whether the utility companies will become privatized or whether privatization will take effect at the Oblast level. Rosgas is promoting the latter inasmuch as it will be easier to manage 71 newly restructured Oblgases rather than companies formed from the thousands of Gorgases. Also an Oblgas is profitable typically because, within its mix of Gorgases, there are highly profitable enterprises with large industrial customers to balance against a larger number of smaller, unprofitable Gorgases, typically with only rural, residential customers.

Conclusions and Recommendations

1. The volumes of gas received in 1993 by each utility company should be guaranteed by the Ministry of Fuel and Energy for subsequent years.

2. The utility company should be considered as the owner of the gas it purchases and given the right to resell that gas to any other party.

3. Utility companies should have the right to compete with all potential suppliers through aggressive pricing and should be taxed only on the basis of actual revenues.

4. The utility company should have the right and timely ability to charge penalties and discontinue service for substantial non-payment of bills.

5. The utility company should have the right to offer discounts to customers willing to advance money to the utility company for gas to be supplied.

6. A methodology for correcting the utility company's markup to reflect local conditions should be developed and implemented.

7. As prices rise toward market levels, the Utility companies should have the right to purchase gas directly from producers.

SUMMARY OF POTENTIAL INVESTMENTS

Potential projects for the gas distribution companies have been identified for each of the four cities with investment requirements ranging from approximately $26 million for Ryazan to

15

$46 million for Voronezh. In combination for each city, the sets of projects have estimated economic rates of return ranging from 26% in Ryazan to 37% in Volgograd.

The industrial energy conservation and district heating plant projects were selected to generate a minimum IRR of 25%.

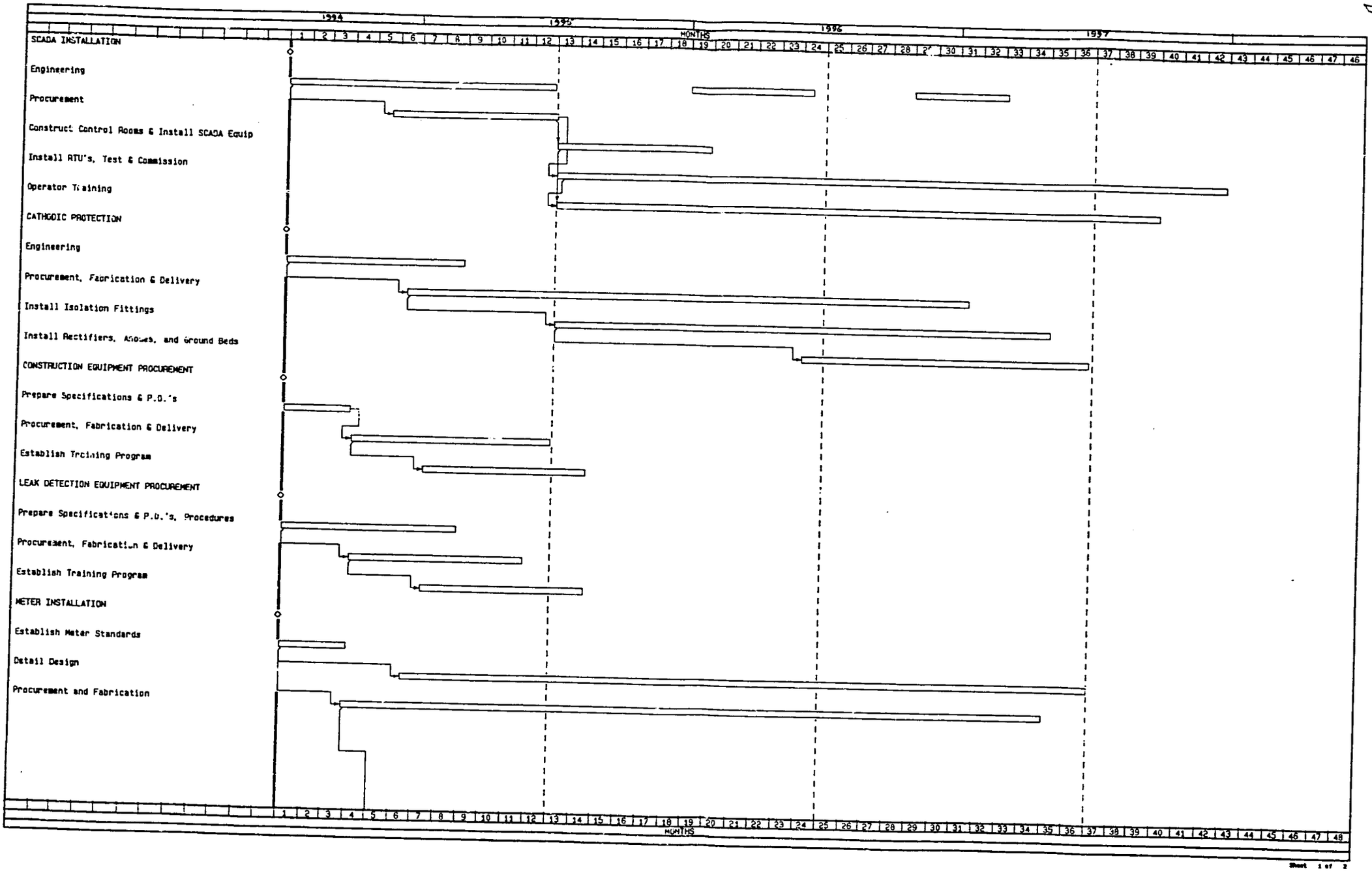
The estimated investment requirements of "qualified" projects are as follows:

	Gas Distribution $000	Industrial Plants $000	District Heating $000
Ryazan	26,000	200	8,500
Saratov	38,000	4,000	10,800
Volgograd	40,000	5,200	13,700
Voronezh	46,000	300	9,000
Totals	150,000	9,700	42,000

ENERGY CONSERVATION PROJECTS FUNDING

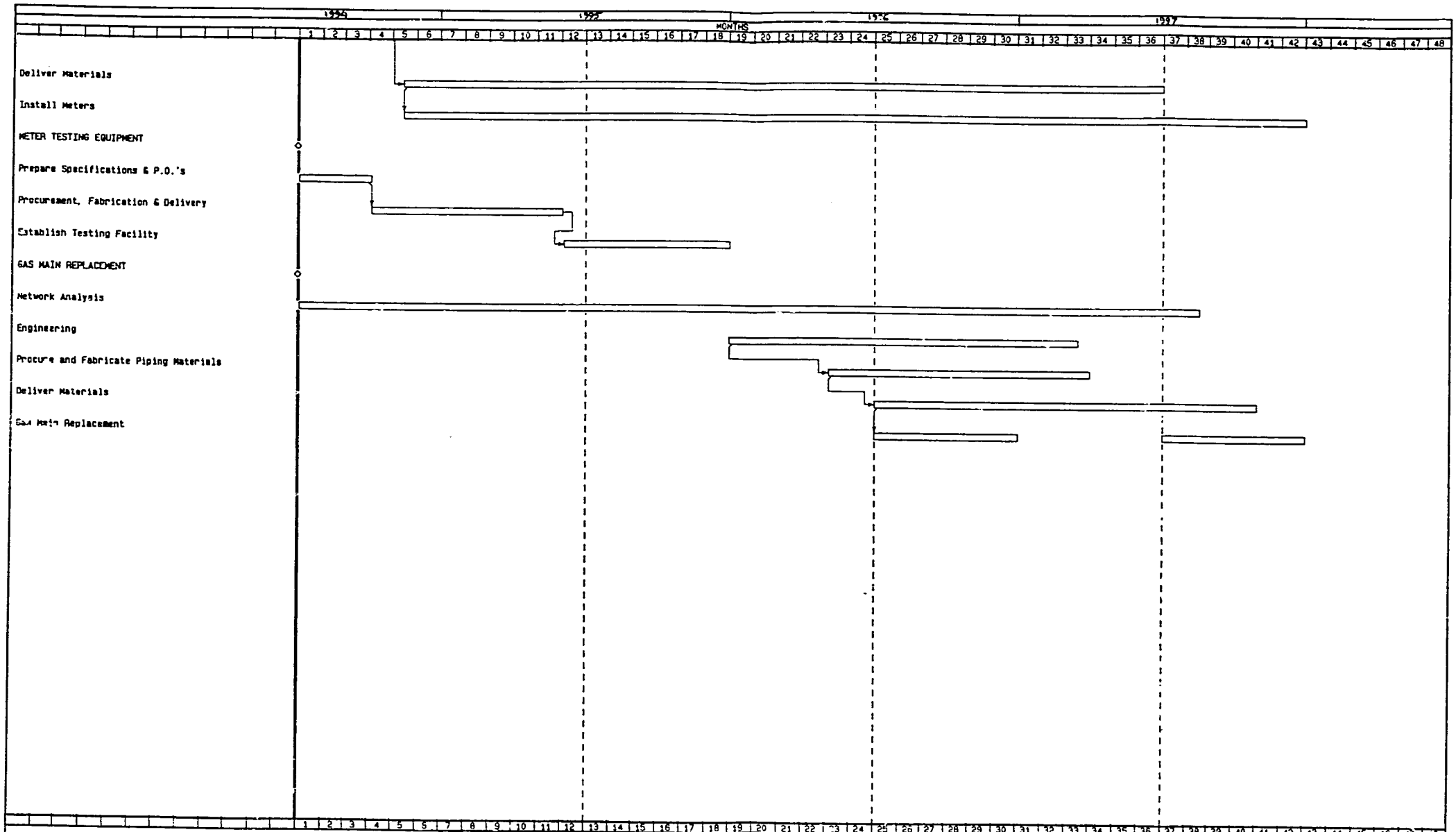
The energy conservation projects will be funded from money loaned by the World Bank or similar financial institution to the Russian Energy Savings Fund. The Savings Fund will review the projects and lend money to the cities who in turn will lend it to the industries. The Russian government has issued resolution No. 568 guaranteeing the repayment of the loan amount to the Energy Savings Fund.

BEST AVAILABLE COPY



Sheet 1 of 2

BEST AVAILABLE COPY



U.S. Agency for International Devel.
NIS Natural Gas System Rehabilitatio
Summary Schedule

Section 1

TABLE OF CONTENTS

1. INTRODUCTION **1**

1.1 BACKGROUND 1

1.2 STUDY OBJECTIVES 1

1.3 SCOPE OF WORK 1

1.4 APPROACH 2

1.5 TASKS TO BE COMPLETED 2

Figure 1-1 Location Map 4

Section 1

INTRODUCTION

1.1 BACKGROUND

The Government of the Russian Federation (GOR) has requested the World Bank to finance a Gas Distribution Rehabilitation Project (GDRP). In support of this request, the United States Agency for International Development (USAID) has agreed to finance a project preparation study for the proposed project. Bechtel Corporation was selected by USAID to perform this study under Contract No. DHR-5741-Q-00-1062-00, Delivery Order No. 4.

The study is designed to:

- Evaluate the existing conditions of the gas distribution systems in four cities - Saratov, Volgograd, Voronezh and Ryazan. Figure 1-1 shows the location of these cities.
- Identify projects that would improve the performance of the gas distribution systems and will result in gas savings.
- Select projects that would qualify for financing by the World Bank.
- Review and analyze the financial structure of the gas utilities "Gorgas" and recommend the required changes for their privatization.

1.2 STUDY OBJECTIVES

The primary objectives of the study are:

- To reduce gas distribution system losses, improve reliability and increase the safety of system operation
- To increase the efficiency of energy use by customers
- To recommend necessary institutional reforms
- To transfer technology and design "know-how" concepts

1.3 . SCOPE OF WORK

Task 1 - Selected Cities Natural Gas Demand Analysis

- Natural Gas Demand Forecast
- Efficient Use of Energy
- The Role of Gas

Task 2 - Project Preparation

- Asset Review
- Network Reconstruction and Development Strategies

- Economic Analysis
- Project Identification, cost estimates and implementation schedule
- Environmental Analysis
- Evaluation of Local Material Supply Capability

Task 3 - Financial Analysis

1.4 APPROACH

The project team, led by Bechtel includes three US and one Russian subcontractor. A team of specialists in the four cities gathered the required data, observed the operation of the systems, and identified projects to improve the efficiency of gas usage. Bechtel assigned the study activities as follows:

- Bechtel - overall study management, evaluation of the gas distribution system, review of apartment building design, evaluation of equipment and material availability, and identification of projects qualifying for World Bank financing.
- Ben Schlesinger & Associates - preparation of estimates of current and projected levels of gas demand under alternative development scenarios.
- Joseph Technology Corporation, Inc. - performance of energy efficiency audits of selected industrial establishments and district heating systems.
- Price Waterhouse - performance of financial analyses of the distribution companies; assessment of the economic viability of gas distribution system improvements; and determination of the institutional changes required to transform the gas utilities to joint stock companies.
- Giproniigas Institute in Saratov - provide technical and financial data on the gas utilities in the four cities.

For the identified projects, Bechtel has developed the scope, schedule and an estimated cost. The cost of labor and material has been segregated to reflect the domestic and foreign components.

A master schedule has been developed to outline the activities from the completion of the study through mechanical completion of the identified projects.

1.5 TASKS TO BE COMPLETED

The following tasks will be completed after the release of this report:

- The World Bank will prepare its Executive Project Summary and issue it for internal review. Based on the internal review and approval of appropriate management personnel, the Bank will establish its position relative to the identified projects. This task is expected to be completed by the end of December 1993.

- In January 1994, the World Bank will review its Appraisal Report with representatives of the utility companies and appropriate Russian authorities. Aide memoire will be signed during this visit.
- Develop technical specifications and contract packages for each project.
- In March 1994, the loans will be negotiated and legal documents prepared.
- In May 1994, the loans will be available to the utility companies.

LOCATION MAP

FIGURE 1 - 1

Section 2

TABLE OF CONTENTS

2. THE ROLE OF GAS 1

2.1 BACKGROUND 1

2.2 DISTRICT VS. LOCALIZED CENTRAL HEATING 1

2.3 GAS VS. ELECTRIC STOVES 3

2.4 CONVERSION OF LP TO MP SYSTEM 4

2.5 GAS USE SCENARIOS 5

2.6 USE OF POLYETHYLENE PIPE 6

2.7 GAS PIPELINE EXTENSIONS 7

2.8 APARTMENT BUILDING DESIGN REVIEW 8

2.8.1 Existing Conditions 8

2.8.2 Recommendations 10

2.9 DESIGN STANDARDS REVIEW 11

Table 2-1 Basis for District Heating and Apartment Block Boiler Costs 16

Table 2-2 Break-Even Calculation for District Heating System 17

Table 2-3 Comparison of the Cost of Gas and Electricity Used for Cooking Only 18

Table 2-4 Electric Power Required to Convert from Gas to Electric Stoves 19

Figure 2-1 Cost of District Heat vs. Distance 20

Figure 2-2 Detail of "Dryvit" Exterior Wall Insulation and Finish System 21

Figure 2-3 Floor Plan of Typical Apartment Building 22

Figure 2-4 Section of Typical Apartment Building 23

Figure 2-5 Detail of Cavity Wall System for Future Construction 24

Section 2

THE ROLE OF GAS

2.1 BACKGROUND

The role and structure of natural gas supply in meeting future energy demands is likely to change over the next decade. This may include:

1) Changes in the role of gas in household energy use and district heating

2) Improvements in end-use energy efficiency due to active energy efficiency efforts coupled with price rationalization and increased use of metering

3) Changes in industrial and commercial sectors due to structural changes in the economy

4) The impact of new technology

This section discusses the first of these issues as a basis for scenarios of future development and treats certain issues of end-use efficiency. Criteria for determining the role of gas in localized central heating as an alternative to continued development of district heating are discussed, as well as the economics of replacement of gas cooking stoves by electric stoves.

Options for conversion of low pressure (LP) piping by medium pressure (MP) piping as a consequence of installing individual apartment block boilers are also presented, and the criteria for choosing among the options on a case by case basis are outlined.

Future gas use scenarios are examined to establish the most economical mix for gas, electricity and district heating systems.

Recommendations on who should pay for pipeline extensions is discussed and the potential for using polyethylene pipe in Russia is also included in this Section.

Energy efficiency in residential building design is also discussed, with recommendations for possible retrofitting. The section concludes with a design standards review for the gas industry, with recommendations that could increase efficiency and safety in gas use.

2.2 DISTRICT VS. LOCALIZED CENTRAL HEATING

The majority of multi-unit apartment buildings are supplied with space heating and hot water from district heating systems. The current operation of district heating systems is considered to be inefficient due to high energy losses; inadequate or lack of controls and service interruptions. Heating controls are not provided and therefore room temperature is largely controlled by opening windows when it gets too hot or by turning on stoves or auxiliary heaters when it gets too cold.

The district heating systems are taken out of service for two weeks or more each summer for repairs during which time hot water supply is curtailed. Many sections of district heating pipes require frequent replacement. The sections of town supplied with hot water from pipes under repairs may be without hot water for extended periods of time.

Some of the problems associated with district heating systems can be solved by improving pipe insulation, protection of distribution pipe from internal and external corrosion and installation of temperature controls in apartments.

The district heating systems become uneconomical when the apartments are located far away from the boiler plants. In order to evaluate the break-even distance beyond which a district heating plant would become uneconomic, unit cost of heat supplied to a 9-story building (250 apartments) was estimated for an on-site boiler. The heat requirement was assumed to be 1,711 m^3 natural gas/apartment/yr for space heating and 367 m^3 natural gas/apartment/yr for hot water.

A boiler with a peak load capacity of 1.2 Gcal/hr (peak gas demand of 250 m^3/hr) would be able to supply heat and hot water to 250 apartments.

The basis of estimating cost of heat delivered by the district heating plant ,as well as by an apartment block boiler, is given in Table 2-1. The cost of apartment block boiler is estimated to be $93,000. The annual capital charges were estimated based on 20 year loan at 15 percent interest. The cost of heat is the sum of the annual loan payment and the cost of fuel. the unit cost of heat supplied by apartment block boiler works out to be $37.80/Gcal as shown in Table 2-1.

The cost of heat delivered by the district heating plant depends upon the total heat provided by the plant as well as the length of the district heat supply pipes.

The peak heat generated by the district heating cogeneration plant is 860 kcal/kw (thermal) as shown in Table 2-1. It is assumed that 42 percent of the cost of fuel required to generate district heat at peak load is charged to district heating and the remainder charged to electric power generation based on operating characteristics of the Russian plants. The cost of fuel at the cogeneration plant is assumed to be $40/1000 m^3.

The cost of delivering heat by district heating system for 25 MW (30 Gcal/h) and 50 MW (60 Gcal/h) cogeneration plants is presented in Table 2-2. The total cost of delivered heat is computed as the cost of fuel, operating and maintenance costs and annual loan payment for the cost of the district heating portion of cogeneration plant and the district heating piping system.

Similar computations were made for different heat capacity cogeneration plants. Figure 2-1 shows the cost of heat delivered to the apartments as a function of their distance from the district heating plant. A line showing the cost of delivering heat using an apartment block boiler ($37.80/Gcal) is also shown in this figure. the break even distance is represented by the point of intersection of the horizontal line representing cost of apartment block boiler and the sloping lines representing cost of heat delivered by district heating plants. As an example, for a typical 60 Gcal/h district heating plant, the break even distance is about 7 km. Thus, a district heating plant is cheaper than apartment block boilers up to a distance of 7 km for a heat load of 60 Gcal/h at that distance. The break even distance increases with an increase in the size of the heat load as shown in Figure 2-1.

Data on exact locations of the district heating and industrial boiler plants in relation to population centers was not available. Since all of the towns included in this study are situated on river banks, the width of towns is quite small in relation to their lengths (along the river). Based on this, it is estimated that about 90 percent of the apartments will be within 7 km of the district heating stations.

The same criteria is valid for new apartment complexes where district heating systems may not exist. If the apartments are located beyond 7 km from an existing district heating plant, then on-site boilers should be considered; otherwise, the hot water distribution piping should be extended to serve them.

Each apartment complex located beyond 6 to 7 km from a district heating supply station must be examined to determine if it will be more economical to upgrade the district heating system

or to build boilers near the apartment complex for supplying heat and hot water. Most towns have extensive MP gas distribution systems. Therefore, in most cases it may not be necessary to convert a significant portion of the LP systems into MP systems in order to supply gas to boilers to be located near apartment complexes. It may be possible to extend the existing MP systems piping to feed these boilers. However the need for converting LP pipes into MP pipes or the possibility of extending the MP systems will have to be established on a case by case basis. Network analysis models should be used to determine the most effective way of supplying gas to these boiler plants.

It should be noted that about 25 percent of fuel can be saved when generating heat and electricity at a cogeneration plant as against a single purpose electric power plant or individual boiler plants producing heat. The reduction in fuel consumption at the cogeneration plant results from the following factors:

1. The power plant boiler is run by experienced operating personnel who monitor and adjust the plant for peak efficiency.

2. A power plant boiler is more efficient than a small boiler sized to meet the heating needs of an apartment building because the power plant boiler is equipped with economizers and combustion air pre-heaters.

3. A cogeneration plant heats the district heating water using steam from an intermediate stage of turbine. It is more efficient to use this steam to heat district heating water than to heat the steam further to generate additional electricity.

4. The seasonal efficiency of an individual apartment building boiler is much lower compared to a cogeneration plant boiler because of part load operation of the small boiler.

Experience in Russia indicates that the above mentioned factors give rise to about 25 percent savings in fuel use by generating district heat at a cogeneration plant compared to an apartment block boiler. Thus, the fuel consumption for hot water and space heating may increase by 25 percent if district heating from cogeneration plants is curtailed. Individual heat only boiler plants should be examined first for curtailment of district heating system.

2.3 GAS VS. ELECTRIC STOVES

Most of the apartment houses in multi-unit apartments use gas for cooking purposes only. The operating and maintenance costs of the LP pipeline systems serving these apartments is estimated to be quite high. In order to recover the full cost of operation of the LP system the price of gas for the residential customers is estimated to rise from US$5/1000 m^3 to US$300/1000 m^3. All prices are expressed in mid 1993 US dollars. With a free market economy the consumers will choose either electric or gas stoves for their cooking needs on the basis of relative costs of gas and electricity.

Table 2-3 summarizes the annual cost of gas and electric stoves for a family of 3 based on current and projected future prices. It shows that the cost of electricity will remain at least three times more than that of gas on an equivalent energy basis.

Switching from gas to electric stoves may require installation of additional electric generation capacity and may also require changes in apartment wiring to withstand extra load. The amount of additional electric power required to replace gas stoves with electric stoves for the four cities is summarized in Table 2-4. The electric generation requirement was based on the current allocation of gas for cooking purposes and assuming a thermal efficiency of 40 percent and distribution losses of 15 percent.

In addition to the cost of installing additional generating capacity, there will be a net increase in gas consumption for production of electricity. Only 34 percent of the heat input at the power plant is delivered to the electric stoves because of losses during generation and transmission of electricity. Thus the residential gas use will become three times its current use if it is assumed that the additional electric power for stoves is generated using gas.

Use of electric stoves in place of gas stoves would not be preferred by the customers because of the higher cost of electricity compared to gas even after the gas price increases become effective.

Use of electric stoves in place of gas stoves is also not preferable from energy conservation and gas savings considerations.

2.4 CONVERSION OF LP TO MP SYSTEM

As noted in Section 2.2, certain sections of LP pipe may have to be replaced by MP pipe to supply gas to individual apartment block boilers. The following options are available for converting LP piping into MP piping:

1. Upgrade the existing LP piping to MP standards through a re-certification program.

2. Insert polyethylene (PE) pipe through the LP piping.

   See Appendix 2-A for details on this technique.

3. Replace the existing LP piping with new piping to meet MP pressure requirements.

In order to determine which options are feasible and most cost effective, the following analysis must be done:

1. A detailed review of each segment of LP system must be performed. The review must determine which options can be supported based on physical characteristics, construction methods, and construction and equipment/material standards.

   The analysis should assume that each Gorgas will want to continue the practice of installing pipe aboveground attached to buildings, especially in the apartment complex environment. This practice is driven by strong concerns over third party damage and the potentially unsafe condition of underground gas migration through neighboring utilities. The aboveground pipe is predominately LP and supplies gas for cooking, and in certain cases, cooking and hot water. Conversion to higher pressures will be restricted to underground piping, and may further be restricted to underground piping located in the street.

   The analysis, therefore, should fall into the two broad categories of private homes and apartment complexes. The LP mains supplying private homes are typically underground, are located in the street, and are interconnected as a grid with service lines to each home. The LP mains supplying apartment complexes are a mix of underground and aboveground mains which usually do not resemble a grid system, and instead are found in a courtyard setting.

2. A hydraulic analysis must be performed on each segment of LP system. The analysis should <u>first</u> determine whether the existing LP system is capable of supporting the range of loads under consideration and may preclude or delay the

need for conversion to HP/MP. Otherwise, the analysis will determine the best higher pressure network design for the range of loads under consideration.

The hydraulic model should include both the existing HP/MP systems if converting to a higher pressure network is justified. The model's load files must include current design load data as well as ultimate load saturation data.

The method of converting LP mains or supplying higher gas demand will depend upon whether the pipe is located near private homes or apartment complexes.

Private Homes. Each Gorgas appears to use the same pipe wall thickness for a given pipe diameter regardless of pressure application. If pipe wall thickness as calculated in accordance with SNiP 2.04.12-86 for each LP subsystem under consideration meets the requirements of HP/MP construction, and the subsystem has a good leak history, then upgrade the existing system by re-certification. This requires replacement of all components of the LP system which do not meet HP/MP standards (fittings, connectors, etc.), the installation of service shutoff valves, house regulators and meters, pressure test, and a general review and upgrade of other components, such as CP systems, emergency main isolation valves, etc.

If pipe wall thickness does not meet the requirements for HP/MP construction, then insertion with plastic is the next best option.

If PE pipe is not available then the LP pipe sections requiring upgrading must be replaced by new pipe. This will be the most costly alternative.

In all cases, services should be electrically isolated at the front wall penetration. In addition, each service line should be considered a candidate for replacement/insertion based on age and leak history.

Apartment Complexes. For safety reasons, house piping and aboveground piping can only operate at LP. This, therefore, fixes riser capacity and may limit the addition of hot-water heating load at specific apartment buildings. The potential for additional water heating load will have to be calculated on a case by case basis.

Hydraulic analysis most likely will indicate that LP systems do not have the capacity to supply gas to apartment complexes for space heating. In most cases, the HP/MP system will have to be extended where new boilers are recommended to replace central heating. There will not, however, be many opportunities to upgrade LP piping to supply these new boilers because of existing aboveground pipe and Gorgas' stated policy to continue replacing buried pipe with aboveground pipe at apartment complexes. Extension of MP piping to the individual apartment complex boiler house will then be the only option for supplying gas.

2.5 GAS USE SCENARIOS

The following scenarios were considered for future gas use:

1. Continue with the existing mix of gas use.

2. Replacement of gas cookers with electric cookers in those areas where gas is used exclusively for cooking.

3. Retirement of central district heating system by providing individual boilers to supply heat and hot water to a block of apartments.

4. Replacement of gas cookers with electric cookers in those areas where gas is used exclusively for cooking, and at the same time retire central district heating systems by providing individual boilers to supply heat and hot water to a block of apartments.

As pointed out in Section 2.3, the cost of electricity remains more than three times the cost of gas per unit of heat delivered to residential cookers even when the full cost of delivering gas to the residential users is considered. Thus, scenarios 2 and 4 are not economical.

The central district heating system needs considerable upgrading to satisfy the consumer needs. As pointed out in Section 2.2, total retirement of district heating systems is not economical. About 10 percent of the residential customers can be more economically served by the use of boilers near a block of apartments. For the other 90 percent of the residences, it would be more economical to upgrade and improve the existing central heating system.

Modified Scenario 3 will be the most economical mix of future gas use. It involves continued use of gas cookers in residences together with retirement of central district heating systems in about 10 percent of the residences that are located more than 6 to 7 km away from central heating plants. New residences located more than 7 km from a district heating plant would not be served by district heating plants.

2.6 USE OF POLYETHYLENE PIPE

The Russian gas supply building code SNip 2.04.08-87 permits the use of polyethylene (PE) pipes operating at pressures up to 3 bars in towns and villages and up to 6 bars for inner city transmission lines. The PE pipes are not permitted for natural gas in the following areas:

- Above ground construction
- Areas with estimated temperatures of -40°C or less
- Heaving or shrinking soils
- Rocky areas
- Mining areas
- Areas with seismic activity over point 6
- Crossing over railway or street car lines, 1st and 2nd class highways, waterways, swamps or other water barriers
- Inlets to buildings

PE pipes have been used to a limited extent in rural areas. The current laws do not allow use of PE pipes within cities. the main concerns are frequent damage due to unauthorized diggings and lack of manufacturing facilities for good quality PE pipes and fittings. Use of PE pipes as inserts in an existing steel pipe is permitted within the city limits.

Giproniigas Institute, which is responsible for developing gas distribution piping standards, had also expressed a concern for the very low ambient temperatures encountered in Russia. For example, the minimum allowable operating temperatures for PE pipes is -18°C. Since the PE pipes will be buried below frost depth in most locations, the minimum operating temperatures will remain above -18°C.

Plants for manufacturing PE pipes and fittings have recently been built. Plants for producing raw materials for producing PE pipes have been built in Kazan and Stavropol. PE pipe fabricating plants have been built in the Ryazan area, St. Petersburg and the Saratov area.

Good quality PE pipe fittings are not produced in Russia. There are plans for producing PE pipe fittings in Saratov area sometime in 1994 or 1995. With the availability of proper materials, Giproniigas is prepared to revise their standards to allow use of PE pipe. However, currently PE pipes and fittings of proper quality are not available in Russia. Therefore, for the pipeline replacement program from the near term, only steel pipes are considered to be a viable choice.

PE pipes can be used either to replace existing steel pipes or as an insert in an LP steel pipe to upgrade it to MP service. It may also be used for extending service to new areas. Experience in the United States indicates that the PE pipe costs about 30 percent less than a steel pipe. It also eliminates the need for cathodic protection.

According to estimates made by Giproniigas Institute, the installed cost of PE pipe is below 50 percent of the cost of steel pipe as summarized below:

Pipe Diameter mm	Cost of Steel Pipe: Material Rubles/m	Cost of Steel Pipe: Material plus Installation Rubles/m	Polyethylene Pipe: Material Rubles/m	Polyethylene Pipe: Material plus Installation Rubles/m
100	3,000	5,204	1,200	2,455
150	6,000	8,632	2,300	3,627
200	10,000	13,053	4,500	5,900

This shows that there is potentially a large economic incentive for using PE pipes in Russian cities. Availability of good quality pipe and fittings and modification of distribution pipe design requirements will give rise to a large scale use of PE pipes in Russia.

2.7 GAS PIPELINE EXTENSIONS

All four Gorgases are responsible for the operation and maintenance of their distribution systems. The Gorgases do not contribute any costs for extending service to new customers. The design and construction of the gas pipeline extensions are carried out by the customers. Since the Gorgases do not contribute towards the cost of pipeline extensions, they are not able to exert sufficient control on the design and construction of these extensions.

In the United States, the gas supply company contributes towards the cost of gas pipeline extensions and thereby acquires ownership of the system. Each new customer is eligible to obtain certain lengths of pipeline extension without cost. This length depends upon the number of gas cookers and size and type of other gas appliances used by the customers. For example, the gas supply company may pay for the first 15 meters of pipeline extension to a customer having one gas cooker. If there are a number of customers (e.g., apartment complex) connected to the same pipeline extension, the total length of pipe for which the gas company will pay the cost of design and construction will be the sum of individual allowances for each apartment in that complex. For example, with a 15 meter allowance, the gas supply company will pay for the first 1,500 meters of pipeline extension if there are 100 cookers in the apartment complex to be served by this extension.

When a pipeline extension is built with part of the cost of design and construction paid by the consumer, then these consumers are refunded money contributed by them when new customers are connected to the same extension. For example, if the gas company has established a free length allowance of 15 meters per gas cooker and a 1,500 meter long pipeline extension is built to serve 50 customers with one gas cooker each, then these customers would have to pay for the 750 meter length of new pipeline extension. If 40 new gas cookers are subsequently connected to the same pipeline, the existing customers will get a refund equal to the cost of 600 meters length of pipe. If on the other hand, 60 new gas cookers are subsequently connected, the previous customers will get full refund of their costs since the total free length allowance with 110 gas cookers exceeds 1,500 meters.

It is recommended that the Gorgas companies consider establishing policies similar to those used in the United States. This would ultimately provide full ownership of the pipeline system to the Gorgases. It would increase their assets and provide much needed control on the design and construction of the pipeline extensions.

2.8 APARTMENT BUILDING DESIGN REVIEW

2.8.1 Existing Conditions

Energy use efficiency can be achieved by improving the design of apartment buildings and by increasing the building insulation where feasible. The design and construction of apartment buildings was reviewed in order to develop recommendations for improving their design.

The following buildings and facilities were visited as a part of this review:

- New apartment building (6 months old).
- Old apartment building (50 years old).
- Apartment building under construction.
- Student dormitory building under construction.
- New cottage started April 1992, not finished.
- Single family wood frame house (50 years old).
- New dacha.
- A wood-window manufacturing plant.
- A precast-concrete-panel manufacturing plant.
- A private building contractor's office.
- The design institute office in Voronezh.

In addition, the following documents were obtained and reviewed:

- A complete set of reproducible architectural plans for typical apartment building construction.
- A copy of the residential building standards for all of Russia, written and updated by a central institute in Moscow.

- A computer printout of all materials and labor costs of residential construction.

- Typical plans of gas distribution in apartment buildings.

Based on site visits and review of the design documents it was found that the building materials are generally limited to:

- Precast concrete used as foundations, floor and roof slabs, exterior walls, columns, beams, lintels, balcony railings, and stairs.

- Brick made of white silicon clay or red clay used as exterior bearing walls, interior bearing and non-bearing walls.

- Steel lintels and beams - are very rarely used.

- Wood window frames, doors and door framers, interior trim, and roof framing.

- Built-up roofing over fiberglass insulation.

- Corrugated metal roofing over waterproof membrane.

- Cement plaster and gypsum plaster.

- Gypsum wallboard and gypsum panels.

- Ceramic tile, sheet vinyl flooring, wood flooring.

- Metal exterior security doors and garage doors.

- Metal grille work and gates.

The building construction techniques include:

- 18 inch to 24 inch thick solid brick exterior walls with no insulation.

- 8 inch thick precast concrete exterior walls with no insulation.

- 8 inch thick precast concrete floor and roof slabs.

- Two sets of windows mounted several inches apart or mounted together.

The residential building heating systems consist of the following:

- Apartments use hot water from central heating plants and pump it through their radiator systems.

- Cottages have individual boiler and radiator systems.

- Dachas are unheated.

- Forced warm air systems are non-existent.

The following information was found for the use of gas for cooking and hot water supply in various buildings:

- At the present time gas used for cooking and heating of water is limited to the first 9 floors of a building.
- All floors above 9 use electricity for cooking and heating of water.
- The reason for the height limit on gas usage is that 9 floors is the maximum height of the fire evacuation ladder trucks, and gas usage above that height is considered to be hazardous and unsafe.
- The maximum allowable height for apartment buildings is 20 floors.

2.8.2 Recommendations

The thousands of apartment buildings built in Russia over the past 50 years vary little in design or construction techniques. The design addresses the heat loss problems by (1) doubling or tripling the windows, (2) thickening the walls and (3) maintaining an attic space even in the flat roofed buildings.

An analysis of these three design features reveals the following:

1. Doubling and tripling the windows is a very effective way of combating heat loss because each pane of glass encloses a dead air space similar to the effect of insulated glass. In addition, wood frames are used exclusively, thus enhancing the resistance to heat loss, versus the use of aluminum frames. Caulking and weather-stripping are required maintenance items to assure that windows are tight and minimize the leakage of air.

2. The only way to retrofit an existing solid brick wall or a precast concrete wall to an R value of 11 or 12 is to apply insulation either to the inside surface or the outside surface. Thickening the brick walls does very little to stop the flow of heat through the walls because bricks have such a low resistance to heat transmission. A 24 inch thick solid brick wall has an approximate total R value of 2-1/2.

   The obvious choice for retrofit would be the outside surface because of its accessibility. A system such as the "Dryvit System" mechanically attaches lightweight polystyrene panels to the existing structure, embedding reinforcing fiberglass mesh in a base coat and applying a Dryvit finish in one of a number of textures and colors. See Figures 2-1, 2-2 and 2-3. This type of retrofitting would cost approximately $6/sf or $2500/apartment. When this cost is compared to the savings in heat loss and ultimately in gas use a determination could be made as to its economic feasibility. A thermographic study has been made by Dryvit Systems Inc. for Poland, and could be used in this comparison.

   A quote from that study is as follows: "The use of Dryvit products for external insulation refurbishment solves the problem of energy loss by wrapping the buildings in a very energy efficient thermal envelope. Dryvit's colorful products also provide an appealing aesthetic contrast with the predominantly drab and colorless environment. The current "payback period" for energy savings from Dryvit refurbishment is currently estimated at between three and four years, however, as government energy subsidies are phased out over the next several years the payback period should decrease to about two years."

For future construction using the same basic materials, a much more heat efficient brick wall can be built by merely introducing a cavity space of say 2 inch and placing a 1 inch panel of foilfaced insulation board similar to "Celetex Tuff-R" in the cavity. The total thickness of the wall can be reduced from 24 inch to 14 inch and the R value increased from approximately 2-1/2 to 13-1/2. See Figure 2-4.

3. Maintaining an attic space is an excellent method of preventing heat loss through the roof. Two important factors are the insulation at the ceiling level and proper ventilation of the attic space. An inspection of existing buildings indicates that both factors have been addressed. However, the type of insulation varies from fiberglass to furnace slag and could easily be retrofitted with additional, more efficient insulation to create an R value of approximately 30. Future construction could also take advantage of high R-value insulations.

2.9 DESIGN STANDARDS REVIEW

The following regulations were reviewed in order to determine what recommendations could be made that would result in an increase of gas use efficiency and safety.

1. Safety Rules (Operational and Labor), Ordinance No. 70-P dated October 30, 1991

2. Safety Rules in Gas Industry

3. Building Code, Gas Supply SNiP 3.05.02-88, revised 1988

4. Building Code, Gas Supply, SNiP 2.04.08-87, revised 1991

<u>General comments for the above regulations</u>

1. Regulations need to be written more in terms of performance expected language to allow the users more flexibility in the design, construction and operation. For example, in the section of the building code describing the requirements of a gas regulating unit (GRU), the regulations dictate not only what equipment is required but sizing and design criteria as well; i.e., filter, safety shut-off valve, gas pressure controller, etc., is required and various sizing and design criteria is given if the inlet pressure exceeds a specified limit and the station capacity is a given size.

   These items should be left up to the user to specify and the regulations should give expected performance requirements. As an example, performance language for a GRU states that "...each pipeline that is connected to a gas source so that the maximum allowable operating pressure could be exceeded as the result of pressure control failure or of some other type of failure, must have pressure-relieving or pressure-limiting devices that meet certain design and capacity requirements." The type of equipment (whether filtration and pressure-relieving or pressure-limiting devices are required) and the capacity is the responsibility of the user.

   Regulations written in this manner allow the user more flexibility to alter the design, if need be, and the opportunity to optimize the design where possible.

2. Gas utility companies should develop their own standards complete with diagrams and sketches to describe the design, construction and operation of specific

facilities that meet or exceed the requirements of the mandated performance objectives.

3. LHG (liquefied hydrocarbon gas) requirements should all be included in a separate section or separate standard instead of being listed in various sections throughout these regulations.

4. A more detailed review of these regulations is required to thoroughly evaluate the specific requirements given. Many references to other regulations are given in these documents which were not available at the time of this review. In order to perform a detailed review of these regulations, all reference regulations, standards and codes need to be reviewed.

Specific comments listed for each regulation

Safety Rules (Operational and Labor)

1. Section 1.3 - A method to accurately determine the heating value of the gas should be added. The method should include the use of continuous samplers and a description of the procedure used to determine the average heating value of the gas.

2. Section 1.13 , Table 1 - A program should be implemented to eliminate the use of mercury containing instruments in favor of the dry bellows type.

3. Section 4.2 - Technical maintenance should include a check of the integrity of the insulating fittings and flanges.

4. Section 4.11 - To test the presence of gas in basements, wells, collectors, etc., an explosion-proof flame ionization leak detector should be used.

5. Sections 5.15-5.19 - Pressure control fittings (punch tees) should be used whenever tapping into an operational gas pipeline.

6. Section 7.10 - A method of prioritizing or grading leaks is required so that the more dangerous leaks requiring immediate attention can be repaired first. The use of more sensitive leak detection equipment would allow the grading of leaks to be done more easily.

7. Section 15.10 - Calibration of the chromatograph should be performed weekly or before any group of samples are run.

8. Section 15.16 - Explosion-proof leak detectors are available so it is not necessary to prohibit the use of gas indicators in enclosed spaces if they contain a flammable gas, as long as the leak detectors are explosion-proof.

9. Section 2.154 - See comment 2 above.

Safety Rules in Gas Industry

1. Section 3.3.1 - Gas utilities should do their own odorometer checks at least once a week. In addition, the use of a sulfur analyzer should be considered to confirm the presence of injected sulfur compounds used for odorization.

2. Section 3.3.3 - Specify the frequency and methods required for gas sampling.

3. Section 3.3.7 - The frequency of the walking inspections should be decreased to once a year. If there is physical movement or external loading which could cause failure or leakage, then patrolling is required at least every 3 months.

4. Section 3.3.9 - A method of prioritizing or grading leaks is required. See comment 6 above.

5. Section 3.4.2 - U.S. safety standards require the following:

   (i) If the maximum allowable operating pressure (MAOP) is 60 psig or more, the pressure may not exceed the MAOP plus 10 percent, or the pressure that produces a hoop stress of 75 percent of the specified minimum yield strength (SMYS), whichever is lower;

   (ii) If the MAOP is 12 psig, or more, but less than 60 psig, the pressure may not exceed the MAOP plus 6 psig; or

   (iii) If the MAOP is less than 12 psig, the pressure may not exceed the MAOP plus 50 percent.

6. Section 3.4.8 - The testing of pressure-relief and overload cut-off valves could be relaxed to only once a year instead of every two months.

7. Annex 2, Section 2.7 - For a welder, low quality performance should be defined as 3 joints or 3 percent of welds, whichever is greater, that are found to be unacceptable.

8. Annex 2, Section 3.1 - Welders should also be tested on their ability to make lateral and saddle connections.

9. Annex 34, Criteria for Tightness and Strength Testing of Gas Pipelines - In the U.S., the test pressure and duration are determined by the stress level that the pipeline operates at. For example, if the MAOP is above 30 percent of SMYS, the test pressure is 1.5 times the design pressure for 8 hours. If the MAOP is 100 psig to 30 percent of SMYS, the test pressure is 1.5 times the design pressure for 1 hour.

10. Annex 36, Section 1.2 - Greater sensitivity gas detectors are available.

<u>Building Code, Gas Supply, SNiP 3.05.02-88, revised 1988</u>

1. Section 2.4 - Welders should also be tested on their ability to perform a branch test.

2. Section 2.9 - A sketch or description of the bevel geometry should be included.

3. Section 2.16 - Criteria for when stress relieving is required should be included here.

4. Section 2.23 - Add the requirement that a weld must be removed if it has a crack that is more than 8 percent of the weld length.

5. Section 2.25 - Nondestructive testing should be performed depending on Class location (population density) for the pipe location. Class 1 and 2 locations require

at least 20 percent of the welds to be tested. Class 3 and 4 locations require 100 percent testing.

6. Section 2.26 - A weld must be removed if it has a crack that is more than 8 percent of the weld length. This section seems to imply that if the length of the defective portion of the weld is less than 25 percent, then the defective portion can be removed and a new weld can be applied.

7. Section 8.4 - It should be stated here that polyethylene (PE) pipe is to be placed on a bed of select, granular fill and covered to a depth of 0.25 meters with this material.

Building Code, Gas Supply, SNiP 2.04.08-87, revised 1991

1. Section 1.4 - Supply of non-odorized gas for industrial plants should not be allowed.

2. Section 3.2 - Gas consumption standards could be more accurately defined if metering was installed. Quantities could be determined by actual metered volumes instead of test cases.

3. Section 4.5 - An accessible shut-off valve is required on every service line. Also, this section mentions heating a living room with an oven. Ovens should never be used for heating. If space heaters are installed, they should be properly vented.

4. Section 4.11 - For low pressure, threaded and flanged connections are acceptable.

5. Section 4.17 - The depth of burial for gas pipelines depends on soil conditions and operating pressure.

6. Section 4.18 - To minimize liquids entering the services, install service taps on the top half of the main.

7. Section 4.84 - Our temperature limitation for PE pipe is:

   -29°C minimum and a 38°C maximum temperature with additional pressure derating at higher temperatures up to an upper temperature limit of 60°C..

   Also, there is no limitation of the diameter for PE pipe given in these regulations. Our limit (in California) is 6 inch except on a trial basis with approval from the CPUC.

8. Section 5.14 - This section itemizes the equipment necessary at a regulator station. By revising the language into performance based requirements such as stating "pressure reducing or pressure limiting devices" allows the user the flexibility to install a facility to their liking and still meet the requirements of the regulation. In this case, the user may decide to install a regulator-monitor station, thus avoiding the added complexity of safety shutoff and relief valves.

9. Section 5.31 - Should be written so that the user has more flexibility.

10. Section 6.2 - Appliance connectors need to be metal to offer more fire resistance.

11. Section 6.3 - For low pressure, threaded or flanged connections are acceptable.

12. Section 6.17 - Shut-off valves should be installed on all risers and they should be accessible.

13. Section 6.26 - Metal flex connectors allow appliances to be moved without breaking the rigid connections and they offer more fire resistance.

14. Section 6.62 - Non-odorized gas should not be allowed.

15. Section 6.69 - Non-ferrous metals includes copper and aluminum tubing. These metals should not be used for instrumentation because of corrosion problems. Stainless steel tubing is preferred.

16. Section 7 - This section should be the responsibility of the Thermal Power Station and should not be covered under this regulation. It involves burner controls and piping facilities located inside the power plant.

17. Section 11.14 - Stainless steel or carbon steel piping or tubing is preferred over copper and rubber. See comment 15 above.

18. Section 11.27, Table 30 - Would not use malleable cast iron, brass or bronze valves for the pressure given.

19. Section 11.37 - Filter specifications should include particle removal size and efficiency.

Table 2-1

Basis for District Heating and Apartment Block Boiler Costs

BASIS:

Cost of Cogeneration	200	$/kW
Cost of District Heating Pipe	1,000	$/m
Financing of Capital Cost	100	%
Interest Rate	15	%
Term of Loan	20	yrs
Capital Charge on Capital Cost	16.0	%/yr
O&M Charge for Cogeneration & Piping	1.5	%/yr
Heat Rate of District Heating Cogeneration Plant	10,000	Btu/kWh
Peak Heat Generated by Cogeneration Plant	860	kcal/kW
Equivalent hr/yr @ Peak Rating	1,900	
Fuel Chargeable to Heat @ Peak Loan	42	%
Cost of Cogeneration Fuel	40	$/1000m^3

COST OF APARTMENT BLOCK BOILER PLANT DELIVERED HEAT:

Cost of Apartment Block Boiler Fuel	150	$/1000m^3	(1)
Size of Block Boiler	1.2	Gcal/h	(2)
Cost of Block Boiler	93,000	$	(3)
Capital Charge for Block Boiler	14,800	$/yr	(4) = .16*(3)
Equivalent hr/yr @ Peak Rating	1,900		(5)
Heat Required	2,280	Gcal/yr	(6) = (2)*(5)
Heat Value of Fuel	8,000	kcal/m^3	(7)
Boiler Efficiency	60	%	(8)
Fuel Required/yr	475,000	m^3	(9) = 10^6*(6)/(7)/(8)
Cost of Fuel	71,250	$/yr	(10) = (1)*(9)/1000
Total Apartment Block Boiler Cost of Heat	86,130	$/yr	(11) = (4) + (10)
Unit Cost of Apartment Block Boiler Heat	37.8	$/Gcal	(12) = (11)/(6)

Table 2-2

Break-Even Calculation for District Heating System

COST OF COGEN PLANT DELIVERED DISTRICT HEAT

DH Pipe Length km (1)	Pipe Cost 1000$ (2)	COGEN PLANT Size MW (3)	COGEN PLANT Cost 1000$ (4)	Total DH Cost (5)	Capital Charges 1000$/yr (6)	O&M Charges 1000$/yr (7)	Heat For DH Gcal/yr (8)	Fuel Charged To DH Gcal/yr (9)	Fuel Charged To DH 1000m^3/yr (10)	Fuel Cost For DH 1000m^3/yr (11)	Total Cost 1000$/yr (12)	DH Heat Cost $/Gcal (13)
1	1,000	25	5,000	6,000	960	90	40,850	17,157	2,145	86	1,136	27.8
2	2,000	25	5,000	7,000	1,120	105	40,850	17,157	2,145	86	1,311	32.1
3	3,000	25	5,000	8,000	1,280	120	40,850	17,157	2,145	86	1,486	36.4
4	4,000	25	5,000	9,000	1,440	135	40,850	17,157	2,145	86	1,661	40.7
5	5,000	25	5,000	10,000	1,600	150	40,850	17,157	2,145	86	1,836	44.9
6	6,000	25	5,000	11,000	1,760	165	40,850	17,157	2,145	86	2,011	49.2
7	7,000	25	5,000	12,000	1,920	180	40,850	17,157	2,145	86	2,186	53.5
8	8,000	25	5,000	13,000	2,080	195	40,850	17,157	2,145	86	2,361	57.8
9	9,000	25	5,000	14,000	2,240	210	40,850	17,157	2,145	86	2,536	62.1
10	10,000	25	5,000	15,000	2,400	225	40,850	17,157	2,145	86	2,711	66.4
1	1,000	50	10,000	11,000	1,760	165	81,700	34,314	4,289	172	2,097	25.7
2	2,000	50	10,000	12,000	1,920	180	81,700	34,314	4,289	172	2,272	27.8
3	3,000	50	10,000	13,000	2,080	195	81,700	34,314	4,289	172	2,447	29.9
4	4,000	50	10,000	14,000	2,240	210	81,700	34,314	4,289	172	2,622	32.1
5	5,000	50	10,000	15,000	2,400	225	81,700	34,314	4,289	172	2,797	34.2
6	6,000	50	10,000	16,000	2,560	240	81,700	34,314	4,289	172	2,972	36.4
7	7,000	50	10,000	17,000	2,720	255	81,700	34,314	4,289	172	3,147	38.5
8	8,000	50	10,000	18,000	2,880	270	81,700	34,314	4,289	172	3,322	40.7
9	9,000	50	10,000	19,000	3,040	285	81,700	34,314	4,289	172	3,497	42.8
10	10,000	50	10,000	20,000	3,200	300	81,700	34,314	4,289	172	3,672	44.9

Notes: (2) = 1000*(1) ; (4) = 200*(3) ; (5) = (2) + (4) ; (6) = .16*(5) ; (7) = .015*(5)

(8) = (3)*.86 Gcal/MW*1900 h/yr ; (9) = .42*(8) ; (10) = (9)/8000 Gcal/m3/1000

(11) = 40*(11)/1000 ; (12) = (6) + (7) + (11) ; (13) = 1000*(12)/(8)

Table 2-3

Comparison of the Cost of Gas and Electricity Used for Cooking Only

	1993 Current	2000 Future
Gas Consumption m^3/yr	72	72
Equivalent electricity consumption, khw/yr	745	745
Gas Price 1000m^3$	5	300
Electricity Price ¢/kwh	3.3	9
Annual Cost with Gas Stove $/yr	0.36	21.60
Annual Cost with Electric Stove	24.59	67.05
Cost of Electricity/Cost of Gas	68.3	3.1

Table 2-4

Electric Power Required to Convert from Gas to Electric Stoves

	Ryazan	Saratov	Volgograd	Voronezh
Number of Apartments	153,229	251,692	259,100	242,800
With Gas Stoves Only	148,229	194,850	259,100	242,800
Number of persons/apartment (1)	3	3	3	3
Gas Consumption, million m^3	32	42	56	52
Equivalent million m^3 (2)	331	436	579	543
Overall Efficiency	0.34	0.34	0.34	0.34
Operating Hr/yr	8,000	8,000	8,000	8,000
Power Plant Capacity, MW	122	160	213	200

(1) Assumed as 3 persons per apartment

(2) 1000 m^3 gas = 3.7 GJ = 10,348 kwh

Figure 2-1

Cost of District Heat vs. Distance

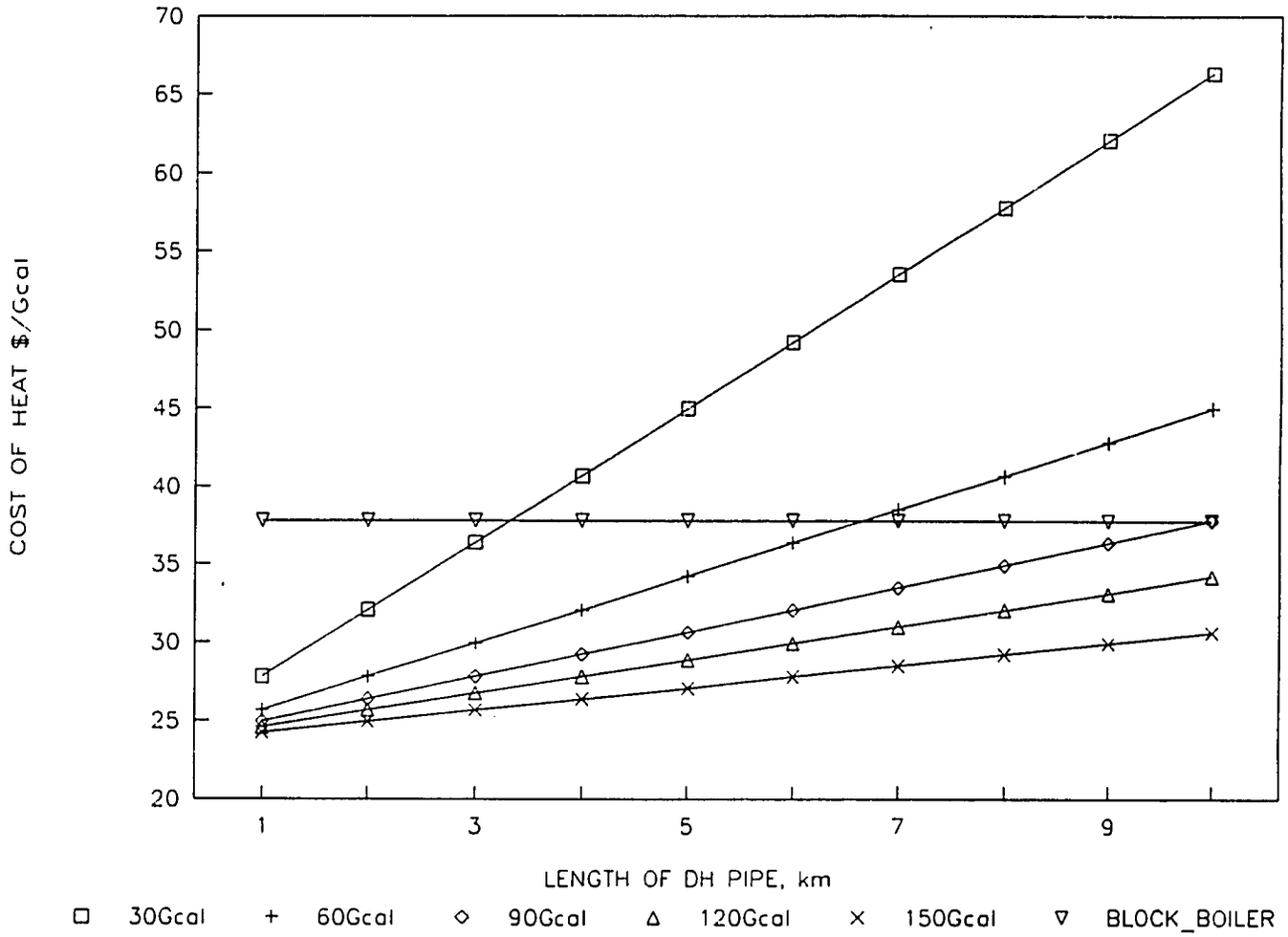
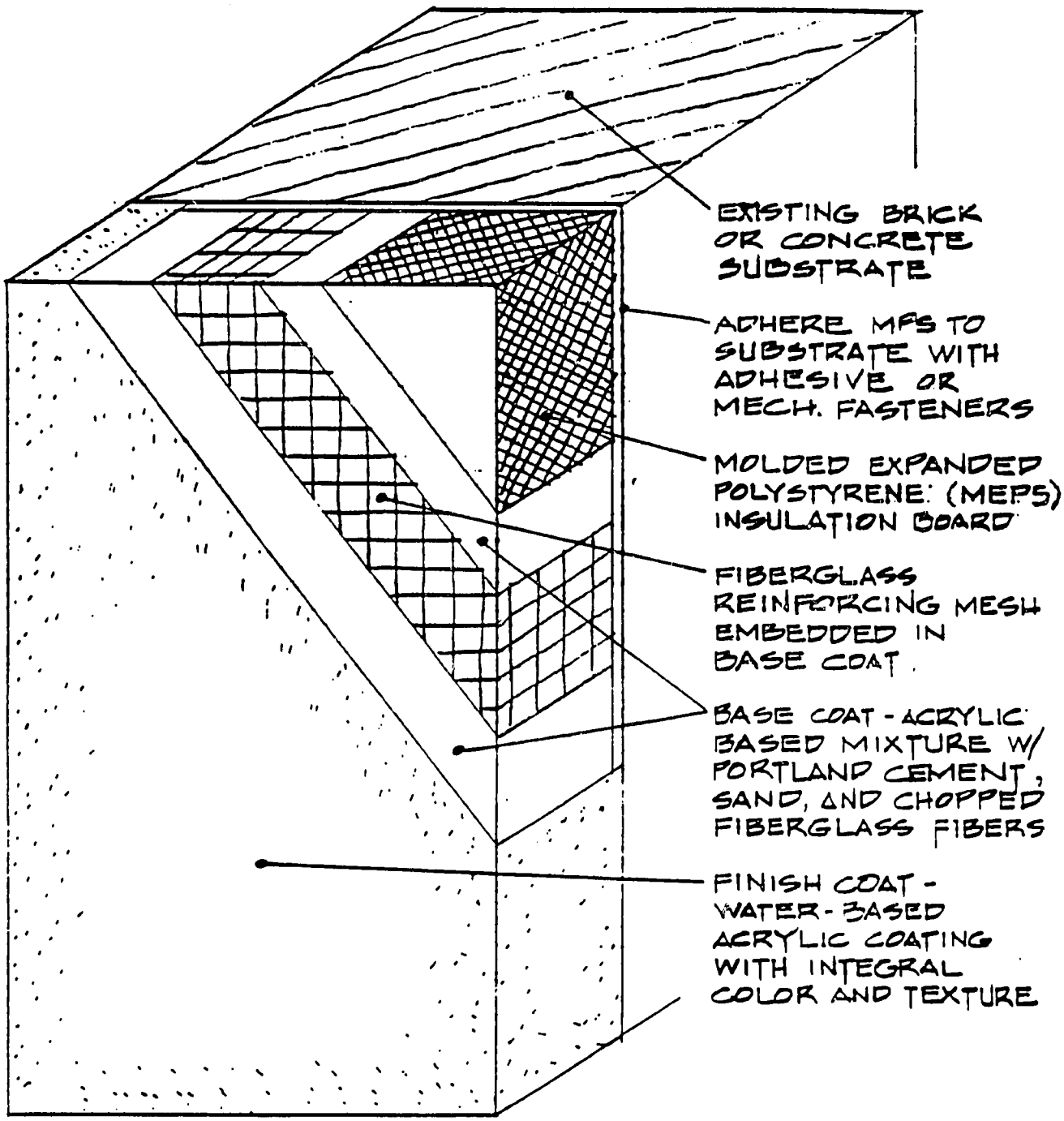


Figure 2-2

Detail of "Dryvit" Exterior Wall Insulation and Finish System



45

Figure 2-3

Floor Plan of Typical Apartment Building

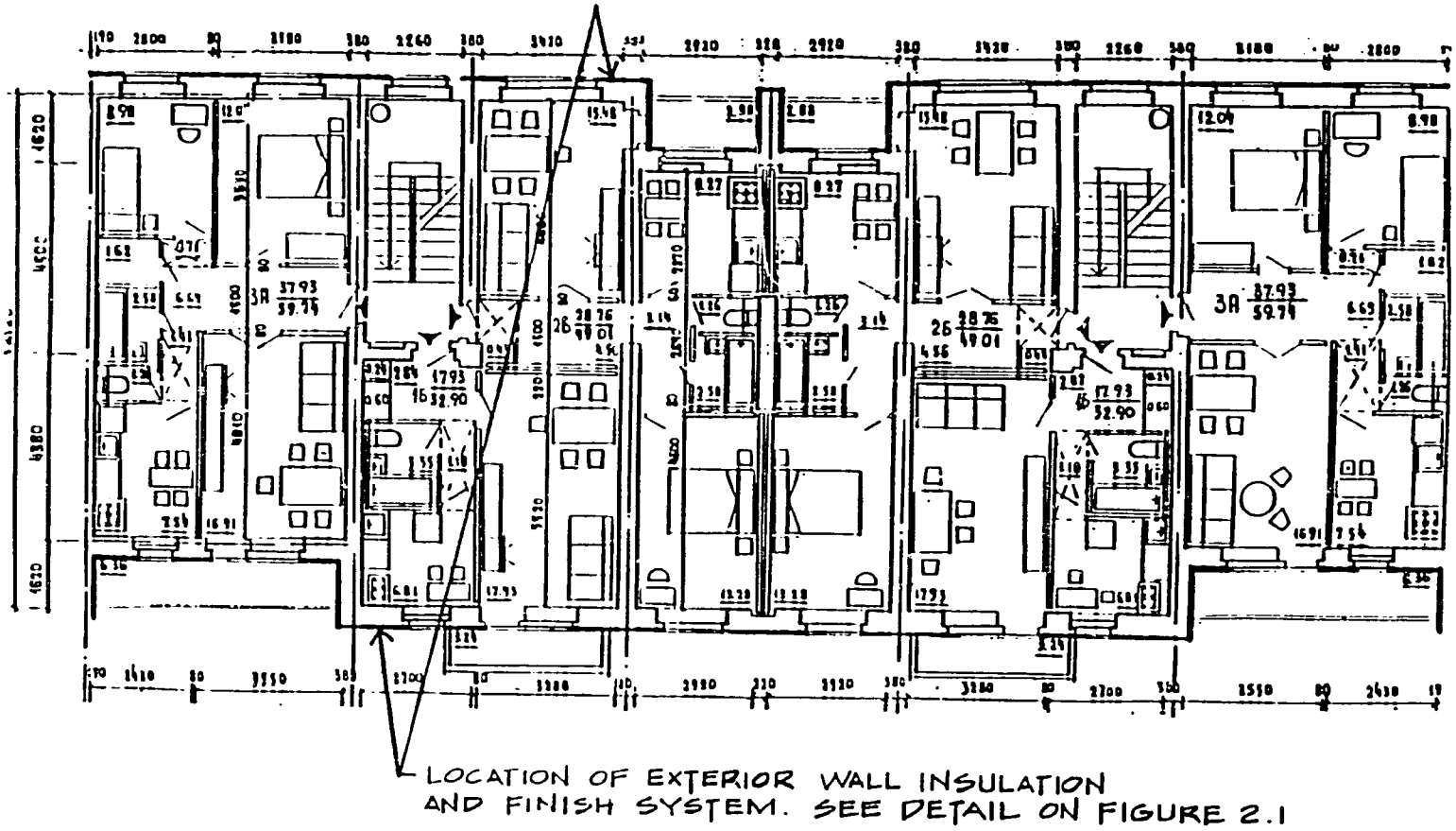


Figure 2-4

Section of Typical Apartment Building

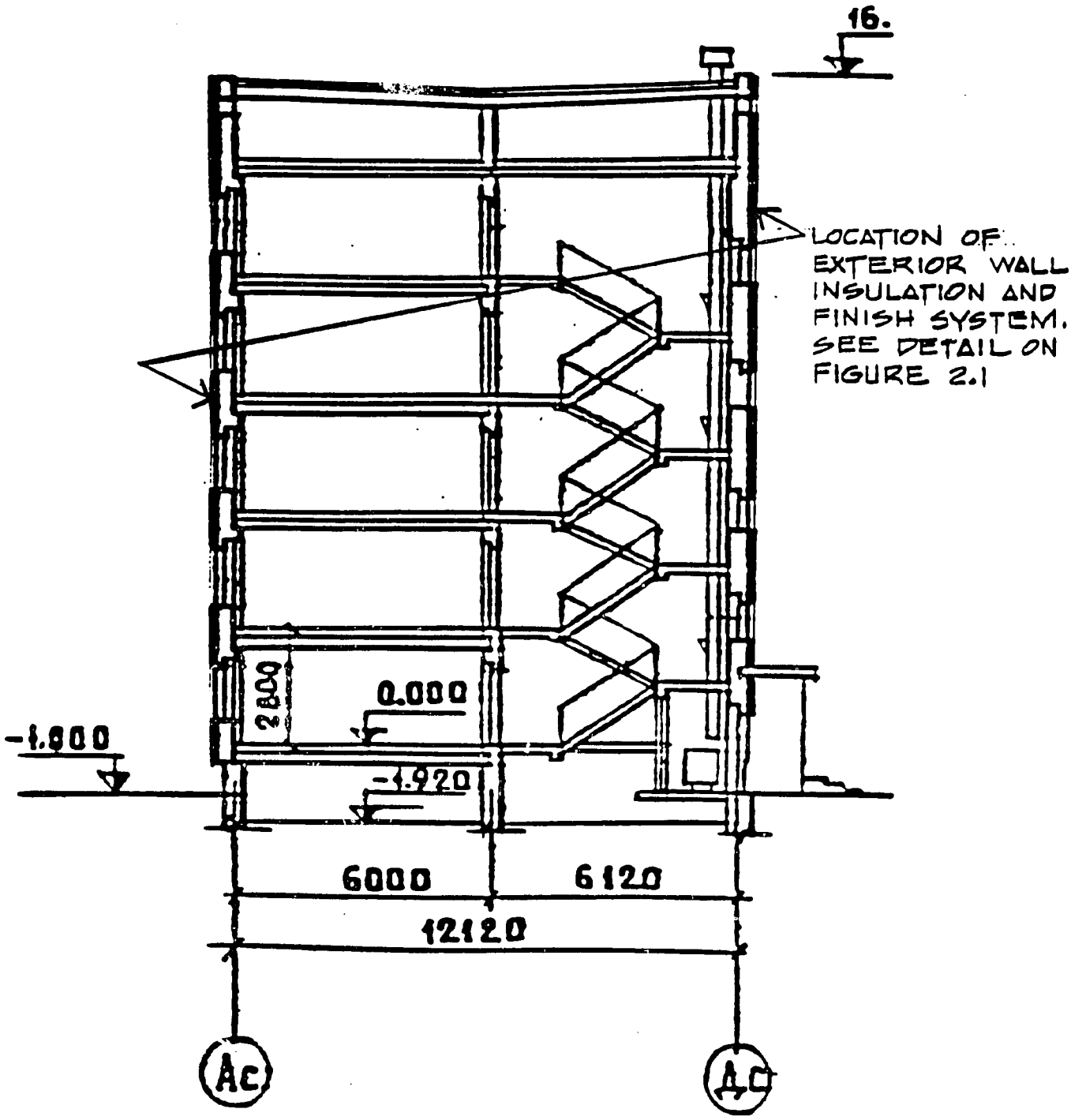
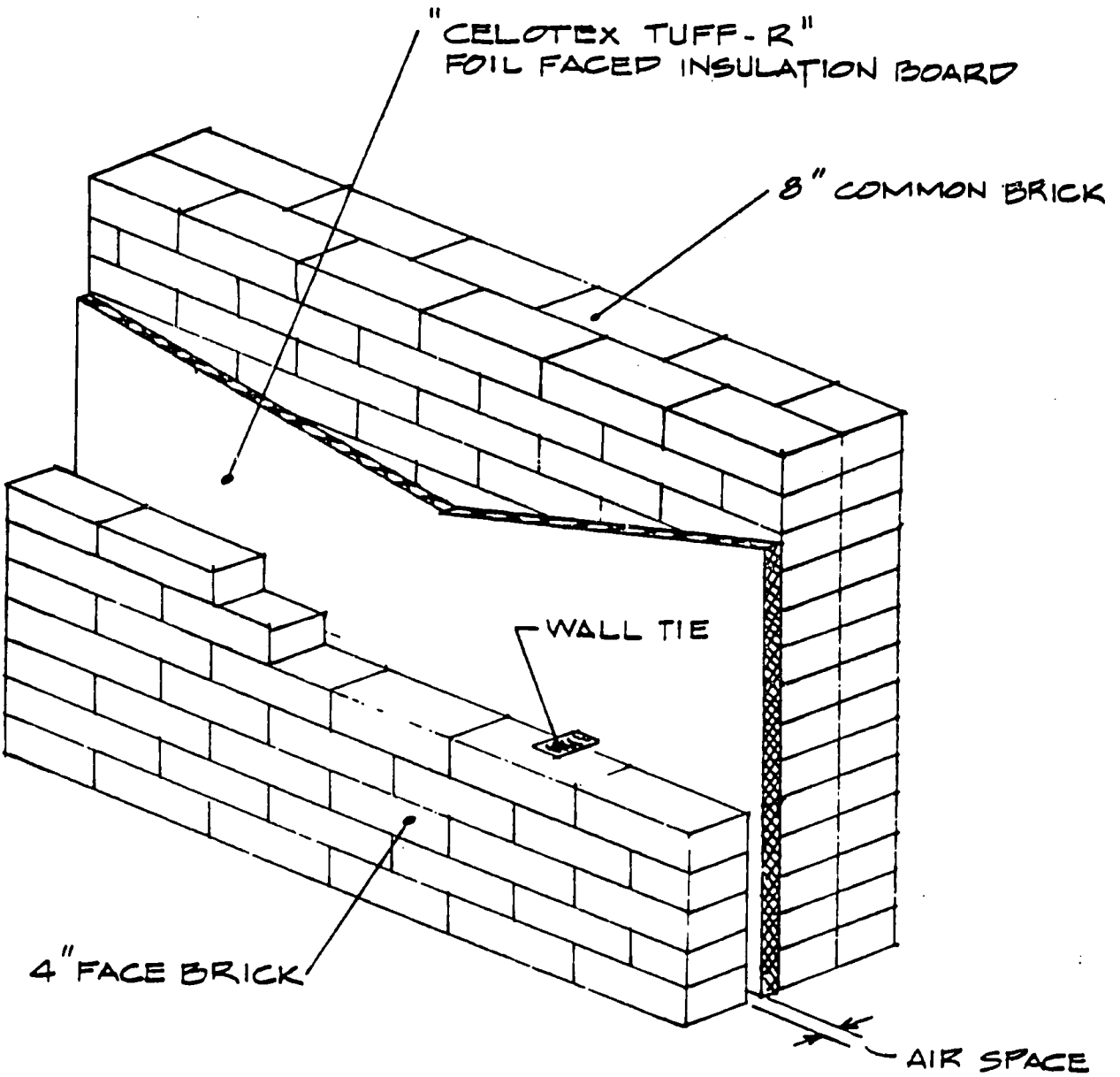


Figure 2-5

Detail of Cavity Wall System for Future Construction



Section 3

TABLE OF CONTENTS

3. NATURAL GAS DEMAND FORECAST 1

3.1 INTRODUCTION AND OVERVIEW 1

3.2 DEFINITION OF DISTRIBUTION SYSTEMS GEOGRAPHIC BOUNDARIES 2

3.3 GAS DEMAND DATA COLLECTED 3

3.3.1 Sources 3

3.3.2 Limitations 4

3.4 DOMESTIC PRICE EVOLUTION 5

3.4.1 Irrelevance of Prices in the Past 5

3.4.2 Price Outlook 5

3.4.3 Future Impact of Price on Gas Demand 5

3.5 DEMAND MODEL 5

3.5.1 Selection Process 5

3.5.2 Structure 6

3.5.3 Basic Assumptions 6

3.5.4 Statistical Correlation 11

3.6 DEMAND SCENARIOS 12

3.6.1 Scenario 1 (Reference Case) 12

3.6.2 Scenario 2 (Base Case) 13

3.6.3 Scenario 3 13

3.6.4 Scenario 4 14

3.6.5 Scenario 5 15

3.7 CONCLUSIONS 16

Table 3-1 Projected Natural Gas Demand for Russian Cities - Scenario 2 (Base Case) 18

Table 3-2 Summary of Fuel Oil Consumed at Large District Heating Plants 18

Table 3-3 Projected Natural Gas Demand for Russian Cities - Scenario 1 19

Table 3-4 Impact of Industrial Energy Efficiency Projects 20

Table 3-5 Impact of District Heating Efficiency Projects on Overall Consumption 20

Table 3-6 Impact of Industrial Efficiency Projects on Overall Industrial Consumption 21

Table 3-7 Impact of Replacement of Gas Cookers with Electric Cookers 21

Table 3-8 Impact of Conversion of District Heating to Gas Based System 22

Table 3-9 Projected Natural Gas Demand for Russian Cities - Scenario 5 23

Table 3-10 Summary of Gas Savings by Scenario Compared to Scenario 1 (Reference Case) 23
Figure 3-1 Projected Natural Gas Demand for Russian Cities - Scenario 2 (Base Case) 24
Figure 3-2 Description of Scenarios 25
Figure 3-3 Impact of Industrial Energy Efficiency Projects - City of Volgograd 26
Figure 3-4 Volgograd - Total Gas Consumption Comparison by Scenario 27
Figure 3-5 Impact of Replacement of Gas Cookers with Electric Cookers - City of Ryazan 28
Figure 3-6 Impact of Conversion of District Heating to Gas Based System - City of Saratov 29

Section 3

NATURAL GAS DEMAND FORECAST

3.1 INTRODUCTION AND OVERVIEW

In development of a gas demand forecast model, the Project Team completed the following tasks:

- Determined the Gas Distribution Systems Geographic Boundaries
- Surveyed Available Demand Data
- Selected a Demand Forecasting Model
- Developed a Demand Model Application Strategy
- Established Demand Scenarios
- Estimated Future Natural Gas Demand
- Evaluated the Sensitivity of the Demand Model to Various Independent Variables

As a first step in our analysis and forecast of gas demand for the Russian cities, team members traveled to Russia to gather historical economic and gas use data needed to initiate our demand forecasting activity. These data were then incorporated with data from other available sources, i.e., previous Bechtel, World Bank, and USAID reports etc., in an effort to gain the best possible understanding of the data derivation, assess the strengths and weaknesses of the data, and verify the accuracy of the data. The resulting compilation of data from many sources was used in the demand model.

The Project Team then independently developed a gas forecasting model after reviewing other existing forecasting models. The challenge became one of preserving as much of the underlying framework incorporated into more sophisticated econometric models, given the limited amount of Russian data available. An evolutionary process ensued during which the model was shaped and reshaped in an effort to expand the model's forecasting capability without overreaching the limitations of the available data. The result is a simplified model that forecasts demand based upon only a handful of factors for which enough data were available to make reasonable assumptions about likely future trends.

The gas demand model is not a price driven market model, i.e., a change in price does not directly relate to a change in demand. Historical data on fuel prices in Russia are meaningless in a market context because under the past and present centrally planned economy price is not related to cost. Only recently has the Russian government made any attempt to align the price of gas with the cost of producing, transporting, and distributing gas to the consumer. Without a meaningful price history, any attempt to definitively link changes in the price of gas as well as the prices of competing fuels to the demand for gas is conjecture.

Projections of future macroeconomic and demographic trends are the primary catalysts for change in gas demand, e.g., the gross domestic product (GDP), population growth, growth in the housing stock, etc. In addition to these influences, gas demand is also heavily dependent upon the outlook for future gains in the efficiency with which gas is used in the economy and on projected oil to gas conversion. Efficiency gains and oil substitution are

expected to come from specific energy saving projects financed by an international agency such as the World Bank, as well as through replacement and refurbishment of the residential, commercial, industrial, and central heating equipment stock.

In consultation with the World Bank, the Project Team selected five primary demand scenarios. These scenarios illustrate the impact on gas demand of:

- The implementation of specific gas efficiency projects
- Replacement of gas cookers with electric cookers in those areas of the low pressure gas distribution system where gas is used exclusively for cooking and the cost of rehabilitating the system may be prohibitive
- Retirement of the central heating and hot water system in those areas where conversion to a gas based system is more cost effective than upgrading the central heating and hot water system

Overall the outlook for gas demand in the four Russian cities follows a similar trend. Scenario 2, the Base Case, is shown in Figure 3-1 and Table 3-1.

In the short term, gas demand in the four cities falls from current levels because of:

- Declining industrial output driven by the overall downturn in the Russian economy
- Conservation in the commercial and residential sectors attributable to the transformation of Russia's centrally planned economy into a market economy with meaningful, but sharply higher prices
- Implementation of gas efficiency projects by specific industrial plants and district heating plants

Over the long term, gas demand is expected to rebound with the revitalized Russian economy led by strong growth in the consumer sector for goods and services, as well as oil to gas conversion especially in industrial and district heating plants. Gas demand is projected to exceed current levels at the end of the forecast period.

3.2 DEFINITION OF DISTRIBUTION SYSTEMS GEOGRAPHIC BOUNDARIES

One of the initial steps toward the development of any forecast is to define the precise limits of what is to be forecast. As discussed, this gas demand forecast model is one of many components of the USAID Gas Distribution Systems Rehabilitation Project. For this reason it was essential that the scope of the demand forecast correspond to the scope of the analysis being conducted by other members of the Project Team. In consultation with the World Bank, the scope of the demand forecast was defined as follows:

- For the cities of Ryazan, Saratov, and Volgograd, each demand forecast is confined to the physical network of high, medium, and low pressure pipeline under the control of the local gas distribution company or gorgaz actually serving the city itself. Everything beyond the network of pipe controlled by the city gorgaz is not included.
- The oblast or region of Voronezh is comprised of a number of urban and rural areas which are served by four different local utilities. The gas

demand forecast for the oblast of Voronezh encompasses gas consumption by all four of these local utilities.

3.3 GAS DEMAND DATA COLLECTED

Team members traveled to Russia and collected historical economic, demographic, and gas use data for each of the four Russian cities, including:

- Population
- Gas price by sector
- Total inventory of potential gas customers by sector
- Number of gas customers by sector
- Breakdown of residential customers by use
- Gas consumption by sector
- Consumption of ten largest industrial users
- Consumption of district heating plants
- Residential norms
- Temperature data

Previous Bechtel, World Bank, and USAID reports containing some of the foregoing information was provided to the Project Team in advance of the Russia trip. These existing data were used as a starting point for in-country data gathering efforts of filling in some of the important blanks, developing an understanding of the data derivation, assessing the strengths and weaknesses of the data, and verifying the accuracy of the data.

The data collected in Russia were then incorporated with available data from other sources in the U.S. in an effort to further verify the accuracy of this data and expand the value of this data.

3.3.1 Sources

The following is a complete list of the sources of information used to compile the necessary data for the gas demand model:

Russian Sources:

- Giproniigas Institute, "Technical Passport" (annual compilation of statistical data for the distribution sector for each Russian oblast or region)
- Gorgazes in Ryazan, Saratov, and Volgograd
- Goskomstata (state committee on statistics for former USSR)

U.S. Sources:

- American Gas Association (AGA)
- Bureau of Census, Center for International Research
- DOE/EIA, Manufacturing Energy Consumption Survey
- Federal Reserve System Division of Research and Statistics, Industrial Production and Capacity Utilization

- Office of Technology Assessment, Energy Efficient Technologies for Central and Eastern Europe
- RCG/Hagler, Bailly, Principles of Natural Gas Pricing in Russia

Project Sources:

- Bechtel
- Gas Energy Inc. (GEI)
- Joseph Technology Corp.
- Benjamin Schlesinger Associates
- The World Bank

3.3.2 Limitations

Much of the data collected on each of the four Russian cities are limited in applicability to the development of a demand forecast with any substantive predictive ability. Historical data are not available to construct an econometric model. At best, the available data provides us with a fairly accurate estimate of how much gas is currently being consumed in the residential, commercial, and industrial sectors of each city. However, because of the lack of metering in the Russian system, even the accuracy of basic consumption data is somewhat tenuous.

Gas consumption of industrial customers is metered, but most of these meters are grossly inaccurate by western standards. Some gas used in the commercial sector and all of the gas consumed by residential customers is determined or rather "guesstimated" through the use of "norms", i.e., a constant volume of gas per person per month independent of actual usage. The use of norms makes it impossible to accurately assess the gas consumption of each sector.

Furthermore, comparison of the data available from different sources reveals areas of gross inconsistency between apparently analogous data. Much of the inconsistency can be attributed to a breakdown in the translation of necessary definitional terminology that results in a misunderstanding by either the fact finder or the finder of fact. For example, the statistical data contained in the "Technical Passports", established each year by Giproniigas, do not contain data limited to the cities themselves as one might be led to believe; instead, data contained in the Passports are for the entire oblast, or region, surrounding the city. For example, the passport data under the heading "Saratov - urban" are data for all of the urban centers within the Saratov oblast, not just the city of Saratov itself.

District heating consumption is particularly troublesome to disaggregate from the gas consumption data provided by the gorgazes in each city. First, gas consumed by the large district heating power plants is included by the gorgazes in consumption figures for the industrial sector. Second, gas consumed in municipal district heating boilers is included in the commercial sector. Third, a significant portion (approximately 35 percent[1]) of "true" industrial consumption, i.e., gas not consumed by the large district heating power plants, is actually gas used to provide district heating to areas in close proximity to industrial facilities.

---

1 ETIP Project Team estimate.

3.4 DOMESTIC PRICE EVOLUTION

3.4.1 Irrelevance of Prices in the Past

Fuel Prices in Russia are meaningless in a market context. The price of a fuel has little relation to the cost of producing and distributing the fuel. The result has been a gross misallocation of resources. This waste is explained by basic economic price theory which tells us, that without pricing signals, it is very difficult to efficiently allocate resources to their highest valued use. Recently, the Russian government has made an attempt to align the price of gas with the cost of producing, transporting, and distributing gas to the consumer.

3.4.2 Price Outlook

The real price of gas is difficult to assess in Russia's current inflationary economy. Much of this difficulty is attributable to the problems associated with assessing the true value of the ruble. For example, if the current ruble/$ exchange rate is undervaluing the ruble, as some believe, then the real price of gas is in fact higher than one would conclude by simply converting the ruble price of gas into dollars.

The Russian government has raised gas prices sharply during the past year. By year-end 1993, residential gas prices, in nominal dollars, will have risen from a few cents per thousand cubic meters (1000 m^3) in 1992 to approximately $5.00 per 1000 m^3. In the short term, gas prices are expected to continue to rise. In a July decree, the Russian government affirmed its commitment to price reform by linking future price increases to inflation. Residential gas prices are expected to rise, in real terms, from current levels to $150.00 per 1000 m^3 by the end of the year 2000 (Price forecasts for natural gas, oil, and electricity were prepared in consultation with the World Bank and are contained in lines 14 through 56 of the gas demand model in Attachment 3-A, however, note that price has no direct effect on the demand model output; see Section 3.5.3, Basic Assumptions, below).

3.4.3 Future Impact of Price on Gas Demand

As the price of natural gas approaches parity with the true cost of providing gas service to consumers, a more efficient allocation of gas to its highest valued use can be expected. The residential price to customers utilizing gas for more than just cooking is estimated to reach $150.00 per 1000 m^3 in 1993$ by the end of 2000. The residential price for customers using gas for cooking only is expected to reach $300.00 per 1000 m^3 in 1993$ by the end of 2000. Industrial prices are expected to reach their approximate cost of service of $40.00 per 1000 m^3 in 1993$ by the end of 1995. Cost of service pricing should promote efficiency and conservation.

Additionally, for price to act as an effective market signal, it is essential that a more definitive link be established between consumption and the billed volume. As discussed, gas is not metered in the residential sector. The installation of meters will be necessary to provide the consumer with more direct knowledge of the cost of various uses.

3.5 DEMAND MODEL

3.5.1 Selection Process

The Project Team independently developed a gas forecasting model after reviewing other existing forecasting models used to project gas demand in the U.S., predominately AGA's Total Energy Resource Analysis (TERA) model. Although the sophistication of TERA far exceeds the basic model the Project Team developed for the four selected Russian cities, our review provided us with a useful understanding of the relationships between the different factors affecting gas demand. In addition to reviewing existing U.S. forecasting models, the Project

Team attempted to contact the Russian Center for Energy Efficiency (CENEF) to discuss existing Russian forecasting models. The Project Team was unable to contact CENEF.

Development of a price sensitive econometric model was precluded by the complete disassociation between the price of gas and the cost of gas service. As an alternative, the Project Team constructed a demand model driven by a handful of macroeconomic, demographic, and gas consumption factors for which there was sufficient data to make reasonable projections.

3.5.2 Structure

The gas demand forecast model is comprised of the following four sectors (see flow diagrams in Attachment 3-B):

- Residential
- Commercial
- Industrial
- District Heating.

Each sector can be divided into three tiers:

Tier I Consumption (the output)

Tier II Number of users and the average intensity of use

Tier III Variables influencing the number of users and intensity of use.

3.5.3 Basic Assumptions

Tier III contains the variables, or engines, which drive the demand forecast. These drivers are shown as triangles in the flow charts contained in Attachment 3-B. The following is a list of assumptions regarding each of the drivers as well as a brief outline of the interconnections between variables (note that these assumptions apply to all of the scenarios discussed below in Section 3.6, Demand Scenarios):

<u>All Sectors</u>

The following assumption applies to the residential, commercial, industrial, and district heating sector:

- Preference for Gas

  As discussed above, the gas demand model is not a price driven market model, nonetheless, an effort was made to introduce some degree of price sensitivity. This proved to be possible only on a crude simplistic level given the lack of meaningful Russian price data. A variable to capture consumer preference for gas over competing fuels at different price levels was introduced in each sector.[2] However, because the price of gas is projected

---

2 In the residential sector, this variable reflects consumer preference for gas over electricity at different price levels. It is assumed that if:

- Electricity prices are at least 150 percent of gas prices, 90 percent of all additions to the apartment stock will be gas
- Electricity prices are greater than 100 percent but less than 150 percent of gas prices, 85 percent of all additions to the apartment stock will be gas

to be less than half the price of electricity and oil throughout the forecast period, these preference variables have no effect on the demand model output. The preference variables have been left in the model for the purpose of running sensitivity cases.

Residential Sector

The following assumptions apply to the residential sector:

- Population Growth

  Historical data on the population of each city was provided by Giproniigas; projections for each city are based upon the population growth for all of Russia provided by Goskomstata and the Center for International Research, U.S. Census Bureau.

The change in population is used to drive the change in the total number of apartments in each city.

- Total Number of Apartments

  Historical data on the number of apartments in each city was provided by Giproniigas. Projections of the apartment stock are directly linked to changes in population.

The total number of apartments in each city is then combined with available data on the number of existing apartments with gas cookers, gas hot water heaters, and/or gas space heaters. The result is a breakdown of the number of existing apartments with gas supply as well as the number of apartments that could potentially switch to gas for each use.

The number of potential additions to the customer base is then funneled through two "filters" to project the number of apartments with gas supply for cooking, hot water, and/or space heat:

- Preference for Gas Over Electricity (discussed above)

  As new apartments are constructed a choice is made between gas and electricity based upon the relative prices of the fuels.

- Availability of Gas for Cooking in the Residential Sector and/or for District Hot Water and Heating

  In Scenarios 3, 4, and 5 (see below) this variable is used to adjust the number of apartments with gas supply based upon:

- Electricity prices are less than gas prices, 75 percent of all additions to the apartment stock will be gas.

For the commercial, industrial, and district heating sectors, preference for gas is based upon the differential between gas and competing fuels. It is assumed that if:

- Alternate fuel prices are at least 150 percent of gas prices, 100 percent of all current gas users will remain gas users

- Alternate fuel prices are greater than 100 percent but less than 150 percent of gas prices, 5 percent of all current gas users will switch from gas to another fuel

- Alternate fuel prices are less than gas prices, 25 percent of all current gas users will switch from gas to another fuel.

- Replacement of gas cookers with electric cookers

- Retirement of the central heating and hot water system in specific areas with conversion of those customers to gas.

After determining the number of apartments with gas supply, the intensity of gas use for cooking, hot water, and space heating is developed. The intensity of use is dependent upon:

- Efficiency of Cookers, Hot Water Heaters, and Space Heaters

  Current consumption of gas cookers, hot water heaters, and space heaters is based upon a statistical analysis of the Technical Passport as well as gas consumption data for these uses in other countries.

  Future efficiency "targets" were established in consultation with the World Bank based upon consumption in other western countries. The efficiency of each use is as follows (in addition, see Statistical Correlation Section below):

  - Cooker consumption decreases from 367 cubic meters per apartment per year (m^3/apt/yr) in 1993 to 259 m^3/apt/yr in 2000. The decline in projected gas consumption is expected to be the result of conservation on the part of users brought about by higher gas prices. Inefficient and wasteful practices such as the use of cookers for space heating are expected to stop as prices rise. No gain in efficiency is projected for the actual equipment, i.e., an old and new cooker are expected to be equally efficient

  - Hot water heater consumption decreases from 367 (m^3/apt/yr) in 1993 to 183 m^3/apt/yr in 2010. In the short term, the decline in projected gas consumption is expected to be the result of conservation on the part of users brought about by higher gas prices. Over the long term, reduced consumption is primarily attributable to increases in the efficiency of hot water heater units, i.e., the replacement of existing inefficient water heaters with new more efficient units by residential customers as the old units wear out. Overall, the decline in consumption is expected to result in a 50 percent reduction in consumption over the forecast period (1993 through 2010),

  - Space heater consumption decreases from 1,711 m^3/apt/yr in 1993 to 855 m^3/apt/yr in 2010 (note: the average size of an apartment remains 40 square meters throughout the forecast period). As with water heaters, it is anticipated that in the short term, conservation will be the primary impetus for reduced consumption. Over the long term, consumption will continue to decline as residential consumers replace their existing space heaters with markedly more efficient units. Overall the average consumption of a space heater will decrease 50 percent over the forecast period

Commercial Sector

The following assumptions apply to the commercial sector:

- GDP

  A one percent change in GDP is assumed to result in a 0.27 percent change in the same direction in the number of commercial establishments (see Statistical Correlation Section below).

- Extraordinary Expansion

  The number of commercial establishments is anticipated to expand an additional 50 percent over the 18 year period from 1993 to 2010 beyond the normal underlying GDP driven expansion noted above. This "extraordinary growth" will be brought about by the surge in demand for goods in the Russian consumer sector as Russian consumers "catch up" with other industrialized countries.

- Preference for Gas Over Electricity and Distillate Fuel Oil (discussed above)

  Fuel switching among commercial customers is based upon the relative difference in prices between gas, electricity, and distillate fuel oil.

After determining the number of commercial gas users, the intensity of gas use per commercial establishment is developed. The intensity of use is dependent upon:

- Efficiency

  In consultation with the World Bank, the efficiency of gas use in commercial establishments is assumed to increase 25 percent over the forecast period (1993 - 2010). Note that current consumption per commercial establishment varies widely from one city to the next. There is no apparent consistency in average use. The source of this inconsistency is believed to be definitional, i.e., the term commercial establishment is defined in different ways by the different gorgazes. By setting future efficiency "targets" in percentage terms, the consumption per commercial establishment is left to vary in proportion with the number of establishments, therefore, the overall consumption picture remains accurate.

Industrial Sector

The following assumptions apply to the industrial sector:

- GDP

  Industrial output is assumed to expand and contract with the Russian economy. Specifically, the output of all industrial enterprises is linked to the World Bank's forecast of industrial output, excluding fuels (see line 163 of the model in Attachment 3-A).[3]

- Efficiency and Availability of Gas

  A two percent per year increase in the efficiency of gas use is assumed for all industrial enterprises through the year 1996. Most of this short term increase is expected to be the result of conservation spurred by sharply higher fuel prices. From 1997 through 2000, industrial efficiency increases

3 World Bank's Energy/environment Projections Model for Russia.

slow to one percent per year as a result of more stable fuel prices and continued capital investment. No increase in industrial efficiency is anticipated after the year 2000. This efficiency increase variable (see line 164 of the model in Attachment 3-A) represents the projected increases in fuel use efficiency achievable by Russian industry without international assistance.

Additional gas savings have been included in Scenarios 2 through 5 to reflect the savings of those enterprises that are likely to be the recipients of efficiency project loans.[4]

- Preference for Gas Over Residual Fuel Oil

  Fuel switching among industrial customers is based upon the relative difference in prices between gas and residual fuel oil (discussed above in Section 3.5.3, Basic Assumptions).

  Consequently, the Project Team forecasted gas consumption in the industrial sector with consideration for the current fuel mix of industrial facilities. It is estimated that fuel oil accounts for approximately 20 percent of the fuel consumed by industrial users.[5] Most of this oil is burned during the winter months when the allocation of gas for industrial uses is reduced. To as lesser extent, some oil is burned for boiler start-up throughout the year. An industrial customer burning higher priced oil because of an unavailability of gas supply is likely to cut oil usage first as plant fuel efficiency increases.

  We anticipate that the increased efficiency of industrial facilities will most likely lead to a reduction in gas use year around, coupled with a reduction in oil use during the winter months. The overall result in terms of forecasted gas demand is likely to be a somewhat smaller reduction in gas demand than if oil use were not considered in the model. We anticipate that approximately 50 percent of all savings attributable to increased fuel use efficiency will go toward reducing oil consumption. As a result, only half of all efficiency gains will result in gas savings.

District Heating Sector

The following assumptions apply to the district heating sector:

- Number of District Heating and Hot Water Customers

  No growth is projected in the number of customers served by the district heating system. All additions to the apartment stock are assumed to be served by either gas or electricity (see residential sector above). The district heating load is reduced in Scenarios 4 and 5 (see below) with the retirement of the district heating and hot water system outside of a 7 kilometer (km) range from each large district heating power plant.[6]

---

4 Calculations of gas savings were made by the project team and the determination of which industrial projects are viable was based upon economic criteria established by the World Bank.

5 Estimate provided by Joseph Technology Corporation.

6 Estimate of 7 km range provided by Joseph Technology Corporation.

- Preference for Gas Over Residual Fuel Oil

  Fuel switching in the district heating sector is based upon the relative difference in prices between gas and residual fuel oil (discussed above in Section 3.5.3, Basic Assumptions).

  As in the industrial sector, gas consumption in the district heating sector has been forecasted with consideration for the current fuel mix of the district heating facilities. Table 3-2 shows the estimated oil consumption of the large district heating plants in each city and the gas that would be necessary to displace this oil consumption:[7]

  Again, most of this oil is burned during the winter months when the allocation of gas is reduced. We anticipate that the increased efficiency of district heating facilities will most likely lead to a reduction in gas use year around coupled with a reduction in oil use primarily during the winter months, therefore, the overall result in terms of forecasted gas demand is likely to be a somewhat smaller reduction in gas demand than if oil use were not considered in the model.

  In addition to gas saved through reduced consumption in the district heating facilities, the model also makes all gas saved in the residential and commercial sectors available to offset the use of oil in the district heating sector. In is anticipated that conservation in the residential and commercial sector will result in an easing of the allocations imposed upon district heating, thus freeing up more gas for consumption in the district heating sector.

  We anticipate that approximately 50 percent of all savings attributable to increased fuel use efficiency in the district heating sector as well as gas saved in the residential and commercial sector will go to reducing oil consumption. As a result, only half of all efficiency gains will result in gas savings.

- Efficiency

  A one percent per year increase in the efficiency of gas use is assumed for all large district heating plants. This increase represents the projected increase in fuel use efficiency achievable by the Russians without international assistance.

3.5.4 Statistical Correlation

The following is a discussion of the results of regression analyses performed on specific data applicable to the residential and commercial sector:

Residential Sector

No correlation was found between the consumption of natural gas and the penetration rate of hot water heaters and space heaters among all urban consumers. Performing regression analysis on the data contained in the Technical Passport for 55 oblasts

7 Estimates developed with Joseph Technology Corporation.

(urban areas only), the R squared[8] value obtained is 0.41 for hot water heaters and 0.54 for space heat (see Attachment 3-C). The penetration rates which are in the same range have various corresponding levels of consumption. No definitive conclusion on the consumption patterns of residential natural gas users can be drawn from the available data.

Regression analysis was also performed on the consumption of LPG and the penetration rate of hot water heaters. The R squared value obtained is 0.43 (see Attachment 3-C). Because of the lack of correlation between gas consumption and gas use, estimates of the average consumption of a Russian gas cooker, gas hot water heater, and gas space heater are based upon consumption patterns in other countries.

Commercial Sector

Intuitively one would expect there to be a link between economic growth and the number of commercial establishments. No Russian data was available to explore this relationship. Furthermore, historical Russian data would prove to be useless given that the economy was centrally planned. In an effort to explore the relationship between economic growth and the growth in commercial establishments, U.S. data was analyzed.

Examination of U.S. data reveals evidence of a correlation between the change in GDP and the change in the number of commercial establishments (see Attachment 3-C). The R squared is 0.78. On average, over the period 1980 to 1991, every one percent change in the GDP resulted in a 0.27 percent change in the number of commercial establishments. This relationship was applied to the Russian data.

3.6 DEMAND SCENARIOS

The following is a description and summary of results for each of five demand scenarios (see Figure 3-2). Additional output charts and tables are contained in Attachment 3-D.

3.6.1 Scenario 1 (Reference Case)

Description

- No international loan money is provided for industrial and/or district heating projects designed to improve gas use efficiency in the four selected Russian cities. Future changes in gas consumption are driven solely by the underlying economic and demographic changes
- The central hot water and heating system remains in operation continuing to serve all existing customers
- The gas distribution system remains operational and is expanded, as necessary, to serve the growing needs of the population.

Assumptions

All assumptions discussed in the Basic Assumptions Section above are applicable.

---

8 The R squared value is a regression statistic that measures the reliability of the regression, i.e., the confidence with which one variable can be said to relate to another. An R squared value of 1 indicates perfect correlation; a value of 0 indicates no correlation.

Results

Results are presented in Table 3-3.

Discussion

The reduction in gas demand in this scenario is primarily the result of declining output in the industrial sector. Gas consumption declines with industrial output and then rebounds when the Russian economy expands.

3.6.2 Scenario 2 (Base Case)

Description

- Loans are made for industrial and district heating efficiency projects meeting the World Bank's economic criteria
- The central hot water and heating system remains in operation continuing to serve all existing customers
- The gas distribution system remains operational and is expanded, as necessary, to serve the growing needs of the population.

Assumptions

All assumptions discussed in the Basic Assumptions Section above are applicable.

Results

In the industrial sector, the implementation of World Bank loan projects is projected to have the effects on gas demand shown in Figures 3-3 and 3-4 and Table 3-4.

In addition to the impact of the industrial efficiency projects, a number of efficiency projects will also be implemented at various district heating facilities. Table 3-5 shows the projected impact on overall gas consumption of the implementation of all district heating efficiency projects at both the large cogenerating district heating plants as well as the municipal boilers.

Discussion

In addition to the decline in gas consumption attributable to the fall in industrial production (see Scenario 1), further gas savings are realized through the implementation of World Bank loan projects by industrial and district heating enterprises. (See Table 3-6.)

3.6.3 Scenario 3

Description

- Loans are made for industrial and district heating efficiency projects meeting the World Bank's economic criteria
- The central hot water and heating system remains in operation continuing to serve all existing customers

- The gas distribution system is retired in those areas where gas is used exclusively for cooking. Gas cookers are replaced with electric cookers.

Assumptions

All assumptions made in the Base Case apply in Scenario Three. However, in each of the four cities, the following percentage of the number of apartments using gas for cooking is eliminated from the gas network over a 5 year (1995-1999) period:[9]

- Ryazan 7 percent
- Saratov 8 percent
- Volgograd 6 percent
- Voronezh 6 percent.

Results

Results are shown in Table 3-7 and Figure 3-5.

Discussion

Shutdown of the gas distribution system in those areas where it is uneconomical to maintain gas service for cooking leads to a small decline in gas demand over the Base Case.

3.6.4 Scenario 4

Description

- Loans are made for industrial and district heating efficiency projects meeting the World Bank's economic criteria

- The central hot water and heating system is retired in those areas where conversion to a gas based system is more cost effective, including both capital and generating costs of shifting gas consumption, versus the cost of rehabilitating district heating systems, as needed

- The gas distribution system remains operational and is expanded, as necessary, to serve the growing needs of the population.

Assumptions

- All assumptions made in the Base Case apply in Scenario Four

- In addition, all central heating and hot water customers outside of a 7 km radius[10] from each of the large district heating plants, estimated at 12 percent of the total number of apartments in the cities of Ryazan, Saratov, and Volgograd, and 6 percent of the number of apartments in the oblast of Voronezh, are switched to gas service over a 5 year (1995-1999) period

- The shutting down of the district heating system outside of a 7 km radius from each of the large power plants is estimated to result in a 15 percent decline in gas

---

9 Estimate by ETIP Project Team.

10 Estimate provided by Joseph Technology Corporation.

consumption at each of the large power plants in the cities of Ryazan, Saratov, and Volgograd; in Voronezh the gas savings are estimated to be 20 percent[11]

- Overall gas demand is estimated to increase 25 percent over the gas saved at the large district heating plants, i.e., for every one unit of gas saved in the district heating sector, 1.25 units of gas are necessary to provide heat and hot water in the residential sector and to provide fuel for additional electricity generation to make up for lost electricity generating capacity at the large cogenerating district heating power plants[12]

Results

Results are shown in Figure 3-6 and Table 3-8.

Discussion

The replacement of the district heating system with a gas based system outside of a 7 km radius from each large district heating plant leads to a shift in gas consumption from the district heating sector to the residential sector. Besides the increase in residential consumption, additional gas must be burned to generate electricity to replace the reduction in electricity production associated with cutbacks at the large cogeneration district heating plants. For modeling purposes the additional gas required to offset electricity production has been rolled back into the district heating sector consumption. The overall result of implementation of this scenario is a 25 percent increase in the amount of gas necessary to provide heat and hot water to the customers cut from the central heating system in order to save capital associated with rehabilitating district heating systems where not cost effective.

3.6.5 Scenario 5

Description

- Loans are made for all efficiency projects meeting the World Bank's economic criteria in the industrial and district heating sector
- The central hot water and heating system is retired in those areas where conversion to a gas based system is more cost effective
- The gas distribution system is retired in those areas where gas is used exclusively for cooking. Gas cookers are replaced with electric cookers.

Assumptions

All assumptions made in the Base Case, Scenario Three, and Scenario Four are incorporated into this scenario.

Results

Results are listed in Table 3-9.

---

11 Estimate provided by Joseph Technology Corporation.

12 Estimate provided by Joseph Technology Corporation.

Discussion

This scenario illustrates the combined effect of replacing the district heating system outside of a 7 km radius of each plant with a gas based system and the shutdown of the gas distribution system in those areas where gas is used exclusively for cooking.

3.7 CONCLUSIONS

Projected natural gas demand in each of the four selected Russian cities follows a similar pattern, as illustrated in Table 3-10.

- Initially overall gas demand declines as industrial output falls. Industrial output remains the primary factor affecting gas demand throughout the forecast period

- Decreased usage in the commercial and residential sectors attributable to conservation spurred by rising prices and more efficient equipment has only a limited impact on gas demand because of the relatively small amount of gas consumed in those sectors

- A significant portion of the reduction in fuel consumption in both the industrial and district heating sectors goes to offset oil consumption prior to its effect on gas consumption, therefore, the overall reduction in gas consumption is somewhat less than would be expected if oil consumption were not considered

- Over the long term, gas demand rebounds with a revitalized Russian economy led by strong growth in industrial production and growth in the consumer sector for goods and services.

The following is a summary of the findings associated with the different demand scenarios discussed in this report:

- Scenario 1 (Reference Case): reduction in gas demand in this scenario is attributable to declining output in the industrial sector. Gas consumption declines with industrial output and then rebounds when the Russian economy expands

- Scenario 2 (Base Case): the implementation of efficiency projects by specific industrial and district heating plants has a limited, but discernible impact on overall gas demand. The extent to which these projects impact overall demand is dependent on the number of projects implemented

- Scenario 3: replacement of gas cookers with electric cookers in those areas of the low pressure gas distribution system where gas is used exclusively for cooking has practically no discernible effect on overall gas demand because of the relatively small share of overall consumption that these cookers represent

- Scenario 4: retirement of the central heating and hot water system in those areas where conversion to a gas based system is more cost effective than upgrading the central heating and hot water system leads to a shift in gas usage from the district heating sector to the residential sector. However, additional gas is necessary to replace the electricity capacity lost by the reduction in output of the large cogenerating district heating plants. Quantifying the overall effect of these shifts in gas demand in a precise manner demands a more detailed study of the district heating, electricity generating, and residential sectors. We estimate the net effect on gas demand from implementation of this scenario to be a 25 percent increase in

gas consumption over the gas saved at the large district heating plants by scaling back the system

- Scenario 5: represents the combined effect of implementing Scenarios 3 and 4. The results of this scenario are essentially the same as those of Scenario 4 because of the negligible effect of the replacement of gas cookers with electric cookers on gas demand in Scenario 3.

Table 3-1

Projected Natural Gas Demand For Russian Cities

Scenario 2 (Base Case)

Total Gas Consumption (Thousand Cubic Meters)

	1992	1995	2010
Ryazan	2,155,162	2,011,413	2,234,674
Saratov	3,205,159	2,952,853	3,377,706
Volgograd	3,686,506	3,280,488	4,293,825
Voronezh	4,291,657	3,885,789	5,189,585

Change In Gas Demand Over Indicated Period

	1992 to 1995	1995 to 2010	1992 to 2010
Ryazan	-6.67%	11.10%	3.69%
Saratov	-7.87%	14.39%	5.38%
Volgograd	-11.01%	30.89%	16.47%
Voronezh	-9.46%	33.55%	20.92%

Table 3-2

Summary Of Fuel Oil Consumed At Large District Heating Plants

	Oil Consumed (TOE)	Gas Equivalent ($1000\ m^3$) (3)
Ryazan	575,532 (1)	671,441
Saratov	369,156	430,673
Volgograd	751,116 (1)	876,284
Voronezh	120,193	140,222 (2)

Notes:
(1) Estimate assuming 30% of fuel consumed by the plant is oil.
(2) Estimate knowing TETS-1 burns 95.3% gas, TETS-2 burns 57% gas.
(3) Conversion: TOE * 40 MMBtu per TOE * 1.03 MMBtu per Mcf / 35.315 Mcf per $1000\ m^3$ = $1000\ m^3$

Table 3-3

Projected Natural Gas Demand For Russian Cities

Scenario 1

Total Gas Consumption (Thousand Cubic Meters)

	1992	1995	2010
Ryazan	2,155,162	2,046,998	2,290,330
Saratov	3,205,159	3,017,014	3,497,803
Volgograd	3,686,506	3,365,026	4,478,020
Voronezh	4,291,657	3,912,541	5,237,865

Change In Gas Demand Over Period Indicated

	1992 to 1995	1995 to 2010	1992 to 2010
Ryazan	-5.02%	11.89%	6.27%
Saratov	-5.87%	15.94%	9.13%
Volgograd	-8.72%	33.08%	21.47%
Voronezh	-8.83%	33.87%	22.05%

Table 3-4

Impact Of Industrial Energy Efficiency Projects

1995 Total Consumption (Thousand Cubic Meters)

	Scenario 1	Scenario 2	% Change
Ryazan	2,046,998	2,011,413	-1.74%
Saratov	3,017,014	2,952,853	-2.13%
Volgograd	3,365,026	3,280,488	-2.51%
Voronezh	3,912,541	3,885,789	-0.68%

1995 Industrial Consumption (Thousand Cubic Meters)

	Scenario 1	Scenario 2	% Change
Ryazan	490,454	488,010	-0.50%
Saratov	879,058	845,487	-3.82%
Volgograd	1,701,475	1,670,915	-1.80%
Voronezh	2,046,478	2,042,145	-0.21%

Table 3-5

Impact Of District Heating Efficiency Projects On Overall Consumption

(Thousand Cubic Meters)

	1992 Total Consumption	Number Of Dh Eff. Projects	Gas Saved By Eff. Projects	Percent Of Gas Saved
Ryazan	2,155,162	9	65,540	3.04%
Saratov	3,205,159	5	61,180	1.91%
Volgograd	3,686,506	7	107,957	2.93%
Voronezh	4,291,657	7	44,840	1.04%

Table 3-6

Impact Of Industrial Efficiency Projects On Overall Industrial Consumption
(Thousand Cubic Meters)

	Total Indust. Cons. In 1992	Indust. Plants Sel. For Eff. Projects	Consumption Of Selected Plants
Ryazan	572,700	4	96,869
Saratov	1,026,469	8	431,900
Volgograd	1,986,800	7	659,400
Voronezh	2,389,657	4	115,700

	# Of Industrial Eff. Projects	Gas Saved By Eff. Projects	Gas Saved As A % Of Total
Ryazan	5	4,888	0.85%
Saratov	9	67,142	6.54%
Volgograd	17	59,420	2.99%
Voronezh	6	8,665	0.36%

Table 3-7

Impact Of Replacement Of Gas Cookers With Electric Cookers

1999 Total Consumption (Thousand Cubic Meters)

	Scenario 2	Scenario 3	% Change
Ryazan	2,062,101	2,060,537	-0.08%
Saratov	3,052,347	3,047,725	-0.15%
Volgograd	3,531,700	3,527,427	-0.12%
Voronezh	4,208,857	4,203,456	-0.13%

1999 Residential Consumption (Thousand Cubic Meters)

	Scenario 2	Scenario 3	% Change
Ryazan	85,974	82,845	-3.64%
Saratov	179,941	173,510	-3.57%
Volgograd	194,197	189,342	-2.50%
Voronezh	264,419	258,283	-2.32%

Table 3-8

Impact Of Conversion Of District Heating To Gas Based System

1999 District Heating Consumption (Thousand Cubic Meters)

	Scenario 2	Scenario 4	% Change	Actual Change
Ryazan	1,304,154	1,094,808	-16.05%	-209,346
Saratov	1,606,228	1,353,065	-15.76%	-253,163
Volgograd	989,774	851,967	-13.92%	-137,807
Voronezh	1,118,363	909,273	-18.70%	-209,090

1999 Residential Consumption (Thousand Cubic Meters)

	Scenario 2	Scenario 4	% Change	Actual Change
Ryazan	85,974	112,002	30.27%	26,028
Saratov	179,941	223,419	24.16%	43,478
Volgograd	194,197	238,072	22.59%	43,875
Voronezh	264,419	351,575	32.96%	87,156

1999 Gas For Electricity Production (Thousand Cubic Meters)

	Scenario 2	Scenario 4	% Change	Actual Change
Ryazan	N/A	215,777	N/A	215,777
Saratov	N/A	255,548	N/A	255,548
Volgograd	N/A	125,977	N/A	125,977
Voronezh	N/A	177,770	N/A	177,770

1999 Total Consumption (Thousand Cubic Meters)

	Scenario 2	Scenario 4	% Change	Actual Change
Ryazan	2,062,101	2,094,560	1.57%	32,459
Saratov	3,052,347	3,098,209	1.50%	45,862
Volgograd	3,531,700	3,563,746	0.91%	32,046
Voronezh	4,208,857	4,264,692	1.33%	55,835

Table 3-9

Projected Natural Gas Demand For Russian Cities

Scenario 5

Total Gas Consumption (Thousand Cubic Meters)

	1992	1995	2010
Ryazan	2,155,162	2,015,162	2,269,271
Saratov	3,205,159	2,957,677	3,417,182
Volgograd	3,686,506	3,282,914	4,317,434
Voronezh	4,291,657	3,889,578	5,216,566

Change In Gas Demand Over Indicated Period

	1992 to 1995	1995 to 2010	1992 to 2010
Ryazan	-6.50%	12.61%	5.29%
Saratov	-7.72%	15.54%	6.62%
Volgograd	-10.95%	31.51%	17.11%
Voronezh	-9.37%	34.12%	21.55%

Table 3-10

Summary Of Gas Savings By Scenario Compared To Scenario 1 (Reference Case)

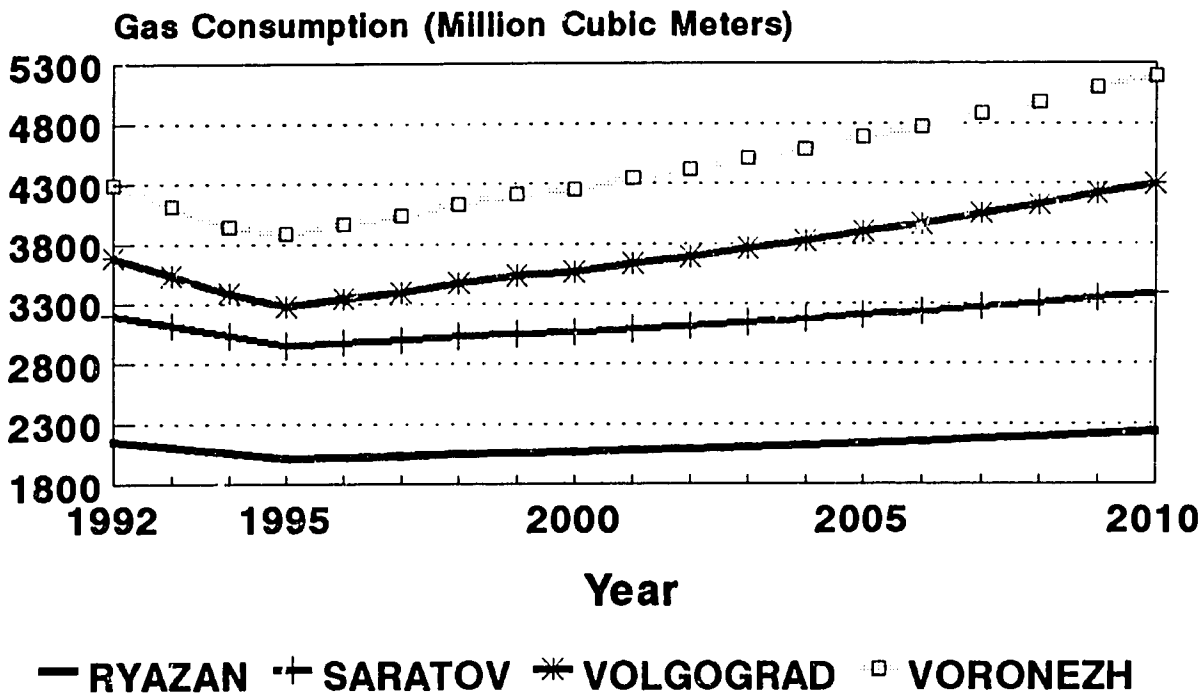
(Thousand Cubic Meters)

	Scenario 2 1995	Scenario 3 1995	Scenario 4 1995	Scenario 5 1995
Ryazan	35,585	35,960	30,981	31,355
Saratov	64,161	64,931	58,567	59,337
Volgograd	84,538	85,120	81,531	82,112
Voronezh	26,752	27,487	22,229	22,963

	Scenario 2 1999	Scenario 3 1999	Scenario 4 1999	Scenario 5 1999
Ryazan	40,362	41,926	7,903	10,657
Saratov	78,052	82,674	32,190	37,851
Volgograd	111,459	115,732	79,413	83,686
Voronezh	30,591	35,992	-25,244	-19,844

Figure 3-1

Projected Natural Gas Demand for Russian Cities - Scenario 2 (Base Case)



Source: BSA, Inc.

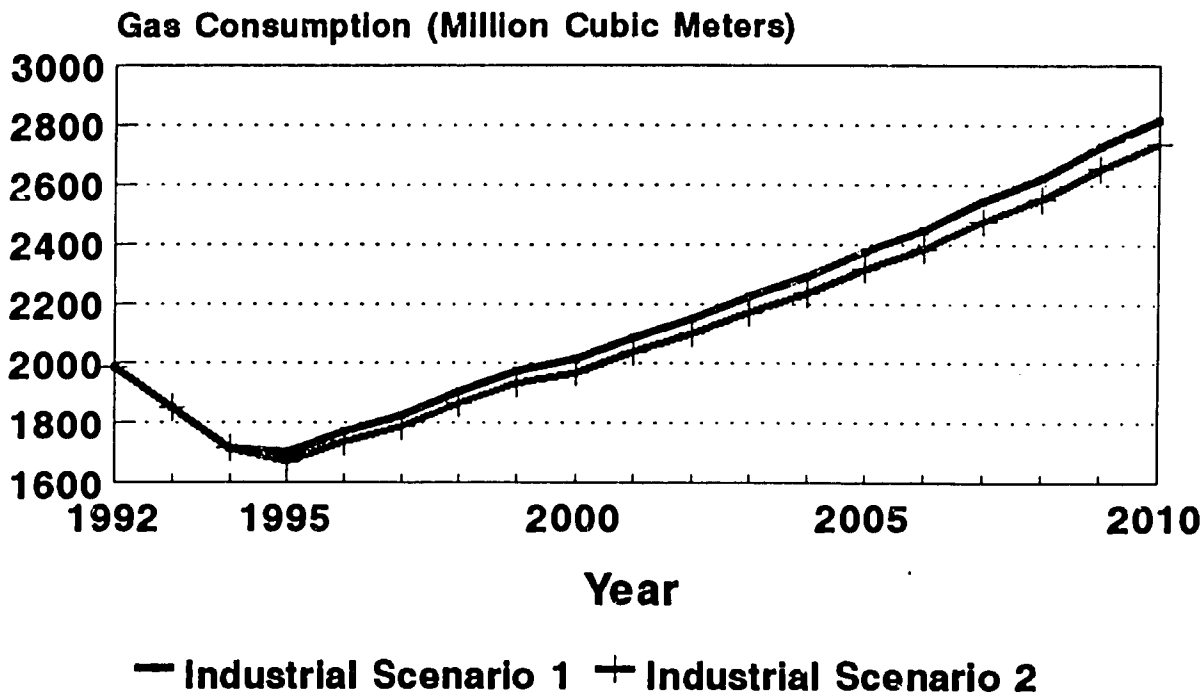
Figure 3-2

Description of Scenarios

	Industrial Efficiency Projects	Conversion of Cookers	District Heating Substitution
Scenario 1			
Scenario 2	✓		
Scenario 3	✓	✓	
Scenario 4	✓		✓
Scenario 5	✓	✓	✓

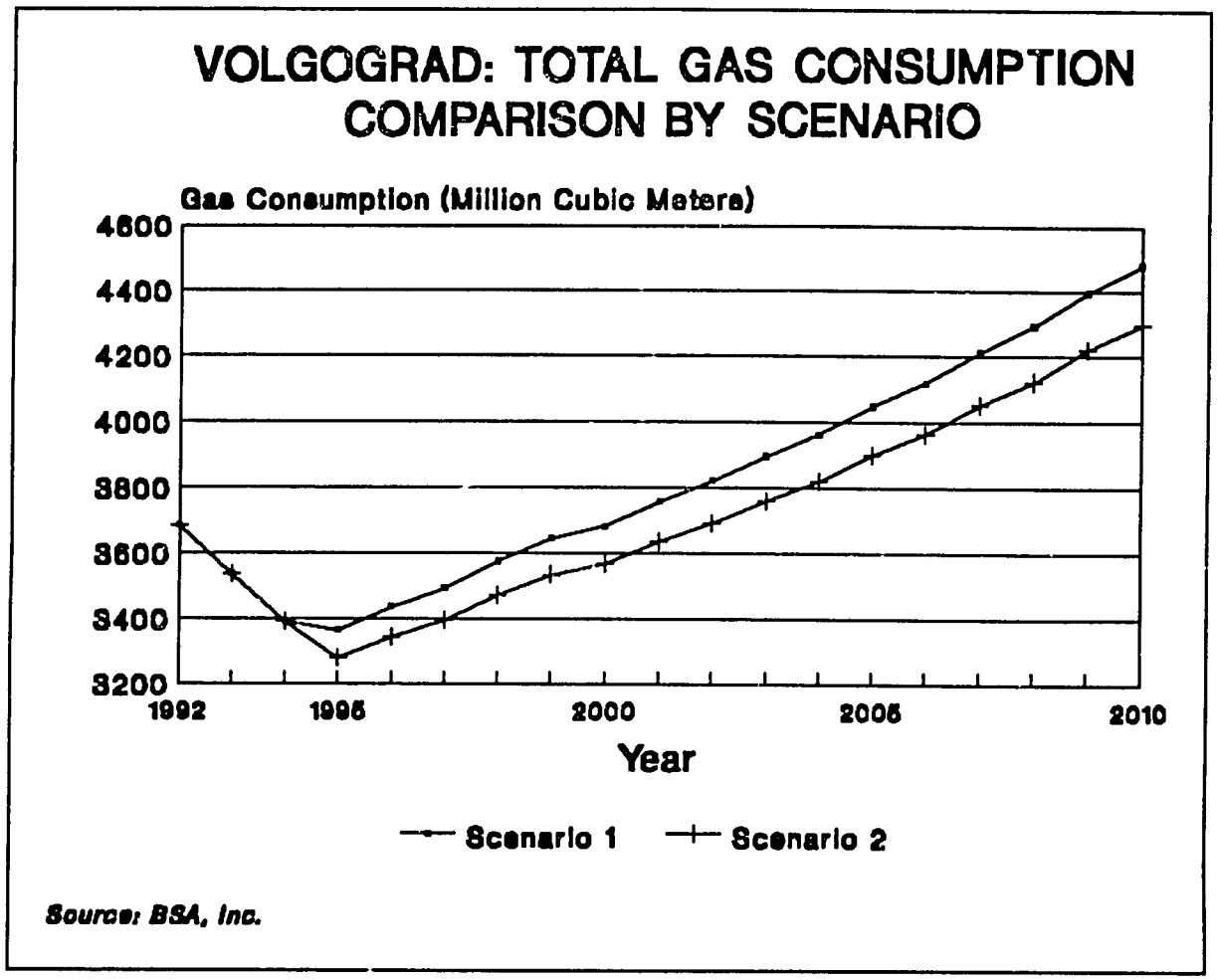
Figure 3-3

Impact of Industrial Energy Efficiency Projects - City of Volgograd



Source: BSA, Inc.

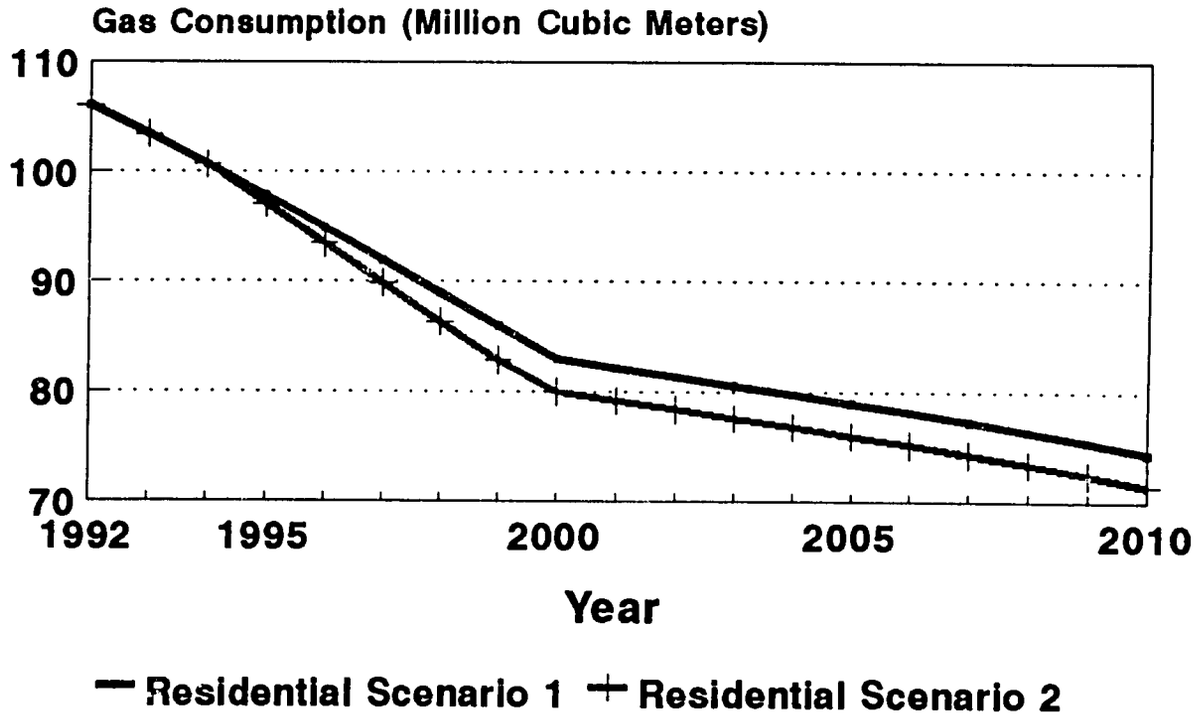
Figure 3-4


VOLGOGRAD: TOTAL GAS CONSUMPTION
COMPARISON BY SCENARIO
Gas Consumption (Million Cubic Meters)
4600
4400
4200
4000
3800
3600
3400
3200
1992
1995
2000
2005
2010
Year
Scenario 1
Scenario 2
Source: BSA, Inc.

77

Figure 3-5

Impact of Replacement of Gas Cookers with Electric Cookers - City of Ryazan

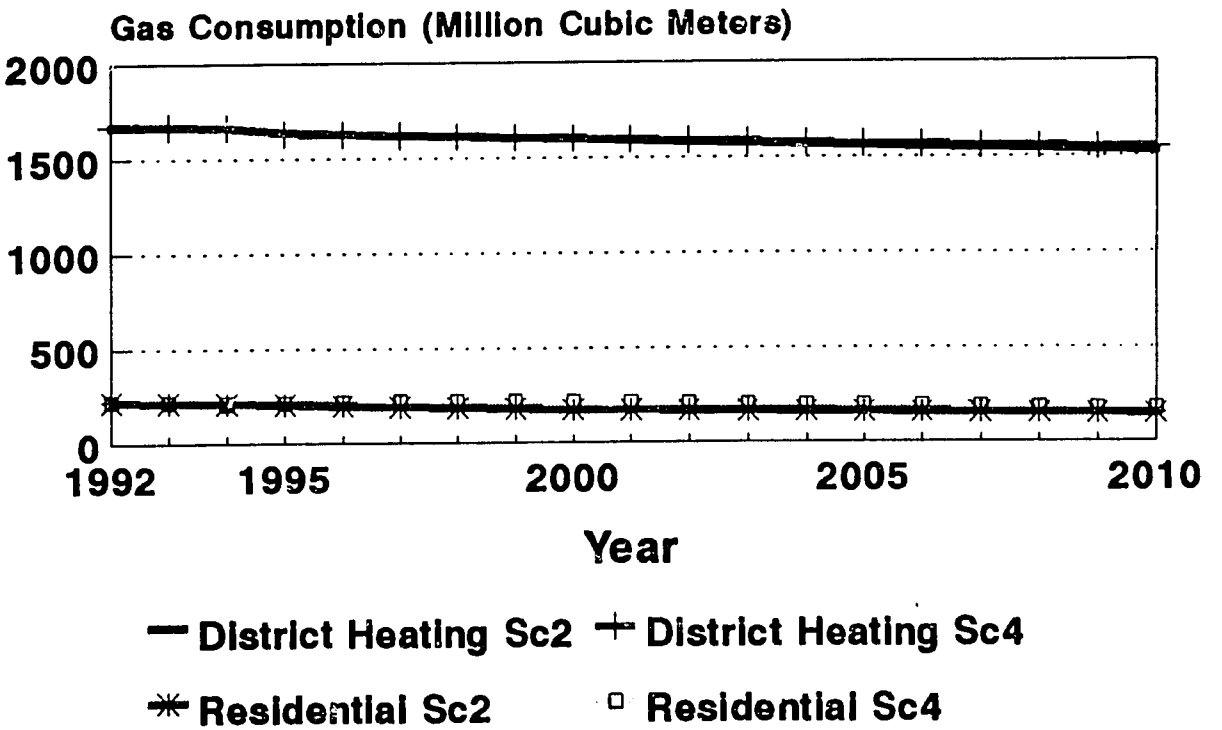


Source: BSA, Inc.

75

Figure 3-6

Impact of Conversion of District Heating to Gas Based System - City of Saratov



Source: BSA, Inc.

Section 4

TABLE OF CONTENTS

4. GAS DISTRIBUTION SYSTEMS 1

4.1 EXISTING CONDITIONS 1

4.1.1 Transmission System Supply Points 1

4.1.2 Distribution System 3

4.1.2.1 Pressure Range 3

4.1.2.2 Pipe Diameter and Wall Thickness 3

4.1.2.3 Pipe Construction 3

4.1.2.4 Regulating Stations 4

4.1.2.5 Service Line Overview 4

4.1.2.6 Apartment Riser Size 5

4.1.2.7 Cathodic Protection 5

4.1.2.8 Pipeline Leak Detection Survey 6

4.1.2.9 Network Analysis 7

4.1.2.10 Emergency Response 8

4.1.3 Customer Metering 9

4.2 PROPOSED PROJECTS 10

4.2.1 SCADA 14

4.2.1.1 Description 14

4.2.1.2 Potential Benefits 15

4.2.1.3 Implementation 15

4.2.1.4 Schedule 16

4.2.1.5 Costs 16

4.2.2 Cathodic Protection Systems 17

4.2.2.1 Description 17

4.2.2.2 Potential Benefits 17

4.2.2.3 Implementation 17

4.2.2.4 Schedule 17

4.2.2.5 Costs 18

4.2.3 Construction Equipment 18

4.2.3.1 Description 18

4.2.3.2 Potential Benefits 18

4.2.3.3 Implementation 18

4.2.3.4 Schedule 19

4.2.3.5 Costs 19

4.2.4 Test Equipment 19
4.2.4.1 Description 19
4.2.4.2 Potential Benefits 19
4.2.4.3 Implementation 19
4.2.4.4 Schedule 20
4.2.4.5 Costs 20
4.2.5 Gas Meters 20
4.2.5.1 Description 20
4.2.5.2 Potential benefits 20
4.2.5.3 Implementation Requirements 21
4.2.5.4 Schedule 22
4.2.5.5 Costs 22
4.2.6 Gas Meter Test Equipment 22
4.2.6.1 Description 22
4.2.6.2 Potential Benefits 22
4.2.6.3 Implementation 23
4.2.6.4 Schedule 23
4.2.6.5 Costs 23
4.2.7 Gas Main Replacement 24
4.3 COST/BENEFIT RANKING OF GAS DISTRIBUTION PROJECTS 25
4.3.1 Evaluation Procedure 25
4.3.2 Project Evaluation 25
4.3.3 Summary 26
4.4 CONTRACT PACKAGES 27
Table 4-1 List of Major Equipment and Materials - City of Ryazan 28
Table 4-2 List of Major Equipment and Materials - City of Saratov 29
Table 4-3 List of Major Equipment and Materials - City of Volgograd 30
Table 4-4 List of Major Equipment and Materials - City of Voronezh 31
Table 4-5 Project Costs for City of Ryazan 32
Table 4-6 Project Costs for City of Saratov 36
Table 4-7 Project Costs for City of Volgograd 40
Table 4-8 Project Costs for City of Voronezh 44
Table 4-9(a) Overseas Shipping Cost Estimate 48
Table 4-9(b) Domestic Shipping Cost Estimate 49
Table 4-10 Installation Labor and Equipment Rental Cost Estimate (Ryazan) 50
Table 4-11 Installation Labor and Equipment Rental Cost Estimate (Saratov) 51
Table 4-12 Installation Labor and Equipment Rental Cost Estimate (Volgograd) 52

Table 4-13 Installation Labor and Equipment Rental Cost Estimate (Voronezh) 53
Table 4-14 Foreign Engineering, Procurement and Construction Management Cost Estimate 54
Table 4-15 Local Engineering, Procurement and Construction Management Cost Estimate 56
Table 4-16 List of CP Equipment 57
Table 4-17 Summary of CP System Components 58
Table 4-18 Construction Equipment Costs 59
Table 4-19 Phase 1 – Metering Commercial Establishments 60
Table 4-20 Phase 2 – Metering Private Homes with Space Heat 61
Table 4-21 Phase 3 – Upgrade Industrial Meters 62
Table 4-22 Phase 4 – Metering Apartment Blocks 63
Table 4-23 Gas Distribution Projects by Rate of Return - City of Ryazan 64
Table 4-24 Gas Distribution Projects by Rate of Return - City of Saratov 65
Table 4-25 Gas Distribution Projects by Rate of Return - City of Volgograd 66
Table 4-26 Gas Distribution Projects by Rate of Return - City of Voronezh 67
Table 4-27 Project Cash Flows 68
Figure 4-1 SCADA Schematic System Configuration 73
Figure 4-2 SCADA System Control Center 74
Figure 4-3 SCADA EPC Schedule 75
Figure 4-4 Cathodic Protection EPC Schedule 76
Figure 4-5 Construction Equipment Procurement 77
Figure 4-6 Leak Detection Equipment Procurement 78
Figure 4-7 Monthly Gas Consumption by Industrial Customers 79
Figure 4-8 Monthly Gas Consumption by Commercial Customers 80
Figure 4-9 Monthly Gas Consumption by Residential Customers 81
Figure 4-10 Meter Installation Schedule 82
Figure 4-11 Gas Main Replacement Schedule 83
Drawing 4-1 Apartment House Riser System 84

Section 4

GAS DISTRIBUTION SYSTEMS

4.1 EXISTING CONDITIONS

Information on existing conditions in the cities of Ryazan, Saratov, Volgograd and Voronezh, was gathered for the following locations: city gate station supply points owned by Gazprom, the gas distribution systems owned/leased by the Gorgas companies, and metering facilities owned by customers in each of the four cities. Technical data and local construction costs obtained from the Gorgas are included in Appendix 4-A. Local material supply data are presented in Appendix 4-B, while the operations related data are given in Appendix 4-C.

4.1.1 Transmission System Supply Points

Gas is supplied to each Gorgas by Gazprom at City Gate Stations (CGSs) owned, operated, and maintained by Gazprom. Gas title transfer takes place immediately at the outlet of the CGS. A total of 14 CGSs supply gas to the four Gorgas companies.

In general, each station is supplied gas from multiple transmission lines which operate at pressures above 12 Bar. Stations can have single or multiple outlet lines operating at either medium pressure (MP) or high pressure (HP). MP ranges from .05 Bar up to 3 Bar, and HP ranges from 3 to 6 Bar or 6 Bar to 12 Bar as defined by SNiP 2.04.08-87. Outlet pressures are set by Gazprom with Gorgas input, and can be changed upon request.

A total of five CGSs were inspected. These stations were located in sparsely populated areas at the city limits, and all had a similar layout which is the basic Russian CGS design.

Station Overview	Ryazan	Saratov	Volgograd	Voronezh
CGS	2	3	6	3
Orifice Metering	Y	Y	Y	Y
Mechanical Recorders	Y	Y	Y	Y
Upstream Scrubbers	Y	Y	Y	Y
Manual Odorization	Y	Y	Y	Y
Single Stage Regulation	Y	Y	Y	Y
Overpressure Protection	Y	Y	Y	Y
Security Valves	Y	Y	Y	Y
Relief Valves	Y	Y	Y	Y
Emergency Shutdown	Y	Y	Y	Y
Manual Pneumatic Valve	Y	Y	Y	Y
Manned Stations	Y	Y	Y	Y
Automated Controls	N	N	N	N

Because these stations lack automated controls, station throughput and outlet pressure are manually changed at the station by opening and closing regulator runs and changing regulator setpoints. Stations do have audible alarms to warn the operator that pressure and flow parameters must be changed.

Gorgas does not have the capability to remotely monitor system pressures and flows at either the CGS or at any point on their distribution system, and must depend on Gazprom to initiate pressure and flow changes to match distribution system demand changes. Gorgas logs hourly flow and some pressure data received by telephone from Gazprom.

CGS metering is under the control of Gazprom. Only Gazprom operates, maintains, calibrates, and changes orifices, chart recorders, and chart integration equipment. Gorgas does not independently measure station flow, nor does it appear to have the necessary controls in place to ensure that Gazprom's metering operation follows good metering practices.

All aspects of CGS metering operation are substandard and do not follow the practices of American National Standards Institute/American Petroleum Institute (ANSI/API) 2530 (AGA) Report #3, as examples,

1. Meter tubes are field fabricated when they should be machined fabricated to exact diameter, length, roughness, and roundness tolerances.

2. Meter tubes and orifice fittings are all welded construction instead of flanged precluding internal inspections for burrs, dirt, grease, roundness, diameter, roughness, protrusions, and tube cleaning.

3. Straightening vanes are not utilized where required.

4. Differential and static sensing lines are very long and oversized when they should be of minimum length and diameter, and therefore are very susceptible to leakage and line losses.

5. Charts and orifices are not properly handled and stored.

6. Charts are integrated with a hand held planimeter on a wooden peg board.

The cumulative effect of these poor practices and substandard metering and calibration equipment can be very poor metering accuracy.

Metering Overview	Ryazan	Saratov	Volgograd	Voronezh
Meter Runs	4	NA	11	7
Total Capacity 1000 m^3/hr	467	635	1,583	650
By station	385	305	225	300
	82	120	320	300
		210	300	50
			368	
			270	
			100	
Orifice Meters	Y	Y	Y	Y
Machined Tubes	N	N	N	N
Straightening Vanes	N	N	N	N
Orifice Fittings	Y	Y	Y	Y
All Welded Construction	Y	Y	Y	Y
Chart Recorders	Y	Y	Y	Y
Differential	Y	Y	Y	Y
Static Pressure	Y	Y	Y	Y
Gas Temperature	Y	Y	Y	Y
Sensing lines >100 ft	Y	Y	Y	Y

Gas odorization is not automated nor based on real-time flow measurement. Odorization rates, therefore, must be changed manually. This can easily lead to both under and over odorization, which are equally unsafe.

24

The overall design of pressure control and overpressure protection is poor. There is insufficient separation of overpressure protection equipment and associated sensing lines from the pressure control equipment. Catastrophic failure of pressure control equipment could disable overpressure protection equipment as well. Relief valve headers and vent pipe appeared to be grossly undersized. In addition, the use of security valves for overpressure protection could inadvertently lead to partial or total loss of station flow which, under high demand conditions, creates an unjustified major interruption of service.

Piping fabrication methods are very poor. Branch connections on high pressure headers are made without reinforcing. Very few welded fittings are used and many fittings on high pressure lines are fabricated from mitered sections.

Gazprom, like Gorgas, has no aggressive preventive maintenance nor equipment replacement programs in place at their CGSs. Most equipment appeared to be in poor working condition, and some appeared not to be working at all. Housekeeping was poor. External corrosion was visible. There appears to be no program of non-destructive testing of pipe and fittings for internal and external corrosion.

Security fencing and lighting were poor. All stations lacked intrusion alarm systems as well as gas detection sensors in enclosed areas. Non explosion proof electrical fittings were observed.

4.1.2 Distribution System

The gas distribution systems at the four Gorgas companies began development on a large scale in the 1950s. These systems are designed and built in compliance with regulations and standards developed by Giproniigas.

4.1.2.1 Pressure Range

State Standard SNiP 2.04.08-87 defines the range of pressures for the high, medium and low pressure systems which are currently in use at all four Gorgas companies.

HP 1st category	6-12 Bars
HP 2nd category	3-6 Bars
MP	.05-3 Bars
LP	less than .05 Bars

4.1.2.2 Pipe Diameter and Wall Thickness

Pipe wall thicknesses range from a minimum of 3mm to a maximum of 10mm, with 4mm to 8mm being the most commonly used by all four Gorgas companies. Pipe diameters range from 25mm for low pressure application up to 700mm for high pressure application. The average pipe diameters were given as follows:

	Ryazan	Saratov	Volgograd	Voronezh
HP system	200 mm	400 mm	700 mm	400 mm
MP system	225 mm	175 mm	100 mm	325 mm
LP system	125 mm	100 mm	100 mm	219 mm

4.1.2.3 Pipe Construction

All four Gorgas company's piping systems are welded steel construction. Underground piping is wrapped, with sections under cathodic protection. Aboveground piping is

not wrapped and is generally not electrically isolated from the underground system. The aboveground piping is usually attached to the outside of buildings at approximately ceiling height of the first story, and remains aboveground if it supplies gas to more than one building. The length of pipe installed above and below ground is summarized as follows:

	Ryazan	Saratov	Volgograd	Voronezh
Total Main length (km)	840	1,634	1965	1,634
Total Buried	692	738	1,805	1,399
Total Aboveground	148	896	160	235
Total HP	111	240	66	208
Total MP	112	19	545	211
Total LP	617	1,375	1,354	1,215
Total under CP	211	558	803	449
% Buried Pipe under CP	30	76	44	32

All four Gorgas companies were unable to provide length of pipe by diameter and wall thickness for any of the pressure systems. This information, however, is contained in thousands of individual project construction ("passport") files at each company.

4.1.2.4 Regulating Stations

Pressure reduction within the distribution systems takes place at either aboveground regulating stations or industrial and some commercial customer's meter trains.

	Ryazan	Saratov	Volgograd	Voronezh
Aboveground HP=>MP	8	NA	2	7
# Meter runs	0	NA	2	21
Aboveground MP=>LP				
Brick Enclosure	109	120	286	161
Cabinet Enclosure	90	NA	100	144

These regulating stations are designed using single stage regulation with both a security and relief valve overpressure protection system. These stations are not built underground, and typically are not isolated from the underground piping system.

In cases where the stations are isolated from the underground piping systems, the upstream and downstream buried systems are electrically bonded.

The overall design of pressure control and overpressure protection at these stations is poor. There is insufficient separation of overpressure protection equipment and associated sensing lines from the pressure control equipment. Catastrophic failure of pressure control equipment could disable overpressure protection equipment as well. In addition, the use of security valves for overpressure protection could inadvertently lead to partial or total loss of station flow which, under high demand conditions, creates an unjustified interruption of service.

4.1.2.5 Service Line Overview

The total length and diameter of service pipe was not available. Generally, service lines enter a building aboveground. Less than 5% of the total service line population is electrically

isolated at either the main or the building entry point. The numbers of service lines to residential customers were estimated as follows:

	Ryazan	Saratov	Volgograd	Voronezh
Total	25,363	42,585	46,955	68,565
Private Homes	11,363	30,000	34,000	44,285
Apartment Buildings	14,000	12,585	12,955	24,280
Number Electrically Isolated	371	NA	6,800	1,733
% Isolated	1.5	NA	14.5	2.5

4.1.2.6 Apartment Riser Size

Apartment riser sizing is based on low pressure and typically ranges from 20mm to 40mm in diameter, depending on the number of stories, type of load, and building code restrictions. House piping is considered a part of the distribution system and must be maintained by the Gorgas companies. The riser size in mm for various size buildings was found to be as follows:

	Cooking Only	Cooking + Hot Water
5 stories or less	20-25 mm	20-40 mm
6 to 9 stories	20-40 mm	not allowed
Above 9 stories	not allowed	not allowed

Gas is restricted to buildings 9 stories or less because of fire safety codes and the height limitation of fire fighting equipment. Gas for hot water is restricted to buildings 5 stories or less because of chimney and ventilation duct capacity limitations. If these restrictions stand, conversion to a gas based system at the apartment/apartment complex level must use a central heating/hot water design.

4.1.2.7 Cathodic Protection

The cathodic protection system design is based on a government standard "Gost 9.602-89", entitled "Unified System of Corrosion and Aging Protection for Underground Construction - General Requirements for Corrosion Protection". This standard contains requirements for cathodic protection, protection potentials, soil resistivity, and pipe protective coating.

The coating system is a hot-applied bituminous mastic coating consisting of 3 layers of glass reinforced bitumen, each 3 mm thick, plus an outer kraft paper layer. Pipe surface is wire brushed and primed before coating is applied.

All four companies use rectifiers (CP Stations) to protect what are essentially electrically continuous distribution systems. In each case, the entire underground system, HP-MP-LP, is electrically continuous from the City Gate Station to the end user. Approximately 95% of the total service line population is also electrically connected to the gas underground piping system at each Gorgas. Because most service lines are not electrically isolated at the front wall, most services are probably grounded at or in the building and electrically connected to the building water piping. This being the case, each company's cathodic protection system is protecting not only its gas distribution system but any other system electrically connected to its gas distribution system.

As a result, it is very difficult to control, monitor, and evaluate the effectiveness the cathodic protection systems. This gives rise to the following problems:

1. The present design creates a large current requirement for cathodic protection without controls over where the current goes.

2. Accelerated corrosion of water lines and other underground utilities structures will occur wherever current drainage occurs.

3. Underground interference and contacts usually leave huge areas of gas piping unprotected.

4. Trouble shooting is extremely difficult, time consuming, and labor intensive. The lack of proper testing equipment compounds the problems of an effective trouble shooting program.

The number of cathodic protection stations and the length of pipe protected in each city is summarized as follows:

	Ryazan	Saratov	Volgograd	Voronezh
Total CP Stations	213	265	655	217
Stations not working	40	NA	178	50
Drainage Stations	3	85	46	54
Anode Beds	9		2	59
Service Isolation Flanges	371		6,800	1,733
Pipe under protection (km)	211	558	803	449
Pipe needing protection (km)	28	178	48	0
Pipe adjacent to tracks (km)	3		54	130

4.1.2.8 Pipeline Leak Detection Survey

Except for Saratov, all companies stated that corrosion related leaks are low or practically non-existent. Up to the present, this may have been true because pipe is relatively new, pipe protective coating has been generally good and worked, and soil corrosivity is relatively low. However, there are indications that as these systems continue to age, leakage due to corrosion will accelerate. For example, in Saratov, 23 leaks due to corrosion were reported. In addition, 114 leaks due to mechanical damage, 32 weld seam ruptures, 323 fitting leaks, 8 casualties and 3 fatalities were reported. Saratov has the oldest pipeline network. It has identified 30 km of pipe requiring urgent replacement. The following observations were made based on the information obtained from the Gorgases:

1. First generation pipe coating systems are showing signs of failure.

2. Underground piping, especially in the courtyard environment, is being replaced with aboveground piping because either the original installation was not properly protected and electrically isolated, or, third party excavation activities are creating problems.

3. Customers, because of increased electricity cost, have started grounding their electric meters to gas and other utility house piping, changing pipe potentials, and creating localized corrosion cells on the underground gas systems.

4. Approximately 25% of each company's CP stations do not function and need to be replaced.

5. Buried pipe running adjacent to train tracks may be exposed to increased stray currents if the electrified track system is not properly maintained.

Pipe replacement is usually driven by a pipe's leak history, and most leaks are usually found through leak survey programs. Leak statistics at all four companies are directly related to their leak survey programs. None of the four companies perform mobile surveys. Each company performs walking surveys which either exceed or meet the minimum requirements of State Safety given below:

	Survey Frequency	Type
Buried Pipe		
HP/MP systems	3 times weekly	Point specific
LP systems > 25 yrs	1 time weekly	Point specific
LP systems < 25 yrs	1 time every 2 weeks	Point specific
HP/MP/LP <25 yrs	1 time every 5 years	Continuous
HP/MP/LP >25 yrs	1 time every 3 years	Continuous
Aboveground pipe	1 time every year	Visual

In a point specific survey, inspectors repeatedly visit specific points along the underground piping system route checking for evidence of gas leakage. Each inspector has a route with a list of points to check: gas valve pits, manhole covers of other utilities, gas drips, etc. This type of survey has very limited value, and is not an appropriate substitute for a continuous annual survey of the entire main and service network.

The gas detection equipment is substandard and in very poor working condition. Companies indicated they would like to replace their entire inventory with modern gas detection equipment. The survey crew and leak detection equipment used in various cities is summarized below:

	Ryazan	Saratov	Volgograd	Voronezh
Inspectors	75	90	120	120
Combustible Gas Detectors	80	55	300	115
In need of Replacement	80	55	200	115

Where and when convenient, companies will also take sections of LP/MP/HP mains out of service to conduct a 5 year air pressure test. This procedure is not applied to aboveground mains.

Even though their standards call for a comprehensive technical survey of each segment of pipe on either a 3 or 5 year cycle, the effectiveness of such surveys is questionable given the poor quality and poor condition of their inspection equipment.

Generally speaking, none of the four Gorgas companies are practicing aggressive leak survey management. This is compounded by the fact that their gas detection equipment often doesn't work. This most likely accounts for the extremely low number of leaks picked up through the survey program.

4.1.2.9 Network Analysis

Presently, hydraulic modeling of gas pipe systems is done by Giproniigas, and then, only on a paid service basis. Models do not exist for the four Gorgas companies, and system modeling has never been performed on any of the Gorgas systems. The basic assumptions and rules that are used to plan and design new projects have not changed in the past 40 years and are not validated once a project is completed. The hydraulic formulas and programs in use have not

evolved with improvements from advanced technology. No modeling is performed for replacement and upgrade projects.

The four Gorgas companies are presently only responsible for the operation and maintenance of their distribution systems. New construction is initiated by new gas customers who pay the cost of design and construction. The construction company installing the new gas facility is under contract with the customer and not Gorgas. State regulations require that construction companies and their employees are certified to perform gas construction work.

Even though these companies have certification and workers are trained to follow state standards, construction practices are poor and often do not meet the state requirements. Gorgas has responsibility to review, but, apparently, cannot effectively control the quality of the contractor's work, most likely because they do not control payment.

None of the four Gorgas companies has the capability of remote real-time monitoring system pressure and flow conditions at any point on their distribution system, including the CGS supply points and major customer take off points. None of this information is telemetered back to their respective control rooms. Gorgas does receive by telephone and logs CGS hourly flow and some pressure data from Gazprom.

Chart recorders are used to record inlet and outlet pressure and some flow data at distribution pressure regulating stations. Chart recorders are also used to record static and differential pressure for orifice meter flow calculations at large industrial customer locations. These charts are reviewed weekly by the Gorgas companies and then returned to the customer. Pressure data in the low pressure system at end-users are not normally recorded.

All four companies must depend on Gazprom to initiate pressure and flow changes to match distribution system demand changes and maintain safe system operating pressures under normal, design, and emergency conditions. Each company has no means to determine if a system component has failed or malfunctioned and is therefore unable to react in a timely and correct manner to make the system safe, minimize gas losses, and protect the public.

4.1.2.10 Emergency Response

All four companies have 24 hour emergency response service with a manned dispatch center. Units are either dispatched by telephone, cellular phone, or radio. Generally, communications are good. Emergency response crews are usually not equipped to make permanent repairs. Such repairs are done by follow-up maintenance crews. The following summarizes the emergency response manpower for each city:

	Ryazan	Saratov	Volgograd	Voronezh
Total Manpower	37	50	116	82
Number of crews per shift	1	6	9	5
Maximum travel distance (km)	20	30	40	40
Maximum travel time (min)	25	35	45	45

None of the four companies use clamps or sleeves to repair leaking mains and services. Pin hole leaks are peened over and welded. More seriously leaking pipe is removed and replaced with welded pipe, no matter how small the piece. This is done as a "hot work operation". This same technique described below is used for new and replacement construction.

1. Pressure in the main is lowered to between 40 mm and 150 mm water column. Positive pressure is maintained at all times. Service to customers along the

affected main is interrupted. Usually, some unspecified quantity of gas is vented to the air.

2. An opening is made using a torch, at which time a bag(s) is inserted in the main to stop the flow of gas.

3. The section of pipe is removed by torch cutting and a new section is welded in place, and all openings are welded close.

4. All purging is done with gas.

No isolation "hot tap" drilling equipment and service tapping equipment is used by any of the four companies. Instead, all connections and appurtenances are welded construction performed using the "hot connection" technique. No threaded fittings are used.

4.1.3 Customer Metering

Currently, metering is limited to the industrial and commercial sector at each Gorgas company. Three types of meters are used: orifice, rotary, and turbine. Private homes and apartment units are not metered. The number and type of meters used in the four cities is as follows:

	Ryazan	Saratov	Volgograd	Voronezh
Rotary	250	250	443	438
Orifice	72	1,133	125	225
Turbine	0	0	0	10

The most typical rotary meter sizes are 40, 100, 250, 400, 600, and 1000 m^3/h. The most typical turbine meter sizes are 200, 400, and 800 m^3/h.

Meters and industrial/commercial house piping are owned by the customer. Ownership usually transfers at the property line or street valve. The meter/regulator train and all piping within industrial complexes are installed and maintained by the customer. Large industrial complexes usually have multiple metering locations. Master metering at the property line is not practiced.

Rotary meters are read by the customer who then telephones in metered volumes to the Gorgas companies. Orifice meter calculations are performed by the industrial customer and annotated on the pressure and differential charts. These charts are reviewed by the Gorgas companies daily and all charts are returned to the customer at the end of the monthly accounting cycle.

Rotary meters are supposed to be inspected and re-certified every two years. The customer is responsible for removing and delivering the meter for inspection and prover testing. A state inspector witnesses the prover test.

Not all rotary metered customers have spare meters. They are either forced to shutdown operations during the re-certification process, or, using the meter bypass piping, continue to use gas and are charged a flat hourly fee based on the connected appliance load for each hour the meter is not in service.

Rotary meter and meter prover technology has not evolved with improvements from advanced technology. No pressure or temperature adjustments are made either at the meter or in the billing process. Handling/shipment practices, poor quality replacement parts, and in some cases, poor maintenance facilities cumulatively contribute to poor rotary meter accuracy. There is no customer incentive to replace aging meters since the customer benefits from poor meter accuracy.

The industrial orifice meter is essentially under the control of the customer. Orifice meters are re-certified each year with a Gorgas representative present. The customers maintain and calibrate their recording and chart integration equipment. Certain aspects of industrial metering are substandard and do not follow the practices of AGA Report #3 or ISO Standard 5167. For example:

1. Meter tubes are field fabricated when they should be machine fabricated to exact diameter, length, roundness, and roughness tolerances.

2. Meter tubes and orifice fittings are all welded construction precluding internal inspections for burrs, grease, roundness, roughness, diameter, protrusions, and tube cleaning.

3. Straightening vanes are not utilized where required.

4. Differential and static sensing lines are long and oversized when they should be of minimum length and diameter, and therefore are susceptible to leakage and line losses.

5. Charts and orifices are not properly handled and stored.

6. Charts are integrated with a hand held planimeter on a wood peg board. Each customer has his own planimeter, which he maintains and calibrates. It is impossible for the Gorgas companies to control calibration standards and practices on these instruments.

7. Recording Chart equipment is calibrated with substandard test equipment owned, maintained and "certified accurate" by each customer. It is impossible for the Gorgas companies to control calibration standards and practices on these instruments.

The cumulative effect of these poor practices and substandard metering and calibration equipment can be very poor metering accuracy.

Private homes and apartment units are not metered. Typically, private homes have individual service lines connected to the gas distribution system. These service lines usually enter the private home aboveground. Apartment units are supplied gas for either cooking or cooking and hot water from a concealed riser system per Drawing 4-1. The riser system can be connected to either a buried distribution system or an aboveground, building supported, distribution system. In both cases, gas usually enters the apartment building aboveground.

Risers are usually concealed in either the kitchen wall or adjacent bathroom wall. Kitchen/bathrooms are typically located at the far end of medium and large size apartments away from the entrance/central hallway door. In small apartments, however, kitchen/bathrooms are typically located near the entrance/central hallway door.

4.2 PROPOSED PROJECTS

From an evaluation of the existing conditions, many areas of improvements in the construction, maintenance and operation of the distribution system were identified.

None of the Gorgas companies have Supervisory Control and Data Acquisition (SCADA) systems or network modeling capability. Gorgases do not have the capability to remotely monitor system pressures and flow and must depend on Gazprom to initiate pressure and

flow changes to match distribution system requirements. It would therefore be necessary to install a SCADA system at each Gorgas. All four Gorgases expressed interest in developing SCADA systems.

Network modeling capability is essential to properly carry out all aspects of new construction/replacement analysis and decision making, system capacity planning, upgrading, and, eventually, construction itself. Network modeling can easily and cost effectively deal with issues of long range planning, system upgrading, saturation loading, emergency and contingency coverage, network simplification, supply restrictions, and much more.

Typically, modeling will identify the least cost option and reduce construction cost by at least 10%. Modeling will also identify potential system weaknesses and therefore potential service interruption, lost revenue, and damage cost.

Commercial software and compatible PC hardware are available that can efficiently and accurately model systems the size of the four Gorgas companies. Most software is capable of supporting graphics. Model development can be done by either a third party or in-house. If model development is done in-house, additional software and hardware is usually required. Model development can be done in phases which will spread cost and manpower requirements.

The existing CP system requires significant upgrading in order to ensure maximum pipeline life. The pipeline life can be extended indefinitely by proper design, operation, and maintenance of the CP system. The existing system is likely to give rise to deterioration of the pipes over the next 20 to 30 years. It will, therefore, be necessary to upgrade the CP system and train the operators to operate and maintain the system.

Some of the Gorgases expressed interest in upgrading their construction and maintenance equipment, which should create the following advantages for each company.

1. Develop improved in-house fabrication and installation expertise, which can be applied to third party construction.

2. Develop improved in-house inspection and quality control capability and expertise, which can be applied to third party construction.

3. Develop an alternative to third party construction, which should force improved quality control measures by third party contractors.

Leak detection equipment and survey procedures require upgrading. Leak detection equipment is substandard and in poor working condition. Thus, the extent of leaks cannot be effectively verified. All Gorgases expressed interest in upgrading their equipment. In addition, each company should upgrade its leak detection survey procedures as follows:

1. Annually perform a continuous walking survey of the entire underground distribution system including service lines with modern flame ionization units. If there is physical movement or external loading on a pipeline which could cause failure or leakage, then surveying is required at least every three months.

2. Develop a leak classification system to prioritize leaks. Such a system is essential if the program successfully discovers large numbers of leaks.

3. Develop a computerized leak management database. All leak information contained in the individual passport files should be captured in this database. During the review of passport files for leak data, other pipe data, such as age,

diameter, wall thickness, etc. should be captured in a database. These databases would be used in pipe replacement analysis.

4. Develop a non-destructive testing program for all aboveground piping, including pressure regulating stations.

5. Consider surveying the MP and HP systems during the periods of minimum load and maximum system pressure. This should help expose minor leaks before they become major leaks.

6. Consider introducing mobile surveys of mains in streets. Each company should first study traffic patterns and parking regulations to determine whether this type of survey is practical.

Saratov Gorgas had identified need for immediate replacement of 30 km of pipes. Other Gorgases had relatively modest need for pipeline replacement.

Pipe age in itself is not a criteria for pipe replacement. However, pipe age is probably an accurate indicator of a pipe's physical parameters and construction methods everywhere within the country. Replacement programs based on poor pipe coatings, welding practices, material quality and fabrication, etc., more than likely, could be tied back to the period of construction. Gorgas companies should exchange technical bulletins which address these concerns.

About 15 percent of the gas delivered by the Gorgases is not metered. This includes residential customers and some commercial and industrial customers. Additionally, the meters used by the industrial and commercial customers require upgrading.

Proper metering and proper pricing is expected to reduce waste and make the customers conserve gas.

Investments in the following projects would dramatically increase gas use efficiency, reduce maintenance and operating costs, and improve safety and reliability of the distribution system:

- Install a Supervisory Control and Data Acquisition system (SCADA) and perform network modeling
- Upgrade cathodic protection (CP) system
- Upgrade construction equipment for operations and maintenance, and personnel safety
- Upgrade test equipment for leak detection
- Install gas meters in unmetered residences with space heating, commercial establishments and apartment blocks, and upgrade industrial meters
- Install meter test facilities
- Replace those underground pipes which are in poor condition.

The following sections describe the proposed projects, their potential benefits, costs (foreign and local), schedule, and implementation requirements. All costs are expressed in mid-1993 US$. An exchange rate of 1000 rubles equal to one US$ was used for converting ruble costs into US$. The cost estimates are order-of-magniture (± 30 percent).

The costs of local materials, supplies, construction costs and labor costs are summarized in Appendix 4-A and are used as a basis for estimating local costs. Telephone quotes or Bechtel's inhouse data were used for the cost of imported materials and equipment. These costs are summarized in Tables 4A-1 through 4A-4 of Appendix 4-A.

The Russian labor costs in 1993 US dollars are expected to increase over the project implementation period. From discussions with World Bank, it was indicated that the Russian labor costs in 1997 will be about the same as the current labor costs in Chile and Turkey. Bechtel's experience also suggests a rapid increase in labor costs in Russia. the rate of growth of real wages (wages in 1993 US$) was estimated as follows:

Time	Rate of Increase Per Month
Aug. 1993 to End of 1993	5%
1994	5%
1995	5%
1996	4.5%
1997	4%

The all in labor costs in September 1993 was $.0.50/hour. The projected future labor costs are as follows:

	Labor Cost in $/h
Start of 1994	0.58
End of 1994	1.04
End of 1995	1.87
End of 1996	3.17
End of 1997	5.07

The average cost of labor in years 1994 through 1997 was rounded to the following values and was used in the cost estimates:

Year	Average Labor Cost 1993 US$/h
1994	0.8
1995	1.5
1996	2.5
1997	4.0

The projected average labor costs in Russia in 1997 are about the same as the current labor costs in Turkey.

The following costs are included in the cost estimates:

- International shipping costs for imported equipment and materials

- Local transportation costs for both domestic and imported equipment and materials

The following costs are excluded from the cost estimates:

- VAT tax
- Duties on imported equipment and materials
- Inflation (all costs are expressed in mid 1993 US dollars)
- Interest during construction and owner's costs

The VAT tax (20%), import duties (5%) and inflation have been considered as a part of the Financial Analysis (Section 8).

4.2.1 SCADA

4.2.1.1 Description

These projects include providing a system control center with computers and communications facilities for:

- Monitoring and controlling distribution operating pressures and flow rates
- Detecting illegal entry and unsafe conditions at City Gate Stations and other controlled access locations
- Analyzing the distribution system performance and forecasting load and operating conditions based on weather forecasts

Figures 4-1 and 4-2 illustrate schematically the arrangement of facilities to provide these operating functions.

The SCADA system consists of a master station located near the central facilities at each gorgas. The master station will communicate with four radio transmitter stations strategically located in the city. The radio transmitter stations will receive data from the field RTUs by radio transmission. The data received at the master station will be processed and displayed for the system operator on the console consisting of color monitor with VGA graphics, keyboard and printer. The printer will log alarm messages and print reports.

A gas chromatograph with sulfur analyzer will be provided at one of the city gate stations in each city. The characteristics of gas will be continuously monitored and these data will be transmitted using RTU provided at the city gate station.

The pressure, temperature and flow data will be transmitted using RTUs from city gate stations and major industrial sites. Pressure at selected regulator stations will also be transmitted using RTUs.

Appendix 4-A summarizes capabilities of Advanced Control Systems MPR-7075 RTU and Alligator Communications, Inc's MAS radio system.

4.2.1.2 Potential Benefits

The equipment installed will provide the system operators with state-of-the-art facilities to monitor and control the distribution system status on a real-time basis. Instant availability and transmission of information on status of pressures, flow-rates, and security conditions at monitored locations will promote safety, and improve maintaining distribution pressures and delivery capacity with varying weather conditions. The ability to control operating pressures from a central control station will allow the system to be operated at the lowest pressure consistent with the required delivery capacity according to the season of the year.

Load forecasting will allow the cities, in cooperation with Gazprom, to estimate future delivery requirements without setting arbitrary take-or-pay allocations, which are counterproductive to gas conservation. Firm gas presently allocated that can be reallocated on a real-time basis will be available for other markets, such as industrial customers who would sotherwise be required to operate on alternative fuel. If the industrial customers must be curtailed, then the actual time of curtailment can be monitored.

Capability to analyze network performance will benefit the gas companies by allowing them to:

- Determine the most efficient operating pressure for each of the district regulator stations by season.
- Select the preferred pipe diameter for pipe replacements for the selected operating pressure within the network.
- Determine the preferred pipe diameter and operating pressure for main extensions to new service areas.
- Determine the preferred routing of new mains to reinforce delivery capacity of areas within or adjacent to the existing network.

4.2.1.3 Implementation

Project engineering would begin after project authorization. Equipment and software specifications would be developed during the first six months of the project. After approval of the specifications, bidding, bid review, and award of contracts would require two months. Currently, lead time to shipment of first materials is estimated to be six (6) months from award of contract. Allowing one month for shipping, initial installation would begin one year after the start of the project.

During fabrication of the equipment, the control software would be developed and tested to be ready for installation and testing after the equipment has been installed and ready for commissioning.

Installation would be by domestic contractors under supervision of the equipment manufacturer. After commissioning, approximately two months of training would be required to develop familiarity with and competence in system operation. Installation, testing, and initial training would be completed in the first year following receipt of equipment for the first phase.

The SCADA system can be further expanded by installing remote terminal units (RTUs), and additional data points in the central control room system models. These later installations would extend the project by two years for a total of four years.

4.2.1.4 Schedule

These projects will be developed as follows:

First year	-	Engineering, procurement, manufacture and shipping.
Second year	-	Install the control center, base communications systems, and remote terminal facilities at the City Gate Stations.
	-	Engineering, procurement of additional system components.
	-	Install computer hardware and software at the control center, and train control center operators and network analysts.
Third year	-	Install remote terminal facilities at industries.
	-	Procurement of components for industrial sites.
	-	Add data to system computer model and test.
Fourth year	-	Install remote terminal facilities at regulator stations.
	-	Procurement of components for regulator stations.
	-	Add data to system computer model and test.

Figure 4-3 shows the project schedule.

4.2.1.5 Costs

Tables 4-1 through 4-4 summarize the list of major equipment and materials required for this project for the four cities.

The costs of the SCADA systems are estimated to be spread over four years. The initial installation will include the central control room, base communication equipment, and remote terminal units (RTUs) at the City Gate Stations. The initial installation will include hardware, software, and operator training to place the system in operation. Tables 4-5 through 4-8 summarize the total estimated costs of the SCADA system for the four cities.

The basis for overseas and local shipping costs is presented in Table 4-9.

Table 4-10 through 4-13 provides the basis for the estimated costs of installation labor and equipment rental. A productivity factor of 2 has been used in estimating the installation labor requirements.

Tables 4-14 and 4-15 provides the basis for the estimated costs of foreign and domestic engineering, procurement and construction management costs. It has been assumed that the basic engineering, overseas procurement, training, support during construction, and commissioning and start-up assistance will be provided by the foreign consultant. The detail engineering, installation, commissioning and operating services will be provided by domestic engineering/construction companies.

4.2.2 Cathodic Protection Systems

4.2.2.1 Description

These projects upgrade the existing CP systems to state-of-the-art standards for operating, maintaining, and preserving the present distribution system piping.

The elements of these projects are:

- A detailed office study of the layout of the distribution mains, and connected facilities. This study will include leak history, locations of interfering facilities such as electrified trolley tracks, and similar installations.
- Sectionalizing the mains into units for field surveys to determine electrical isolation requirements.
- Progressively electrically isolating the sections by installing insulating fittings or fittings in all service risers and other connected facilities.
- Performing required pipe-to-soil potential and electric current drain surveys.
- Installing CP rectifier stations, anodes, and ground beds as required.

A list of cathodic protection test equipment needed for designing, testing and monitoring CP circuits is given in Table 4-16.

4.2.2.2 Potential Benefits

These projects will:

- Extend the life of the existing system indefinitely into the next century with proper performance of operating inspections and maintenance procedures.
- Reduce the electrical power consumption to less than 10 percent of the present annual consumption.
- Improve the public image and safety by reducing deterioration of and leakage from the system.

4.2.2.3 Implementation

The projects will begin with the engineering office studies sectionalizing the existing systems. Maximum use of existing engineering information is assumed in the schedule.

The procurement cycles will proceed concurrently with the engineering and field studies. Installation will follow as materials are received, and the sections tested and balanced for maximum effectiveness.

4.2.2.4 Schedule

These projects will be developed with the engineering and procurement cycles extending through the four year period. The number of areas into which the buried systems will be divided, the number of isolation units, rectifier stations, and isolation flanges required for each city are summarized in Table 4-17.

Figure 4-4 shows the project schedule.

4.2.2.5 Costs

Tables 4-1 through 4-4 summarize the list of major equipment and materials required for this project for the four cities.

Estimated costs of these projects are listed in Tables 4-5 through 4-8.

The basis for overseas and local shipping costs is presented in Table 4-9.

Table 4-10 through 4-13 provides the basis for the estimated costs of installation labor and equipment rental. A productivity factor of 2 has been used in estimating the installation labor requirements.

Tables 4-14 and 4-15 provides the basis for the estimated costs of foreign and domestic engineering, procurement and construction management costs. It has been assumed that the basic engineering, overseas procurement, training, support during construction, and commissioning and start-up assistance will be provided by the foreign consultant. The detail engineering, installation, commissioning and operating services will be provided by domestic engineering/construction companies.

4.2.3 Construction Equipment

4.2.3.1 Description

These projects provide the cities with new tools and equipment for operations, maintenance, and personnel safety to conform with present-day standards and practices. Items included for two crews for each city are truck-mounted equipment for emergency response, excavating equipment, X-ray equipment for inspecting welds, pipe bending machines, and miscellaneous tools and safety equipment for personnel. These items are listed in Tabled 4-18.

4.2.3.2 Potential Benefits

The potential benefits result from reducing response time to emergencies caused by unauthorized excavations that rupture or puncture distribution piping, providing present-day tools and equipment for accomplishing the required maintenance and repair procedures, and providing protective equipment for employees, including items such as work gloves, eye goggles, barricades, and toe protectors for use when operating pneumatic excavating and compation tools.

Additionally, quicker response to emergencies of escaping gas will improve public image of the gas companies, reduce release of natural gas to the atmosphere, and reduce the amount of gas attributed to leakage.

4.2.3.3 Implementation

Specifications for the tools and equipment would be prepared by the engineering and construction staffs of the gas companies. Bidding, bid reviews, and award of bids would follow. During the manufacturing and delivery period, shop inspections and equipment performance testing will be required before acceptance for delivery.

After receipt of new equipment, a training program for equipment operators and maintenance personnel would be required.

100

4.2.3.4 Schedule

- Preparations of specifications and bids - 3 months
- Bidding, bid review, and award - 2 months
- Delivery - within 7 months of award

Figure 4-5 shows the project schedule.

4.2.3.5 Costs

The summary of costs presented in Table 4-18 is based on domestic purchase of all items at equivalent cost in the U.S. market. A contingency factor of 15 percent is included to account for uncertainty of production costs in the domestic market.

4.2.4 Test Equipment

4.2.4.1 Description

These projects provide essential, modern leak detectors, gas analyzers, and calibration equipment to replace old equipment of uncertain reliability that is difficult to maintain because of age and origin from various foreign and domestic manufacturers.

4.2.4.2 Potential Benefits

The operational safety of gas distribution systems depends upon the best information available to the operating and maintenance personnel of the gas company operating the system. The State standards requiring inspections for gas leaks are conducive to maintaining a leak-free distribution system, provided that leak detection equipment responds to indications of leaks. Providing new detection equipment will furnish the operating and maintenance personnel with current equipment with leak detection capability, and reduce the time and costs required to maintain the existing equipment in a reliable working condition.

Under present conditions, the reliability of existing old equipment is uncertain, and depends upon availability of parts from suppliers of foreign manufacturers who have supplied equipment in the past.

Testing and calibration equipment for cathodic protection operation and maintenance checks will be upgraded; in a similar manner, the performance of personnel assigned to the inspection requirements of CP systems will be improved.

Providing meter provers for positive displacement gas meters will enable the gas companies to assure the accuracy of gas metered to the respective customers. This ability will be new to the gas company operators, and will provide revenue from gas sales that now and formerly have been assumed on the basis of "norms."

4.2.4.3 Implementation

Specifications for these items will be prepared in cooperation with the engineering staffs of the gas companies. Bidding, bid review, and award of bids would follow. During the manufacturing and delivery period, instructions, and procedures would be developed for operating, testing, and repairing all new test equipment.

101

Establishing a meter testing facility with the gas distribution companies may require additional standards and procedures by the appropriate government bodies. Initially, the stock of meters to be tested will be mainly new residential and small commercial meters. The interval for proving in-service meters will have to be established by the appropriate government bodies.

Implementation of new cathodic protection test equipment and test calibration equipment will require technical personnel to become familiar with the characteristics of the new equipment.

4.2.4.4 Schedule

The schedule for these projects include:

- Preparation of specifications and bids - 6 months
- Bidding, bid review, and award - 3 months
- Deliver - within 6 months after award

Figure 4-6 shows the project schedule.

4.2.4.5 Costs

Tables 4-1 through 4-4 summarize the list of major equipment and materials required for this project for the four cities.

Costs of test equipment is based on supply from foreign sources. These costs are tabulated in Table 4-5 through 4-8 for the four cities.

The overseas and local shipping costs are based on two shipments.

Table 4-14 provides the basis for the estimated costs of foreign engineering and procurement costs. It has been assumed that the basic engineering, overseas procurement and training will be provided by the foreign consultant.

4.2.5 Gas Meters

4.2.5.1 Description

These projects will install gas meters in phases as follows:

- Phase 1 - Commercial establishments
- Phase 2 - Private homes with space heating
- Phase 3 - Upgrade industrial customers
- Phase 4 - Apartment blocks

4.2.5.2 Potential benefits

At present, residential customers in urban areas, small commercial establishments and residential blocks are supplied with unmetered gas. The benefits from installing meters to these customers will provide revenue from the individual users on the basis of actual gas consumed. Additionally, metering will conserve natural gas by increasing the cost to actual market value, thus promoting economy of usage by cost. These benefits will accrue to society as a whole and provide

additional revenue to the respective gas companies, although actual sales volume will decrease in the short term.

Upgrading the sales meters to industrial consumers will improve metering accuracy by replacing existing outdated meters with meters of present-day standards for accuracy. The effect of increasing meter accuracy together with adjustments of cost of the commodity may or may not be expected to increase revenue with decreased consumption. However, selling conserved gas to customers using alternative fuels or to the export market could generate additional revenue. It should be noted that the rotary meters used for metering industrial customers have a tendency to undermeter as they become older. Therefore, replacing these meters with more accurate meters should result in an increase in revenue to the gas utility.

In Volgograd, residential customers are not metered while other customers are metered. The residential gas consumption is computed as the difference between gas receipts and gas consumed by industrial and commercial customers. Figures 4-7, 4-8 and 4-9, respectively, show monthly gas consumption in Volgograd for industrial, commercial and residential customers.

It is evident from these figures that the monthly gas consumption increases substantially during the winter months. This is to be expected for the industrial and commercial customers since their loads include space heating requirements. However, most of the residential customers use gas for cooking purposes only. Thus, the eight fold increase (about 19 million m^3) in gas consumption by the residential customers appears to have been caused by the following:

1) Use of cooking stoves for space heating when district heating system is unable to provide sufficient heat.

2) Inaccuracy in measurement of industrial customers (including district heating plants) which will be reflected in residential gas use. For example, in January the total gas received was 461.2 million m^3, out of which 432 million m^3 was metered. If these meters under read by 2 percent, then the actual residential gas demand will be 8.6 million m^3 more than attributed.

3) Additional gas consumed by apartments and private homes having hot water heaters (115,940 apartments @ 9 m^3/apartment = 1 million m^3).

4) Gas consumed by private homes provided with space heat (about 33,000 homes @ 250 m^3/home = 8.3 million m^3).

The number of meters required and potential savings for each phase is summarized in Tables 4-19 through 4-22.

The size of meters to be used at industrial and commercial establishments will be determined based on their gas consumption data. Standard details for mounting of each size meter will be developed. The details will also provide a list of fittings and materials needed for installing the meters. During detail design, the actual site conditions will be considered to develop construction plans.

Standard details for private home and apartment block meters will also be developed for ease of procurement of local materials and fittings.

4.2.5.3 Implementation Requirements

Implementation requirements include establishing standards that do not exist for meter installations at apartment blocks. Standards are assumed to exist for residential houses with space heating, commercial establishments, and industrial customers. Standards may need revision,

however, and should be reviewed and revised to meet international present-day standards. These standards will include selection of type (positive displacement, rotary, turbine, or orifice) depending on metering pressure and required flow capacity.

Prior to receiving the meters for installation, preparations for meter storage and a training program for selection, installation, care and operation of meters will be required.

4.2.5.4 Schedule

Installation of meters in these projects will be scheduled for completion within four years after beginning receipt of meters. The schedule of activities to begin receipt of meters for each phase is:

- Engineering - 3 years
- Procurement - 3 years
- Installation - Up to 3 years depending on number of meters and application

Figure 4-10 shows the project schedule.

4.2.5.5 Costs

Tables 4-1 through 4-4 summarize the list of major equipment and materials required for this project for the four cities.

Tables 4-5 through 4-8 summarize cost estimates for these projects.

The basis for overseas and local shipping costs is presented in Table 4-9.

Table 4-10 through 4-13 provides the basis for the estimated costs of installation labor and equipment rental. A productivity factor of 2 has been used in estimating the installation labor requirements.

Tables 4-14 and 4-15 provides the basis for the estimated costs of foreign and domestic engineering, procurement and construction management costs. It has been assumed that the basic engineering, overseas procurement, training, support during construction, and commissioning and start-up assistance will be provided by the foreign consultant. The detail engineering, installation, commissioning and operating services will be provided by domestic engineering/construction companies.

4.2.6 Gas Meter Test Equipment

4.2.6.1 Description

These projects provide gas meter testing facilities with state-of-the-art electronic measurement of gas flow through meters for providing accuracy of calibration. Meters are assumed to be shop-tested on a 10-year basis, and have internal moving parts replaced to restore the meter to new condition.

4.2.6.2 Potential Benefits

The potential benefits from these project are:

- Accurate measurement of gas delivered to customers for billing, and replacement of the arbitrary "norms" now used.

- Improved accounting standards for measurement of gas delivered to all customers, equal to world standards.

4.2.6.3 Implementation

Specifications for meter testing equipment would be prepared in cooperation with the engineering staffs of the gas companies. Bidding, bid review, and award of bids would follow.

During the manufacturing and delivery period, a training program would be developed for testing, repair, and documenting repair and calibration of meters. A database system would be developed for these permanent records.

Establishing a meter testing facility with the gas distribution companies may require additional standards and procedures by the appropriate government bodies. Initially, the stock of meters to be tested will be mainly new residential and small commercial meters. The interval between meter shop proving should be established by the appropriate government bodies. Retesting for calibration and renewals of moving parts would begin after the first recalibration cycle of approximately 10 years.

4.2.6.4 Schedule

The schedule for these projects include:

- Preparation of specifications and bids - 6 months

- Bidding, bid review, and award - 6 months

- Delivery - 6 months after award

- Installation and initial operation - 2 months

Figure 4-10 shows the project schedule.

4.2.6.5 Costs

Tables 4-1 through 4-4 lists the major equipment and materials required for this project for the four cities.

Cost of gas meter test equipment is based on supply from foreign sources. Other meter shop supporting equipment is assumed from domestic sources.

These costs are summarized in Tables 4-5 through 4-8 for the four cities.

The overseas and local shipping costs are based on two shipments.

Table 4-10 through 4-13 provides the basis for the estimated costs of installation labor and equipment rental. A productivity factor of 2 has been used in estimating the installation labor requirements.

Tables 4-14 and 4-15 provides the basis for the estimated costs of foreign and domestic engineering, procurement and construction management costs. It has been assumed that the basic engineering, overseas procurement, training, support during construction, and commissioning and

105

start-up assistance will be provided by the foreign consultant. The detail engineering, installation, commissioning and operating services will be provided by domestic engineering/construction companies.

4.2.7 Gas Main Replacement

A replacement program of burying abovegound distribution lines was proposed to remove these lines from aboveground hazards and interference with ground surface uses. Additionally, at a later time the aesthetic appearance and considerations for compatibility with neighborhood spatial development can be expected to require burying aboveground piping. These projects would have included replacing short sections of existing, buried pipe now identified for replacement.

The proposed programs were considered desirable on the basis that present pipe coating standards with state-of-the-art welding technology, testing, pipe cathodic protection surveys, and protective practices will provide many years of extended service beyond the years of service now experienced by the older piping in the distribution systems. Comparative experience between Saratov, the oldest distribution system, with the new systems demonstrates the importance of providing present state-of-the-art technology for buried installations.

Additionally, availability of database programs will provide capability for determining replacement programs on the basis of leak history by categories of age, diameter, soil properties, coating type, cathodic protection methods, or any other list of categories. Combining this capability with analysis of network operating characteristics of present and projected load performance will determine the preferred combined economic programs for pipe replacement, network reinforcement, and expansion.

In discussing these proposed projects with the Gorgas companies, the companies stated that they were replacing buried pipe with aboveground pipe to preclude underground gas leaks from the existing buried gas lines. The above ground LP lines are cheaper to install and maintain and leaks from above ground pipes do not pose an explosion hazard.

In view of these considerations, the pipe replacement programs for burying aboveground pipe were not included in these proposed projects.

However, the cities of Saratov and Volgograd expressed a need to replace some of their underground pipe because of its poor condition and leak history. Saratov estimates that they need to replace about 30 km and Volgograd estimates they need to replace about 70 km. In addition, Ryazan has a 20 year plan to replace approximately 100 km of underground pipe (5 km/year) and Voronezh has a need to replace 17 km of underground pipe that is subject to stray currents and cannot be cathodically protected. A thorough analysis of the pipeline system using the network analysis model and determination of pipeline condition using CP system improvement will be required to identify sections of pipe to be replaced. These projects will therefore be delayed until the CP system is improved and the network analysis is performed. Figure 4-11 shows the project schedule.

Gas main replacement costs for each city were estimated based on an average pipe diameter of 150 mm and yearly pipe replacement lengths of 5, 10, 10 and 6 km, respectively by Ryazan, Savatov, Volgograd and Voronezh. Tables 4-1 through 4-4 summarizes the list of major equipment and materials required for the four cities. The estimated costs of these projects for the four cities are summarized in Tables 4-5 through 4-8.

Table 4-10 through 4-13 provides the basis for the estimated costs of installation labor and equipment rental. A productivity factor of 2 has been used in estimating the installation labor requirements.

106

Table 4-15 provides the basis for the estimated costs of domestic engineering and construction management. It has been assumed that the basic engineering, detail engineering, installation, commissioning and operating services will be provided by domestic engineering/construction companies.

4.3 COST/BENEFIT RANKING OF GAS DISTRIBUTION PROJECTS

4.3.1 Evaluation Procedure

A real rate of return based on 1993 costs and values was calculated to rank the various gas distribution projects. Benefits from the projects considered include deferred pipe replacement, conservation of electrical energy (in cathodic protection), and gas savings. Constant 1993 values were used throughout. For most users, gas is valued at the industrial price, which is assumed to rise to \$40/1000 m^3 by the end of 1995. Electricity was valued at a price that rises to \$0.065/kwh by 1999. Expenditures were assumed to take place during the first four years, according to the preceding project descriptions. Benefits were taken from project completion through 2015, and an internal rate of return (IRR) for the cash flow was calculated. It should be noted that not all benefits accrue to the distribution companies in a direct manner: gas savings may not result in higher billings (if gas is not sold to new customers) and the savings from pipe replacement may not appear in the balance sheet of companies that are deferring replacement at the expense of safety. Methods of financing the projects will depend on issues of company viability, discussed in Section 8.

4.3.2 Project Evaluation

The projects described in this section are essentially synergistic and form a package of measures necessary to preserve existing assets and create viable gas distribution companies in the four cities. The same set of projects applies to each city, with minor variations. The projects in the various cities are therefore discussed by type for all four cities, and a summary for the individual cities follows in Tables 4-23 through 4-26.

Pipeline Improvement Projects Based on preserving the existing asset of the buried pipe system, cathodic protection project has rates of return ranging from 44% in Saratov to 72% in Volgograd. The benefits of cathodic protection are based on assumptions that:

- Under current conditions (without the project) average life of buried pipe is 20 years, and a corresponding fraction of the already aged system must be replaced every year to avoid severely compromising public safety and the operability of the system.

- The cathodic protection system proposed will extend the life of the buried pipe virtually indefinitely, based on experience in the U.S. A lifetime of 60 years was assumed for the fully protected systems. The following total system values were assumed for the four cities:

City	Buried Pipe Length km	Value 1,000 US\$
Ryazan	692	151,968
Saratov	738	162,070
Volgograd	1,805	396,391
Voronezh	1,399	307,230

107

- There will be an additional electric power savings from the proposed system, ranging from 600,000 to 1.8 million kwh/year according to the city, based on information on current practices.

No gas savings were identified as part of these project benefits, since reported losses due to leaks are relatively small.

The installation of a SCADA system, provision of test equipment, and network analysis , and pipeline replacement have some identifiable consequences for operating and maintenance costs, but do not provide a clear and separable benefit stream sufficient to justify those projects on a rate-of-return basis. However, as stated above, they should be regarded as part of a package, along with cathodic protection, that is necessary to support the creation of a commercially viable distribution company. Rates of return for these combinations of pipeline improvements range from 22% to 41%, including the costs of environmental mitigation.

Metering Projects. Accurate metering is an essential part of a viable gas distribution company and is generally lacking in the four cities studied. The four metering projects (industrial, commercial, apartments, and private homes) were all treated similarly and were evaluated on the basis of estimated costs and gas savings only. Gas savings was estimated based on the assumption that the inaccurate industrial meters read low by 1 to 2% and that this usage would be conserved or paid for with upgraded metering. Commercial and private-home metering was assumed to induce conservation of 25% of current usage through providing accountability. Comparable savings in apartments was estimated at 40% of current usage. It has been common practice in Russia to require the user to pay the cost of the meters, which would be an alternative way to pass through the costs. However, such an approach would very likely represent a too severe price shock for present consumer income levels. The alternative of incorporating the value of the meters into the companies' "rate base" and recovering it over time would require an intermediary capable of providing some form of long-term financing.

- Upgrade of industrial metering has rates of return from 16% (Saratov) to 27% (Ryazan).

- Metering of private homes with space heating appears to be a justifiable project with rates of return ranging from 52% (Ryazan) to 57% (Voronezh).

- Apartment metering, considered alone, has indicated rates of return from 18% (Voronezh) to 31% (Volgograd) which are limited due to the relatively high cost of the meters and relatively low rates of gas consumption (cooking only).

The tables list costs, savings, and rates of return for all metering projects individually and combined. Overall rates of return for all metering projects combined range from 22% (Ryazan) to 37% (Volgograd).

4.3.3 Summary

Investment requirements for the identified project packages for gas distribution projects (including environmental costs) in the four cities are as follows:

City	Cost, $000	IRR, %
Ryazan	25,776	26
Saratov	37,613	27
Volgograd	39,836	37
Voronezh	46,348	31
Total	149,573	

Cash flows and rate-of-return calculations for the projects are presented in Table 4-27.

4.4 CONTRACT PACKAGES

The recommended projects can be grouped into four contract packages as follows:

1. Cathodic protection system, pipeline replacement and construction equipment
2. Metering projects and SCADA systems
3. Test equipment including gas meter testing
4. Network modeling

Each contract package will provide the following information:

1. Project description - giving the scope of work to be performed by the contractor
2. General conditions - giving contractual data
3. Specific conditions - describing in detail the procedures and specifications to be used for meeting the scope of work.
4. Specifications to be used for the purchase of equipment and materials, and installation of equipment and materials.

Contract packages will be developed as a part of basic engineering.

109

Table 4-1

List of Major Equipment and Materials - City of Ryazan

Description of Equipment/Material	Unit	# Units	Source
1. SCADA			
PC based system with hard drive, Color Monitors, modem and printers	#	2	F
Gas Chromatograph & Sulfur Analyzers	#	1	F
RTU Consisting of 8 analog input, 8 digital input and 8 digital output devices, and a 1200 baud modem	#	212	F
Enclosure with heater/blower and UPS	#	212	F
Cables & Wiring	#	212	F
Remote Radio, antenna, pole, cables	#	212	F
Base Radio Station with radio, antenna, modem and support structure	#	4	F
2. NETWORK MODELLING			
IBM Compatible 486/66 MHz DX2 Computer with 16 MB RAM, 1GB hard drive, 500 MB tape backup drive, 20 inch SVGA monitor, disk drives, mouse, 101 keyboard, multipen color plotter, laste printer and digitizer	#	1	F
Software package for network analysis	#	1	F
3. CATHODIC PROTECTION			
Isolation flanges, 150 mm diameter	#	120	F
Anode/Rectifiers	#	18	F
Isolation unions, 150 mm	#	452	F
Isolation unions, 50 mm	#	25,363	F
Isolation unions, 13 mm	#	1,206	F
4. LEAK DETECTION TEST EQUIPMENT			
Flame Ionization units	#	2	F
Portable detectors	#	80	F
CP Test Equipment	#	1	F
Dead Weight Tester	#	1	F
Coating Tester	#	1	F
5. COMMERCIAL METERS			
Meter including valves and fittings (34 cm/h @ pressure drop=5 mm water)	#	1,105	F
6. PRIVATE HOME METERS			
Meter including valves and fittings (7 cm/h @ pressure drop=5 mm water)	#	11,363	F
7. INDUSTRIAL METERS			
Turbine Meters (4000 cm/h) including regulators, isolation valves, relief valves, flow transmitters and fittings	#	77	F
8. APARTMENT BLOCK METERS			
Meter including valves & fittings (34 cm/h @ pressure drop=5 mm water)	#	14,000	F
9. GAS METER TEST EQUIPMENT			
Sonic Nozzle meter for proving meters up to 34 cm/h capacity	#	1	F
10. PIPE REPLACEMENT			
Average 150 mm diameter grade B pipe with 3.4 mm wall thickness	Ton	70	D

110

Table 4-2

List of Major Equipment and Materials - City of Saratov

Description of Equipment/Material	Unit	# Units	Source
1. SCADA			
PC based system with hard drive, Color Monitors, modem and printers	#	2	F
Gas Chromatograph & Sulfur Analyzers	#	1	F
RTU Consisting of 8 analog input, 8 digital input and 8 digital output devices, and a 1200 baud modem	#	482	F
Enclosure with heater/blower and UPS	#	482	F
Cables & Wiring	#	482	F
Remote Radio, antenna, pole, cables	#	482	F
Base Radio Station with radio, antenna, modem and support structure	#	4	F
2. NETWORK MODELLING			
IBM Compatible 486/66 MHz DX2 Computer with 16 MB RAM, 1GB hard drive, 500 MB tape backup drive, 20 inch SVGA monitor, disk drives, mouse, 101 keyboard, multipen color plotter, laste printer and digitizer	#	1	F
Software package for network analysis	#	1	F
3. CATHODIC PROTECTION			
Isolation flanges, 150 mm diameter	#	290	F
Anode/Rectifiers	#	44	F
Isolation unions, 150 mm	#	1,102	F
Isolation unions, 50 mm	#	42,585	F
Isolation unions, 13 mm	#	2,700	F
4. LEAK DETECTION TEST EQUIPMENT			
Flame Ionization units	#	3	F
Portable detectors	#	55	F
CP Test Equipment	#	1	F
Dead Weight Tester	#	1	F
Coating Tester	#	1	F
5. COMMERCIAL METERS			
Meter including valves and fittings (34 cm/h @ pressure drop=5 mm water)	#	1,133	F
6. PRIVATE HOME METERS			
Meter including valves and fittings (7 cm/h @ pressure drop=5 mm water)	#	30,000	F
7. INDUSTRIAL METERS			
Turbine Meters (4000 cm/h) including regulators, isolation valves, relief valves, flow transmitters and fittings	#	250	F
8. APARTMENT BLOCK METERS			
Meter including valves & fittings(34 cm/h @ pressure drop=5 mm water)	#	12,585	F
9. GAS METER TEST EQUIPMENT			
Sonic Nozzle meter for proving meters up to 34 cm/h capacity	#	1	F
10. PIPE REPLACEMENT			
Average 150 mm diameter grade B pipe with 3.4 mm wall thickness	Ton	140	D

Table 4-3

List of Major Equipment and Materials - City of Volgograd

Description of Equipment/Material	Unit	# Units	Source
1. SCADA			
PC based system with hard drive, Color Monitors, modem and printers	#	2	F
Gas Chromatograph & Sulfur Analyzers	#	1	F
RTU Consisting of 8 analog input, 8 digital input and 8 digital output devices, and a 1200 baud modem	#	518	F
Enclosure with heater/blower and UPS	#	518	F
Cables & Wiring	#	518	F
Remote Radio, antenna, pole, cables	#	518	F
Base Radio Station with radio, antenna, modem and support structure	#	4	F
2. NETWORK MODELLING			
IBM Compatible 486/66 MHz DX2 Computer with 16 MB RAM, 1GB hard drive, 500 MB tape backup drive, 20 inch SVGA monitor, disk drives, mouse, 101 keyboard, multipen color plotter, laste printer and digitizer	#	1	F
Software package for network analysis	#	1	F
3. CATHODIC PROTECTION			
Isolation flanges, 150 mm diameter	#	460	F
Anode/Rectifiers	#	69	F
Isolation unions, 150 mm	#	887	F
Isolation unions, 50 mm	#	46,955	F
Isolation unions, 13 mm	#	2,364	F
4. LEAK DETECTION TEST EQUIPMENT			
Flame Ionization units	#	6	F
Portable detectors	#	200	F
CP Test Equipment	#	1	F
Dead Weight Tester	#	1	F
Coating Tester	#	1	F
5. COMMERCIAL METERS			
Meter including valves and fittings (34 cm/h @ pressure drop=5 mm water)	#	650	F
6. PRIVATE HOME METERS			
Meter including valves and fittings (7 cm/h @ pressure drop=5 mm water)	#	34,000	F
7. INDUSTRIAL METERS			
Turbine Meters (4000 cm/h) including regulators, isolation valves, relief valves, flow transmitters and fittings	#	180	F
8. APARTMENT BLOCK METERS			
Meter including valves & fittings (34 cm/h @ pressure drop=5 mm water)	#	12,955	F
9. GAS METER TEST EQUIPMENT			
Sonic Nozzle meter for proving meters up to 34 cm/h capacity	#	1	F
10. PIPE REPLACEMENT			
Average 150 mm diameter grade B pipe with 3.4 mm wall thickness	Ton	140	D

112

Table 4-4

List of Major Equipment and Materials - City of Voronezh

Description of Equipment/Material	Unit	# Units	Source
1. SCADA			
PC based system with hard drive, Color Monitors, modem and printers	#	2	F
Gas Chromatograph & Sulfur Analyzers	#	1	F
RTU Consisting of 8 analog input, 8 digital input and 8 digital output devices, and a 1200 baud modem	#	340	F
Enclosure with heater/blower and UPS	#	340	F
Cables & Wiring	#	340	F
Remote Radio, antenna, pole, cables	#	340	F
Base Radio Station with radio, antenna, modem and support structure	#	4	F
2. NETWORK MODELLING			
IBM Compatible 486/66 MHz DX2 Computer with 16 MB RAM, 1GB hard drive, 500 MB tape backup drive, 20 inch SVGA monitor, disk drives, mouse, 101 keyboard, multipen color plotter, laste printer and digitizer	#	1	F
Software package for network analysis	#	1	F
3. CATHODIC PROTECTION			
Isolation flanges, 150 mm diameter	#	210	F
Anode/Rectifiers	#	32	F
Isolation unions, 150 mm	#	709	F
Isolation unions, 50 mm	#	68,565	F
Isolation unions, 13 mm	#	1,890	F
4. LEAK DETECTION TEST EQUIPMENT			
Flame Ionization units	#	5	F
Portable detectors	#	115	F
CP Test Equipment	#	1	F
Dead Weight Tester	#	1	F
Coating Tester	#	1	F
5. COMMERCIAL METERS			
Meter including valves and fittings (34 cm/h @ pressure drop=5 mm water)	#	243	F
6. PRIVATE HOME METERS			
Meter including valves and fittings (7 cm/h @ pressure drop=5 mm water)	#	44,285	F
7. INDUSTRIAL METERS			
Turbine Meters (4000 cm/h) including regulators, isolation valves, relief valves, flow transmitters and fittings	#	188	F
8. APARTMENT BLOCK METERS			
Meter including valves & fittings (34 cm/h @ pressure drop=5 mm water)	#	24,280	F
9. GAS METER TEST EQUIPMENT			
Sonic Nozzle meter for proving meters up to 34 cm/h capacity	#	1	F
10. PIPE REPLACEMENT			
Average 150 mm diameter grade B pipe with 3.4 mm wall thickness	Ton	85	D

Table 4-5

Project Costs for City of Ryazan

COST ESTIMATE (thousand US $ 1993)	Year 1 1994	Year 2 1995	Year 3 1996	Year 4 1997	Total Project	Percent For/Loc
RYAZAN						
1. SCADA						
Foreign						
Engineering	270	120			390	
Procurement	40	40	35		115	
Procurement of Materials	85	560	1290	820	2,755	
Installation		25	40	40	105	
Shipping		6	14	10	30	
Construction management		100	150	50	300	
Sub-total	395	851	1,529	920	3,695	94.4%
Local						
Engineering	1	9	13	21	44	
Procurement of Materials	5	10			15	
Installation	0	5	35	100	140	
Shipping	1	2	2		5	
Construction management	1	3	5	7	16	
Sub-total	8	29	55	128	220	5.6%
TOTAL	403	880	1,584	1,048	3,915	100.0%
2. NETWORK MODELING						
Foreign						
Engineering	50				50	
Procurement	125				125	
Hardware	25	25			50	
Software	100	100	25	25	250	
Programming		90	40	10	140	
Shipping (11%)	3	3			[illegible]	
Sub-total	303	218	65	35	621	76.5%
Local						
Engineering	1				1	
Procurement of Materials						
Programming		35	60	95	190	
Shipping	1	1			2	
Sub-total	2	36	60	95	191	23.5%
TOTAL	305	254	125	130	812	100.0%
3. CATHODIC PROTECTION						
Foreign						
Engineering	200	76			276	
Procurement		80	53		133	
Procurement of materials	260	770	780	190	2,000	
Installation		76			76	
Shipping	1	4	4	1	10	
Construction Management		100	150	50	300	
Sub-total	461	1,106	987	241	2,795	53.9%
Local						
Engineering	5	10	10	10	35	
Procurement of Materials		15			15	
Installation		670	1,360	270	2,300	
Shipping		1	1		2	
Construction Management		10	15	15	40	
Sub-total	5	706	1,386	295	2,392	46.1%
TOTAL	466	1,812	2,373	536	5,187	100.0%

114

Table 4-5 (Continued)

COST ESTIMATE (thousand US $ 1993)	Year 1 1994	Year 2 1995	Year 3 1996	Year 4 1997	Total Project	Percent For/Loc
RYAZAN						
4. LEAK DETECTION, TEST EQUIPMENT						
Foreign						
Engineering	75				75	
Procurement	130				130	
Procurement of materials	182	182			363	
Installation						
Shipping	3	3			6	
Construction management						
Sub-total	390	185	0	0	574	95.2%
Local						
Engineering						
Procurement of Materials	2	2			4	
Installation	10	10			20	
Shipping	5				5	
Construction Management						
Sub-total	17	12	0	0	29	4.8%
TOTAL	407	197	0	0	603	100.0%
5. COMMERCIAL METERS						
Foreign						
Engineering	75				75	
Procurement	50	100	20		170	
Procurement of materials	80	190	120		390	
Installation		65			65	
Shipping	5	11	6		22	
Construction Management		150			150	
Sub-total	210	516	146	0	872	90.0%
Local						
Engineering		6	3		9	
Procurement of Materials	8	19	12		39	
Installation		12	24		36	
Shipping	1	1	1		3	
Construction Management		5	5		10	
Sub-total	9	43	45	0	97	10.0%
TOTAL	219	559	191	0	969	100.0%
6. PRIVATE HOMES METERING						
Foreign						
Engineering						
Procurement						
Procurement of materials	110	210	205	100	625	
Installation						
Shipping	11	22	21	10	64	
Construction Management						
Sub-total	121	232	226	110	689	65.5%
Local						
Engineering	2				2	
Procurement of Materials	11	21	21	10	63	
Installation		46	76	120	242	
Shipping	1	2	2	1	6	
Construction Management	5	10	15	20	50	
Sub-total	19	79	114	151	363	34.5%
TOTAL	140	311	340	261	1,052	100.0%

115

Table 4-5 (Continued)

COST ESTIMATE (thousand US $ 1993)	Year 1 1994	Year 2 1995	Year 3 1996	Year 4 1997	Total Project	Percent For/Loc
RYAZAN						
7. INDUSTRIAL METERS						
Foreign						
Engineering	130				130	
Procurement		100	75		175	
Procurement of materials		510	645		1,155	
Installation			150		150	
Shipping		3	3		6	
Construction Management			100		100	
Sub-total	130	613	973	0	1,716	87.2%
Local						
Engineering		20			20	
Procurement of Materials		80	80		160	
Installation			50		50	
Shipping		1			1	
Construction Management			20		20	
Sub-total	0	101	150	0	251	12.8%
TOTAL	130	714	1,123	0	1,967	100.0%
8. APARTMENT BLOCKS METERS						
Foreign						
Engineering	60				60	
Procurement	50				50	
Procurement of materials	1,080	1,430	1,430	960	4,900	
Installation	100				100	
Shipping	60	79	79	53	271	
Construction Management						
Sub-total	1,350	1,509	1,509	1,013	5,381	75.7%
Local						
Engineering	4	8	12	6	30	
Procurement of Materials	110	140	140	100	490	
Installation	45	196	326	524	1,091	
Shipping	5	6	6	6	23	
Construction Management	10	20	30	20	80	
Sub-total	174	370	514	656	1,714	24.3%
TOTAL	1,524	1,879	2,023	1,669	7,095	100.0%
9. GAS METER TEST EQUIPMENT						
Foreign						
Engineering	50				50	
Procurement						
Procurement of materials	34	34			67	
Installation		80			80	
Shipping	3	3			6	
Construction Management						
Sub-total	87	117	0	0	203	78.4%
Local						
Engineering	5	10			15	
Procurement of Materials	12	12			24	
Installation		9			9	
Shipping	2				2	
Construction Management		6			6	
Sub-total	19	37	0	0	56	21.6%
TOTAL	106	154	0	0	259	100.0%

116

Table 4-5 (Continued)

COST ESTIMATE (thousand US $ 1993)	Year 1 1994	Year 2 1995	Year 3 1996	Year 4 1997	Total Project	Percent For/Loc
RYAZAN						
10. PIPE REPLACEMENT						
Foreign						
Engineering						
Procurement						
Procurement of materials						
Installation						
Shipping						
Construction Management						
Sub-total	0	0	0	0	0	0.0%
Local						
Engineering			8	10	18	
Procurement of Materials			114	114	228	
Installation			106	169	275	
Shipping			1	1	2	
Construction Management			4	6	10	
Sub-total	0	0	233	300	533	100.0%
TOTAL	0	0	233	300	533	100.0%
TOTAL PROJECT, WITHOUT CONTINGENCIES AND INFLATION						
Foreign	3,396	5,346	5,435	2,319	16,496	73.8%
Local	253	1,413	2,557	1,625	5,846	26.2%
TOTAL	3,649	6,759	7,992	3,944	22,342	100.0%
Physical contingencies (15%)	547	1,014	1,199	592	3,351	
TOTAL project, with physical contingencies	4,196	7,773	9,191	4,536	25,693	

117

Table 4-6

Project Costs for City of Saratov

COST ESTIMATE (thousand US $ 1993)	Year 1 1994	Year 2 1995	Year 3 1996	Year 4 1997	Total Project	Percent For/Loc
SARATOV						
1. SCADA						
Foreign						
Engineering	270	120			390	
Procurement	40	40	35		115	
Procurement of Materials	90	1,630	2,945	1,410	6,075	
Installation		35	65	65	165	
Shipping	1	6	14	9	30	
Construction management		100	150	50	300	
Sub-Total	401	1,931	3,209	1,534	7,075	94.5%
Local						
Engineering	1	16	29	47	93	
Procurement of Materials	2	6			8	
Installation		6	115	166	287	
Shipping	1	2	4	2	9	
Construction management		4	5	7	16	
Sub-Total	4	34	153	222	413	5.5%
TOTAL	405	1,965	3,362	1,756	7,488	100.0%
2. NETWORK MODELING						
Foreign						
Engineering	50				50	
Procurement	125				125	
Hardware	25	25			50	
Software	100	100	25	25	250	
Programming		90	40	10	140	
Shipping	3	3			6	
Sub-Total	303	218	65	35	621	76.3%
Local						
Engineering	1				1	
Procurement of Materials						
Programming		35	60	95	190	
Shipping	1	1			2	
Sub-Total	2	36	60	95	193	23.7%
TOTAL	305	254	125	130	814	100.0%
3. CATHODIC PROTECTION						
Foreign						
Engineering	200	76			276	
Procurement		80	53		133	
Procurement of materials	360	1,110	1,310	670	3,450	
Installation		76			76	
Shipping	3	4	4	3	14	
Construction management		100	150	50	300	
Sub-Total	563	1,446	1,517	723	4,249	55.4%
Local						
Engineering	5	10	10	10	35	
Procurement of Materials		15			15	
Installation		768	1,598	954	3,320	
Shipping	1	1	1	1	4	
Construction management		10	15	15	40	
Sub-Total	6	804	1,624	980	3,414	44.6%
TOTAL	569	2,250	3,141	1,703	7,663	100.0%

Table 4-6 (Continued)

COST ESTIMATE (thousand US $ 1993)	Year 1 1994	Year 2 1995	Year 3 1996	Year 4 1997	Total Project	Percent For/Loc
SARATOV						
4. LEAK DETECTION, TEST EQUIPMENT						
Foreign						
Engineering	75				75	
Procurement	130				130	
Procurement of materials	138	139			277	
Installation						
Shipping	3	3			6	
Construction management						
Sub-Total	346	142	0	0	488	94.0%
Local						
Engineering	2				2	
Procurement of Materials	2	2			4	
Installation	10	10			20	
Shipping	5				5	
Construction management						
Sub-Total	19	12	0	0	31	6.0%
TOTAL	365	154	0	0	519	100.0%
5. COMMERCIAL METERS						
Foreign						
Engineering	75				75	
Procurement	50	100	20		170	
Procurement of materials	80	200	120		400	
Installation		65			65	
Shipping	11	11			22	
Construction management		150			150	
Sub-Total	216	526	140	0	882	90.4%
Local						
Engineering		6			6	
Procurement of Materials	20	20			40	
Installation		14	25		39	
Shipping	2	2			4	
Construction management		5			5	
Sub-Total	22	47	25	0	94	9.6%
TOTAL	238	573	165	0	976	100.0%
6. PRIVATE HOMES METERING						
Foreign						
Engineering						
Procurement						
Procurement of materials	270	550	550	280	1,650	
Installation						
Shipping	27	55	55	29	166	
Construction management						
Sub-Total	297	605	605	309	1,816	68.0%
Local						
Engineering	2				2	
Procurement of Materials	27	55	55	28	165	
Installation		120	200	320	640	
Shipping	4	8	8	5	25	
Construction management		5	8	10	23	
Sub-Total	33	188	271	363	855	32.0%
TOTAL	330	793	876	672	2,671	100.0%

Table 4-6 (Continued)

COST ESTIMATE (thousand US $ 1993)	Year 1 1994	Year 2 1995	Year 3 1996	Year 4 1997	Total Project	Percent For/Loc
SARATOV						
7. INDUSTRIAL METERS						
Foreign						
Engineering	130				130	
Procurement		100	75		175	
Procurement of materials		1,880	1,870		3,750	
Installation			150		150	
Shipping		3	3		6	
Construction management			100		100	
Sub-Total	130	1,983	2,198	0	4,311	88.7%
Local						
Engineering		2	3		5	
Procurement of Materials		180	180		360	
Installation			164		164	
Shipping		1	1		2	
Construction management			20		20	
Sub-Total	0	183	368	0	551	11.3%
TOTAL	130	2,166	2,566	0	4,862	100.0%
8. APARTMENT BLOCKS METERS						
Foreign						
Engineering	60				60	
Procurement	50				50	
Procurement of materials	960	1,290	1,290	865	4,405	
Installation	100				100	
Shipping	53	71	71	47	242	
Construction management						
Sub-Total	1,223	1,361	1,361	912	4,857	75.6%
Local						
Engineering	4	8	12	6	30	
Procurement of Materials	96	129	129	86	440	
Installation	38	177	296	473	984	
Shipping	3	11	11	7	37	
Construction management	10	20	30	20	80	
Sub-Total	156	345	478	592	1,571	24.4%
TOTAL	1,379	1,706	1,839	1,504	6,428	100.0%
9. GAS METER TEST EQUIPMENT						
Foreign						
Engineering	50				50	
Procurement						
Procurement of materials	34	34			67	
Installation		80			80	
Shipping	3	3			6	
Construction management						
Sub-Total	87	117	0	0	203	78.4%
Local						
Engineering	5	10			15	
Procurement of Materials	12	12			24	
Installation		9			9	
Shipping	2	0			2	
Construction management	0	6			6	
Sub-Total	19	37	0	0	56	21.6%
TOTAL	106	154	0	0	259	100.0%

120

Table 4-6 (Continued)

COST ESTIMATE (thousand US $ 1993)	Year 1 1994	Year 2 1995	Year 3 1996	Year 4 1997	Total Project	Percent For/Loc
SARATOV						
10. PIPE REPLACEMENT						
Foreign						
Engineering						
Procurement						
Procurement of materials						
Installation						
Shipping						
Construction management						
Sub-Total	0	0	0	0	0	0.0%
Local						
Engineering			15	20	35	
Procurement of Materials			228	228	456	
Installation			211	338	549	
Shipping			2	2	4	
Construction management			10	15	25	
Sub-Total	0	0	466	603	1,069	100.0%
TOTAL	0	0	466	603	1,069	100.0%
TOTAL PROJECT, WITHOUT CONTINGENCIES AND INFLATION						
Foreign	3,566	8,329	9,095	3,513	24,502	72.8%
Local	261	1,686	3,445	2,855	8,247	25.2%
TOTAL	3,827	10,015	12,540	6,368	32,749	100.0%
Physical contingencies (15%)	574	1,502	1,881	955	4,912	
Total project, with physical contingencies	4,400	11,517	14,421	7,323	37,661	

121

Table 4-7

Project Costs for City of Volgograd

COST ESTIMATE (thousand US $ 1993)	Year 1 1994	Year 2 1995	Year 3 1996	Year 4 1997	Total Project	Percent For/Loc
VOLGOGRAD						
1. SCADA						
Foreign						
Engineering	270	120			390	
Procurement	40	40	35		115	
Procurement of Materials	110	1,220	3,150	2,040	6,520	
Installation		40	70	70	180	
Shipping	1	6	14	9	30	
Construction management		100	150	50	300	
Sub-Total	421	1,526	3,419	2,169	7,535	94.2%
Local						
Engineering	2	18	32	51	103	
Procurement of Materials	2	6			8	
Installation		6	83	241	330	
Shipping	1	2	4	3	10	
Construction management		4	5	7	16	
Sub-Total	5	34	124	302	467	5.8%
TOTAL	426	1,562	3,543	2,471	8,002	100.0%
2. NETWORK MODELING						
Foreign						
Engineering	50				50	
Procurement	125				125	
Hardware	25	25			50	
Software	100	100	25	25	250	
Programming		90	40	10	140	
Shipping	3	3			6	
Sub-Total	303	218	65	35	621	76.3%
Local						
Engineering	1				1	
Procurement of Materials						
Programming		35	60	95	190	
Shipping	2				2	
Sub-Total	3	35	60	95	193	23.7%
TOTAL	306	253	125	130	814	100.0%
3. CATHODIC PROTECTION						
Foreign						
Engineering	200	100			300	
Procurement	80	53			133	
Procurement of materials	380	1,230	1,515	750	3,875	
Installation		100			100	
Shipping	3	4	4	3	14	
Construction management		150	200	80	430	
Sub-Total	663	1,637	1,719	833	4,852	56.8%
Local						
Engineering	5	10	10	10	35	
Procurement of Materials		15			15	
Installation		775	1,708	1,095	3,578	
Shipping	1	1	2	1	5	
Construction management		15	20	20	55	
Sub-Total	6	816	1,740	1,126	3,688	43.2%
TOTAL	669	2,453	3,459	1,959	8,540	100.0%

Table 4-7 (Continued)

COST ESTIMATE (thousand US $ 1993)	Year 1 1994	Year 2 1995	Year 3 1996	Year 4 1997	Total Project	Percent For/Loc
VOLGOGRAD						
4. LEAK DETECTION, TEST EQUIPMENT						
Foreign						
Engineering	75				75	
Procurement	130				130	
Procurement of materials	429	429			858	
Installation						
Shipping	3	3			6	
Construction management						
Sub-Total	637	432	0	0	1,069	97.4%
Local						
Engineering						
Procurement of Materials	2	2			4	
Installation	10	10			20	
Shipping	5				5	
Construction management						
Sub-Total	17	12	0	0	29	2.6%
TOTAL	654	444	0	0	1,098	100.0%
5. COMMERCIAL METERS						
Foreign						
Engineering	75				75	
Procurement	50	100			150	
Procurement of materials	115	115			230	
Installation		65			65	
Shipping	6	760			766	
Construction management		150			150	
Sub-Total	246	1,190	0	0	1,436	96.4%
Local						
Engineering		6			6	
Procurement of Materials	12	12			24	
Installation		16			16	
Shipping	1	1			2	
Construction management		5			5	
Sub-Total	13	40	0	0	53	3.6%
TOTAL	259	1,230	0	0	1,489	100.0%
6. PRIVATE HOMES METERING						
Foreign						
Engineering						
Procurement						
Procurement of materials	300	635	635	300	1,870	
Installation						
Shipping	30	64	64	30	188	
Construction management						
Sub-Total	330	699	699	330	2,058	67.3%
Local						
Engineering	2				2	
Procurement of Materials	30	64	64	30	188	
Installation		132	240	352	724	
Shipping	6	12	12	6	36	
Construction management	5	10	15	20	50	
Sub-Total	43	218	331	408	1,000	32.7%
TOTAL	373	917	1,030	738	3,058	100.0%

122

Table 4-7 (Continued)

COST ESTIMATE (thousand US $ 1993)	Year 1 1994	Year 2 1995	Year 3 1996	Year 4 1997	Total Project	Percent For/Loc
VOLGOGRAD						
7. INDUSTRIAL METERS						
Foreign						
Engineering	130				130	
Procurement		100	75		175	
Procurement of materials		1,350	1,350		2,700	
Installation			150		150	
Shipping		6	7		13	
Construction management			100		100	
Sub-Total	130	1,456	1,682	0	3,268	96.2%
Local						
Engineering	5	10	20		35	
Procurement of Materials		180	180		360	
Installation			118		118	
Shipping		1	1		2	
Construction management			9		9	
Sub-Total	5	191	328	0	524	13.8%
TOTAL	135	1,647	2,010	0	3,792	100.0%
8. APARTMENT BLOCKS METERS						
Foreign						
Engineering	60				60	
Procurement	50				50	
Procurement of materials	860	1,340	1,340	995	4,535	
Installation	100				100	
Shipping	47	74	74	55	250	
Construction management						
Sub-Total	1,117	1,414	1,414	1,050	4,995	77.4%
Local						
Engineering	4	8	12	6	30	
Procurement of Materials	86	134	134	100	454	
Installation	111	138	230	368	847	
Shipping	8	14	14	10	46	
Construction management	10	20	30	20	80	
Sub-Total	219	314	420	504	1,457	22.6%
TOTAL	1,336	1,728	1,834	1,554	6,452	100.0%
9. GAS METER TEST EQUIPMENT						
Foreign						
Engineering	50				50	
Procurement						
Procurement of materials	34	34			68	
Installation		80			80	
Shipping	3	3			6	
Construction management						
Sub-Total	87	117	0	0	204	78.4%
Local						
Engineering	5	10			15	
Procurement of Materials	12	12			24	
Installation		9			9	
Shipping	2				2	
Construction management		6			6	
Sub-Total	19	37	0	0	56	21.6%
TOTAL	106	154	0	0	260	100.0%

Table 4-7 (Continued)

COST ESTIMATE (thousand US $ 1993)	Year 1 1994	Year 2 1995	Year 3 1996	Year 4 1997	Total Project	Percent For/Loc
VOLGOGRAD						
10. PIPE REPLACEMENT						
Foreign						
Engineering						
Procurement						
Procurement of materials						
Installation						
Shipping						
Construction management						
Sub-Total	0	0	0	0	0	0%
Local						
Engineering			15	20	35	
Procurement of Materials			228	228	456	
Installation			211	338	549	
Shipping			2	2	4	
Construction management			10	15	25	
Sub-Total	0	0	466	603	1,069	100.0%
TOTAL	0	0	466	603	1,069	100.0%
TOTAL PROJECT, WITHOUT CONTINGENCIES AND INFLATION						
Foreign	3,933	8,688	8,998	4,417	26,036	75.3%
Local	330	1,699	3,469	3,038	8,536	24.5%
TOTAL	4,263	10,387	12,467	7,455	34,572	100.0%
Physical contingencies (15%)	39	1,558	1,870	1,118	5,186	
Total project, with physical contingencies	4,902	11,945	14,337	8,573	39,757	

125

Table 4-8

Project Costs for City of Voronezh

COST ESTIMATE (thousand US $ 1993)	Year 1 1994	Year 2 1995	Year 3 1996	Year 4 1997	Total Project	Percent For/Loc
VORONEZH						
1. SCADA						
Foreign						
Engineering	270	120			390	
Procurement	40	40	30		110	
Procurement of Materials	90	1,250	2,070	920	4,330	
Installation		30	55	55	140	
Shipping		6	14	9	29	
Construction management		100	150	50	300	
Sub-Total	400	1,546	2,319	1,034	5,299	94.7%
Local						
Engineering	1	12	21	33	67	
Procurement of Materials	2	6			8	
Installation		6	87	108	201	
Shipping	1	1	2	3	7	
Construction management		4	5	7	16	
Sub-Total	4	29	115	151	299	5.3%
TOTAL	404	1,575	2,434	1,185	5,598	100.0%
2. NETWORK MODELING						
Foreign						
Engineering	50				50	
Procurement	125				125	
Hardware	25	25			50	
Software	100	100	25	25	250	
Programming		90	40	10	140	
Shipping	3	3			6	
Sub-Total	303	218	65	35	621	76.3%
Local						
Engineering	1				1	
Procurement of Materials						
Programming		35	60	95	190	
Shipping	1	1			2	
Sub-Total	2	36	60	95	193	23.7%
TOTAL	305	254	125	130	814	100.0%
3. CATHODIC PROTECTION						
Foreign						
Engineering	200	100			300	
Procurement		80	53		133	
Procurement of materials	370	1,480	2,210	1,080	5,140	
Installation		100			100	
Shipping	3	4	6	3	16	
Construction management		150	200	80	430	
Sub-Total	573	1,914	2,469	1,163	6,119	57.2%
Local						
Engineering	5	10	10	10	35	
Procurement of Materials		15			15	
Installation		770	2,210	1,511	4,491	
Shipping	1	1	2	1	5	
Construction management		10	15	15	40	
Sub-Total	6	806	2,237	1,537	4,586	42.8%
TOTAL	579	2,720	4,706	2,700	10,705	100.0%

Table 4-8 - City of Voronezh (Continued)

COST ESTIMATE (thousand US $ 1993)	Year 1 1994	Year 2 1995	Year 3 1996	Year 4 1997	Total Project	Percent For/Loc
VORONEZH						
4. LEAK DETECTION, TEST EQUIPMENT						
Foreign						
Engineering	75				75	
Procurement	130				130	
Procurement of materials	287	287			574	
Installation						
Shipping	3	3			6	
Construction management						
Sub-Total	495	290	0	0	785	96.4%
Local						
Engineering						
Procurement of Materials	2	2			4	
Installation	10	10			20	
Shipping	5				5	
Construction management						
Sub-Total	17	12	0	0	29	3.6%
TOTAL	512	302	0	0	814	100.0%
5. COMMERCIAL METERS						
Foreign						
Engineering	75				75	
Procurement	50	100			150	
Procurement of materials	40	45			85	
Installation		65			65	
Shipping	3	3			6	
Construction management		150			150	
Sub-Total	168	363	0	0	531	95.5%
Local						
Engineering	1	2			3	
Procurement of Materials	4	5			9	
Installation		6			6	
Shipping	1	1			2	
Construction management		5			5	
Sub-Total	6	19	0	0	25	4.5%
TOTAL	174	382	0	0	556	100.0%
6. PRIVATE HOMES METERING						
Foreign						
Engineering						
Procurement	200	810	810	620	2,440	
Procurement of materials						
Installation	20	82	82	62	246	
Shipping						
Construction management						
Sub-Total	220	892	892	682	2,686	67.8%
Local						
Engineering	2				2	
Procurement of Materials	20	81	81	62	244	
Installation		177	295	473	945	
Shipping	3	11	11	7	32	
Construction management	5	10	15	20	50	
Sub-Total	30	279	402	562	1,273	32.2%
TOTAL	250	1,171	1,294	1,244	3,959	100.0%

127

Table 4-8 - City of Voronezh (Continued)

COST ESTIMATE (thousand US $ 1993)	Year 1 1994	Year 2 1995	Year 3 1996	Year 4 1997	Total Project	Percent For/Loc
VORONEZH						
7. INDUSTRIAL METERS						
Foreign						
Engineering	130				130	
Procurement		100	75		175	
Procurement of materials		1,400	1,420		2,820	
Installation			150		150	
Shipping		6	7		13	
Construction management			100		100	
Sub-Total	130	1,506	1,752	0	3,388	85.9%
Local						
Engineering	5	10	20		35	
Procurement of Materials		188	188		376	
Installation			123		123	
Shipping		1	1		2	
Construction management			20		20	
Sub-Total	5	199	352	0	556	14.1%
TOTAL	135	1,705	2,104	0	3,944	100.0%
8. APARTMENT BLOCKS METERS						
Foreign						
Engineering	60				60	
Procurement	50				50	
Procurement of materials	1,700	2,470	2,470	1,860	8,500	
Installation	100				100	
Shipping	246	357	357	269	1,229	
Construction management						
Sub-Total	2,156	2,827	2,827	2,129	9,939	76.8%
Local						
Engineering	4	8	12	6	30	
Procurement of Materials	170	247	247	186	850	
Installation	79	339	565	904	1,887	
Shipping	32	46	46	35	159	
Construction management	10	20	30	20	80	
Sub-Total	295	660	900	1,151	3,006	23.2%
TOTAL	2,451	3,487	3,727	3,280	12,945	100.0%
9. GAS METER TEST EQUIPMENT						
Foreign						
Engineering	50				50	
Procurement						
Procurement of materials	34	34			68	
Installation		80			80	
Shipping	3	3			6	
Construction management						
Sub-Total	87	117			204	78.4
Local						
Engineering	5	10			15	
Procurement of Materials	12	12			24	
Installation		9			9	
Shipping	2				2	
Construction management		6			6	
Sub-Total	19	37	0	0	56	21.6%
TOTAL	106	154			260	100.0%

125

Table 4-8 - City of Voronezh (Continued)

COST ESTIMATE (thousand US $ 1993)	Year 1 1994	Year 2 1995	Year 3 1996	Year 4 1997	Total Project	Percent For/Loc
VORONEZH						
10. PIPE REPLACEMENT						
Foreign						
Engineering						
Procurement						
Procurement of materials						
Installation						
Shipping						
Construction management						
Sub-Total	0	0	0	0	0	0%
Local						
Engineering			5	6	11	
Procurement of Materials			137	137	274	
Installation			127	203	330	
Shipping			2	2	4	
Construction management			9	14	23	
Sub-Total			280	362	642	100.0%
TOTAL			280	362	642	100.0%
TOTAL PROJECT, WITHOUT CONTINGENCIES AND INFLATION						
Foreign	4,532	9,672	10,324	5,043	29,571	73.5%
Local	384	2,077	4,346	3,858	10,665	26.5%
TOTAL	4,916	11,749	14,670	8,901	40,236	100.0%
Physical contingencies (15%)	737	1,762	2,201	1,335	6,035	
Total project, with physical contingencies	5,653	13,512	16,870	10,236	46,271	

Table 4-9(a)

Overseas Shipping Cost Estimate

SCADA SYSTEM

CITY	NUMBER OF CARRIERS NEEDED FOR 20 FT CONTAINER				COST	OVERSEAS TRANSPORT COST IN 1000US$			
	BASE STAION	RTU AND RADIO TRANSMITTERS			PER UNIT				
		CGS	INDUSTRY	REGULATORS		CGS	INDUSTRY	REGULATORS	TOTAL
RYAZON	1	1	4	4	3,200	3.2	12.8	12.8	28.80
SARATOV	1	1	4	4	3,200	3.2	12.8	12.8	28.80
VOLGOGRAD	1	1	4	4	3,200	3.2	12.8	12.8	28.80
VORONEZH	1	1	4	4	3,200	3.2	12.8	12.8	28.80
TOTAL	4	4	16	16		12.80	51.20	51.20	115.20

CP SYSTEM

CITY	NUMBER OF CARRIERS NEEDED FOR 20 FT CONTAINER				COST PER UNIT	OVERSEAS TRANSPORT COST IN 1000US$			
	FLANGES	RECTIFIERS	UNIONS			FLANGES	RECTIFIERS	UNIONS	TOTAL
RYAZON	1	1	4		3,200	1.60	1.60	6.40	9.60
SARATOV	1	2	6		3,200	1.60	3.20	9.60	14.40
VOLGOGRAD	1	2	6		3,200	1.60	3.20	9.60	14.40
VORONEZH	1	1	8		3,200	1.60	1.60	12.80	16.00
TOTAL	4	6	24			6.40	9.60	38.40	54.40

METERING PROJECTS

CITY	NUMBER OF CARRIERS NEEDED FOR 20 FT CONTAINER				OVERSEAS TRANSPORT COST 1000US$ FOR 20 FT CONTAINER				
	COMMERCIA	PRIVATE HOMES	INDUSTRIES	APARTMENTS	COMMERCIA	PRIVATE HOMES	INDUSTRIES	APARTMENTS	TOTAL
RYAZON	7	20	2	85	22	64	6	272	365
SARATOV	7	52	5	76	22	166	16	243	448
VOLGOGRAD	4	59	4	78	13	189	13	250	464
VORONEZH	2	77	4	384	6	246	13	1,229	1,494
TOTAL	20	208	15	623	64	666	48	1,994	2,771

Table 4-9(b)

Domestic Shipping Cost Estimate

SCADA SYSTEM

CITY	NUMBER OF CARRIERS NEEDED FOR 20 FT CONTAINER				DISTANCE MILE	DOMESTIC TRANSPORT COST IN 1000US$			
	BASE STAION	RTU AND RADIO TRANSMITTERS							
		CGS	INDUSTRY	REGULATORS		CGS	INDUSTRY	REGULATORS	TOTAL
RYAZON	1	1	4	4	550	0.55	2.20	2.20	4.95
SARATOV	1	1	4	4	975	0.96	3.90	3.90	8.78
VOLGOGRAD	1	1	4	4	1,175	1.18	4.70	4.70	10.58
VORONEZH	1	1	4	4	825	0.83	3.30	3.30	7.43
TOTAL	4	4	16	16		3.53	14.10	14.10	31.73

CP SYSTEM

CITY	NUMBER OF CARRIERS NEEDED FOR 20 FT CONTAINER				DISTANCE MILE	DOMESTIC TRANSPORT COST IN 1000US$			
	FLANGES	RECTIFIERS	UNIONS			FLANGES	RECTIFIERS	UNIONS	TOTAL
RYAZON	1	1	4		550	0.28	0.28	1.10	1.65
SARATOV	1	2	6		975	0.49	0.98	2.93	4.39
VOLGOGRAD	1	2	6		1,175	0.59	1.18	3.53	5.29
VORONEZH	1	1	8		825	0.41	0.41	3.30	4.13
TOTAL	4	6	24			1.76	2.84	10.85	15.45

METERING PROJECTS

CITY	NUMBER OF CARRIERS NEEDED FOR 20 FT CONTAINER				DISTANCE MILE	DOMESTIC SHIPPING COST 1000 US $				
	COMMERCIA	PRIVATE HOMES	NDUSTRIES	APARTMENTS		COMMERCIA	PRIVATE HOMES	INDUSTRIES	APARTMENTS	TOTAL
RYAZON	7	20	2	85	550	2	6	1	23	31
SARATOV	7	52	5	76	975	3	25	2	37	68
VOLGOGRAD	4	59	4	78	1,175	2	35	2	46	85
VORONEZH	2	77	4	384	825	1	32	2	158	193
TOTAL	20	208	15	623		0	0	0	0	377

Table 4-10
Installation Labor and Equipment Rental cost Estimate (RYAZAN)

	NUMBER OF UNITS INSTALLED IN				MHRS PER	PRODU-	1994	1995	1996	1997	TOTAL
	1994	1995	1996	1997	UNIT	-CTIVITY	COST IN 1000 US$ FOR SALARY IN US$/H				1993
SCADA SYSTEM							0.80	1.50	2.50	4.00	1000$
BASE STATION		2	2	2	100	2	0.0	0.6	1.0	1.6	3.2
GAS CHROMATOGRAPH		1			200	2	0.0	0.6	0.0	0.0	0.6
RTU's		2	77	133	10	2	0.0	0.1	3.9	10.6	14.6
ENCLOSURES		2	77	133	10	2	0.0	0.1	3.9	10.6	14.6
RADIO/ANTENNA		2	77	133	20	2	0.0	0.1	7.7	21.3	29.1
CABLES & WIRING		2	77	133	50	2	0.0	0.3	19.3	53.2	72.8
SUPPORT STRUCTURES		1			1,200	2	0.0	3.6	0.0	0.0	3.6
TOTALS							0.0	5.3	35.7	97.4	138.4
NETWORK MODELLING											
COMPUTER HARDWARE	1	1			300	2	0.5	0.9	0.0	0.0	1.4
SOFTWARE DEVELOPMENT		1			200	2	0.0	0.6	0.0	0.0	0.6
TRAINING		1			5,000	2	0.0	15.0	0.0	0.0	15.0
PROGRAMMING (6 MAN)/UNIT		0.5	1	1	12,000	2	0.0	18.0	60.0	96.0	174.0
TOTALS							0.5	34.5	60.0	96.0	191.0
CATHODIC PROTECTION											
INSTALL ISOLATION FLANGES		120			18	2	0.0	6.5	0.0	0.0	6.5
ISOLATION UNIONS		8,000	15,000	4,020	8	2	0.0	192.0	600.0	257.3	1049.3
TEMPORARY RECTIFIERS		1			200	2	0.0	0.6	0.0	0.0	0.6
CP SURVEY(# of SECTIONS)		12			60	2	0.0	2.2	0.0	0.0	2.2
TRAINING		1			2,000	2	0.0	6.0	0.0	0.0	6.0
INSTALL ANODE/RECTIFIERS			12	6	300	2	0.0	0.0	18.0	14.4	32.4
EQUIPMENT RENTAL/MATERIAL		120	0					460	740		1200.0
TOTALS							0.0	667.2	1358.0	271.7	2296.9
COMMERCIAL METERS											
INSTALL METERS		500	605		8	2	0.0	12.0	24.2	0.0	36.2
PRIVATE HOMES METERS											
INSTALL METERS		3,800	3,800	3,763	4	2	0.0	45.6	76.0	120.4	242.0
INDUSTRIAL METERS											
INSTALL METERS			77		96	2	0.0	0.0	37.0	0.0	0.0
EQUIPMENT RENTAL/MATERIALS			77				0.0	0.0	13.5	0.0	0.0
TOTALS							0.0	0.0	50.5	0.0	0.0
APARTMENT BLOCK METERS											
INSTALL METERS	1,750	4,080	4,080	4,090	16	2	44.8	195.8	326.4	523.5	0.0
GAS METER TEST EQUIPMENT											
INSTALL EQUIPMENT		1			500	2	0.0	1.5	0.0	0.0	0.0
TRAINING		20			120	2	0.0	7.2	0.0	0.0	0.0
TOTALS							0.0	8.7	0.0	0.0	0.0

Table 4-11
Installation Labor and Equipment Rental cost Estimate (SARATOV)

SARATOV GORGAS	NUMBER OF UNITS INSTALLED IN				MHRS PER	PRODU-	1994	1995	1996	1997	TOTAL
	1994	1995	1996	1997	UNIT	-CTIVITY	COST IN 1000 US$ FOR SALARY IN US$/H				1993
SCADA SYSTEM							0.80	1.50	2.50	4.00	1000$
BASE STATION		2	4	2	100	2	0.0	0.6	2.0	1.6	4.2
GAS CHROMATOGRAPH		1			200	2	0.0	0.6	0.0	0.0	0.6
RTU's		3	250	229	10	2	0.0	0.1	12.5	18.3	30.9
ENCLOSURES		3	250	229	10	2	0.0	0.1	12.5	18.3	30.9
RADIO/ANTENNA		3	250	229	20	2	0.0	0.2	25.0	36.6	61.8
CABLES & WIRING		3	250	229	50	2	0.0	0.5	62.5	91.6	154.5
SUPPORT STRUCTURES		1			1,200	2	0.0	3.6	0.0	0.0	3.6
TOTALS							0.0	5.6	114.5	166.5	286.6
NETWORK MODELLING											
COMPUTER HARDWARE	1	1			300	2	0.5	0.9	0.0	0.0	1.4
SOFTWARE DEVELOPMENT		1			200	2	0.0	0.6	0.0	0.0	0.6
TRAINING		1			5,000	2	0.0	15.0	0.0	0.0	15.0
PROGRAMMING (6 MAN)/UNIT		0.5	1	1	12,000	2	0.0	18.0	60.0	96.0	174.0
TOTALS							0.5	34.5	60.0	96.0	191.0
CATHODIC PROTECTION											
INSTALL ISOLATION FLANGES		145	145		18	2	0.0	7.8	13.1	0.0	20.9
ISOLATION UNIONS		12,000	20,000	14,387	8	2	0.0	288.0	800.0	920.8	2008.8
TEMPORARY RECTIFIERS		1			200	2	0.0	0.6	0.0	0.0	0.6
CP SURVEY(# of SECTIONS)		29			60	2	0.0	5.2	0.0	0.0	5.2
TRAINING		1			2,000	2	0.0	6.0	0.0	0.0	6.0
INSTALL ANODE/RECTIFIERS			30	14	300	2	0.0	0.0	45.0	33.6	78.6
EQUIPMENT RENTAL/MATERIAL		145	145					460	740		1200.0
TOTALS							0.0	767.7	1598.1	954.4	3320.1
COMMERCIAL METERS											
INSTALL METERS		500	633		8	2	0.0	12.0	25.3	0.0	0.0
PRIVATE HOMES METERS											
INSTALL METERS		10000	10000	10000	4	2	0.0	120.0	200.0	320.0	0.0
INDUSTRIAL METERS											
INSTALL METERS			250		96	2	0.0	0.0	120.0	0.0	0.0
EQUIPMENT RENTAL/MATERIALS			250				0.0	0.0	43.8	0.0	0.0
TOTALS							0.0	0.0	163.8	0.0	163.8
APARTMENT BLOCK METERS											
INSTALL METERS	1500	3695	3695	3695	16	2	33.4	177.4	295.6	473.0	0.0
GAS METER TEST EQUIPMENT											
INSTALL EQUIPMENT		1			500	2	0.0	1.5	0.0	0.0	0.0
TRAINING		30			120	2	0.0	10.8	0.0	0.0	0.0
TOTALS							0.0	12.3	0.0	0.0	0.0

Table 4-12
Installation Labor and Equipment Rental cost Estimate (VOLGOGRAD)

	NUMBER OF UNITS INSTALLED IN				MHRS PER	PRODU-	1994	1995	1996	1997	TOTAL
	1994	1995	1996	1997	UNIT	-CTIVITY	COST IN 1000 US$ FOR SALARY IN US$/H				1993
SCADA SYSTEM							0.80	1.50	2.50	4.00	1000$
BASE STATION		2	4	2	100	2	0.0	0.6	2.0	1.6	4.2
GAS CHROMATOGRAPH		1			200	2	0.0	0.6	0.0	0.0	0.6
RTU's		6	180	332	10	2	0.0	0.2	9.0	26.6	35.7
ENCLOSURES		6	180	332	10	2	0.0	0.2	9.0	26.6	35.7
RADIO/ANTENNA		6	180	332	20	2	0.0	0.4	18.0	53.1	71.5
CABLES & WIRING		6	180	332	50	2	0.0	0.9	45.0	132.8	178.7
SUPPORT STRUCTURES		1			1,200	2	0.0	3.6	0.0	0.0	3.6
TOTALS							0.0	6.4	83.0	240.6	330.1
NETWORK MODELLING											
COMPUTER HARDWARE	1	1			300	2	0.5	0.9	0.0	0.0	1.4
SOFTWARE DEVELOPMENT		1			200	2	0.0	0.6	0.0	0.0	0.6
TRAINING		1			5,000	2	0.0	15.0	0.0	0.0	15.0
PROGRAMMING (6 MAN)/UNIT		0.5	1	1	12,000	2	0.0	18.0	60.0	96.0	174.0
TOTALS							0.5	34.5	60.0	96.0	191.0
CATHODIC PROTECTION											
INSTALL ISOLATION FLANGES		230	230		18	2	0.0	12.4	20.7	0.0	33.1
ISOLATION UNIONS		12,000	22,000	16,206	8	2	0.0	288.0	880.0	1037.2	2205.2
TEMPORARY RECTIFIERS		1			200	2	0.0	0.6	0.0	0.0	0.6
CP SURVEY(# of SECTIONS)		46			60	2	0.0	8.3	0.0	0.0	8.3
TRAINING		1			2,000	2	0.0	6.0	0.0	0.0	6.0
INSTALL ANODE/RECTIFIERS			45	24	300	2	0.0	0.0	67.5	57.6	125.1
EQUIPMENT RENTAL/MATERIAL		230	230					460	740		1200.0
TOTALS							0.0	775.3	1708.2	1094.8	3578.3
COMMERCIAL METERS											
INSTALL METERS		650			8	2	0.0	15.6	0.0	0.0	15.6
PRIVATE HOMES METERS											
INSTALL METERS		11000	12000	11000	4	2	0.0	132.0	240.0	352.0	724.0
INDUSTRIAL METERS											
INSTALL METERS			180		96	2	0.0	0.0	86.4	0.0	86.4
EQUIPMENT RENTAL/MATERIALS			180				0.0	0.0	31.5	0.0	0.0
TOTALS							0.0	0.0	117.9	0.0	117.9
APARTMENT BLOCK METERS											
INSTALL METERS	1500	3818	3818	3818	16	2	38.4	183.3	305.5	488.7	1015.9
GAS METER TEST EQUIPMENT											
INSTALL EQUIPMENT		1			500	2	0.0	1.5	0.0	0.0	1.5
TRAINING		40			120	2	0.0	14.4	0.0	0.0	14.4
TOTALS							0.0	15.9	0.0	0.0	15.9

Table 4-13
Installation Labor and Equipment Rental cost Estimate (VORONEZH)

	NUMBER OF UNITS INSTALLED IN				MHRS PER	PRODU-	1994	1995	1996	1997	TOTAL
	1994	1995	1996	1997	UNIT	-CTIVITY	COST IN 1000 US$ FOR SALARY IN US$/H				1993
SCADA SYSTEM							0.80	1.50	2.50	4.00	1000$
BASE STATION		2	4	2	100	2	0.0	0.6	2.0	1.6	4.2
GAS CHROMATOGRAPH		1			200	2	0.0	0.6	0.0	0.0	0.6
RTU's		3	188	149	10	2	0.0	0.1	9.4	11.9	21.4
ENCLOSURES		3	188	149	10	2	0.0	0.1	9.4	11.9	21.4
RADIO/ANTENNA		3	188	149	20	2	0.0	0.2	18.8	23.8	42.8
CABLES & WIRING		3	188	149	50	2	0.0	0.5	47.0	59.6	107.1
SUPPORT STRUCTURES		1			1,200	2	0.0	3.6	0.0	0.0	3.6
TOTALS							0.0	5.6	86.6	108.9	201.1
NETWORK MODELLING											
COMPUTER HARDWARE	1	1			300	2	0.5	0.9	0.0	0.0	1.4
SOFTWARE DEVELOPMENT		1			200	2	0.0	0.6	0.0	0.0	0.6
TRAINING		1			5,000	2	0.0	15.0	0.0	0.0	15.0
PROGRAMMING (6 MAN)/UNIT		0.5	1	1	12,000	2	0.0	18.0	60.0	96.0	174.0
TOTALS							0.5	34.5	60.0	96.0	191.0
CATHODIC PROTECTION											
INSTALL ISOLATION FLANGES		210			18	2	0.0	11.3	0.0	0.0	11.3
ISOLATION UNIONS		12,000	36,000	23,164	8	2	0.0	288.0	1440.0	1482.5	3210.5
TEMPORARY RECTIFIERS		1			200	2	0.0	0.6	0.0	0.0	0.6
CP SURVEY(# of SECTIONS)		21			60	2	0.0	3.8	0.0	0.0	3.8
TRAINING		1			2,000	2	0.0	6.0	0.0	0.0	6.0
INSTALL ANODE/RECTIFIERS			20	12	300	2	0.0	0.0	30.0	28.8	58.8
EQUIPMENT RENTAL/MATERIAL		210	0					460	740		1200.0
TOTALS							0.0	769.7	2210.0	1511.3	4491.0
COMMERCIAL METERS											
INSTALL METERS		243			8	2	0.0	5.8	0.0	0.0	5.8
PRIVATE HOMES METERS											
INSTALL METERS		14,760	14,760	14,765	4	2	0.0	177.1	295.2	472.5	944.6
INDUSTRIAL METERS											
INSTALL METERS			188		96	2	0.0	0.0	90.2	0.0	90.2
EQUIPMENT RENTAL/MATERIALS			188				0.0	0.0	32.9	0.0	0.0
TOTALS							0.0	0.0	123.1	0.0	123.1
APARTMENT BLOCK METERS											
INSTALL METERS	3,100	7,060	7,060	7,060	16	2	79.4	338.9	564.8	903.7	1886.7
GAS METER TEST EQUIPMENT											
INSTALL EQUIPMENT		1			500	2	0.0	1.5	0.0	0.0	1.5
TRAINING		30			120	2	0.0	10.8	0.0	0.0	10.8
TOTALS							0.0	12.3	0.0	0.0	12.3

Table 4-14

Foreign Engineering, Procurement and Construction Management Cost Estimate

	1994		1995				1996				1997		
	III	IV	I	II	III	IV	I	II	III	IV	I	II	III
SCADA PROJECTS													
ENGINEERING	100	125	60	50									
PROCUREMENT		40	10	10			20	15					
TRAVEL & SUBSISTENCE		45	10	5									
TOTAL	100	210	80	65			20	15					
INSTALLATIN/TESTING					10	10			25	25		25	25
CONSTRUCTION MANAGEMENT					40	40			60	60		20	20
TRAVEL & SUBSISTENCE					20	15			30	15		15	10
TOTAL					70	65			115	100		60	55
NETWORK MODELLING PROJECTS													
ENGINEERING	30	20											
PROCUREMENT	40	60											
TRAVEL & SUBSISTENCE	10	15											
TOTAL	80	95											
PROGRAMMING/TRAINING					30	30	10	10	5		5		
TRAVEL & SUBSISTENCE					15	15	5	5	5		5		
TOTAL					45	45	15	15	10		10		
CATHODIC PROTECTION PROJECTS													
ENGINEERING	100	90	30	30	10	10	20	20					
PROCUREMENT			30	10			8	5					
TRAVEL & SUBSISTENCE		10	18	18									
TOTAL	100	100	78	58	10	10	28	25					
INSTALLATIN/TESTING					30	30							
CONSTRUCTION MANAGEMENT			20	20	20	10	20	35	30	20	20	12	
TRAVEL & SUBSISTENCE			10	5	13	18	10	15	10	10	10	8	
TOTAL			30	25	63	58	30	50	40	30	30	20	
LEAK DETECTION TEST EQUIPMENT													
ENGINEERING	50	25											
PROCUREMENT	40	80											
TRAVEL & SUBSISTENCE		10											
TOTAL	90	115											
COMMERCIAL METERS													
ENGINEERING	40	25											
PROCUREMENT	10	30	25	25	25	25	20						
TRAVEL & SUBSISTENCE	10	10											
TOTAL	60	65	25	25	25	25	20						
INSTALLATION/TESTING				45									
CONSTRUCTION MANAGEMENT					60	60							
TRAVEL & SUBSISTENCE				20	15	15							
TOTAL				65	75	75							
INDUSTRIAL METERS													
ENGINEERING	70	40											
PROCUREMENT					60	30	30	30					
TRAVEL & SUBSISTENCE	10	10				10	10	5					
TOTAL	80	50			60	40	40	35					
INSTALLATION/TESTING								40	40	30			
CONSTRUCTION MANAGEMENT								20	40	20			
TRAVEL & SUBSISTENCE								20	25	15			
TOTAL								80	105	65			

Table 4-14 (Continued)

Foreign Engineering, Procurement and Construction Management Cost Estimate

	1994		1995				1996				1997		
	III	IV	I	II	III	IV	I	II	III	IV	I	II	III
APARTMENT BLOCK METERS													
ENGINEERING	30	20											
PROCUREMENT		40											
TRAVEL & SUBSISTENCE	10	10											
TOTAL	40	70											
INSTALLATION/TESTING		80											
CONSTRUCTION MANAGEMENT													
TRAVEL & SUBSISTENCE		20											
TOTAL		100											
GAS METER TEST EQUIPMENT													
ENGINEERING	50												
PROCUREMENT		34	34										
TRAVEL & SUBSISTENCE													
TOTAL	50	34	34										
INSTALLATION/TESTING				30	30								
CONSTRUCTION MANAGEMENT													
TRAVEL & SUBSISTENCE				10	10								
TOTAL				40	40								

Table 4-15

Local Engineering, Procurement and Construction Management Cost Estimate

	1994		1995				1996				1997			
	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
SCADA PROJECTS														
ENGINEERING		1	2	2	3	2								
CONSTRUCTION MANAGEMENT		1			2	1			3	2		4	3	
NETWORK MODELLING PROJECTS														
ENGINEERING		1												
CATHODIC PROTECTION PROJECTS														
ENG.(CONRUCTION SUPPORT)	3	2	2	2	3	3	3	3	2	2	4	4	2	
CONSTRUCTION MANAGEMENT					4	6	2	3	4	6	4	6	5	
LEAK DETECTION TEST EQUIPMENT														
ENGINEERING														
COMMERCIAL METERS														
ENGINEERING	0.5	0.5	1	1										
CONSTRUCTION MANAGEMENT					2	3								
PRIVATE HOME METERS														
ENGINEERING	1	1												
CONSTRUCTION MANAGEMENT					4	6	4	4	4	3	6	6	8	
INDUSTRIAL METERS														
ENGINEERING		5	4	3	2	1	4	4	6	6				
CONSTRUCTION MANAGEMENT								5	7	8				
APARTMENT BLOCK METERS														
ENGINEERING	2	2	2	2	2	2	3	3	3	3	3	3		
CONSTRUCTION MANAGEMENT		10	5	5	5	5	7.5	7.5	7.5	7.5	5	5	5	5
GAS METER TEST EQUIPMENT														
ENGINEERING	2	3	4	6										
CONSTRUCTION MANAGEMENT			3	3										
PIPELINE REPLACEMENT														
ENGINEERING							1	2	1	1	3	3		
CONSTRUCTION MANAGEMENT									4	5			6	8

Table 4-16

List of CP Equipment

Item	Description	Recommendations
1	Multi-Combination Meter	M.C. Miller # B-3-A2
2	Digital Multi-Meter	M.C. Miller # LC-4
3	Digital Multi-Meter	Beckman # HD 100
4	Current Interrupter w/battery	Nilsson # 820 & 110 Battery
5	Pipe & Short Locator w/battery	Nilsson # 715 & 110 Battery
6	Strip Chart Recorder	M.C. Miller # NR-1
7	Soil Resistance Meter	Nilsson # 400
8	DC Amp Clip Meter	Swain # .02-100A
9	AC Amp Clip Meter	Swain # .02-100A
10	Portable Rectifier	J.A. Electronics # 60 V-24 A
11	Portable Gas Generator	Honda 1,800 Watt
12	Inductive Pipe Locator	Fisher M Scope
13	Copper Sulfate Electrodes	M.C. Miller # RE-5C
14	Copper Sulfate Crystals	M.C. Miller Type
15	$CuSO_4$ Anti-Freeze Solution	M.C. Miller Type
16	Soil Box	M.C. Miller Model
17	Soil Resistivity Pins	M.C. Miller # SS-30 inch T
18	Insulation Checker	Gas Electronics # 601
19	Antimony (pH) Electrode	AGRA Type
20	Test Leads	#16 awg at Various Lengths
21	Test Reel - Hand Type	AGRA w/250 foot #16 awg
22	Test Reel - Stand Type	Hykon # 9XC w/2,000 foot #18 awg
23	Heavy Duty Jumpers	# 6-2 awg at Various Lengths
24	Misc. Test Leads	#16 awg w/Various Clips
25	Portable Shunts	Various CP Types
26	Electrode Extension	M.C. Miller 30 inch PVC
27	Adapter Plate for LC-4	M.C. Miller Type
28	Computerized Data Logger	Optional
29	CP Computer Software	Optional
30	PC Station	Optional
31	Vehicle	Van Type
32	AC Converter in Vehicle	Various Types
33	Motorized Reel in Vehicle	Hannay Type w/1 mi #16 awg

Table 4-17

Summary of CP System Components

	Ryazan	Saratov	Volgograd	Voronezh
CP Areas Proposed	12	29	46	21
Isolation Units required (10 per area)	120	290	460	210
Anode/Rectifier stations required	18	44	69	32
Isolation flanges at				
GRUs	452	1,102	887	709
Residential Service Lines	25,363	42,585	46,955	68,565
At Instrument Lines	1,206	2,700	2,364	1,890
Savings - 1993 US$/yr(1)				
Gas	0	0	0	0
Reduction of Power Costs				
Present @ 3.1¢/kwh	18,800	35,000	63,000	35,000
Future @ 6.5¢/kwh	39,000	65,000	117,000	64,350

(1) The pipeline life will be extended indefinitely by installing and maintaining the CP System. This would translate into a significant savings in pipe replacement costs in future years.

Table 4-18

Construction Equipment Costs

	Quantity	Ryazan	Saratov	Volgograd	Voronezh
Backhoe (excavator)	2	30,000	30,000	30,000	30,000
Crane, 14 ton, truck mounted	2	280,000	280,000	280,000	280,000
Compressors, 5 hp	2	20,000	20,000	20,000	20,000
Flat bed, 35 feet, with tractor	2	70,000	70,000	70,000	70,000
Welding Machine, mounted on truck	2	40,000	40,000	40,000	40,000
X-ray machine with Lab, on truck (darkroom)	1	60,000	60,000	60,000	60,000
Trenching machine	2	60,000	60,000	60,000	60,000
Bending machine, 24-in	1	150,000	150,000	150,000	150,000
Miscellaneous tools	1	25,000	25,000	25,000	25,000
Sub-Total		735,000	735,000	735,000	735,000
Shipping @ 3%		22,050	22,050	22,050	22,050
Contingency @ 15%		113,558	113,558	113,558	113,558
TOTAL		870,608	870,608	870,608	870,608
Savings – 1993 US$/yr					
Gas		0	0	0	0
O&M Costs		0	0	0	0

Note: All equipment assumed to be Russian-made

141

Table 4-19

Phase 1 – Metering Commercial Establishments

	Ryazan	Saratov	Volgograd	Voronezh
Number of Establishments	1,015	1,133	650	243
Meters to be replaced	1,015	1,133	650	243
Gas Consumption, 1000 m^3/yr	72,200	447,605	481,500	455,507
Savings in Gas Use				
1000 m^3/yr	3,610	22,380	24,075	22,775
1993 US$/yr	144,400	895,210	963,000	911,000
Savings in O&M Cost, 1993 USR/yr	0	0	0	0
Total Savings, 1993 US$/yr	144,400	895,210	963,000	911,000

Note: Accordinging to these Gorgases, most of their commercial customers are metered. Approximately 10 customers are believed to have been unmetered.

142

Table 4-20

Phase 2 – Metering Private Homes with Space Heat

	Ryazan	Saratov	Volgograd	Voronezh
Number of Private Homes	11,363	30,000	34,000	44,285
Private Homes without meters	11,363	30,000	34,000	44,285
Gas Consumption, 1000 m^3/yr (1)	40,907	108,000	122,400	159,426
Savings in Gas Use				
1000 m^3/yr	10,277	27,000	30,600	39,857
1993 US$/yr @ US$150/1000 m^3	1,534,000	4,050,000	4,590,000	5,979,000
Savings in O&M Cost, 1993 USR/yr	0	0	0	0
Total Savings, 1993 US$/yr	1,534,000	4,050,000	4,590,000	5,979,000

(1) 10 m^3/mo/person*3 person + 4.5 m^3/sqm/mo*60 sqm = 300 m^3/mo.

Table 4-21

Phase 3 – Upgrade Industrial Meters

	Ryazan	Saratov	Volgograd	Voronezh
Number of Industrial Sites	77	250	180	188
Sites to be Upgraded	77	250	180	188
Gas Consumption, 1000 m^3/yr	1,915,100	2,685,000	2,968,200	3,537,657
Savings in Gas Use (1)				
1000 m^3yr	19,151	26,850	29,682	35,377
1993 US$/yr	766,040	1,074,000	1,187,280	1,415,063
Savings in O&M Cost, 1993 USR/yr	0	0	0	0
Total Savings, 1993 US$/yr	766,040	1,074,000	1,187,280	1,415,063

(1) Assumes 1% higher flow rate recorded due to accurate metering.

144

Table 4-22

Phase 4 – Metering Apartment Blocks

	Ryazan	Saratov	Volgograd	Voronezh
Number of Apartments	148,229	251,692	259,100	242,800
Number of Service Lines	14,000	12,585	12,955	24,280
Number of Service Lines without meters	14,000	12,585	12,955	24,280
Gas Consumption, 1000 m^3/yr (1)	53,362	90,609	93,276	87,408
Number of Meters	14,000	12,585	12,955	24,280
Savings in Gas Use				
1000 m^3/yr	14,971	25,421	26,169	24,523
1993 US$/yr @ US$150/1000 m^3	1,437,000	3,813,000	3,925,000	3,678,000
Savings in O&M Cost, 1993 USR/yr	0	0	0	0
Total Savings, 1993 US$/yr	1,437,000	3,813,000	3,925,000	3,678,000

(1) 10 m^3/mo/person*3 person* 12 mo = 360 m^3/yr, reduced to 259 m^3/yr by conservation

145

Table 4-23.

Gas Distribution Projects by Rate of Return - City of Ryazan

Ryazan Gorgas	Investment 93$ 000	Savings mcm	IRR
Metering, Pvt Homes, Space Heat	1,052	10,227	52%
Cathodic Protection	5,187		51%
Network Analysis	814		34%
Metering, Industrial Upgrade	1,967	19,151	27%
Metering, Apartments	7,045	14,971	19%
Metering, Commercial	969	3,610	10%
Meter Test Equipment	260		
Pipe Replacement	533		
SCADA System	3,915		
Leak Detection	606		
All Projects	22,348	47,959	
Contingencies	3,352		
Environmental (first 4 years)	76		
Total	25,776		26%
CP, SCADA, Eqpt., Netwk , Pipe Repl.	12,749		29%
All Metering	12,951	47,959	22%

146

Table 4-24

Gas Distribution Projects by Rate of Return - City of Saratov

Saratov Gorgas	Investment 93$ 000	Savings mcm	IRR
Metering, Pvt Homes, Space Heat	2,563	27,000	55%
Metering, Commercial	976	22,380	43%
Network Analysis	814		35%
Cathodic Protection	7,663		44%
Metering, Apartments	6,428	25,421	30%
Metering, Industrial Upgrade	4,862	26,850	16%
Meter Test Equipment	259		
Pipe Replacement	1,069		
SCADA System	7,488		
Leak Detection	519		
All Projects	32,641	101,651	
Contingencies	4,896		
Environmental (first 4 years)	76		
Total	37,613		27%
CP, SCADA, Eqpt., Netwk Anal., Pipe Rep.	20,186		22%
All Metering	17,351	74,801	30%

Table 4-25

Gas Distribution Projects by Rate of Return - City of Volgograd

Volgograd Gorgas	Investment 93$ 000	Savings mcm	IRR
Network Analysis	814		60%
Cathodic Protection	8,540		72%
Metering, Commercial	1489	24 075	34%
Metering, Pvt Homes, Space Heat	3,058	30,600	54%
Metering, Industrial Upgrade	3,792	29,682	22%
Metering, Apartments	6,452	26,169	31%
Meter Test Equipment	260		
Pipe Replacement	1,069		
SCADA System	8,002		
Leak Detection	1,098		
All Projects	34,574	110,526	
Contingencies	5,186		
Environmental (first 4 years)	76		
Total	39,836		37%
CP, SCADA, Eqpt., Netwk Anal., Pipe Rep.	22,451		41%
All Metering	17,309	110,526	32%

Table 4-26

Gas Distribution Projects by Rate of Return - City of Voronezh

Voronezh Oblgas	Investment 93$ 000	Savings mcm	IRR
Network Analysis	814		52%
Metering, Commercial	556	22,775	57%
Metering, Pvt Homes, Space Heat	3,959	39,857	57%
Cathodic Protection	10,705		55%
Metering, Industrial Upgrade	3,944	35,377	25%
Metering, Apartments	12,945	24,523	18%
Meter Test Equipment	260		
Pipe Replacement	641		
SCADA System	5,598		
Leak Detection	814		
All Projects	40,236	122,532	
Contingencies	6,035		
Environmental (first 4 years)	76		
Total	46,348		31%
CP, SCADA, Eqpt., Netwk Anal., Pipe Rep.	21,355		35%
All Metering	24,914	122,532	27%

149

Table 4-27

Project Cash Flows

Industrial gas price, 1993$/1000 m^3	20	30	40	40	40	40	40
Residential gas price, 1993$/1000 m^3	3	6	12	24	48	96	150
Calendar Year	1994	1995	1996	1997	1998	1999	2000
							*
Meters, Commercial							
Ryazan, Cash Flow, 1993 $000	-219	-559	-191	0	144	144	144
Project Costs	-219	-559	-191	0			
Gas Saved, mcm					3,610	3,610	3,610
Saratov	-238	-573	-165	0	895	895	895
Project Costs	-238	-573	-165	0			
Gas Saved, mcm					22,380	22,380	22,380
Volgograd	-259	-1,230	0	0	963	963	963
Project Costs	-259	-1,230	0	0			
Gas Saved, mcm					24,075	24,075	24,075
Voronezh	-174	-382	0	0	911	911	911
Project Costs	-174	-382	0	0			
Gas Saved, mcm					22,775	22,775	22,775
	IRR	PV @ 15%	pvB/pvC	Cost	Gas Svd		
Ryazan	10%	-239	-0.26	969	3,610	10%	
Saratov	43%	2,346	12.54	976	22,380	43%	
Volgograd	34%	2,174	10.85	1,489	24,075	34%	
Voronezh	57%	2,752	19.19	556	22,775	57%	
Meters, Private Homes with Space Heat							
Ryazan, Cash Flow, 1993 $000	-140	-311	-340	-261	491	982	1,534
Project Costs	-140	-311	-340	-261			
Gas Saved, mcm					10,227	10,227	10,227
Saratov	-330	-685	-876	-672	1,296	2,592	4,050
Project Costs	-330	-685	-876	-672			
Gas Saved, mcm					27,000	27,000	27,000
Volgograd	-373	-917	-1,030	-738	1,469	2,938	4,590
Project Costs	-373	-917	-1,030	-738			
Gas Saved, mcm					30,600	30,600	30,600
Voronezh	-250	-1,171	-1,294	-1,244	1,913	3,826	5,979
Project Costs	-250	-1,171	-1,294	-1,244			
Gas Saved, mcm					39,857	39,857	39,857
	IRR	PV @ 15%	pvB/pvC	Cost	Gas Svd		
Ryazan	52%	3,817	32.35	1,052	10,227	52%	
Saratov	55%	10,238	37.33	2,563	27,000	55%	
Volgograd	54%	11,487	37.07	3,058	30,600	54%	
Voronezh	57%	15,330	71.52	3,959	39,857	57%	

* All cash flows constant from year 2000 to 2015. Numbers rounded in printing from spreadsheet.

Table 4-27 (Continued)

Project Cash Flows

Industrial gas price, 1993$/1000 m^3	20	30	40	40	40	40	40
Residential gas price, 1993$/1000 m^3	3	6	12	24	48	96	150
Calendar Year	1994	1995	1996	1997	1998	1999	2000
							*

Meters, Apartment Blocks							
Ryazan, Cash Flow, 1993 $000	-1,474	-1,879	-2,023	-1,669	719	1,437	2,246
Project Costs	-1,474	-1,879	-2,023	-1,669			
Gas Saved, mcm					14,971	14,971	14,971
Saratov	-1,379	-1,706	-1,839	-1,504	1,220	2,440	3,813
Project Costs	-1,379	-1,706	-1,839	-1,504			
Gas Saved, mcm					25,421	25,421	25,421
Volgograd	-1,336	-1,728	-1,834	-1,554	1,256	2,512	3,925
Project Costs	-1,336	-1,728	-1,834	-1,554			
Gas Saved, mcm					26,169	26,169	26,169
Voronezh	-2,451	-3,487	-3,727	-3,280	1,177	2,354	3,678
Project Costs	-2,451	-3,487	-3,727	-3,280			
Gas Saved, mcm					24,523	24,523	24,523

	IRR	PV @ 15%	pvB/pvC	Cost	Gas Svd	
Ryazan	19%	1,772	2.37	7,045	14,971	19%
Saratov	30%	6,919	4.40	6,428	25,421	30%
Volgograd	31%	7,252	4.53	6,452	26,169	31%
Voronezh	18%	1,978	2.13	12,945	24,523	18%

Meters, Industrial Upgrade							
Ryazan, Cash Flow, 1993 $000	-130	-714	-1,123	0	766	766	766
Project Costs	-130	-714	-1,123	0			
Gas Saved, mcm					19,151	19,151	19,151
Saratov	-130	-2,166	-2,566	0	1,074	1,074	1,074
Project Costs	-130	-2,166	-2,566	0			
Gas Saved, mcm					26,850	26,850	26,850
Volgograd	-135	-1,647	-2,010	0	1,187	1,187	1,187
Project Costs	-135	-1,647	-2,010	0			
Gas Saved, mcm					29,682	29,682	29,682
Voronezh	-135	-1,713	-2,096	0	1,415	1,415	1,415
Project Costs	-135	-1,713	-2,096	0			
Gas Saved, mcm					35,377	35,377	35,377

	IRR	PV @ 15%	pvB/pvC	Cost	Gas Svd	
Ryazan	27%	1,257	12.12	1,967	19,151	27%
Saratov	16%	275	3.87	4,862	26,850	16%
Volgograd	22%	1,421	13.57	3,792	29,682	22%
Voronezh	25%	2,167	19.46	3,944	35,377	25%

* All cash flows constant from year 2000 to 2015. Numbers rounded in printing from spreadsheet.

Table 4-27 (Continued)

Project Cash Flows

Industrial gas price, 1993$/1000 m^3	20	30	40	40	40	40	40
Residential gas price, 1993$/1000 m^3	3	6	12	24	48	96	150
Calendar Year	1994	1995	1996	1997	1998	1999	2000
							*

Cathodic Protection							
Ryazan (Investment &Cash Flow)	-466	-1,812	-2,373	-536	5,099	5,105	5,105
System Replacement Cost	151,968						
Deferred Maintenance with 60 yr life					5,066	5,066	5,066
Electric Power Savings					33	39	39
Saratov	-569	-2,250	-3,141	-1,703	5,457	5,467	5,467
System Replacement Cost	162,070						
Deferred Maintenance with 60 yr life					5,402	5,402	5,402
Electric Power Savings					55	65	65
Volgograd	-669	-2,453	-3,459	-1,959	13,312	13,330	13,330
System Replacement Cost	396,391						
Deferred Maintenance with 60 yr life					13,213	13,213	13,213
Electric Power Savings					99	117	117
Voronezh	-579	-2,720	-4,706	-2,700	10,295	10,305	10,305
System Replacement Cost	307,230						
Deferred Maintenance with 60 yr life					10,241	10,241	10,241
Electric Power Savings					54	64	64
Savings factor on deferred maint.	30						

	IRR	PV @ 15%	Cost
Ryazan	51%	14,240	-5,187
Saratov	44%	13,916	-7,663
Volgograd	72%	40,864	-8,540
Voronezh	55%	28,904	-10,705

Network Analysis							
Ryazan, Cash Flow, 1993 $000	-305	-254	-125	-130	507	507	507
Project Cost	-305	-254	-125	-130			
Savings on deferred maintenance					507	507	507
Saratov	-305	-254	-125	-130	540	540	540
Project Cost	-305	-254	-125	-130			
Savings on deferred maintenance					540	540	540
Volgograd	-306	-253	-125	-130	1,321	1,321	1,321
Project Cost	-306	-253	-125	-130			
Savings on deferred maintenance					1,321	1,321	1,321
Voronezh	-305	-254	-125	-130	1,024	1,024	1,024
Project Cost	-305	-254	-125	-130			
Savings on deferred maintenance					1,024	1,024	1,024

	IRR	PV @ 15%	Cost
Ryazan	34%	1,161	-814
Saratov	35%	1,279	-814
Volgograd	60%	4,016	-814
Voronezh	52%	2,974	-814

* All cash flows constant from year 2000 to 2015. Numbers rounded in printing from spreadsheet.

Table 4-27 (Continued)

Project Cash Flows

Industrial gas price, 1993$/1000 m^3	20	30	40	40	40	40	40
Residential gas price, 1993$/1000 m^3	3	6	12	24	48	96	150
Calendar Year	1994	1995	1996	1997	1998	1999	2000 *
Leak Detection							
Ryazan, Cash Flow, 1993 $000	-409	-197	0	0	0	0	0
Saratov	-365	-154	0	0	0	0	0
Volgograd	-654	-444	0	0	0	0	0
Voronezh	-512	-302	0	0	0	0	0
SCADA System							
Ryazan, Cash Flow, 1993 $000	-403	-880	-1,584	-1,048	0	0	0
Saratov	-405	-1,965	-3,362	-1,756	0	0	0
Volgograd	-426	-1,562	-3,543	-2,471	0	0	0
Voronezh	-404	-1,575	-2,434	-1,185	0	0	0
Gas Meter Test Equipment							
Ryazan, Cash Flow, 1993 $000	-106	-154	0	0	0	0	0
Saratov	-106	-154	0	0	0	0	0
Volgograd	-106	-154	0	0	0	0	0
Voronezh	-106	-154	0	0	0	0	0
Pipe Replacement							
Ryazan, Cash Flow, 1993 $000	0	0	-233	-300	0	0	0
Saratov	0	0	-466	-603	0	0	0
Volgograd	0	0	-466	-603	0	0	0
Voronezh	0	0	-280	-362	0	0	0
Contingencies							
Ryazan Network	-237	-471	-647	-302			
Ryazan Metering	-310	-543	-552	-290			
Saratov Network	-247	-693	-1,064	-629			
Saratov Metering	-327	-793	-817	-326			
Volgograd Network	-308	-707	-1,139	-774			
Volgograd Metering	-331	-851	-731	-344			
Voronezh Network	-270	-728	-1,132	-657			
Voronezh Metering	-467	-1,036	-1,068	-679			

* All cash flows constant from year 2000 to 2015. Numbers rounded in printing from spreadsheet.

Table 4-27 (Continued)

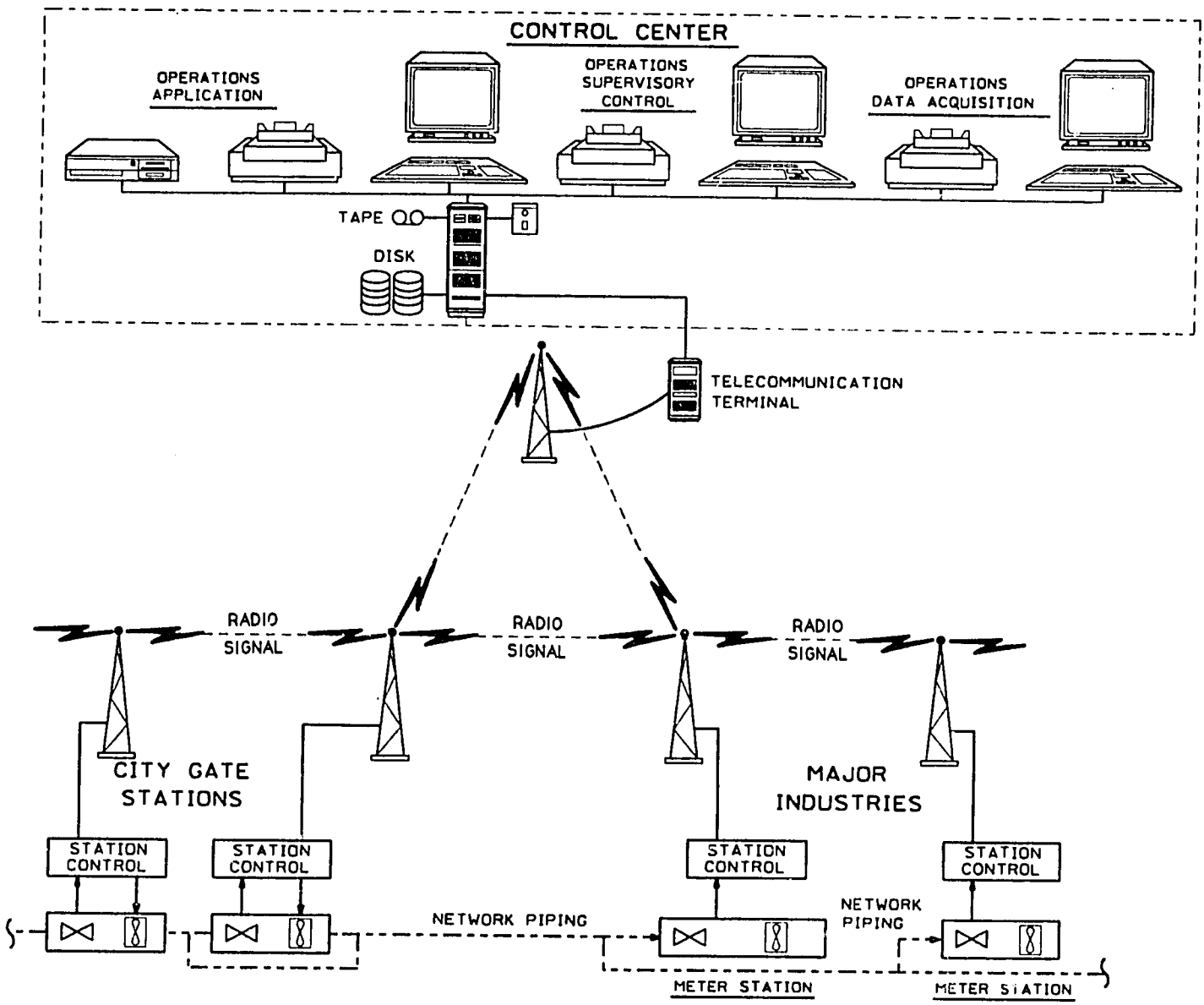
Project Cash Flows

Industrial gas price, 1993$/1000 m^3	20	30	40	40	40	40	40
Residential gas price, 1993$/1000 m^3	3	6	12	24	48	96	150
Calendar Year	1994	1995	1996	1997	1998	1999	2000 *
Environmental Management							
Each City	-39	-27	-5	-5	-5	-5	-5
Cash Flow all projects, 1993 $000							
Ryazan	-4,239	-7,801	-9,196	-4,541	7,720	8,936	10,296
Saratov	-4,440	-11,419	-14,426	-7,328	10,478	13,004	15,835
Volgograd	-4,943	-11,973	-14,342	-8,578	19,504	22,246	25,312
Voronezh	-5,693	-13,548	-16,866	-10,241	16,731	19,831	23,308
	IRR	PV @ 15%	Cost				
Ryazan	26%	15,979	-25,776				
Saratov	27%	25,423	-37,613				
Volgograd	37%	56,786	-39,836				
Voronezh	31%	44,750	-46,348				
Cash Flow, All Metering Projects							
Ryazan	-2,379	-4,160	-4,229	-2,220	2,120	3,329	4,690
Saratov	-2,510	-6,076	-6,263	-2,502	4,485	7,002	9,832
Volgograd	-2,540	-6,527	-5,605	-2,636	4,875	7,600	10,666
Voronezh	-3,583	-7,943	-8,185	-5,203	5,416	8,507	11,983
	IRR	PV @ 15%	Cost				
Ryazan	22%	5,086	-12,987				
Saratov	30%	17,787	-17,351				
Volgograd	32%	20,335	-17,309				
Voronezh	27%	19,185	-24,914				
Cash Flow, Cathodic Protection, SCADA, Leak Detection, NetworkAnalysis, Pipe Replacement, Environmental							
Ryazan	-1,860	-3,641	-4,967	-2,321	5,600	5,606	5,606
Saratov	-1,930	-5,343	-8,163	-4,826	5,993	6,003	6,003
Volgograd	-2,403	-5,446	-8,737	-5,942	14,628	14,646	14,646
Voronezh	-2,109	-5,605	-8,681	-5,038	11,315	11,324	11,324
	IRR	PV @ 15%	Cost				
Ryazan	29%	10,892	-12,789				
Saratov	22%	7,635	-20,262				
Volgograd	41%	36,451	-22,527				
Voronezh	35%	25,565	-21,434				

* All cash flows constant from year 2000 to 2015. Numbers rounded in printing from spreadsheet.

Figure 4-1

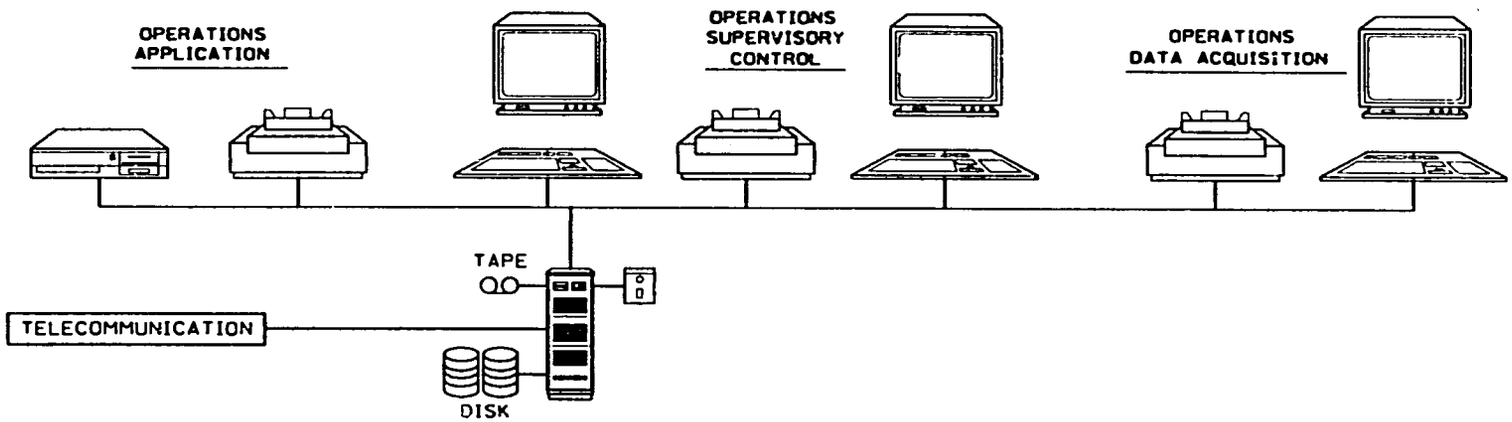
SCADA Schematic System Configuration



155

Figure 4-2

SCADA System Control Center

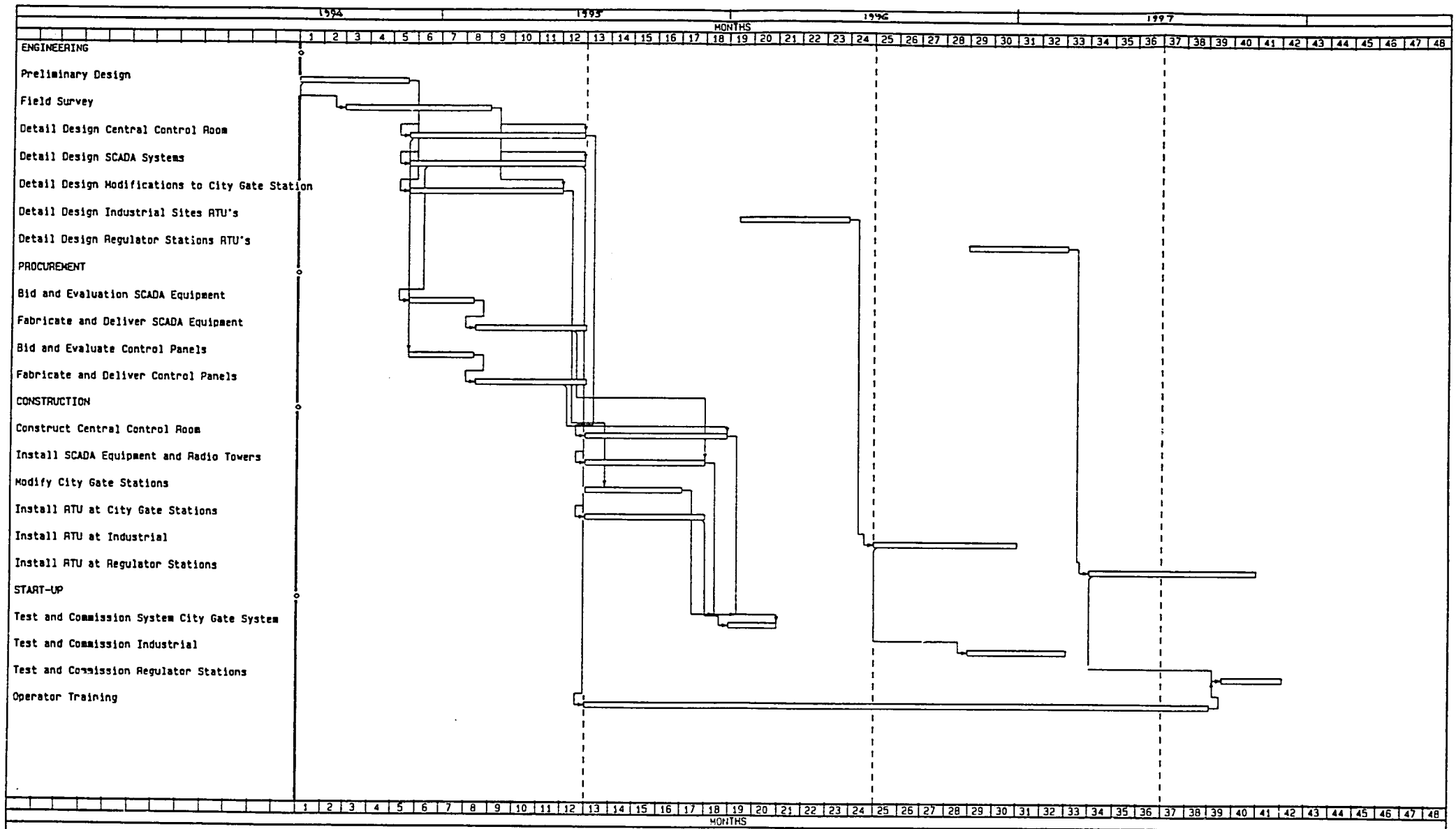


- NETWORK OPTIMIZATION PROGRAMS, DELIVERY REQUIREMENTS
- GAS DELIVERY FORECASTS
- GAS PURCHASE/DELIVERY BALANCE

- CITY GATE STATION OPERATIONS
- PRESSURE CONTROL
- GAS CURTAILMENT OPERATIONS

- OPERATING LIMITS
- ALARMS/SITE SECURITY STATUS
- NETWORK PRESSURE/PROFILE
- NETWORK TEMPERATURES/PROFILE
- NETWORK FLOW RATES
- GAS QUALITY
- NETWORK STATUS
- DISTRICT REGULATOR STATUS

156



Plot Date 18JAN94
Data Date 1JAN93
Project Start 1JAN93
Project Finish 2JAN98

(c) Primavera Systems, Inc.

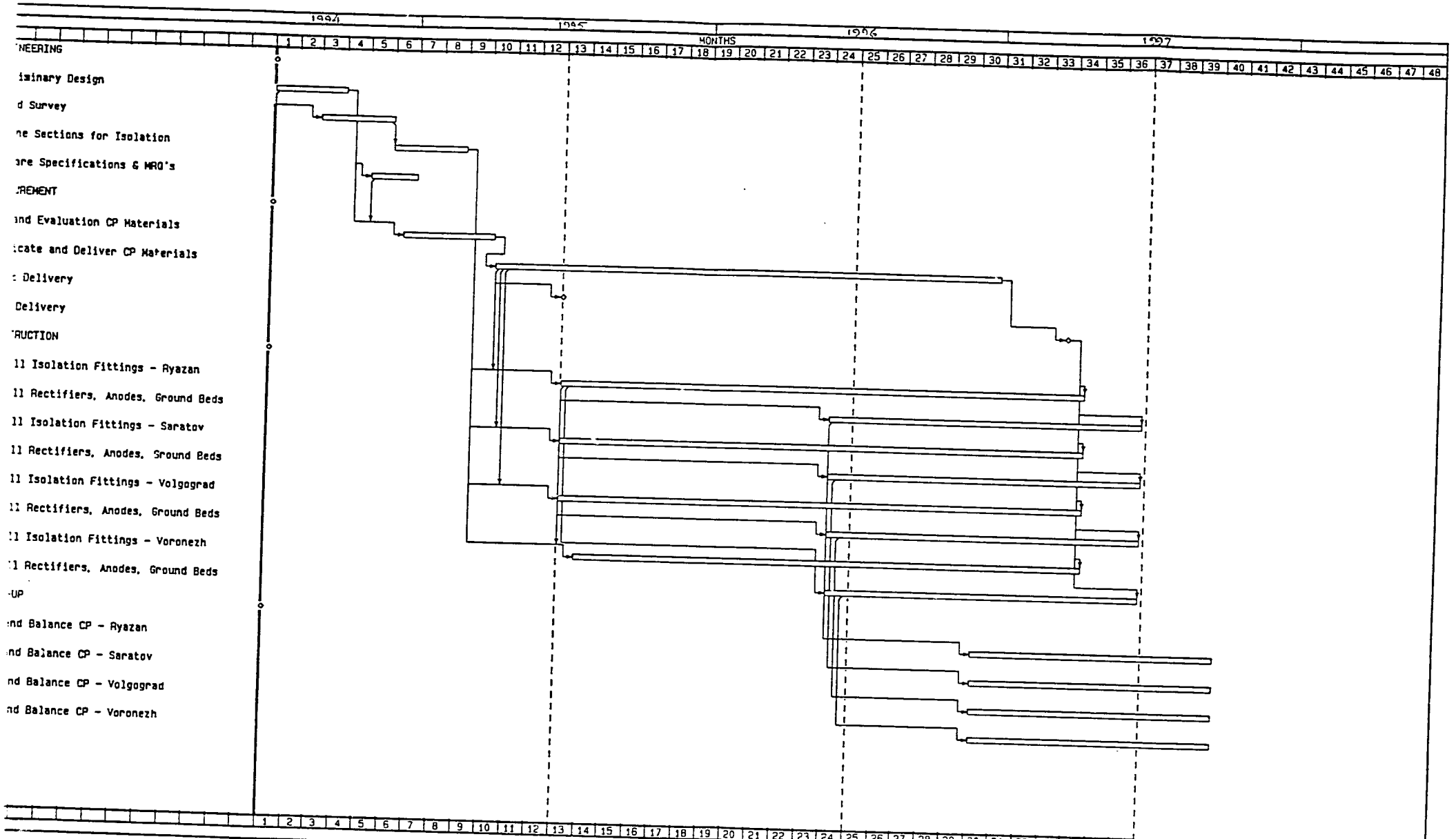
Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

SCAD

Sheet 1 of 1

U.S. Agency for International Devel.
NIS Natural Gas System Rehabilitatio
Figure 4-3 - SCADA E.P.C. Schedule

Date	Revision	Checked	Approved



18JAN94
1JAN95
1JAN95
31MAR98

Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

CATH

Figure 4-4

U.S. Agency for International Devel.
NIS Natural Gas System Rehabilitatio
Cathodic Protection E.P.C. Schedule

Sheet 1 of 1

Date	Revision	Checked	Approved

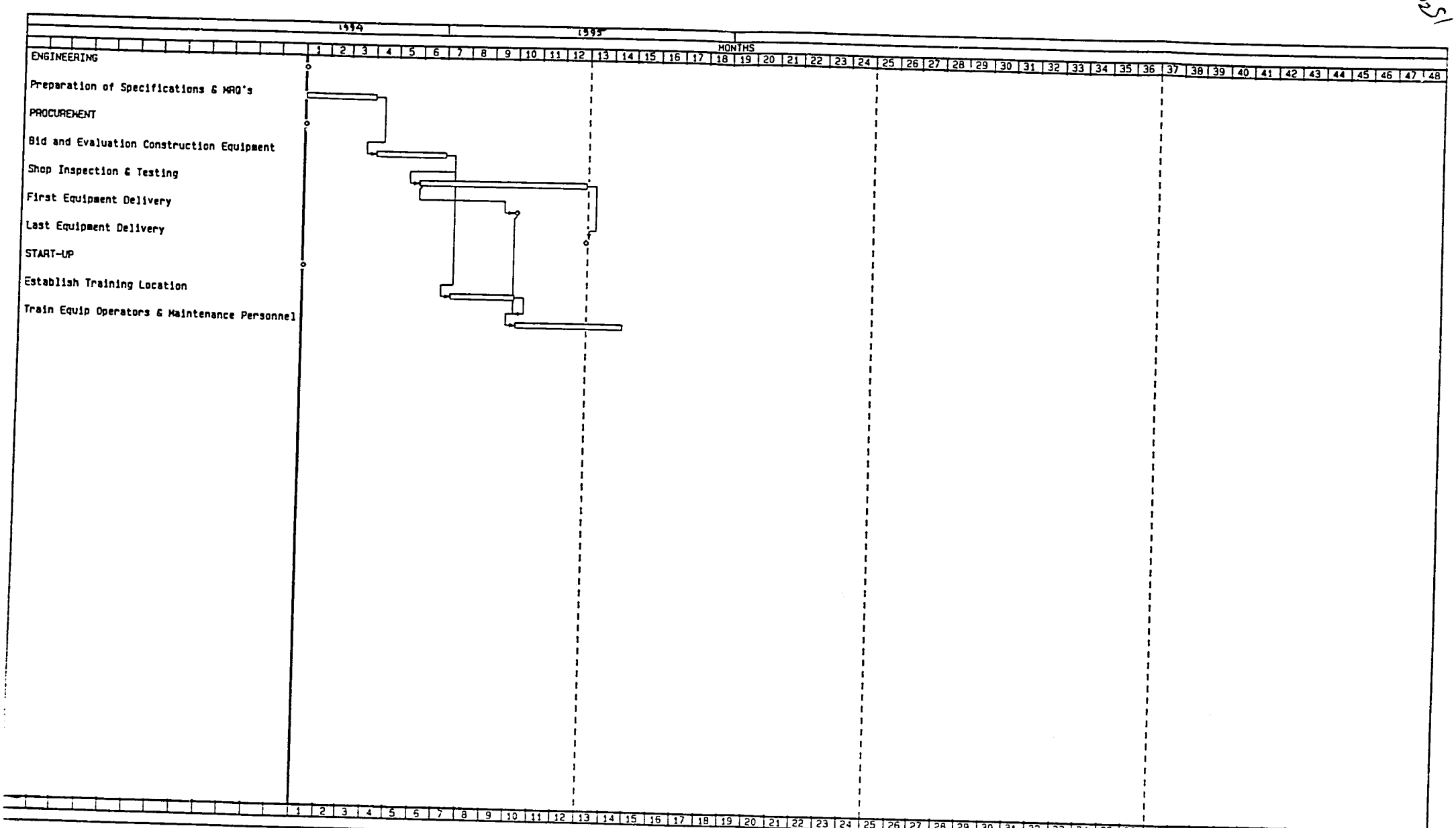


Figure 4-5

U.S. Agency for International Devel.
NIS Natural Gas System Rehabilitatio
Construction Equipment Procurement

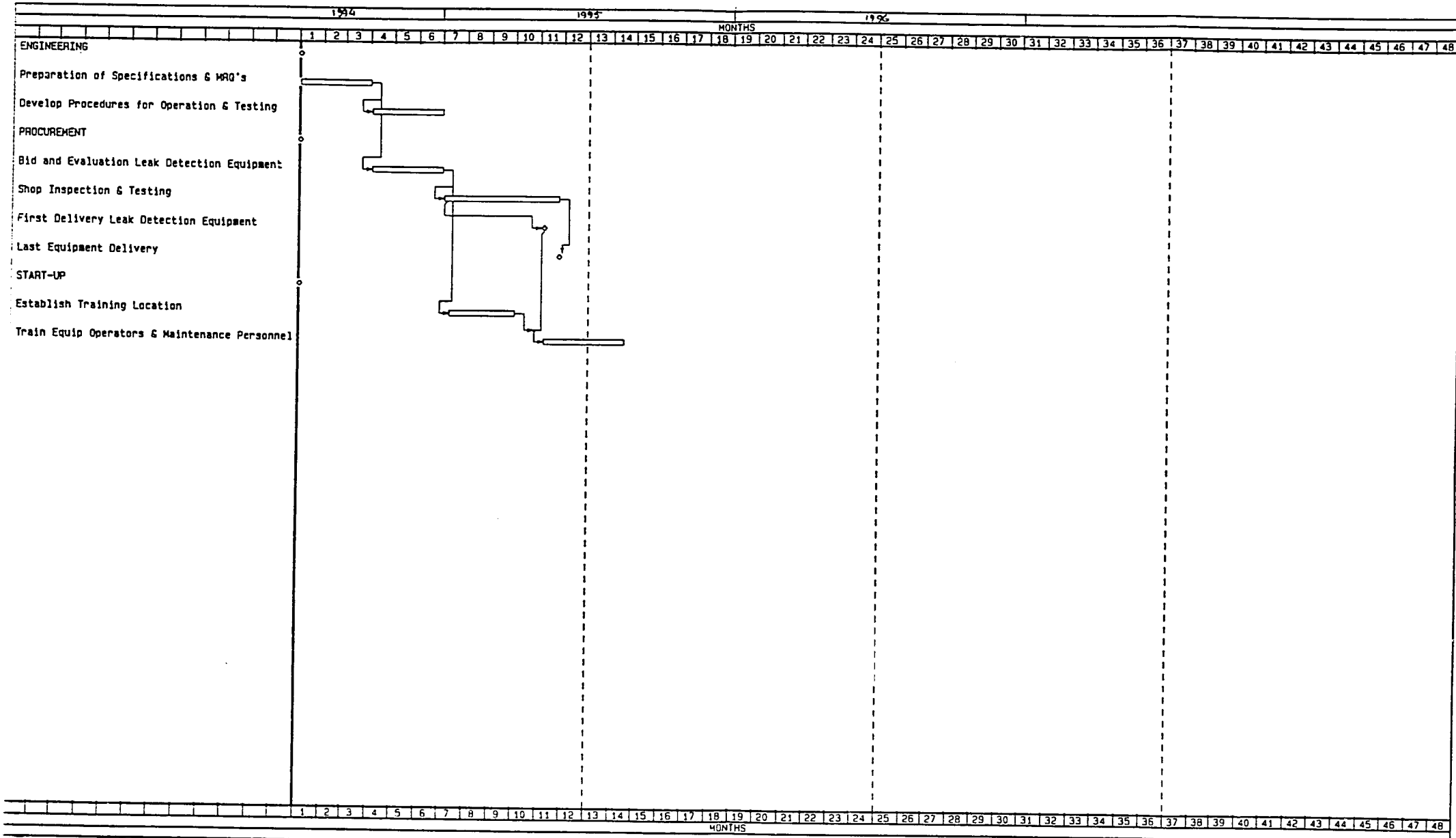
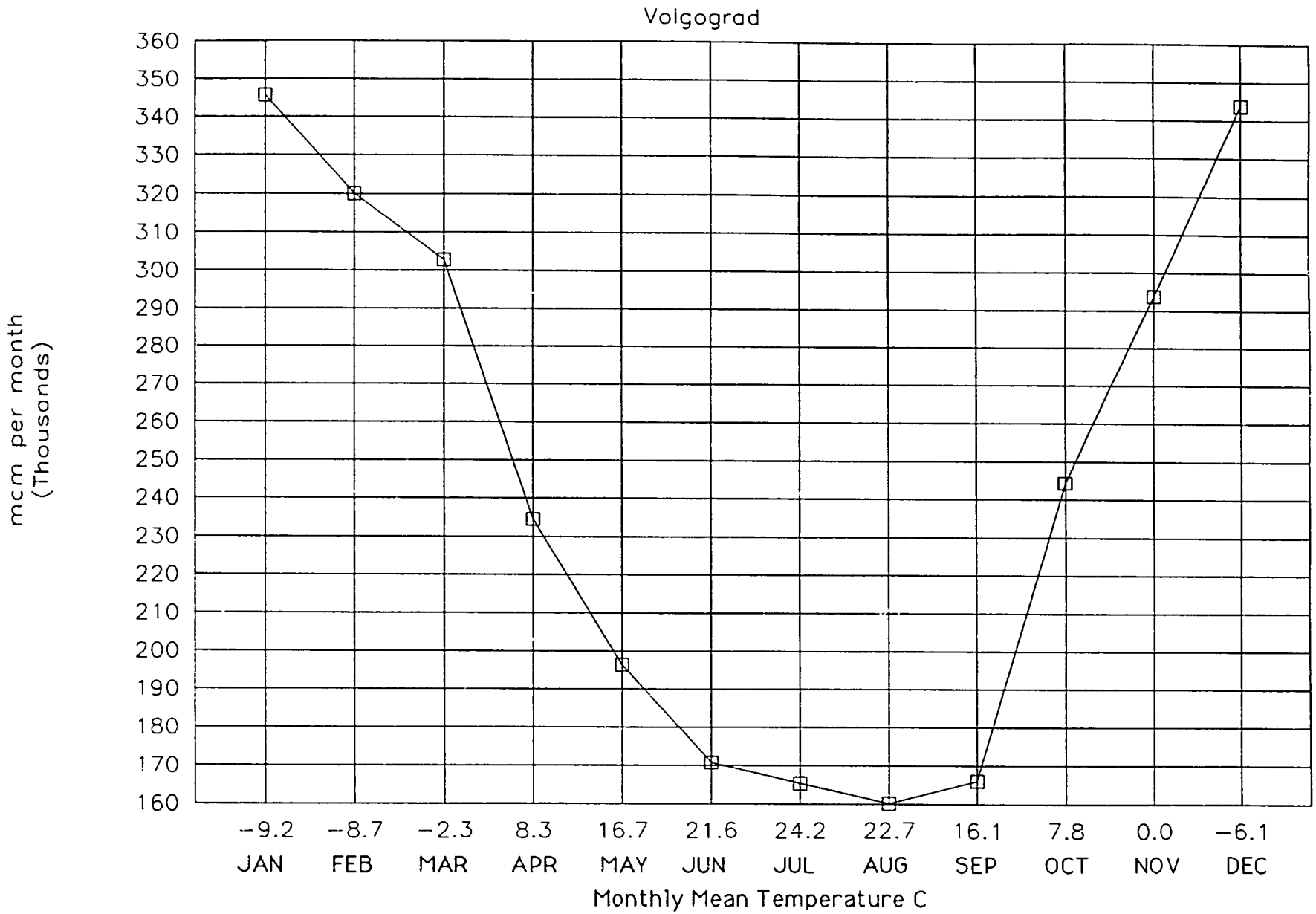
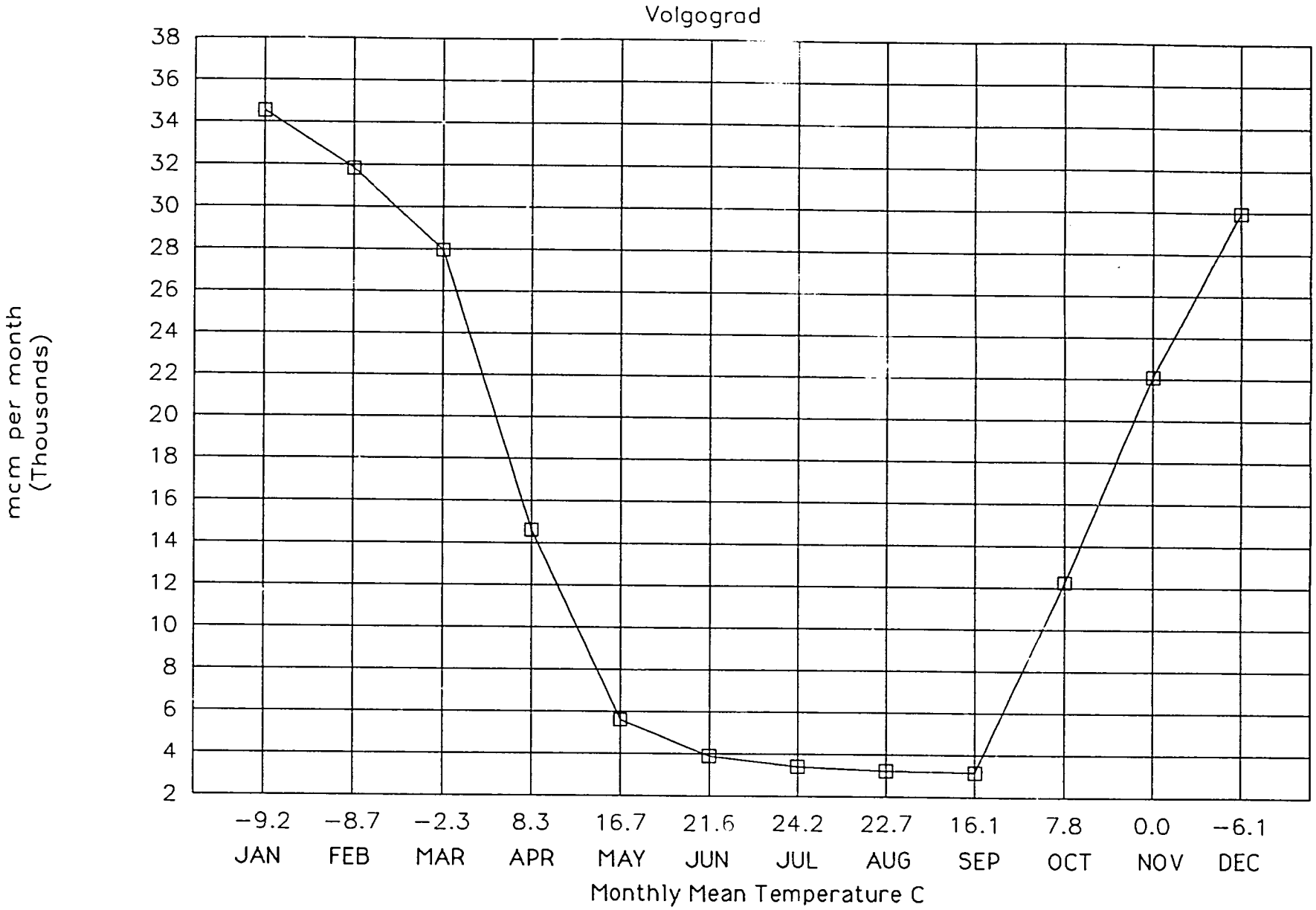


Figure 4-6

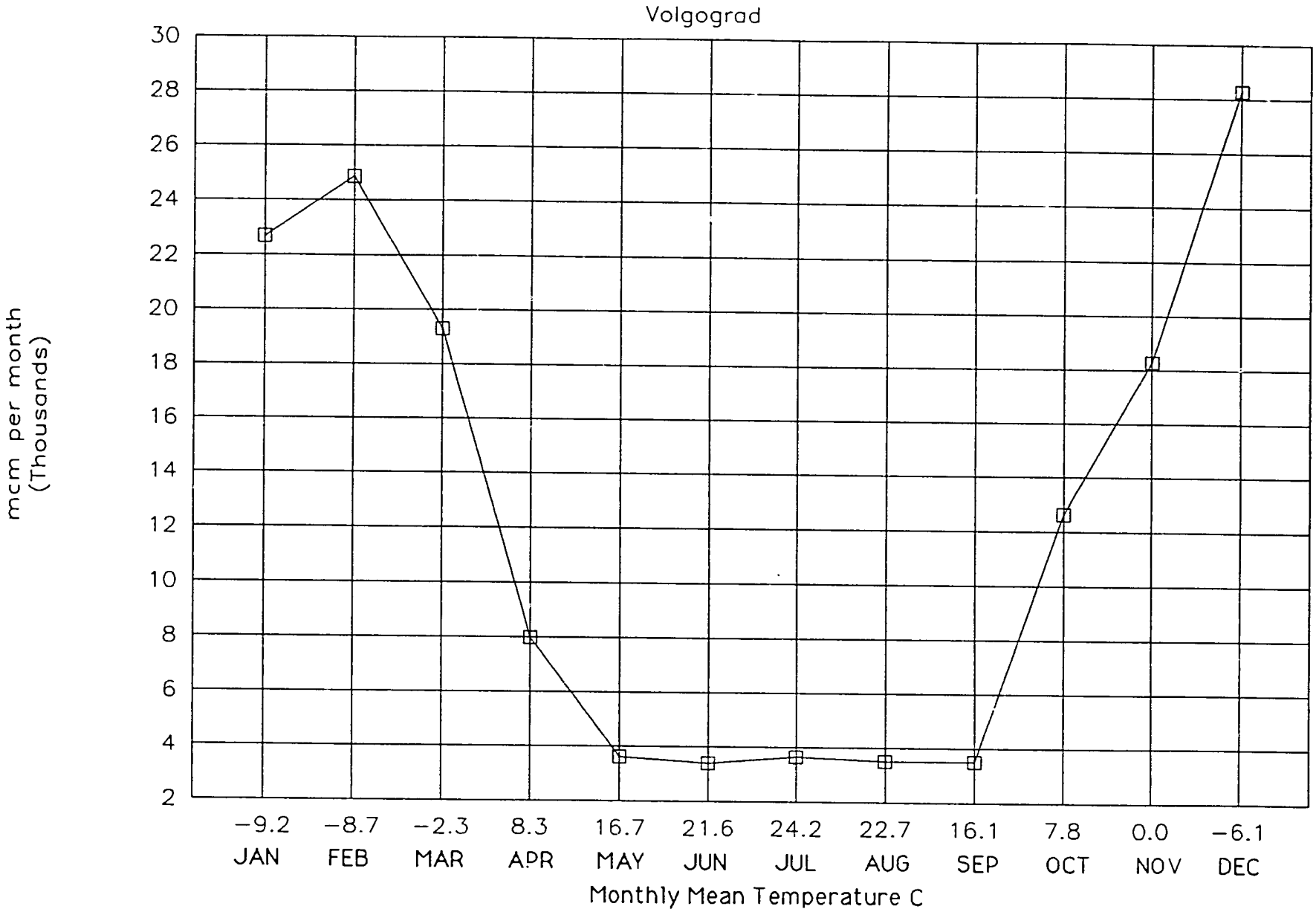
U.S. Agency for International Devel.
NIS Natural Gas System Rehabilitatio
Leak Detection Equipment Procurement



MONTHLY GAS CONSUMPTION
By INDUSTRIAL CUSTOMERS
FIGURE 4 - 7



MONTHLY GAS CONSUMPTION
By COMMERCIAL CUSTOMERS
FIGURE 4 - 8



MONTHLY GAS CONSUMPTION
By RESIDENTIAL CUSTOMERS
FIGURE 4 - 9

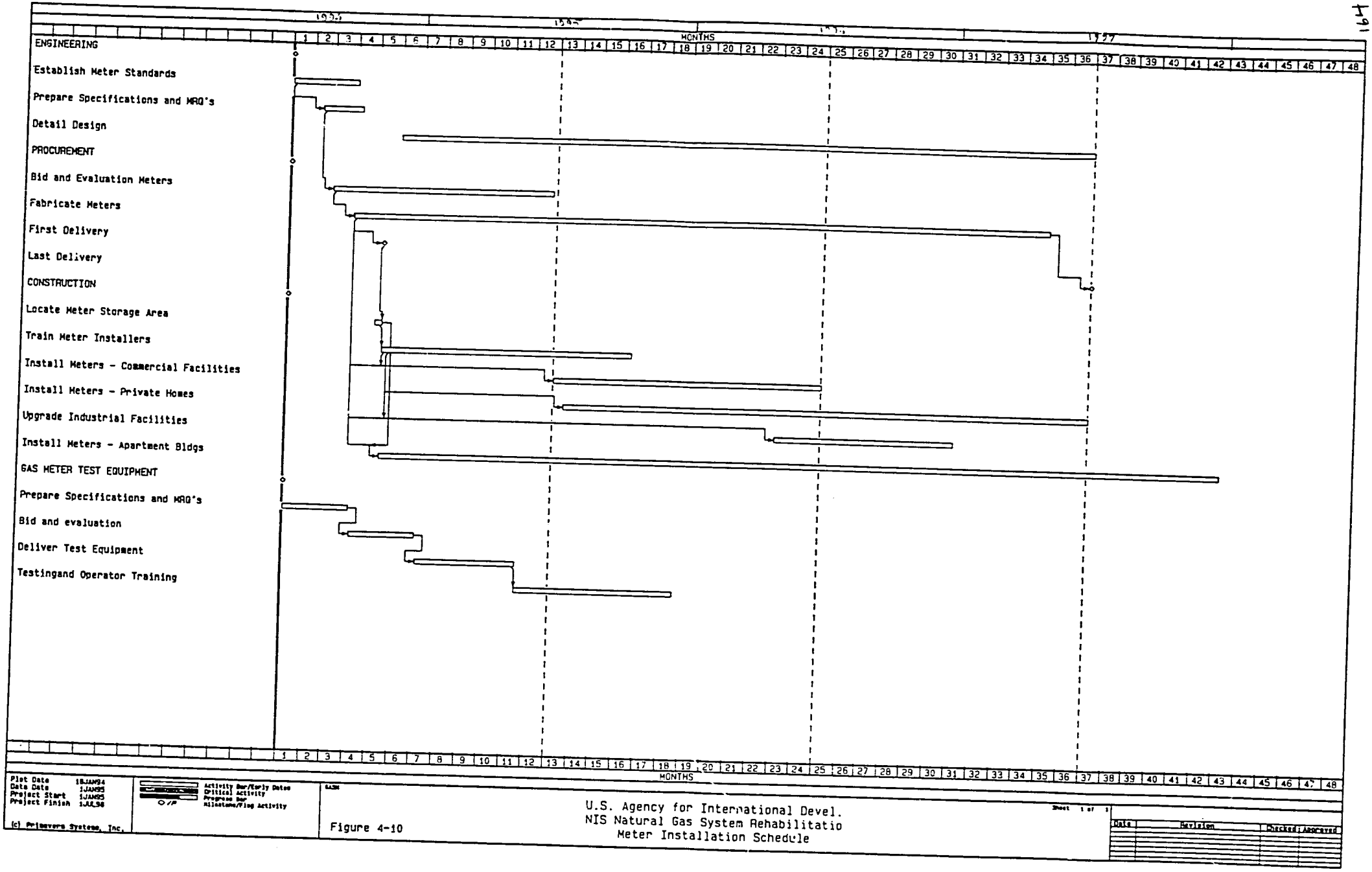


Figure 4-10

U.S. Agency for International Devel.
NIS Natural Gas System Rehabilitatio
Meter Installation Schedule

BEST AVAILABLE COPY

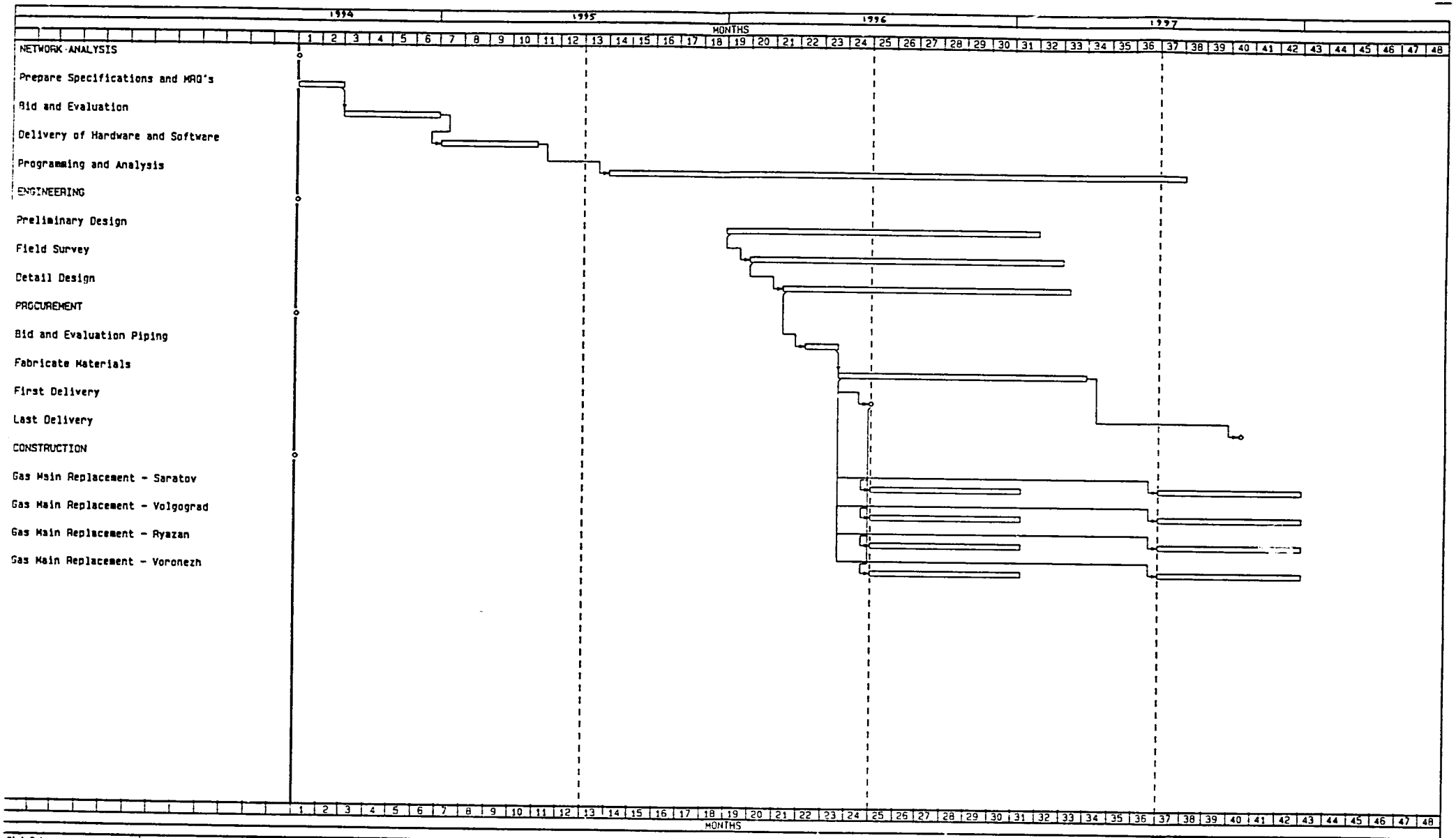
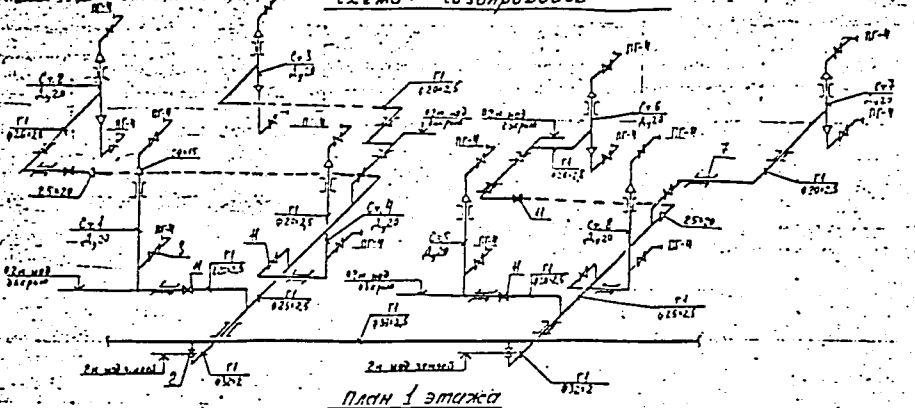


Figure 4-11

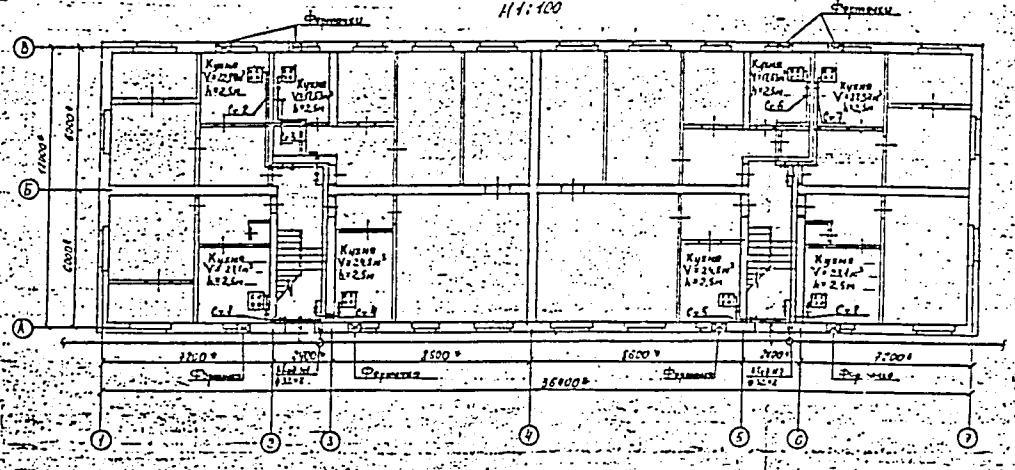
U.S. Agency for International Devel.
NIS Natural Gas System Rehabilitatio
Gas Main Replacement Schedule

BEST AVAILABLE COPY

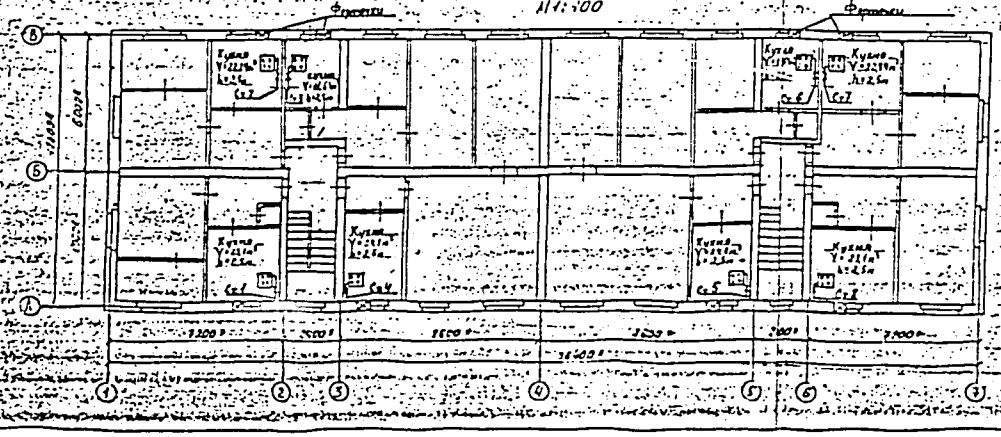
Схема газопроводов



План 1 этажа
М1:100



План 2 этажа
М1:100



Спецификация на газовод наружный и газооборудование внутреннее

Поз.	Обозначение	Наименование	Кол.	Масса ед. кг	Примечание
		Газопровод наружный			
1		Труба	4	1,16	м
2		Кран 11с35с, Ду25, Ру1,6			
		ТУ26-07-1121-87	2	4,9	
3	Серия 5905-9; УСГ 2 СО-1	Гравийная тряпка			
		через газопровод Ду25			
		в траншеях сухих	13	1,93	
		Газооборудование внутреннее			
4		Труба 35×2,8 ГОСТ 10704-91	41	3,39	м
5		Труба 20×2,5 ГОСТ 10704-91	65	1,18	м
6		Труба 15×2,5 ГОСТ 10704-91	10	0,84	м
7	УГН-14-СО-00	Отвод вокруг			
		колена 90 Ду25	24	0,50	
8		Кран 11С27с Ду25 Ру1,6	16		
		ТУ26-07-440-87		0,75	
9	Серия 5905-10; УГ 6.004	Установка гравийная			
		на газ. плитах ПГ-4			
		ГОСТ 10798-75	15	520	
10	Серия 5905-9; УСГ 1.01	Краны	50	0,03	
11		Кран 11С12с Ду20			
		Гр. 4 ТУ26-07-440-87	8	0,37	

DRAWING 4-1

Изм.	Кол.уч.	Лист	Nдок.	Подп.	Дата
Разраб.				
Пров.				
Т.контр.				
Н.контр.				
Утв.				

5810/93-1-ЖС-ГСВ

Газоснабжение по верхним распределительным сетям (Сетевой) объекта: Реконструкция жилого дома № 3 по ул. Кулешова

Стадия: Р | Лист: 6 | Листов:

План 1 этажа, План 2 этажа

Институт: НИИПромзернопроект

BEST AVAILABLE COPY

Section 5

TABLE OF CONTENTS

5. DISTRICT HEATING GAS CONSERSERVATION PROJECTS 1

5.1 INTRODUCTION 1

5.2 EXISTING CONDITIONS AND RECOMMENDED PROJECTS 2

5.2.1 City of Ryazan 2

5.2.2 City of Saratov 3

5.2.3 City of Volgograd 5

5.2.4 City of Voronezh 8

5.3 COST/BENEFIT RANKING OF DISTRICT HEATING PROJECTS 10

5.3.1 Selection Criterion 10

5.3.2 Project Ranking 10

5.4 SUMMARY 11

Table 5-1 Capacity of the District Heating System in City of Ryazan 12

Table 5-2 Summary of District Heating Projects in City of Ryazan 13

Table 5-3 Capacity of District Heating System in City of Saratov 14

Table 5-4 Summary of District Heating Projects in City of Saratov 15

Table 5-5 Capacity of District Heating System in City of Volgograd 16

Table 5-6 Summary of District Heating Projects in City of Volgograd 17

Table 5-7 Capacity of District Heating System in City of Voronezh 18

Table 5-8 Summary of District Heating Projects in City of Voronezh 19

Table 5-9 Ranking of District Heating Conservation Projects in City of Ryazan 20

Table 5-10 Ranking of District Heating Conservation Projects in City of Saratov 20

Table 5-11 Ranking of District Heating Conservation Projects in City of Volgograd 21

Table 5-12 Ranking of District Heating Conservation Projects in City of Voronezh 21

Table 5-13 Summary of District Heating Conservation Projects by City 22

Section 5

DISTRICT HEATING GAS CONSERVATION PROJECTS

5.1 INTRODUCTION

The objective of the Gas Rehabilitation Project is to develop measures that will increase the efficiency of natural gas use in industrial and district heating systems, thereby achieving a reduction in the demand and consumption. Natural gas use was assessed in four Russian cities– Ryazan, Saratov, Volgograd and Voronezh. All these cities have similar gas supply systems.

Typically all cities have 2 to 5 cogeneration plants owned by the energy utility, for example, Ryazanenergo, which generates electricity and heat. The heating medium, usually hot water, is heated in hot water boilers and/or steam-water heat exchangers by steam extracted from the turbines. The hot water is pumped through the transmission piping to the intermediate substations owned by municipal district heating companies, which resell the heat to the customers. The power plants do not usually sell heat directly to the customers, although there are exceptions. In turn, municipal companies usually have their own hot water boilers and, in addition to the resold heat, sell hot water directly to the customers.

Theoretically the temperature of the water supplied is 150°C and that of the return water is 70°C, but in practice the temperature of the supply water is lower while the return water exceeds 70°C. Typically, the heat is not metered–the customers do not have BTU meters. The power plants and municipal boiler plants have flow meters but they are often not accurate or not functioning. The condition of transmission and distribution piping is very poor, with heat loss due to leaks and poor insulation. The average efficiency of boilers installed at power plants is relatively high and close to 90% whereas municipal boilers are very inefficient, in the range of 45 to 50%.

The gas conservation measures recommended include:

1. Burner replacement at municipal boilers.
2. Implementation of portable control instrumentation sets for leak localization, emission control, diagnostic, etc., at power plants and municipal boilers.
3. Heat recovery at power plants and municipal boilers.
4. Reduction of air infiltration to the boilers by sealing the boiler tubes.
5. Installation of automated control systems at boiler plants.
6. Installation of control valves and BTU meters in buildings.

All these recommendations correspond with those made by the following companies conducting energy work in Russia: Honeywell, Johnson Controls, RGG/ Hagler Bailly and Russian Center for Energy Efficiency.

5.2 EXISTING CONDITIONS AND RECOMMENDED PROJECTS

5.2.1 City of Ryazan

District heating is supplied from three primary sources including:

- Ryazanenergo, which owns two cogeneration power plants–Novoryazanskaya TETS and Dyagilevskaya TETS
- Municipal District Heating Company
- Industrial Boiler Plants

Capacities are presented in Table 5-1.

The Novoryazanskaya TETS is a producer of electricity, steam, and hot water as a part of Ryazanenergo Utility. The station is rated at 400 MW electric production. there are four 25 MW, four 59 MW, and one 100 MW turbine/generator sets at the station. They provide steam from non-condensing turbines for industrial customers and hot water for district heating from their turbines as well as six dedicated heating district boilers. There are five boilers of two types supplying the 500°C at 100 kg/cm^2 steam header and five boilers of a single type supplying the 540°C at 140 kg/cm^2 steam header. The hot water export to the city is done from the condensing turbines and six heating district boilers of two designs. Those boilers are rated for 100 and 180 Gcal/hr.

There is approximately 160 km of piping in this system. The heating district piping is in general above ground until it reaches the city substation interfaces. There are approximately 100 substations in the system, and each substation serves 10 to 20 buildings. Some older apartment buildings, large factories, and hospitals typically have their own heating boilers.

The power plant consums 1 million m^3 of natural gas in the course of a year. In 1992, the power plant produced 2,085 MWh.

The gas saving recommendations include:

- Replacement of old burners with new high efficiency burners with incorporated controls to increase an overall boiler efficiency.
- Installation of automated controls at boilers.
- Implementation of a portable set of control instrumentation for diagnostics, leak localization and control.
- Air infiltration reduction at the boiler system.

Dyagilevskaya TETS provides heat (steam and hot water) to a number of industrial customers and also provides district heating to the nearby residential districts. The plant has installed capacity of 100 MW (electric) and 196 Gcal/hr (heating). There are three turbines at the plant rated at 50 MW each. The annual electric production of the station is 531,000 MWh. The total installed district heating capacity is 396 Gcal/hr including district heating capacity of turbines. The total heat produced for 1992 was 1,286 Gcal, and the plant consumed 242.9 million m^3 of gas fuel.

The gas saving recommendations include:

- Economizer installation to utilize flue gas heat for water pre-heating at open type design heating system
- Air infiltration reduction
- Replacement of old gas burners with new high efficiency burners with controls at power plants
- Replacement of old inefficient burners with new high efficiency burners with associated controls at municipal boiler plants
- Installation of BTU meters and control valves in the buildings

The proposed gas conservation projects are consolidated in Table 5-2.

The total implementation cost for selected district heating gas conservation projects in Ryazan is $9,942,800 and the expected reduction in gas consumption is 69,440/1000 m^3 per year. Individual projects are summarized in Appendix 5-A.

5.2.2 City of Saratov

District heating in Saratov is supplied from the three primary sources listed below. Capacities are indicated in Table 5-3.

- Saratovenergo, which owns four cogeneration power plants, GRES, TETS 1, TETS 2, TETS 5 and a district heating boiler plant.
- Municipal District Heating Company, which owns 52 boiler plants and 33 substations

The following plants are owned by various Saratov entities:

- Industrial Boiler Plants, consisting of 196 boiler facilities
- District Heating Boiler Plants, consisting of 304 heat-only boiler facilities

Saratovenergo supplies heat in transmission lines to the substations. This piping ranges in diameter from 325 to 1220 mm. Lower diameter piping is the responsibility of the municipal district heating company. There is approximately 500 km of primary piping installed in Saratov of which 200 km is owned by Saratovenergo. The balance is owned by the municipal district heating company and industrial sites. The 33 substations are owned by the municipal district heating company.

The Municipal District Heating Company in Saratov owns 52 boiler plants and the 33 substations. Thirty three substations separate the responsibility of the central cogeneration plant system from the municipal district heating systems. Equipment arrangements vary from system to system. Most systems have heat exchangers for heating domestic hot water. Domestic hot water heat exchangers have been abandoned in many cases as a result of corrosion and plugged tubes due to poor water treatment of the raw water for the system. End-users are forced to withdraw hot water from the space heating supply system which causes hydraulic instability and poor heat control. Total heating capacity of the domestic hot water load is about 100 Gcal/hr.

170

For 1992, total gas consumption by 52 municipally owned heat-only boiler plants was reported as approximately 31,444/1000 m^3. The average efficiency of boiler plants is 50 to 52%. Total peak heat load of the 52 boiler plants is estimated at 55 Gcal/hr. The years of installation range from 1954 to 1990.

There is approximately 17,000 m of underground piping with sizes up to 219 mm installed in the substation districts. Piping system integrity is fair to poor. Deterioration of insulation from ground water exposure has caused significant heat loss problems. In addition to heat loss, existing underground systems are also experiencing corrosion and leakage.

Gas saving recommendations include:

- Installation of new controls at substations
- New municipal boilers installation
- Replacement of old burners with new high efficiency burners with associated controls
- Implementation of a portable set of control instrumentation for leak localization, diagnostics and monitoring
- Replacement of existing deteriorated piping sections

Saratovenergo cogeneration plants. The total service territory of Saratovenergo is 100,000 sq. km. Saratovenergo has 60,000 km of transmission and distribution electric lines ranging from 0.4 to 500 kV. Saratovenergo comprises 37 administration districts and seven electrical transmission centers. Saratovenergo includes 5 TETS (1 through 5) and 1 GRES The TETS are dispatched in accordance with the district heating schedule. In the winter, Saratovenergo purchases approximately 20% of the electricity from a nuclear plant and in the summer they take approximately 500 MW because of maintenance and repair of power plants

District heating is supplied to three cities: in Saratov 700,000 people are supplied with district heat; in Engels (population of 200,000) 50% of the population are supplied with heat; and in Balacovo (population 250,000 people) 90% of the population is supplied with heat.

- Saratov GRES has five turbines with electric capacity from 6 to 25 MW and total capacity of 55 MW. The installation year ranges from 1941 to 1985. There are nine steam boilers installed rated from 45 to 95 tons/hr. Their installation year ranges from 1930 to 1951. It also has two hot water boilers with capacity of 100 Gcal/hr each. The total heating capacity of the plant is 276 Gcal/hr. The GRES produced and supplied to the customers 1,353,204 Gcal of heat in 1992. The total gas consumption for 1992 was 196,663/1000 m^3.

- TETS 1 is old and has working equipment built in 1934. The first stage consisted of boilers 1, 2 and 3 with capacity of 90 tons/hr of steam at 35 atm and 435°C. There are three turbines at the power plant rated from 6 to 12 MW with total capacity of 25 MW. There are five steam boilers rated from 75 to 90 tons/hr. There is also one hot water boiler with a capacity of 100 Gcal/hr. The total heating capacity of the plant is 276 Gcal/hr. The TETS

produced and supplied to the customers 976,440 Gcal of heat in 1992. The total gas consumption for 1992 was 140,505/1000 m^3.

- TETS 2 is quite old–the first stage was installed in 1955 with a steam capacity of 170 tons/hr and one 25 MW turbine with steam at 500°C and 90 atm. The first stage of the power plant from 1955 to 1958 included five coal fired boilers and 25 MW turbines. The second stage of construction from 1959 to 1965 included 3 boilers with steam capacity of 210 tons/hr at 140 atm. The third construction stage was concluded in 1969. Only one boiler is still coal fired; the other boilers were converted to gas and oil. There are eight turbines at the power plant now rated from 20 to 55 MW with a total capacity of 315 MW and working steam pressures of 90 atm (first four) and 130 atm (the remainder). There are 11 boilers rated from 170 tons/hr to 420 tons/hr. The total heating capacity of the plant is 1,090 Gcal/hr. It produced and supplied to the customers 4,127,286 Gcal of heat in 1992. The total gas consumption for 1992 was 702,987/1000 m^3.

- TETS 5 was started in October 1978. The installed capacity as of the end of 1992 was 440 MW (electric) and 1240 Gcal/hr (heating), including 700 Gcal/hr heating capacity of turbines. There are four district heating units consisting of 4 turbines with a capacity of 100 MW working with steam at 130 atm and 530°C and 4 generating units with a steam capacity of 480 tons/hr (unit 1) and 500 tons/hr (units 2,3,4). Unit #2 was installed in 1980 while unit #3 in 1982 and unit #4 in 1986. The power plant also has three hot water boilers with a capacity of 180 Gcal/hr, installed in 1976, 1978 and 1980, respectively. The total gas consumption for 1992 was 565,168/1000 m^3. Available district heating capacity in 1992 was 700 Gcal/hr which is equal to the heating capacity of the turbines. The installed capacity was in use for 3,589 hours in 1992 and the total amount of heat supplied was 2,537,892 Gcal.

The gas saving measures include:

- Installation of a condensing economizer
- Installation of variable speed controls at district heating pumps motors
- Reduction of air infiltration by sealing the boiler tubes
- Installation of BTU meters and control valves in residential buildings

The proposed gas conservation projects are consolidated in Table 5-4.

The total implementation cost for selected district heating gas conservation projects in Saratov is $17,054,000 and the expected reduction in gas consumption is 75,390/1000 m^3 per year. Individual projects are summarized in Appendix 5-B.

5.2.3 City of Volgograd

The city of Volgograd has an elevation of approximately 41 meters and is located on the west bank of the Volga river. The city is approximately 80 km long and only 5 km wide. The fact that the city is stretched along the Volga river bank over 80 km and is relatively narrow has resulted in numerous small district heating plants united in several groups.

172

District heating is supplied from three primary sources including:

- Volgogradenergo which owns three cogeneration power plants–GRES, TETS-2 and TETS-3, and 3 district heating boiler plants.
- Municipal District Heating Company which owns 203 boiler plants;
  - Voroshilovsky District Heating Company consisting of 16 heat-only boiler facilities
  - Other 187 boiler rooms
- Industrial Boiler Plants consisting of 189 boiler facilities

Capacities are presented in Table 5-5

Volgogradenergo district heating system supplies hot water to four major city districts: Krasnoarmeysky, Central, Voroshilovsky and Dzerzhinsky. The DH system is a closed type with supply/return water temperature of 150/70°C. Each district is equipped with an individual, independent DH system which is not interconnected. The boiler room controls have either failed or were removed. As a result, there are no combustion controls, draft controls, excess air controls, or steam drum level controls for conductivity. In addition all boiler rooms have no pollution control devices and exceed the required emission standards.

The total length of the pipelines is 60.7 km and varies in diameter from 300 to 500 mm. The pipe insulation is mineral wool of which approximately 50% requires replacement . The pipeline network consists of 27% of above ground piping and 73% of underground.

The gas saving measures proposed include:

- Replacement of old burners with new high efficiency burners with incorporated controls to increase an overall boiler efficiency
- Replacement of sections of piping with new pre-insulated pipes
- Implementation of a portable set of control instrumentation for diagnostics, leaks localization and control

Volgogradenergo District Heating system also includes Volgograd GRES, which is described below. No gas saving recommendations were developed regarding this power plant. The station is too old and has to be retired.

The first stage of Volgograd GRES was built in 1930-1931. The cogeneration plant was expanded with the second stage (medium pressure system) before 1941 and the plant was completed in 1950. During the following years, in order to provide district heat to the growing industrial neighborhoods, the station was continuously remodeled and became a major heat and electricity supplier in the city of Volgograd. The primary fuel for the GRES is gas and the secondary fuel is coal. Mazut is used to start the boilers, and there are four tanks available at 175 m^3 each. In 1991–1992 the plant burned 15% coal with a lower heating value of 5,400 kcal/kg and 85% natural gas. The gas is supplied to GRES by pipeline of 600 mm diameter and 3 kg/cm^2. The scheduled amount of gas that GRES is planning to burn in 1993 is 452.6 million m^3, and the hourly rate is 51,600 m^3/hr. The plant is equipped with a hydraulic ash removal system, water treatment system, heat exchanger for converting steam to hot water, cooling tower, pumping station,

feed water pumps and water supply system. Heat capacity of the GRES is 650 Gcal/hr. The system is a closed type and provides heating and domestic hot water to civil districts and steam for industrial enterprises.

The Municipal District Heating System owns 203 boiler plants. It includes the independent Voroshilovsky District Heating Company, described separately, which owns 16 heat-only boiler facilities.

The total gas consumption of the other 187 boiler rooms is estimated at 430 million m^3 per year. The total heat production capacity is 2,423 Gcal/hr. Boiler rooms are usually located in stand-alone buildings and have their own transmission and distribution piping systems.

The gas saving measures proposed include:

- Installation of new district heating boilers with associated controls instead of existing low efficiency boilers
- Replacement of old burners with new high efficiency burners with incorporated controls to increase an overall boiler efficiency
- Implementation of a portable set of control instrumentation for diagnostics, leak localization and control

Voroshilovsky District Heating System is an independent company which owns 16 heat-only boiler facilities. Six of 16 boiler rooms are located in residential apartment buildings and ten boiler rooms are in separate buildings. Fifteen boiler rooms operate on gas and one operates on coal. The average age of the system is about 30 years. The facility employs 195 people including seasonal workers. For 1992, total gas consumption by 15 municipally owned heat-only boiler plants was reported as approximately 18.64 million m^3. Total peak heat load of the 16 boiler plants is estimated at 89.5 Gcal/hr. Installation year ranges from 1958 to 1990. About 90% of customers are residential and institutional buildings and 10% are industrial enterprises.

There is approximately 31,700 m of transmission and distribution piping installed in the municipal district heating system in the Voroshilovsky Distric. Pipe diameters range from 50 to 100 mm (9,000 m length), from 100 to 200 mm (12,800 m), from 200 to 300 mm (8,600 m) and above 300 mm (1,300 m). Piping system integrity is fair to poor. Deterioration of insulation from ground water exposure has caused significant heat loss problems. In addition to heat loss, existing underground systems are also experiencing corrosion and leakage. Overall, more than 70% of piping requires replacement.

The gas saving measures proposed include:

- Installation of 16 new district heating boilers with associated controls
- Replacement of old burners with new high efficiency burners with incorporated controls to increase an overall boiler efficiency
- Implementation of a portable set of control instrumentation for diagnostics, leaks localization and control
- Replacement of sections of piping with new pre-insulated pipes
- Installation of heat meters at the end-user facilities

The proposed gas conservation projects are consolidated in Table 5-6.

The total implementation cost for selected district heating gas conservation projects in Volgograd is $ 18,166,000 and the expected reduction in gas consumption is 115,870/1000 m^3 per year. Individual projects are summarized in Appendix 5-C.

5.2.4 City of Voronezh

Voronezh is a city with a population of approximately 1 million people. The district heating system has a residential saturation of in excess of 90 percent according to municipal authorities. District heating is supplied from three primary sources including:

- Voronezhenergo
  - Two cogeneration power plants–TETS-1 and TETS-2
  - District Heating Company which purchases heat from co-gen plants and owns two small boiler rooms containing 8 boilers
- Municipal District Heating Company which owns 137 boilers
- Industrial Boiler Plants consisting of 10 boiler facilities

TETS-1 and TETS-2 belong to Voronezhenergo and produce about 25% of the total heat consumed by the city. They supply this heat to Voronezhenergo DH Company which produces an additional 10 to 12% of heat and sells all the heat produced by Voronezhenergo (35 to 37% of the total heat supply).

Voronezh industrial facilities are scattered throughout the area and surrounded by residential areas, making it easy to serve the heat load from a number of industrial plants.

These systems are independent without interconnections but have several operating methods in common. They use a 150°C supply and 70°C return water temperature. The water temperature of all the independent districts is coordinated by the central dispatcher of the Voronezh Administration. Except in the instance of a few industrial steam customers, no individual consumer metering is installed. Individual customers are billed on the basis of the size of the area and type of use or the number of members living in the space.

The current distribution of loads served is approximately: Voronezhenergo 35 to 37%, Municipal DH Company about 20%, and industrial boiler plants 43 to 45% of the total city heat supply. Capacities are presented in Table 5-7.

TETS 1 is a production plant for heat and electricity built in 1933and consisting of 13 steam boilers, 6 hot water boilers and 7 turbines. The total installed heating capacity is 1,550 Gcal/hr and the electric capacity is 165 MW. The boilers operate on a combination of coal, mazut and gas. The operating and maintenance staff total 900 employees.

There are 13 steam boilers and 6 hot water boilers at TETS 1. There are seven condensing turbines each rated at 25 MW at the TETS having a 10 atm extraction point for plant steam and steam for sale. TETS 1 has a plan to replace all but 6 of the existing boilers and 3 of the existing turbines with 3 new 520 ton/hr boilers and 2 new turbines rated at 185 MW and 135 MW.

Gas saving recommendations include:

- Replacement of old burners on existing boilers with new high efficiency burners equipped with appropriate controls to increase an overall boiler efficiency
- Reduction of air infiltration by sealing boiler tubes
- Installation of automated controls at existing boilers
- Installation of variable speed motor drives on the distribution pumps

Voronezhenergo DH Company. The company's primary purpose is to distribute heat generated by TETS 1 and TETS 2; however, they also have two small boiler plants containing 8 boilers to meet the needs of their customers. They have 350 people on their operating and maintenance staff. Their total hot water boiler capacity is 210 Gcal/hrf. The company has two small boiler plants and five hot water boilers, three at 50 and two at 30 Gcal/hr. They also have three 10.5 tons/hr steam boilers for use in deaeration and heating of mazut when required. These boilers operate primarily on gas with mazut as an emergency backup. The water treatment is the same as TETS 2 and causes them some problems. The boilers are 25 to 30 years old but appear to be in reasonable condition. The boilers have some form of automatic control but it needs to be brought up to current standards to improve efficiency.

The distribution system serves four districts and consists of 172 km of pipe ranging in size from 155 mm to 1200 mm. About 10 km of pipe is replaced every year, although the company claims average life is 20 to 30 years. Higher replacements occur in problem areas. They have installed individual metering on a few large customers but they still bill on contract usage rather than actual usage.

Municipal DH Company is a part of the city administration and supplies about 20 percent of the district heating. The system is divided into five districts serving the central portion of the city. Each district has a primary boiler plant with supplemental boilers as required to serve the load of the district. The system has a total of 137 boilers with a total capacity in excess of 1,000 Gcal and 150 km of distribution piping. About 10 percent of their heat is purchased from Voronezhenergo as hot water. Their system is operated and served by 1,670 employees. They are permitted to make a profit on the business not to exceed 25% of their costs and they actually make about 11 to 12%. In the center of the city some of the boilers are small and installed underground.

Gas saving measures include:

- Replacement of old burners with new high efficiency burners with associated controls
- Installation of automated controls on existing boilers
- Replacement of insulation on a section of piping and installation of new sections of piping

The proposed gas conservation projects are consolidated in Table 5-8.

The total implementation cost for selected district heating gas conservation projects in Voronezh is $ 8,874,000 and the expected reduction in gas consumption is 28,020/1000 m^3 per year. Individual projects are summarized in Appendix 5-D.

5.3 COST/BENEFIT RANKING OF DISTRICT HEATING PROJECTS

5.3.1 Selection Criterion

In view of the relatively stable and long-term nature of district heating activities, a real rate of return of at least 20 percent was selected as a suitable level for qualifying energy conservation loans as compared with 25 percent for industrial projects.

Gas savings and life extension wsere the identified benefits for all projects. Life extension benefits were estimated on average at 13 years–from 7 years remaining life "as is" to 20 years with retrofit. At a 15% real discount rate, the present value of this life extension amounts to 30% of the total capital cost. Constant 1993 values were used throughout. Gas is valued at a price that rises to $40/1000 m^3 by the end of 1995, before the first year of gas savings. Benefits were taken over 20 years and all expenditures were assumed to take place in the first year.

5.3.2 Project Ranking

The projects described in the preceding sections are ranked in the tables that follow, and implications of the ranking in each city are briefly as follows:

- Ryazan. Eleven projects were considered, of which nine have a real IRR over 20%. Five of the projects that qualify are at Novoryanskaya TETS, three at the Municipal District Heating Company, and two at Dyagilevskaya TETS. The projects involve burner replacement, reduction of air infiltration with new boiler tube seals, control instrumentation, and automated controls. The nine projects provide approximately 65 million c.m. of gas savings at a project cost of just over $8.5 million, which gives a collective rate of return of 41%. Results are summarized in Table 5-9. Cumulative totals at the left of the table sum the cost and gas savings of all projects above the current line.

- Saratov. Nine projects were considered, of which five have a real IRR over 20%. These have a total cost of approximately $9 million and provide a total gas savings of 45 million c.m. The qualifying projects include instrumentation, reduction of air infiltration, burner replacement, BTU meters, and a condensing economizer. The collective rate of return is 30%. Results are summarized in Table 5-10.

- Volgograd. Eleven projects were considered, of which seven have a real IRR over 20%. These have a total cost of approximately $13.6 million and provide a total gas savings of 108 million c.m. (A collective IRR of 42%.) The projects involve instrumentation and burner replacement at facilities of Volgogradernergo, Voroshilovsky, and the Municipal District Heating Companies. Results are summarized in Table 5-11.

- Voronezh. Twelve projects were considered, of which seven meet the criterion for 20% real IRR. The seven projects require a total investment of approximately $9 million and provide gas savings of 45 million c.m., for a collective rate of return of 26%. The projects involve automated controls for TETS 1, TETS 2, and the Municipal District Heating Facilities, and reduction of air infiltration in boiler systems at TETS 1 and TETS 2. Results are summarized in Table 5-12.

5.4 SUMMARY

Results of the district heating conservation survey are summarized in Table 5-13. Some 28 of the 43 projects considered would have a real rate of return of 20% or above. The 28 projects that "qualify" based on rate of return would require a total investment of approximately $42million (1993 $), an average size of approximately $1.5 million. At $40/1000 m^3, the value of the total gas saved would be in excess of $11 million/year, which provides a payback period under four years.

Table 5-1

Capacity of District Heating System in City of Ryazan

	Ryazanenergo		Municipal DH Company	Industrial Boiler Plants	Total
	Novoryazanskaya TETS	Dyagilevskaya TETS			
Number	1	1			
Installed Electric Capacity (MW)	400	100	–	–	500
Installed District Heating Capacity (Gcal/hr)	2,009	396	1,545		3,950
Annual Electric Generation (1000 MWh)	2,124	531	–	–	2,655
Annual Heat Generation (1000 Gcal)	6,522	1,286	4,992		12,800
Annual Gas Consumption (million m^3)	1,100	242.9	572.1		1,915

Table 5-2

Summary Of District Heating Projects in City of Ryazan

Gas saving action	Gas savings	Implementation cost
	1000 m^3/yr.	US $
Dyagilevskaya TETS		
• Air infiltration reduction	650	63,000
• Condensing economizer installation	2,250	394,000
Municipal DH Company		
• Automated control installation	4,760	420,000
• BTU meters and controls in buildings	3,900	1,440,000
• Burner replacement	15,900	1,440,000
• Portable sets of instrumentation	11,200	800,000
Novoryazanskaya TETS		
• Air infiltration reduction	1,100	115,000
• Automated controls installation	1,120	120,000
• Portable set of instrumentation	1,660	100,000
Ryazanenergo		
• BTU meters and controls in buildings	26,900	5,050,000
TOTAL	69,440	9,942,000

Table 5-3

Capacity Of District Heating System in City of Saratov

	Saratovenergo					Municipal System	Industrial Boiler Plants	District Heating Boilers	Total
	GRES	TETS-1	TETS-2	TETS-5	Boiler Plant				
Number	1	1	1	1	1	52	196	304	
Installed Electric Capacity (MW)	55	25	315	440					835
Installed District Heat Capacity (Gcal/hr)	479	276	1090	1240	109.6	158	2100	820	6273
Annual Electric Generation (MWHR)	203,071	70,625	1,044,092	1,968,916					3,286,700
Annual Heat Generation (Gcal)	1,353,204	976,440	4,127,286	2,537,900	166,264	130,000	7,400,000 est.	1,410,000 est.	17,408,000
Annual Gas Consumption (1000 m^3)	196,663	140,505	702,987	565,168	23,970	31,400	771,000 est.	175,000 est.	2,606,700 est. (appears to disagree with GORGAS figures)
Annual Oil Consumption (tons)	37,141	9,702	159,133	163,180			641,000 est.	146,000 est.	1,156,000 est.

Table 5- 4

Summary Of District Heating Projects in City of Saratov

Gas saving action	Gas savings	Implementation cost
	1000 m^3/yr.	US $
Cogeneration plant (TETS 5)		
• Variable speed drives	4,000	1,684,000
• Air infiltration reduction	750	90,000
• Condensing economizer installation	6,300	1,500,000
Municipal DH Company		
• Burner replacement	3,100	420,000
• Controls installation at substations	1,150	552,000
• New boiler installation	3,900	2,593,000
• Portable set of instrumentation	2,850	225,000
• BTU meters and controls in buildings	5,160	1,440,000
Saratovenergo		
• BTU meters and controls in buildings	48,180	8,550,000
TOTAL	75,390	17,054,000

Table 5-5

Capacity Of District Heating System in City of Volgograd

	Volgogradenergo						Voroshilovsky District Heating Company.	Municipal System (rest)	Industrial Boiler Plants	Total
	GRES	TETS-2	TETS-3	Central	Dzerzhinsky	Voroshilovsky				
Number	1	1	1	1	1	1	16	187	189	
Installed Electric Capacity(MW)	121	260	300	–	–	–	–	–	–	681
Installed District Heating Capacity Gcal/hr	650	500	800	200	150	150	89	430	1100	4069
Annual (1992) Heat Generation (Gcal)	343,434	333,874	652,57[illegible]	392,094	321,758	313,949	90,000 est.	2,423,142	1,321,246	6,192,069
Annual Gas Consumption (1000 m^3)	452,600	440,000	860,000	6[illegible],700	47,000	51,400	18,644	462,850	1,366,904	3,762,098

Table 5-6

Summary Of District Heating Projects in City of Volgograd

Gas saving action	Gas savings	Implementation cost
	1000 m^3/yr.	US $
Municipal DH Company		
• Boiler replacement	34,700	8,870,000
• Burner replacement	21,900	1,400,000
• Portable sets of instrumentation (extended)	23,143	902,400
Volgogradenergo DH Company		
• Portable set of instrumentation (extended)	8,050	222,400
Volgogradenergo DH System		
• Section of piping replacement	4,374	2,392,000
Voroshilovsky DH Company		
• BTU meters and controls	746	235,000
• New boiler installation	2,820	1,883,000
• Portable set of instrumentation	1,864	90,000
TOTAL	97,597	15,994,800

Table 5-7

Capacity Of District Heating System in City of Voronezh

	Voronezhenergo				Municipal DH Company	Industrial Plants	Total
	TETS-1	TETS-2	DH Company (boilers)	Total Voronezhenergo			
Number	1	1	8		137	10	
Installed Electric Capacity (MW)	164	12	–	176	–		176
Installed District Heating Capacity (Gcal/hr)	1550	655	210	2415	1000 approx.	2750	6165
Annual Electric Generation (1000 MWh)	1195	34	–	1229	–	–	1229
Annual Heat Generation (1000 Gcal)	5612(1)	1372(2)	400	7384	800 est.	5225 est.	13404
Annual Gas Consumption (million m^3)	1030.6	118.5	81.1	1230.2	201.3	836(3) est.	2267.5

(1) - natural gas is 95.3% of the fuel consumed, the rest is mazut and coal.
(2) - natural gas is 57.1% of the total plant fuel consumption.
(3) - estimated industrial plants gas consumption only for district heating.

Table 5-8

Summary Of District Heating Projects in City of Voronezh

Gas saving action	Gas savings	Implementation cost
	1000 m^3/yr.	US $
Municipal DH Company		
• Automated controls	4,000	308,400
• BTU meters and controls in the buildings	4,050	1,250,000
• Burner replacement	8,800	1,781,500
• Sections of piping replacement	2,020	1,258,000
TETS 1		
• Air infiltration reduction	1,350	120,000
• Automated controls	2,040	170,000
• Variable speed motor controls	3,160	1,362,000
TETS 2		
• Air infiltration reduction	600	63,000
• Automated controls	550	84,000
• Superheater tube replacement	320	107,000
Voronezhenergo		
• BTU meters and controls in the buildings	27,500	6,550,000
TOTAL	54,390	13,053,900

Table 5-9

Ranking of District Heating Conservation Projects in City of Ryazan

Ryazan District Heating Projects	Investment Required 93 $000	Gas Saved 1000 m^3	IRR	Cumulative Investment 93 $000	Cumulative Gas Saving 1000 m^3
Novoryanskaya TETS - Control Instrumentation	100	1,660	84%	100	1,660
Municipal DH Co. -Instrumentation	800	11,200	72%	900	12,860
Municipal DH Co. - Automated Controls	420	4,760	59%	1,320	17,620
Municipal DH Co. - Burner replacement	1,440	15,900	57%	2,760	33,520
Dyagilevskaya TETS - Reduce Air Infiltration	63	650	54%	2,823	34,170
Novoryanskaya TETS - Reduce Air Infiltration	115	1,100	50%	2,938	35,270
Novoryanskaya TETS - Automated Controls	120	1,120	49%	3,058	36,390
Dyagilevskaya TETS - Install Economizer	394	2,250	31%	3,452	38,640
Ryazanenergo - BTU Meters & Controls	5,050	26,900	29%	8,502	65,540
Municipal DH Co. - BTU Meters & Controls	1,440	3,900	14%	9,942	69,440
Dyagilevskaya TETS - Replace Burners	2,636	1,650	-4%	12,778	71,090

Table 5-10

Ranking of District Heating Conservation Projects in City of Saratov

Saratov District Heating Projects	Investment Required 93 $000	Gas Saved 1000 m^3	IRR	Cumulative Investment 93 $000	Cumulative Gas Saving 1000 m^3
Municipal DH - Instrumentation	225	2,850	65%	225	2,850
TETS 5 - Reduce Air Infiltration	90	750	44%	315	3,600
Municipal DH - Replace Burners	420	3,100	39%	735	6,700
Saratovenergo - BTU Meters & Controls	8,550	48,180	30%	9,285	54,880
TETS 5 - Install Condensing Economizer	1,500	6,300	22%	10,785	61,180
Municipal DH - BTU Meters & Controls	1,440	5,160	19%	12,225	66,340
TETS 5 - Install Variable Speed Drives	1,684	4,000	12%	13,909	70,340
Municipal DH - Controls at Substations	552	1,150	10%	14,461	71,490
Municipal DH - New Boiler	2,593	3,900	6%	17,054	75,390

Table 5-11

Ranking of District Heating Conservation Projects in City of Volgograd

Volgograd District Heating Projects	Investment Required 93 $000	Gas Saved 1000 m^3	IRR	Cumulative	
				Investment 93 $000	Gas Saving 1000 m^3
Volgogradenergo - Instrumentation	222	8,050	174%	222	8,050
Municipal DH - Instrumentation	902	23,143	126%	1,125	31,193
Voroshilovsky - Instrumentation	90	1,864	103%	1,215	33,057
Municipal DH - New burners	1,400	21,900	79%	2,615	54,957
Volgogradenergo - New Burners	1,577	14,100	47%	4,191	69,057
Voroshilovsky - New burners	596	4,200	37%	4,787	73,257
Municipal DH - New boilers	8,870	34,700	21%	13,657	107,957
Voroshilovsky - BTU Meters	235	746	17%	13,892	108,703
Volgogradenergo - New Piping	2,392	4,347	8%	16,284	113,050
Voroshilovsky - New boilers	1,883	2,820	6%	18,167	115,870
Voroshilovsky - New piping	1,577	1,163	-2%	19,743	117,033

Table 5-12

Ranking of District Heating Conservation Projects in City of Voronezh

Voronezh District Heating Projects	Investment Required 93 $000	Gas Saved 1000 m^3	IRR	Cumulative	
				Investment 93 $000	Gas Saving 1000 m^3
Municipal DH - Automated Controls	308	4,000	67%	308	4,000
TETS 1 - Automated Controls	170	2,040	62%	478	6,040
TETS 1 - Reduce Air Infiltration	120	1,350	58%	598	7,390
TETS 2 - Reduce Air Infiltration	63	600	50%	661	7,990
TETS 2 - Automated Controls	84	550	35%	745	8,540
Municipal DH - Replace Burners	1,782	8,800	26%	2,527	17,340
Voronezhenergo	6,550	27,500	22%	9,077	44,840
Municipal DH - BTU Meters & Controls	1,250	4,050	17%	10,327	48,890
TETS 2 - Replace Superheater Tubes	107	320	16%	10,434	49,210
TETS 1 -Install Motor Controls	1,362	3,160	11%	11,796	52,370
Municipal DH - Replace Piping/Insulation	1,258	2,020	6%	13,054	54,390
TETS 1 - Replace burners	1,806	1,180	-3%	14,860	55,570

Table 5-13

Summary of District Heating Conservation Projects by City

Summary	Projects Considered	"Qualified" Projects	Investment Required 1993 $000	Gas Saved 1000 m^3
Ryazan	11	9	8,502	65,540
Saratov	9	5	10,785	61,180
Volgograd	11	7	13,657	107,957
Voronezh	12	7	9,077	44,840
Totals	43	26	42,021	279,517

Section 6

TABLE OF CONTENTS

6. INDUSTRIAL ENERGY CONSERVATION PROJECTS 1

6.1 INTRODUCTION 1

6.2 EXISTING CONDITIONS AND PROPOSED PROJECTS 1

6.2.1 City of Ryazan 1

6.2.2 City of Saratov 3

6.2.3 City of Volgograd 7

6.2.4 City of Voronezh 10

6.3 COST/BENEFIT RANKING OF INDUSTRIAL PROJECTS 12

6.3.1 Selection Criterion 12

6.3.2 Project Ranking 13

6.4 SUMMARY 13

Table 6-1 Summary of Industrial Conservation in City of Ryazan 15

Table 6-2 Summary of Industrial Conservation in City of Saratov 16

Table 6-3 Summary of Industrial Conservation in City of Volgograd 17

Table 6-4 Summary of Industrial Conservation in City of Voronezh 18

Table 6-5 Ranking of Industrial Conservation Projects in City of Ryazan 19

Table 6-6 Ranking of Industrial Conservation Projects in City of Saratov 19

Table 6-7 Ranking of Industrial Conservation Projects in City of Volgograd 20

Table 6-8 Ranking of Industrial Conservation Projects in City of Voronezh 21

Table 6-9 Summary of Industrial Conservation Projects by City 21

Section 6

INDUSTRIAL ENERGY CONSERVATION PROJECTS

6.1 INTRODUCTION

One objective of the Gas Rehabilitation Project is to develop measures to increase the efficiency of natural gas use in industrial plants. To develop such measures, energy audits were performed in the four cities with the support of the State Research Institute GIPRONIIGAS and the local city gas supply utility GORGAS. GORGAS provided general information on gas consumption of each city and identified industrial enterprises with the largest gas consumption. The Project Team audited six to eight of the largest gas consumers in each city. At the industrial plants, the Team was accompanied by the Chief Energy Engineer or his staff and assessed plant process equipment and operations, reviewed schematics of energy utilization systems wherever possible, and obtained records of natural gas use by the facility. During the audit, an assessment was made of the gas firing equipment including furnaces, kilns and boilers. After the assessment, preliminary gas saving actions were identified.

There are two main areas of gas consumption at almost any industrial plant–the production process and boiler room. Gas utilized in the process is fired in ovens and furnaces, used for cutting, welding, etc., or as part of the feedstock. Some industrial customers do not have boiler plants and purchase heat from the local energy utility, utilizing all gas in the process. Alternatively, all gas may be fired in a large boiler room belonging to the particular industrial facility, but usually gas is utilized in both ways. Gas fired boiler plants supply heat (steam often for the process and hot water for heating) and sometimes supply other industrial plants in the same area and very often district heating for the adjacent residential buildings as well.

The Team surveyed various industrial plants to examine the different uses of gas. Those included steel facilities, brick factories, glass factories, oil refinery plants, greenhouses, aluminum plants, automobile components plants, electronic device manufacturers, tannery, construction materials factories, rubber plants, chemical industries, food processing plants and others. Some of the identified enterprises could not be surveyed for reasons of military security. At others plants the information on the process and its equipment was not released for the same reasons.

The estimate of the amount of gas that can be conserved was based on the waste heat stream flow rate and heating value of gas fuel. All assessments were made based on U.S. equipment costs, except when known Russian equipment met the world standards. Installation costs were based on the cost of local Russian labor with an average monthly salary of 75,000 rubles ($75/mo) for construction workers and 100,000 rubles ($100/mo) for engineering staff. Engineering support by western specialists was costed at western rates. All cost estimates are preliminary and include an 11% surcharge for shipping to St. Petersburg and 3% for shipping inside Russia.

6.2 EXISTING CONDITIONS AND PROPOSED PROJECTS

6.2.1 City of Ryazan

The total gas consumption by all industrial customers, including power plants, was 1,915,100/1000 m^3 in 1992. Gas consumption of all industrial facilities in the city was 572,700/1000 m^3. The Team examined six industrial facilities which consume 247,200/1000 m^3, or 43.2% of the total industrial gas consumption. Principal industries include metal processing plants, an automobile component manufacturer, and an electronic device manufacturer. The largest

industrial gas consumer in the city is the ZIL Automobile Component Plant, which consumed 115 million m^3 of gas in 1992.

The industries examined are described in the following paragraphs:

Electktronpribor Corporation primarily manufactures electronic devices, modulator and generator bulbs (for welding purposes) and many kinds of lighting bulbs including halogen bulbs. Purchased raw materials are metals, including precious metals, and glass components. The company employs 9,000 people working in three operating shifts. The total natural gas consumption for 1992 was 33,269,000 m^3.

The gas saving recommendations include:

- Replace the 1963 steam boiler with one new hot water boiler
- Install a heat exchanger to preheat the makeup water with the hot boiler blowdown
- Install automatic controls for the two glass furnaces
- Install a refractory lined stack with heat recovery equipment located behind the stack.

ZIL Automobile Component Plant manufactures front and rear axles, crankshafts, beams and frames, plastic molding and cold stampings of automobile and truck parts. The axles are manufactured by hot forging processes which require high temperatures and consume large amounts of gas. The hot oven furnaces are gas-fired, and the percentage of energy cost in the final product is 42%. The total gas consumption in 1992 was 115 million m^3.

The gas saving recommendation is:

- Installation of a heat recovery equipment to lower the exhaust temperature while preheating the combustion air.

Ryazan Color Metal Manufacturing and Reprocessing Plant consists of five major shops. They include a melting shop, which performs the primary step in the alloy processing, a metal processing shop, and a hydro-metallurgical shop, which produces tin and lead alloys from its ores. The cleaning shop, which receives products from the melting shop, performs a rough cleaning of the alloy. The fifth major shop contains the cold rolling process. The plant consumed 30 million m^3 of natural gas in 1992.

After review of the current process, no short-term gas conservation measures are recommended. The company is considering replacing the existing evaporators with multi-case vacuum evaporators in the next three years.

Metal Forging/Press Plant is privatized as a joint stock company with 2,000 employees working two and three shifts a day. There are seven shops located in the factory. The facility has 40 gas fired furnaces for forging and metal heating purposes, which use 13.75 million m^3 of gas per year.

The gas saving recommendation is:

- Install automatic controls on the melting furnace.

Implementation of automatic controls would result in fuel savings and improve the quality of the product by more accurately maintaining the proper temperatures.

Ryazan Tannery Plant employs 2000 people. The plant processes cattle skins into sheets of leather. The factory was built as a turnkey project by an Italian firm and the major process equipment is Italian manufactured. There are seven major and seven auxiliary shops in the plant. Some of the auxiliary shops are the boiler room, compressor station, sewage treatment plant and ventilation shop. The annual gas consumption is 19.85 million m^3.

The gas saving recommendation is:

- Install heat recovery equipment to recover a greater portion of the flue gas heat if the production load is expected to increase.

Recovered heat from high temperature furnaces can be utilized by supplemental firing of flue gases in new waste heat recovery boilers (low temperature thermal furnaces)

The proposed gas conservation projects are consolidated in Table 6-1. Individual projects are summarized in Appendix 6-A.

Summary

The total implementation cost for proposed industrial gas conservation projects in Ryazan is $4,052,000 and the expected reduction in gas consumption is 29,502/1000 m^3 per year. Project estimated costs and savings are summarized in Table 6-1.

6.2.2 City of Saratov

The total gas consumption by all industrial customers in 1992 was 946,010 (1000 m^3). The Team examined thirteen industrial facilities which consume 520,290/1000 m^3 of gas or 55% of the city's total industrial gas consumption. The principal industries include construction material production, a glass manufacturer, a rubber products manufacturer, electronic equipment production, food processing and chemical products factories, and an oil refinery. The largest industrial gas consumer is Nitron Chemical Factory, which uses 80 to 90 million m^3 of natural gas per year.

The industrial facilities surveyed are described in the following paragraphs.

The Red Brick Factory consists of two independent factories that make identical red brick products. The major raw material, clay, is heated with steam, mixed with water, and pressed into a mold. A cutting machine slices the material into bricks, which are then dried and moved to a kiln, where they are baked for 56 hours at 960°C.

The major gas consuming equipment consists of a steam boiler, two hot water boilers, five hot air furnaces and a brick kiln. The gas used in manufacturing the bricks makes up 22% of the cost of the bricks. Production has remained steady, despite an increase in the cost of materials.

The gas saving recommendations include:

- Install a heat recovery wheel in the exhaust of the brick kiln
- Replace a hot water boiler.

This unit will save gas and allow maintenance to be performed on any of the 5 hot air furnaces without having to stop the production process. There is no recommendation to reduce the

energy consumption on the steam boiler. However, a modulating gas burner and replacement boiler for two of the three hot water boilers which serve 500 apartments is recommended.

Reinforced Concrete Factory. The reinforced concrete is produced in molds consisting of a large metal base with four sides hinged to the base. Rebar is bent to shape by hand and put in the mold after it is greased. The sides are then raised and locked into position, and concrete is poured into the mold. Several molds are in a diked area. After the lid is placed over the mold, steam heats the concrete to 80 to 90°C for 8 to 12 hours. The annual gas consumption of the factory is 32 million m^3.

Gas saving recommendation is:

- Convert all of the steam concrete dryers to a gas fired hot air drying system

Rubber Products Facility. The main products, which constitute 70% of the production, are battery cases for cars and motorcycles. The scrap rubber from this process is used to make plastic lawn chairs, pails, shopping bags, pipe for farm irrigation and garden hoses. The annual gas consumption of the factory is 19.5 million m^3. Gas fired equipment consists of 4 boilers rated for 18 tons/hour of steam at a pressure of 23 atm, but operating at 8 atm. One of the two boilers in each boiler room is dual fuel fired.

Gas saving recommendations include:

- Replace one boiler in each of the two boiler rooms
- Install condensate recovery system
- Install a condensate receiver in each vulcanization shop.

The first two steps would allow operation during the summer at full fire and improved tracking of the load during mild winter days.

Electrounit Production Operation (SEPO). This factory was built in 1940 as an electrical and electronic specialty equipment manufacturer of airplane equipment. The factory now produces refrigerators, which make up 70% of production. Other products include arc welders. The factory is privatized and employs 20,000 people, working 6 days a week, 2 or 3 shifts per day. The annual gas consumption is 28 million m^3.

The boiler plant generates steam for use within the factory and produces hot water, which is pumped to the nearby town. There are seven boilers installed at the factory. Four are gas fired water wall steam boilers which operate at 4 atmospheres (150°C) and are rated for 15 ton/hr. Two are used year round and two are backup. All four are as old as the factory, about 50 years.

Gas saving recommendations include:

- Replace steam boiler
- Replace gas burners with new burners with associated controls.

The new boiler should have automatically modulating gas burner controls. The steam pressure will then remain constant, increasing the quality of production and reducing the cost of production. This equipment will also reduce the factory's emissions.

The Dry Ice & Ice Cream Facility was built in 1973 and is "open" privatized. (Anyone can buy stock in the company.) They manufacture ice cream and dry ice to keep the ice cream cold

during transport and sales. 10 million m^3 of gas is consumed per year. 470 people are employed on two shifts to make 3,500 tons of ice cream and 1 ton/day of dry ice.

Gas saving recommendations include:

- Replace existing CO_2 recovery
- Replace one of the production lines.

One of the smaller boilers should also have automatic burner controls installed for accurate load following.

The Nitron Chemical Factory was built in 1953 and uses 80 to 90 million m^3 of gas per year. The five product lines have the following production capacity:

• Fibers (Nitron)	60 tons/day
• Nitrite acrylic acid	25 car train load/day
• Vinegar-technical	35 tons/day
• Acetone-nail polish	40,000 tons/year
• Formic acid	not yet functioning

The factory maintains production 24 hr./day, 7 days a week employing 6,000 people.

The gas conservation recommendation is:

- Install automatic controls on the 6 waste heat recovery boilers

The implementation of this measure would reduce the stack temperature from 170°C to 130 to 140°C.

The Glass Factory has six large glass smelters and six small ones, all fired by gas. Three of the small smelters are used to produce crystal. The factory produces 5.5 million m^2 of 4 to 6 mm thick glass per year. The maximum dimension is 3 x 3.5 m. The factory fires 600,000 m^3/day in winter and 420,000 m^3/day in the summer. The factory employs 7,000 workers. The amount of gas used in 1992 was 195.67 million m^3.

The glass smelters use about 75% of the gas. Over the years some smelter improvements have included a change of design and better insulation, which reduced the original gas consumption by 17 to 20%. Presently the efficiency of the smelters is about 30%.

The gas saving recommendation is:

- Install heat recovery system behind the refractory lining of the stack

A more cost effective solution than the previous improvements is to install heat recovery equipment. The stack would be 90 to 120 feet high. This height will allow the particles to settle out at the base of the stack. Automatic equipment to remove the particles without having to shut down the stack can be installed. This equipment is not recommended on the small ovens at this time because they will have exhaust of different chemical composition that may raise the cost of the heat recovery equipment.

The Food Fat-Products Factory makes margarine, mayonnaise, stearine, glycerin, soup, olive oil, fatty acids and dry ice. The plant employs 904 people. Some products are manufactured around the clock. Gas consumption is 2.3% of the product cost. The annual gas consumption for 1992 was 36.324 million m^3

The gas saving recommendation is:

- Install two new boilers.

A 10 ton/hr and a 3 ton/hr boiler will provide the required range of load-following. This project will provide an updated burner and control system in addition to a backup boiler during the winter. The existing boilers can be used for the base load and the new boilers will track the load. When the larger of the two new boilers reduces to low fire, that could automatically signal the new smaller boiler to turn on and go to high fire. The other boilers will remain on high fire where they can be set to run efficiently. This procedure will minimize the investment required and provide considerable cost savings.

The Concrete Factory manufactures concrete elements and cuts stone (marble, granite) for the construction industry. They also manufacture wooden window frames, chair legs, and doors. The factory generates 18,000 Gcal/month of hot water during the winter for the local village. They use 15,000 Gcal/month of concrete products. There are extra steam boilers which generate hot water for local region heating. In a separate building, hot water is generated by steam in a heat exchanger to serve the military barracks where the military recruits sleep. The total annual gas consumption is 32 million m^3.

The concrete drying ovens would benefit from conversion of the current steam drying system to a direct gas fired hot air system, if production picks up again. It may be more economical to have the concrete products built at other, larger factories that have already been privatized. The factory could switch to making more wood products. No measures are recommended for this facility.

The White Brick Factory uses 30,000 m^3/day of gas in the winter and 17,000 m^3/day of gas in summer, for a total of about 8 million m^3/yr. The factory manufactures approximately 400,000 bricks per day which totals about 140 million bricks per year, in 3 shifts/day, 7 days a week. The bricks are made primarily from silicate, mixed with lime and hot condensate. The bricks are formed in an automatic process and manually transferred to a wheeled pallet on railroad tracks. These carts are then put into an autoclave (a large kiln) which takes approximately 1-1/2 hours to preheat, and remains at about 180 to 185°C for 6-1/2 hours and takes about 1 hour to cool down.

The only way the factory can reduce fuel consumption is to replace some older boilers which are 88% efficient with new boilers which will be 90% efficient. That would not be cost effective. Wider use of this type of brick instead of the red bricks whose production consumes five times more energy would be the best way to encourage energy efficiency. Thus, no gas conservation measures are recommended.

The Almaz Electronics Research Factory manufactures electronics and electrical products. At present they are more concerned with scientific and industrial research than with manufacturing. The principal project in conjunction with GIPRONIIGAS Institute is to develop manufacture of electronic gas meters. It is felt by Almaz that by installing meters in each apartment, gas consumption will be reduced. Therefore no gas conservation measures can be offered.

The Bread Factory was built in 1961 and uses 1.8 million m^3 of gas per year. The plant bakes approximately 70 tons of bread each day. The factory maintains production 24 hr/day, 7

days a week employing 250 people. The demand for bread has risen, despite price increases, because other foods have risen even higher.

The bread factory plans on replacing ovens due to the quick payback. It would not be cost effective to equip one of the boilers with automatic burner controls. A savings of 10% on the annual fuel bill would result in a 10,000 m^3/year savings. That would not justify an investment of $10,000. There are no recommended changes for this factory.

The Oil Refinery was built in 1940 for the production of petroleum products. Crude oil is the basic raw material and produces:

- gasoline
- kerosene
- diesel
- lubricating oil

The factory uses 27 million m^3 of gas each year. 95% of that gas is used in refinery ovens. A US and two Spanish firms have already offered new, high efficiency ovens. But since any new ovens would not allow older ovens to be taken out of service, there is no recommendation for this factory.

The proposed gas conservation projects for Saratov are consolidated in Table 6-2. Individual projects for industrial plants in Saratov are presented in Appendix 6-B.

The total implementation cost for selected industrial gas conservation projects in Saratov is $5,039,970 and the expected reduction in gas consumption is 102,435/1000 m^3 per year.

6.2.3 City of Volgograd

The total gas consumption by Volgograd's industrial plants in 1992 was 1,366,900/1000 m^3. The Team examined seven industrial facilities which consume 657,400/1000 m^3 or 48.1% of the city's total industrial gas consumption. Principal industries include tractor manufacturing, steel and aluminum production, and petroleum refining. Woodworking plants process timber floated down the Volga. Other industries include petrochemicals, synthetic fibers, and brick production. Much of the electric power consumed by industry is generated by a 2500 MW hydroelectric station on the Volga River, the largest hydroelectric station in European Russia, completed in 1957.

The industrial facilities surveyed are described in the following paragraphs:

The Aluminum Plant was built in 1958, presently employs 3500 people and it is one of the largest enterprises in the city of Volgograd. The plant uses bauxite as a feedstock and produces aluminum powder, bars, round stock, and cookware. The annual production is 144,000 tons of final product. The plant operates 24 hours per day in four shifts and has orders for its full production capacity through December 1993. Presently the plant has formed a joint venture with a Greek company to produce aluminum window and door frames from roll stock. The plant process utilizes electricity, gas, and steam. The electric base load of 350 MWh is supplied by the Volgograd hydroelectric plant. The total natural gas consumption of the plant for 1992 was 36.5 million m^3. There are three main areas of the gas consumption at the plant: the casting shop, boiler room and rotary kilns.

Gas saving recommendations include:

- Seal eight ovens in the casting shop to reduce infiltration
- Install up-to-date burner controls at the ovens to stabilize the combustion process and improve its efficiency
- Install one supplementary fired heat recovery steam generator in the boiler room to generate process steam to unload existing steam generators
- Replace old burners with new high-efficiency burners with automatic controls

The Silica Building Materials Factory was constructed in 1930 to build tractors. Later an adjacent factory was installed to produce construction materials. In 1950, the separate factories were combined and converted to the building materials factory. The factory is a joint stock company which owns all of its equipment and land. The firm is economically independent and has access to all materials and equipment necessary to manufacture its products. The enterprise is a monopoly whose profit is limited to 25% by the government. The company employs 1,130 people and consists of four major groups of shops producing 29 million bricks per month. The company also produces wall panels and intends to produce 3,000 units per year of bath and kitchen equipment and 3,000,000 square meters per month of linoleum. They plan to build a shop for natural stone surface treatment with the design capacity of 300,000 square meters per month.

The gas used in the brick manufacturing makes up 19 to 25% of the cost of the bricks, depending on the physical condition of the feedstock. The annual gas consumption is 48.5 million m^3, of which approximately 60% goes to limestone production and 40% to the boiler room.

Gas saving recommendations include:

- Replace old inefficient burners on boilers with new high efficiency burners with associated controls
- Replace old vertical smelters with two horizontal fluidized bed kilns with incorporated controls and heat recovery system
- Install condensate cleaning equipment and a condensate recovery system (non-existent now).

Greenhouse "Zarya" employs 500 people. The greenhouse occupies 12.5 hectares under glass. The main products are tomatoes, cucumbers, peppers and other vegetables. The total gas consumption for 1992 was 16.5 million m^3. This gas is fired in a boiler room containing 4 boilers. Heat is used for the process and for outside customers–residential apartment buildings and family cottages. The fuel cost is approximately 25 to 30% of the unit cost of production.

The gas saving measure is:

- Replace old inefficient burners with new high efficiency burners with associated controls

"Red October" is a steel making facility employing 17,000 people. It was constructed in three phases in 1900, 1937 and 1965, and covers an area of 2.5 km long by 1.0 km wide. The plant receives cast iron and scrap steel as feed stock to be processed in the open-hearth and electric arc furnaces. The intermediate products are steel billets, wire steel sheets and stainless steel. The annual production is 1,620,640 tons of steel. The total gas consumption for 1992 was

352.7 million m^3. The boiler room consumes about 25% of gas supplied and the remainder is used in steel making.

The plant is currently marketing its products to Turkey, Germany, Taiwan, Europe, Cyprus, Southeast Asia and the United States. It currently survives by selling low carbon steel, which is not an economically viable course of action.

Gas saving recommendations include:

- Replace old inefficient burners on boilers with new high efficiency burners with associated controls
- Install heat recovery equipment in the boiler room and furnaces.

The Protein Vitamin Concentrates Factory manufactures agricultural additives for animals feed employing approximately 2,300 people. It started operation in 1975, and covers an area of 1.5 km long by 0.4 km wide. The factory produces an agricultural vitamin concentrate from natural gas and other feedstocks. The final product is 10,000 tons per year of goprin and 55,000 tons per year of poprin. The total gas consumption is 40.0 million m^3 per year, and about 28 to 30% of final product cost is energy cost. Gas is used as a part of the feedstock for goprin production and also fired in nine drying ovens.

Most sales are in Russia, Yugoslavia, and Bulgaria. The plant has been trying to market the product in Korea but cannot meet the packaging requirements at this time.

Gas saving recommendations include:

- Replace old inefficient burners at drying ovens with new high efficiency burners with associated controls
- Install heat recovery equipment at ovens

Volgograd Scientific and Production Association "Volgograd/NefteMash" ("Petrov" Factory) presently employs 5,683 people and operates with constant load all year in two shifts. The factory manufactures oil refinery equipment, centrifugal oil pumps, gas separators, heat exchangers and auxialiaries such as gas heaters and small boilers for single family houses.

The plant process utilizes electricity, gas and steam. The cost of energy is 2.6% of the cost of final product. Annual gas consumption of the factory is 80.7 million m^3 per year. About 60% of the gas is used in the boiler room and the remainder for the process (heat treating furnaces, welding, cutting etc.).

The enterprise is a closed type and the Team was now allowed to see the process. Product information was supplied in writing. The only facility examined was the boiler room.

Gas saving recommendations include:

- Replace old inefficient burners at boilers with new high efficiency burners with associated controls
- Install one high efficiency hot water boiler followed by demolition of one or two existing boilers
- Install a condensate recovery system, including condensate cleaning equipment and appropriate piping.

The Drilling Equipment Factory manufactures the equipment for the oil and gas industry. The only gas consumption at the factory is in the boiler room, which consumes 80 million m^3 annually. The boiler room supplies heat to the Drilling Equipment Factory and to a number of outside industrial customers (approximately 45% of the heating capacity is used to heat outside customers) and residential facilities.

The enterprise is a closed type and the Team was not allowed to survey the entire facility. Only the boiler room was examined. This boiler room is the largest industrial boiler plant, and also one of the largest district heating boiling plants.

Gas saving recommendations include:

- Replace old dual fuel burners with new high efficiency gas burners with associated controls
- Provide instrumentation for localization of air leaks, flue gas analysis, diagnostics and monitoring of boiler operation
- Replace insulation on three of nine existing boilers

The proposed gas conservation projects for Volgograd are consolidated in Tables 6-3. The total implementation cost for the proposed industrial gas conservation projects in Volgograd is $11,732,400, and the expected reduction in gas consumption is 67,920/1000 m^3 per year. Individual projects are described in Appendix 6-C.

6.2.4 City of Voronezh

The total gas consumption by industrial customers was 2,388,571/1000 m^3 (including out-of-city sites). The industrial facilities surveyed consume 164,400/1000 m^3 of gas which is 7% of the city's total industrial gas consumption. Principal industries include building materials, aluminum production, machinery and others. The largest gas consumer is the Ceramic Plant, which consumes 40.8 million m^3 of gas per year.

The Team examined six industrial facilities, which are described in the following paragraphs.

The Ceramic Plant is a joint stock company that was privatized after being purchased from the state by its staff. It produces a variety of interior and exterior tiles, pottery items and special (proprietary) pigmentations used in the ceramic industry. The company employs 1,500 workers. The plant operates 24 hours a day in 3 shifts and has an annual production of 4 million m^2 of tiles per year. The total annual gas consumption in 1992 was 40.8 million m^3.

Gas saving measures include:

- Replace an existing production line with new equipment
- Reinsulate and seal glass fiber making kilns

The Building Materials Company (VBM) is a private, joint stock company that currently produces insulation materials for buildings and ships, and white construction bricks. Its annual gas consumption averages 36.9 million m^3, although use in 1992 was lower due to lower production. The expanding construction industry, particularly private homes, indicates a higher demand for the near future. The annual production rate is 300 million bricks. VBM operates in four shifts 12 hours each, and every two shifts get the following day off.

Gas is consumed in two areas: the boiler room and insulation ("mineral plates") material process. Planned expansion includes the construction of a new building to house new presses for production of bricks with holes and a building to house a new plant to product automobile parts (catalytic converters). The automobile parts department is a joint venture with a Czech group. A new department for the production of steel pipes, 20 to 100 mm in diameter, is planned.

Gas saving recommendations include:

- Install heat recovery system with incorporated cleaning equipment
- Replace old burners with new high efficiency burners with associated controls
- Reseal the 38 existing brick drying kilns by replacing gaskets to eliminate steam leaks

The Locomotive Maintenance Plant is responsible for the repair and maintenance of locomotive engines and the production of high wear parts, such as wheels. Gas is consumed in three areas: the boiler plant, forging kilns, and the metal cutting equipment. The plant operates in two shifts of eight hours each and employs 3,000 people. The annual gas consumption is 29.9 million m^3/per year.

Gas saving recommendations include:

- Install automatic controls on kilns
- Install condensate return equipment, as currently there is no condensate returned to the boiler room
- Install new insulation on the existing above ground steam piping

The Voronezh Aluminum Plant (VAP) produces a variety of aluminum products, such as panels, tiles, window/door frames, etc., used in the construction industry. About 20 different products make up 900 tons of annual production. The plant employs 2,000 workers in three equal shifts. There are 10 buildings of various sizes housing several departments.

The main areas of gas consumption include the boiler room, the drying equipment and the Forging Department. The annual gas consumption for 1992 was 24 million m^3. Most of the equipment that operates with gas is relatively new (5 to 10 years old) and does not offer opportunities for energy efficiency.

Gas saving recommendation is:

- Install automatic controls and new high efficiency burners

This is the only improvement that may affect the overall efficiency. There is also a need to retube the steam boilers and replace the heat exchangers. Additional maintenance needs include the replacement of pumps and ventilation units.

The Brick Factory (VBF) is a joint stock company that produces red bricks used in the local construction industry. VBF employes 300 workers in three shifts and operates 24 hours a day. The total annual gas consumption is 8.2 million m^3. Three kilns used to cure the bricks account for most of the gas consumption. Each kiln produces approximately 12 million bricks annually. The first kiln was built in 1972, the second in 1980 and the third in 1989. Approximately 18 to 20% of the cost of bricks is attributed to energy. VBF anticipates increasing demand for their

product with new private housing and industrial construction in the upcoming years and hopes to expand their operations.

Gas saving measures are:

- Construct a new kiln with larger capacity to replace the existing kiln. In addition to increasing energy efficiency, the new kiln will produce higher quality bricks and will reduce some environmental problems

Alternatively, to maintain existing kilns:

- Replace existing hot air ducts used for heat recovery from the cooling section of the kilns. The ducts are significantly damaged and deteriorated, resulting in substantial heat losses

- Improve the insulation of the existing kilns, ensure that openings, such as end-doors are properly sealed, and replace the burners with modern counterparts

The Heavy Excavator Plant (VHE) is a joint stock or privatized company that produces a variety of excavation equipment, differing in size, capacity, function and features. The main products include 30, 40, and 50 ton excavators. Prices vary depending on the customer, yet typically a 25% profit is expected. All of the raw materials and components are domestic. Approximately 70% of all components are manufactured in this facility. The entire plant consist of 30 buildings, including workshops, warehouses and offices. Production is based on contracts. The current monthly output is 65 units of different sizes, while the full capacity is about 125 units. VHE has established 50 service stations throughout Russia and they expect to introduce some in the west in order to expand exports, which are currently limited to eastern countries.

The total annual gas consumption is 27.1 million m^3 Gas consumption accounts for about 15% of the total energy requirements.

Gas saving recommendations include:

- Reconstruct the two kilns in the Forging Department

- Replace burners on four existing steam boilers with new high efficiency burners with associated controls

The proposed gas conservation projects for Voronezh are consolidated in Table 6-4.

The total implementation cost for selected industrial gas conservation projects in Voronezh is $18,933,250, and the expected reduction in gas consumption is 24,428/1000 m^3 per year. Individual projects are described in Appendix 6-D.

6.3 COST/BENEFIT RANKING OF INDUSTRIAL PROJECTS

6.3.1 Selection Criterion

In view of the uncertanties facing Russian industry, a real rate of return of at least 25 percent was selected as a suitable level for qualifying energy conservation loans.

As with district heating projects, gas savings and life extension were the identified benefits for all projects. Life extension benefits were estimated on average at 13 years–from 7 years remaining life "as is" to 20 years with retrofit. At a 15% real discount rate, the present value of this life extension amounts to 30% of the total capital cost. No consideration was given to the

possibility of using gas saved for increased production or to displace use of other fuels, uses that might enhance the value of the savings to the individual factories. It has not been possible at this time to determine the commercial viability of the various enterprises, which may or may not qualify them for energy conservation loans.

Constant 1993 values were used throughout. Gas is valued at a price that rises to \$40/1000 m^3 by the end of 1995, before the first year of gas savings. Benefits were taken over 20 years and all expenditures were assumed to take place in the first year. No consideration was given to methods of financing that might also make the projects more attractive to individual factories.

6.3.2 Project Ranking

- Ryazan. Of eight projects investigated, four have a real IRR over 25%. Results are summarized in Table 6-5. Cumulative totals at the left of the table sum the cost and gas savings of all projects above the each table line.

- Saratov. Of thirteen projects investigated, nine projects have a real IRR over 25%. These nine projects have a total cost of approximately \$4 million and provide a total gas savings of 67 million m3. (A combined IRR of 85%.) The savings on the nine projects would represent 13% of the total gas consumed by all surveyed plants and 6.5% of the total consumption of gas by industries in Saratov. Results are summarized in Table 6-6.

- Volgograd. Of eighteen projects considered, seventeen have a real IRR over 25%. These have a total cost of approximately \$5.2 million and provide a total gas savings of 61 million m3. (A combined IRR of 43%.) The savings on the seventeen projects represents approximately 9% of the consumption of all factories surveyed and 2% of the total industrial gas usage in Volgograd. Results are summarized in Table 6-7.

- Voronezh. Of thirteen industrial projects considered, four meet the criterion for 25% real IRR. The four projects would require a total investment of approximately \$309,000 and provide gas savings of 3.4 million m3, or 2% of the consumption of the factories surveyed. Results are summarized in Table 6-8.

6.4 SUMMARY

Results of the industrial conservation survey are summarized in Table 6-9. Although results vary considerably from city to city, over 60% of the projects considered appear to have a real rate of return in excess of 25%. The 34 projects that "qualify" based on rate of return would require a total investment of approximately \$9.7 million (1993 \$), an average size of approximately \$285,000.

Plants representing approximately 26% of the total gas consumption by industries in the four cities were surveyed. The potential savings of these high-return projects represents over 11% of the consumption of the all plants surveyed. Overall, the industries of the four cities consume over 6 billion cm. annually, so potential saving over the entire industrial sector in these cities could be as high as 500 to 600 million cm. of gas annually. Although these plants represent a significant part of the largest consumers, most of the individual projects with high rate of return are of moderate size, so similar projects are likely to be found in smaller factories. It might reasonably be assumed, therefore, that some multiple of the total investment requirement indicated by the survey, say \$20 to \$25 million, could find qualifying projects if an energy conservation loan program were

put in place. However, in view of the uncertainties facing commercial enterprises in Russia, no extrapolation is made beyond the identified projects.

Table 6-1

Summary of Industrial Conservation in City of Ryazan

Action	*Gas savings* (1000 m^3)	*Implementation cost ** US $
Elecktronpribor Corp.		
• Install boiler blowdown heat exchanger	260	8,000
• Install stack with heat recovery	3,465	1,003,000
• Convert boiler, replace burner	285	31,000
• Install hot water boiler	475	508,000
Ryazan Tannery		
• Install 4 combustion air preheaters	993	68,000
Color Metal Manufact. and Reprocessing Plant		
• Install controls on melting furnace	600	126,000
Ryazan Metal Forging/Press Plant		
• Install 4 new waste recovery boilers with auxiliary burners	2,750	633,000
ZIL Automobile Components Plant		
• Install stack with heat recovery	4,170	1,675,000
TOTAL	12,998	4,052,000

* - Implementation cost is based on world prices for the equipment and cost of Russian labor with the conversion factor $1 = 1,000 rubles.

Table 6-2

Summary of Industrial Conservation in City of Saratov

Action	*Gas savings* (1000 m^3)	*Implementation cost ** US $
Dry Ice & Ice Cream Factory		
• Install the process for recovery an additional 67% of CO_2 from the boilers' exhaust.	600	46,000
• Install automatic burner controls on one of the smaller boilers.	1,000	400,000
• Install automatic burner controls on one of the smaller boilers.	1,000	400,000
Rubber Products Facility		
• Install a condensate receiver in each vulcanization shop	1,472	21,000
• Install a 90% efficient boiler in each of the 2 boiler rooms.	5,400	350,000
Nitron Chemical Factory		
• Install automatic controls on the 6 waste heat recovery boilers.	320	67,000
Glass Factory		
• Install heat recovery behind the refractory lining of the stack.	40,000	2,006,000
Reinforced Concrete Constructions Factory		
• Convert all of the steam concrete dryers to a gas fired hot air drying system.	9,300	350,000
Electrounit Production Operation (SEPO).		
• Replace one of the 50 year old steam boilers with an equal sized brand new	4,200	604,000
• Install a new burner on an existing boiler.	1,400	400,000
Food-Fat Products Processing Plant		
• Install 2 new boilers.	4,230	426,970
Red Brick Factory		
• Replace a hot water boiler.	1,620	143,000
• Install a heat recovery wheel in the exhaust of the brick kiln.	763	226,000
TOTAL	71,305	5,439,970

* - Implementation cost is based on world prices for the equipment and cost of Russian labor with the conversion factor $1 = 1,000 rubles.

Table 6-3

Summary of Industrial Conservation in City of Volgograd

Action	*Gas savings* (1000 m^3)	*Implementation cost ** US $
Silica Building Materials		
• Condensate recovery system	1,600	48,000
• Burner replacement	3,100	307,500
• Smelters replacement	7,000	579,000
Aluminum Plant		
• Insulation at ovens	900	50,400
• Heat recovery system (HRSG)	1,700	138,400
• Combustion controls installation (ovens)	1,000	130,600
• Burner replacement (boilers)	2,000	172,400
Petrov Factory		
• Condensate recovery system	2,400	54,300
• Burner replacement	5,600	627,600
• New hot water boiler installation	6,800	6,572,100
Red October Factory		
• Heat recovery system	7,900	560,000
• Burner replacement (boilers)	7,920	847,500
Drilling Equipment Factory		
• Boiler insulation replacement	2,800	182,500
• Portable set of control instrumentation	4,100	110,200
• Burner replacement	7,300	817,300
Greenhouse Zarya		
• Burner replacement	2,100	189,600
Protein Vitamin Factory		
• New burners at drying ovens	2,100	192,000
• Heat recovery system	1,600	153,000
TOTAL	67,920	11,732,400

* - Implementation cost is based on world prices for the equipment and cost of Russian labor with the conversion factor $1 = 1,000 rubles.

Table 6-4

Summary of Industrial Conservation in City of Voronezh

Action	*Gas savings* (1000 m^3)	*Implementation cost* * US $
Aluminum Materials		
• Automated controls installation on steam boilers	950	26,125
• Burner replacement	1,900	535,200
Building Materials Co.		
• Heat recovery in regenerator kilns	864	75,000
• Reseal brick drying kilns	916	157,700
• Burner replacement (boilers)	3,435	829,000
Ceramic Plant		
• Production line replacement	12,150	12,000,000
Locomotive Maintenance Plant		
• Automated control installation on 29 kilns	406	218,175
Brick Factory		
• Construction of a new kiln	1,148	4,000,000
• Insulation of existing kiln and sealing doors	172	151,500
• Replacement of 3 hot air recovery ducts	574	252,150
Heavy Excavator Plant		
• Rebuilding of 2 kilns on 4 steam boilers	113	203,600
• Burner replacement	1,800	484,800
TOTAL	24,428	18,933,250

* - Implementation cost is based on world prices for the equipment and cost of Russian labor with the conversion factor $1 = 1,000 rubles.

Table 6-5

Ranking of Industrial Conservation Projects in City of Ryazan

Ryazan Projects	Investment Required 93 $000	Gas Saved 1000 m^3	IRR	Cumulative	
				Investment 93 $000	Gas Saving 1000 m^3
Electronpribor Corp - Blowdown Heat Recovery	8	260	157%	8	260
Tannery Plant - Combustion Air Preheaters	68	993	75%	76	1,253
Electronpribor Corp - New burner, boiler conversion	31	285	48%	107	1,538
Color Metal Mfg & Reproc Plant - Controls	126	600	26%	233	2,138
Metal Forging/Press Plant - Waste Heat Recovery	633	2,750	23%	866	4,888
Electronpribor Corp - Stack Heat Recovery	1,003	3,465	18%	1,869	8,353
Zil Auto Component Plant - Heat Recovery	1,675	4,170	12%	3,544	12,523
Electronpribor Corp - Boiler Replacement	508	475	1%	4,052	12,998

Table 6-6

Ranking of Industrial Conservation Projects in City of Saratov

Saratov Projects	Investment Required 93 $000	Gas Saved 1000 m^3	IRR	Cumulative	
				Investment 93 $000	Gas Saving 1000 m^3
Rubber Products Factory, Condensate Recovery	21	1,472	324%	21	1,472
Reinforced Concrete Factory - Boilers	350	9.300	130%	371	10,772
Glass Factory, Heat recovery	2,006	40,000	100%	2,377	50,772
Rubber Products Factory, Boilers	350	5,400	78%	2,727	56,172
Dry Ice/Ice Cream Factory CO2 Recovery	46	600	67%	2,773	56,772
Red Brick Factory Boiler Replacement	143	1,620	59%	2,916	58,392
Food Processing Plant	427	4,230	52%	3,343	62,622
Electrounit Production, Steam boiler	604	4,200	37%	3,947	66,822
Nitron Chemical Factory, Controls	67	320	26%	4,014	67,142
Electrounit Production, Burner	400	1,400	19%	4,414	68,542
Red Brick Factory Heat Recovery	226	763	18%	4,640	69,305
Dry Ice/Ice Cream Factory Burner controls	400	1,000	13%	5,040	70,305
Dry Ice/Ice Cream Factory Production Line	708	100	0%	5,748	70,405

Table 6-7

Ranking of Industrial Conservation Projects in City of Volgograd

Volgograd Projects	Investment Required 93 $000	Gas Saved 1000 m^3	IRR	Cumulative	
				Investment 93 $000	Gas Saving 1000 m^3
Petrov Factory - Condensate return	54	2,400	210%	54	2,400
Drilling Equipment Factory - Control Instrumentation	110	4,100	179%	165	6,500
Silica Bldg Mats Factory - Condensate Recovery	48	1,600	161%	213	8,100
Aluminum Plant - Insulation	50	900	90%	263	9,000
Drilling Equipment Factory - Insulation	183	2,800	78%	446	11,800
Red October - Heat Recovery	560	7,900	72%	1,006	19,700
Aluminum Plant - Heat recovery	138	1,700	63%	1,144	21,400
Silica Bldg Mats Factory - Smelter Replacement	579	7,000	62%	1,723	28,400
Aluminum Plant - New burners	172	2,000	60%	1,895	30,400
Greenhouse Zarya - New burners	190	2,100	58%	2,085	32,500
Protein Vitamin Concentrates Factory -New Burners	192	2,100	57%	2,277	34,600
Protein Vitamin Concentrates Factory - Heat Recovery	153	1,600	54%	2,430	36,200
Silica Bldg Mats Factory - New Burners	308	3,100	53%	2,737	47,220
Red October - New Burners	848	7,920	49%	3,585	51,420
Drilling Equipment Factory - Burner Replacement	817	7,200	47%	4,402	54,520
Petrov Factory - New burners	628	5,600	47%	5,030	60,120
Aluminum Plant -Automatic controls	131	1,000	41%	5,160	61,120
Petrov Factory - New boiler	6,572	6,800	2%	11,733	67,920

Table 6-8

Ranking of Industrial Conservation Projects in City of Voronezh

Voronezh Projects	Investment Required 93 $000	Gas Saved 1000 m^3	IRR	Cumulative	
				Investment 93 $000	Gas Saving 1000 m^3
Aluminum Materials Plant - Control replacement	26	950	175%	26	950
Locomotive Maint. Plant - Condensate Recovery	50	700	72%	76	1,650
Building Materials Co. - Heat Recovery	75	864	60%	151	2,514
Building Materials Co. - Reseal kilns	158	916	31%	309	3,430
Building Materials Co. - Burner Replacement	829	3,435	22%	1,138	6,865
Heavy Excavator Plant - Burner replacement	485	1,800	20%	1,623	8,665
Aluminum Materials Plant - Burner replacement	535	1,900	19%	2,158	10,565
Brick Factory - Heat recovery ducts	252	574	11%	2,410	11,139
Locomotive Maint. Plant - Controls	218	406	8%	2,628	11,545
Brick Factory - Improve insulation	152	172	2%	2,780	11,717
Ceramic Plant - Production line	12,000	12,150	1%	14,780	23,867
Heavy Excavator Plant - Kiln Reconstruction	204	113	-4%	14,983	23,980
Brick Factory - New kiln	4,000	1,148	-9%	18,983	25,128

Table 6-9

Summary of Industrial Conservation Projects by City

Summary	Projects Considered	"Qualified" Projects	Investment Required 1993 $000	Gas Saved 1000 m^3	Percent of Market Surveyed
Ryazan	8	4	233	2,138	43%
Saratov	13	9	4,014	67,142	51%
Volgograd	18	17	5,160	61,120	32%
Voronezh	13	4	309	3,430	13%
Totals	52	34	9,716	133,830	32%

Section 7

TABLE OF CONTENTS

7. ENVIRONMENTAL ASSESSMENT 1

7.1 INTRODUCTION 1

7.1.1 Purpose of the Project 1

7.1.2 Purpose of the Environmental Assessment (EA) 1

7.1.3 EA Requirements 1

7.1.4 Description of the Project 2

7.1.5 Project Schedule 2

7.1.6 Implementation Mechanisms 3

7.1.6.1 Financial Arrangements 3

7.1.6.2 Institutional Changes 4

7.2 DESCRIPTION OF THE PROPOSED PROJECT 4

7.2.1 Replacement of Degraded Gas Distribution Pipe 4

7.2.1.1 Project Parameters 4

7.2.1.2 Installation Procedures 5

7.2.2 Cathodic Protection 6

7.2.2.1 Project Components 6

7.2.2.2 Cathodic Protection - Installation, Operation & Maintenance 6

7.2.3 SCADA-Supervisory Control and Data Acquisition System 7

7.2.3.1 Project Function 7

7.2.3.2 Installation, Operation and Maintenance Procedures 8

7.2.4 Construction and Maintenance Equipment 9

7.2.5 Metering 9

7.2.5.1 Project Components 9

7.2.5.2 Installation, Operations and Maintenance Procedures 9

7.3 PROJECT OBJECTIVES 10

7.3.1 Elimination of Leaks 10

7.3.1.1 Replacement of submerged or inaccessible pipe 10

7.3.1.2 Cathodic Protection 10

7.3.1.3 Construction, Maintenance, Test, and Leak Detection Equipment 11

7.3.2 Better System Controls—SCADA-Supervisory Control and Data Acquisition 11

7.3.3 Framework for Gas Conservation and for Increased Revenues—Installation of Meters at Unmetered User Locations 11
7.3.4 Improvement of Regional Air Quality and Reduction of the Greenhouse Effect 12
7.4 BASELINE DATA 12
7.4.1 Existing Conditions-Gas Distribution System 12
7.4.1.1 Pipeline System Characteristics 12
7.4.1.2 Major Users of Natural Gas 13
7.4.1.3 Emergency Response Preparedness 13
7.4.1.4 Need for Pipe Replacement and Cathodic Protection 14
7.4.1.5 Need for System Controls 15
7.4.1.6 Need for Construction, Maintenance, and Operating Equipment 15
7.4.1.7 Need for Meters and Metering Procedures 16
7.4.2 Physiography and Land Use 17
7.4.3 Demographic Data 22
7.5 ENVIRONMENTAL ASSESSMENT REQUIREMENTS 22
7.6 SIGNIFICANT IMPACTS ON THE ENVIRONMENT 23
7.6.1 Potential Adverse Impacts 23
7.6.2 Potential Beneficial Impacts 25
7.7 PROJECT ALTERNATIVES AND THEIR IMPACTS 26
7.8 MITIGATION MEASURES 28
7.8.1 Construction Mitigation Measures for Pipe Replacement 29
7.8.1.1 Protection of Other Utilities 29
7.8.1.2 Construction Safety 29
7.8.1.3 Construction Procedures 30
7.8.2 Enhancement of Environmental Management Capability 32
7.8.3 Public Involvement During Project Implementation 33
7.8.4 Implementation, Schedule and Cost of Mitigation Measures 34
7.8.4.1 Implementation Responsibilities 34
7.8.4.2 Schedule 34
7.8.4.3 Cost of Mitigation Measures 35
7.9 DOCUMENTS CONSULTED 36
7.10 MINISTRIES AND OTHER GOVERNMENT AGENCIES CONSULTED 36
7.11 ENVIRONMENTAL ASSESSMENT PREPARERS 37
Table 7-1 Measured Ambient Air Pollutant Concentrations for Volgograd in 1992 38
Table 7-2 Measured Ambient Air Pollutant Concentrations for Saratov in 1992 39

Table 7-3 Measured Ambient Air Pollutant Concentrations for Voronezh in 1992.....40
Table 7-4 Measured Ambient Air Pollutant Concentrations for Ryazan in 1992.....41

ENVIRONMENTAL ASSESSMENT

NIS NATURAL GAS SYSTEM REHABILITATION PROJECT

This Environmental Assessment has been prepared as a chapter of the Feasibility Study for the NIS Natural Gas System Rehabilitation Program in accordance with the World Bank Category B Environmental Assessment requirements.

Section 7

ENVIRONMENTAL ASSESSMENT

7.1 INTRODUCTION

The United States Agency for International Development (USAID) selected Bechtel Corporation to perform a study to identify investment projects for natural gas distribution system rehabilitation and end use efficiency improvement in the Russian cities of Ryazan, Saratov, Volgograd and Voronezh. The World Bank is planning to invest about $50 million in each city for investment projects that show high rates of return and a short gestation time and would result in the best natural gas utilization and long term gas distribution system development.

The Bechtel Corporation was also requested by the Russian Government and the USAID to prepare an Environmental Assessment for the project to conform to the World Bank and the Russian Federation requirements. The EA has been prepared according to Terms of Reference (TOR) agreed to by the Ministry of Fuel and Energy and the Ministry of the Environment on September 17, 1993. The TOR is attached to the EA as Annex A attached to Appendix 7-A.

A summary of the Environmental Assessment (EA) was prepared under separate cover and submitted to the Ministry of Fuel and Energy and the Ministry of Environmental and Natural Resources.

7.1.1 Purpose of the Project

The purpose of the Gas Distribution Rehabilitation Project is to increase the efficiency of gas distribution within the purview of the gas utility companies in the cities of Saratov, Volgograd, Voronezh, and Ryazan. Efficiency has been defined by the World Bank as follows:

- Reduction of gas losses through elimination of leaks
- Improved control and metering of the distribution system
- Improved construction, maintenance, operation practices, and safety
- New metering for unmetered commercial and residential users
- Gas use conservation and increased revenues through metering and new pricing policy

7.1.2 Purpose of the Environmental Assessment (EA)

The purpose of the EA is to describe the potential environmental impacts which may result from the project, and to recommend mitigation measures for these impacts, to either eliminate them or reduce them to insignificant levels. This EA is presented as a combined document to conform to the environmental reporting requirements of The World Bank and the Russian Federation.

7.1.3 EA Requirements

For the purpose of the World Bank environmental assessment requirements (O.D. 4.01), this project has been classified as category B. Although a full environmental assessment is not required under this category, environmental analysis of the project is required.

216

This document has been prepared with all of the required sections in a full Environmental Assessment, in order to present a complete disclosure document and to satisfy the Russian Federal requirements.

According to the Russian Federation regulations governing preparation of an EA for a project, the project sponsor, in this case the gas utility company for each city, would be responsible for the document. However, the Ministry of Fuel and Energy is responsible for this EA because the loan amount for the project is over US$100,000. The EA is subject to review by the Ministry of Environment.

At this time, the NIS Natural Gas System Rehabilitation Project is in the form of a policy document, and the specific engineering of the project is scheduled for the next phase of work. The EA has been prepared with as much specificity as possible consistent with the level of information available about the project at this time. Subsequent EAs will be prepared by each of the four cities on the specific projects to be identified in the engineering phase following approval of the loan by the World Bank. These EAs will be reviewed by the Ministry of Fuel and Energy and the Ministry of the Environment and by other agencies as appropriate. The general public will participate in the review process by the agencies.

7.1.4 Description of the Project

The proposed project is a multi-faceted program for rehabilitation of the gas distribution system in the four cities. The program consists of the following individual projects to be undertaken within the service areas of the gas utility companies in Saratov, Volgograd, Voronezh, and Ryazan:

- Replacement of defective segments of gas distribution pipe
- Upgrading of corrosion and cathodic protection systems
- Installation of SCADA (Supervisory Controls and Data Acquisition) system
- Improvement of Construction & Maintenance Equipment
- Metering of unmetered residential, industrial consumers and commercial units

After approval of the loan, site specific engineering will be undertaken in order to determine the parameters of each project. The engineering phase will result in specific recommendations for locations of pipe replacement and specific amounts of pipe to be replaced. Locations for implementation of cathodic protection will be determined after new leak detection equipment is in place and a survey of the system has been completed. Specifications for SCADA system will be developed, required RTU and meters for the industrial and commercial customers will be identified and suppliers selected after evaluation of competitive bids is completed.

The engineering phase will also result in preparation of specifications for the installation of burners, controls, BTU meters, control valves for district heating systems and district heating plant modifications, and specifications of similar equipment as well as heat recovery systems for the individual plant energy conservation projects.

7.1.5 Project Schedule

The World Bank has scheduled the appraisal process for this project for early November, 1993. The EA must be in place prior to that time. Subsequent to completion of the appraisal, project activities will proceed according to the following sequence:

Construction on all projects will begin approximately one year after approval of project. Engineering, procurement, manufacturing and delivery will occur during the first year after approval of project. Actual construction will vary by project and city as follows:

Cathodic Protection Systems

Installation during the first year will include insulating fittings in the buried pipe and at risers to apartment buildings and boiler houses in selected areas, and rectifiers and ground beds. These installations may complete installation for Ryazan.

Installation of these facilities can be completed in Saratov and Voronezh during the second year.

Installations in Volgograd can be expected to continue for three years.

SCADA

Initial installation for all cities—one year after receipt of materials (will include control center, communications system and installations at City Gate stations).

Second year of construction—installation of facilities at major industries.

Third year of construction—installation of facilities of district regulator stations.

Construction and Maintenance

Equipment will be placed in service immediately after receipt and personnel training—within two months.

Test Equipment

Equipment will be placed in service immediately after receipt and personnel training—within two months.

Gas Meters

Installation will begin with meters for commercial establishments and small industrial customers, estimated for completion during first and second years. Meters for residential customers with space heating—3 to 4 years. Upgrading industrial meters the first and second years. Installation at apartment blocks—first through fourth year.

Gas Meter Test Equipment

Three months after receipt of equipment.

Gas Main Replacement

Each year of project.

7.1.6 Implementation Mechanisms

7.1.6.1 Financial Arrangements

The project will be financed by the World Bank. A maximum amount of $200,000,000 for all four cities represent 60% of total project cost, with local backing by the utility companies in

each city supplying the remaining portion. Approximately $50,000,000 will be loaned by the World Bank in each city for all the gas distribution projects identified, with a portion reserved for other energy conservation projects involving upgrading of equipment in industrial plants and district heating plants in the four cities.

7.1.6.2 Institutional Changes

In order for the gas utility companies to fully benefit from the greater efficiency in gas distribution and the resulting gas conservation and from metering, certain institutional changes will be needed. These include the following:

- The volumes of gas received in 1993 by each gas utility in the four cities should be guaranteed by the Ministry of Fuel and Energy for subsequent years so that any results of energy conservation activities would not adversely affect their ability to receive gas from the transmission company.

- The gas utility should be the owner of that gas with the unrestricted right of resale to any other party.

- If the gas utility's customers require gas in excess of its allocation, the utility should have the right to compete with all potential suppliers—e.g., gas exchanges, transmission companies, etc.—through aggressive pricing, and should be taxed only on the basis of actual revenues.

- If any customer is delinquent in payment for gas, the gas utility should have the rights and ability to discontinue service to that customer and to charge penalties without disbursement thereof to other parties.

- Rosgaz and GiproNiiGas, with the participation of local government, should correct the gas utilities' markup to reflect local conditions including the local customer profile, the size and condition of its network, as well as geographical, climatological and other relevant conditions.

- As gas prices for industrial customers rise toward export levels, the gas utilities should have the right and opportunity to purchase some or all of their requirements directly from the gas producing company or other suppliers in direct competition with the transmission company.

7.2 DESCRIPTION OF THE PROPOSED PROJECT

7.2.1 Replacement of Degraded Gas Distribution Pipe

7.2.1.1 Project Parameters

The proposed project is to replace degraded buried pipes that are leaking; corroded, have defective coating, are flooded, or are in inaccessible locations.

Although the project definition phase of this study resulted in an early recommendation to replace all of the above-ground pipe underground with polyethylene pipe in order to conform to best international practices and standards , the gas utilities did not consider the replacement of above ground pipe to be critical in the short term. Therefore only replacement of degraded underground pipe is being proposed in this project.

The exact locations and amounts of pipe to be replaced will be determined after detailed surveys are completed in the engineering phase of the project.

219

Pipe replacement will be performed according to RSFSR Law No. 2060-1, On Protection of the Environment, 19 December, 1991, and all other applicable local and Federal codes, standards, and permits.

7.2.1.2 Installation Procedures

Pipeline construction will consist of a planned continuous operation, carefully scheduled and coordinated with other utilities and affected agencies. Most activities will be underway simultaneously as soon as construction has started, so as to keep each construction phase on schedule as planned and to avoid delays.

Cleanup and restoration activities will follow construction. All reasonable precautions will be taken to avoid damage to existing gas system facilities which are not to be replaced.

Before excavation begins, arrangements will be made with the affected city departments to avoid conflicts with vehicular movement, or work planned for the same areas by other city departments or utilities. A traffic control plan will be prepared for heavily traveled areas. Arrangements will be made to allow for continuation of above ground activities during construction to the extent possible.

Installation will be by burial in a trench with not less than 0.6m cover measured from the top of the pipe. The trench will be dug by back-hoe and by hand labor where the pipe will cross other utilities.

The trench will be at least 0.3 meters wider than the pipe. The trenches will have the minimum cover depths as follows for anticipated conditions:

- Drainage ditches, unlined canals, and canals—at least 1.5 meters below the flow line
- Public and private roads—a minimum of 0.8 meters below gutters or drain ditch
- All other locations—at least 0.6 meters deep

Insulating fittings will be installed at various locations on the pipeline where segments require electrical isolation.

Soil excavated from the pipe trench will be stored alongside the trench until it is used for backfilling. Sand or soft soil will be placed around and under the pipe to a depth of at least 0.1 meters. The remainder of the trench will then be filled to grade with the soil removed during the trenching or with off-site structural backfill material if the material removed from the trench is unsuitable. The remaining soil will then be disposed off at approved disposal sites.

Pipe joints will be joined by welding and will then be visually inspected and land spotted by radiography. The welded pipe sections will be pressure-tested hydrostatically at 1.25 times the maximum allowable operating pressure, then dried, field wrapped, laid in the trench on a compacted bed, and backfilled.

Backfilled material will be compacted. Pipe trench dug in streets will be repaved after compaction of the backfill material.

Existing drainage patterns at various locations near bodies of water or open spaces may be altered by trenching and grading. The effects will be temporary and drainage will be restored or

120

improved as a part of the project. At river crossings, the new pipeline will be buried at least 1.5 meters under the scour line to prevent the future alteration of the drainage patterns and prevent pipe washout.

The construction site will be restored to the pre-construction conditions or better to the extent possible. Any vegetation that needs to be removed will be replaced, and trees replanted as necessary according to the specifications of the appropriate city department. Construction debris will be removed and all property fences, private roads, irrigation and drainage structures will be left in good repair.

7.2.2 Cathodic Protection

For each utility company, a project is proposed for planning and performing cathodic protection surveys of the buried gas distribution system, subdividing the systems into isolated areas, and installing the necessary protective materials and equipment to mitigate the causes of corrosive activity. The proposed project includes both active (cathodic) and passive (coatings) corrosion protection.

7.2.2.1 Project Components

The proposed Cathodic Protection project consists of instituting state-of-the-art standards for operating, maintaining, and the preserving the present distribution system piping. The components of these projects are:

- A detailed survey of the layout of the distribution mains and connected facilities. This study will include leak history, locations of interfering facilities such electrified trolley tracks, and similar installations.
- Sectionalizing the mains into units for field surveys to determine electrical isolation requirements. The area will include approximately 30,000 square meters of pipe surface.
- Progressively electrically isolating the sections by installing insulating fittings or fittings in all service risers and other connected facilities.
- Performing required pipe-to-soil potential and electric current drain surveys.
- Installing cathodic protection rectifier stations, anodes, and ground beds as required.
- Improving procedures and practices in testing equipment, in frequency of leak detection checks, etc.

7.2.2.2 Cathodic Protection - Installation, Operation & Maintenance

Installation

The elements installed for cathodic protection are:

- Rectifier stations that convert 220-volt alternating current to direct current and reduce the voltage connected to the pipe to 0.87 volts from 220 volts. Rectifiers are aboveground, and may be mounted on poles, or may be installed in small, locked enclosures.

- Anodes, blocks of magnesium or zinc, that are buried beneath or alongside the pipe. These anodes are connected to the pipe by an insulated electrical conductor. There is no visible indication of these locations. Installation requires digging a small trench alongside, or to a lower depth approximately under the pipe. The trench is usually short, mainly large enough to contain the anode, or several anodes, as the case may require. Individual anodes may weigh 22 kg, and may be .3 to .6 meters long.

- Ground beds that contain electrically inert anodes of carbon surrounded by granulated carbon particles. These anodes are lowered into holes of .3 to .6 meters in diameter augured into the ground. The holes may be from 3 to 6 meters into the ground, depending on the type of soil and number of anodes buried in each augured hole.

The equipment to install rectifiers includes a small truck and a lifting device to lift the rectifier to its place on the pole. Alternatively, the rectifier will be placed in the surface enclosure. These operations are of short duration with minimal activity and noise.

Installation for anodes may be done by hand or dug by a small back hoe or similar excavator.

Insulating fittings are welded in the buried pipe and are invisible.

Ground beds are installed most efficiently by an auger similar to those used for drilling domestic water wells, or drilling holes to install power or telephone lines. Each of these installations is a one-time occurrence.

Operations and Maintenance

Operations and maintenance activities include the monthly and other visitations by operating personnel. These checks usually include testing electrical circuits for continuity or shorts, and electrical current flow to the pipe by a single operator. Transportation for these checks is by a pickup truck or a van. All these installations are noiseless, and only the above ground rectifier installations are visible. In most cases the above ground installations present no unusual configurations from other above ground service installations.

7.2.3 SCADA-Supervisory Control and Data Acquisition System

7.2.3.1 Project Function

This project will provide each utility company with a system control center with computers and communication facilities for:

- Monitoring and controlling distribution operating pressures and flow rates on a real-time basis

- Detecting illegal entry and unsafe conditions at City Gate Stations

- Analyzing the distribution system performance and forecasting load and operating condition based on weather forecasts

7.2.3.2 Installation, Operation and Maintenance Procedures

Figures 4-1 and 4-2 in Section 4 of this report illustrate the physical features of SCADA systems. The following procedures are followed to install, operate, and maintain this system.

Installation

The essential physical components of a SCADA system are:

- A modem high-speed communication system to transmit information between the locations monitored and controlled from the control center. The communication system proposed for these projects is microwave.

- A control room located at a control center. This center may be located in the gas utility headquarters. Microwave dishes may or may not be adjacent to the location actually monitored and controlled from the control center. Connection between the microwave tower and monitored site may be fiber optic or wire cable. These connections may be either buried or above ground, with the former as the preferred choice.

- Electronic control equipment and a communications terminal at each location receiving and sending information between the location and the control center.

Microwave towers may be shared with other microwave installations, depending upon the practicality of the shared location with the requirements for the respective locations monitored. In the case of the gas utility systems, these monitored sites are generally widely dispersed. Towers may be located at each site building or in buildings removed from headquarters. These locations are expected to be of very low public interest or concern. The latter locations are frequently chosen for security reasons. This location is the focal point of all communications illustrated in Section 4, Figures 4-1 and 4-2 of this report.

Microwave Communications Equipment

Microwave communications equipment requires installation of transmitting/receiving "dishes" at sending and receiving locations. The sites for these transmitting/receiving dishes will require separate installation of a microwave dish. However, many of the sites will be located favorably for mounting the dish on the roof of a building nearby the monitored site.

The control center is installed in a room of approximately 140 to 185 square meters. These rooms are air conditioned, with telephones, computer hardware, printers, and adjacent sanitary facilities.

Operations and Maintenance

The control center is attended continuously by two or three operators. Operations are silent, with no noise or mechanical disturbances inside or outside the building.

Terminals at monitored sites are unattended. These sites will be checked on a schedule for preventive maintenance once or twice a month. Electronic equipment and the controlled operating equipment will be installed in controlled access buildings or enclosures, with sensors to monitor illegal entry and unsafe conditions such as fire or gas leakage.

Physical activity at these sites will be visitation for operating checks. Repair and replacement of equipment, on infrequent occurrences, will be silent by one or two operating

personnel. Traffic to and from the sites will be by one pickup or van as determined by the operating and repair requirements.

7.2.4 Construction and Maintenance Equipment

This project will provide each utility company with new tools and equipment for operations, maintenance, construction and personnel safety to conform with present-day standards and practices. Items included for two crews are truck-mounted equipment for emergency response, excavating equipment, X-ray equipment for inspecting welds, pipe bending machines, and miscellaneous tools and safety equipment for personnel. The origin and specifications of the equipment will not be known until the evaluation of competitive bid packages is completed and vendor or vendors are selected.

7.2.5 Metering

7.2.5.1 Project Components

At present, residential customers in urban areas, small commercial establishments, and apartment complexes are supplied with unmetered gas. The proposed project for each utility company will install meters in phases as follows:

- Phase 1 - Commercial establishments
- Phase 2 - Private homes with space heating
- Phase 3 - Upgrade Industrial customers
- Phase 4 - Apartment blocks

7.2.5.2 Installation, Operations and Maintenance Procedures

Installation

A gas metering installation will vary depending upon its purpose, as follows:

- City Gate Stations—these installations are located inside a controlled access enclosure, and include one or several meter runs, a small building of approximately 120 meters, SCADA and a microwave tower. The site will vary in size from approximately 30 meters by 30 meters (900 square meters) to 30 meters by 90 meters (2,700 square meters), depending upon the size and number of orifice meter runs. The meter runs are pipe, mounted above ground on concrete supports. Pipe diameter may vary between 30 to 50 cm in diameter.

- Industrial meter sites will vary depending upon type of meter installed. Orifice meters for large industries will be smaller and shorter than the orifice meters at the city gate station because of lower flow rates of gas through the meters. Meter sites for these meters will be located in controlled access enclosures that may be as small as 8 meters by 16 meters (128 square meters) or 8 meters by 30 meters (240 square meters).

Installation of this equipment requires a small crane, truck mounted, some electrical welding, and a small work crew, 3 to 10 personnel depending upon size and equipment necessary to complete the installation.

The smaller industrial sites will use rotary or turbine meters. These meters occupy very little space. Dimensions of enclosures for these installations may be approximately 8 meters by 10 meters (80 square meters). The enclosures are sized to include vehicles, and ancillary equipment for operating and maintenance checks.

- Commercial meter sites may or may not be enclosed in a controlled access location. Enclosures for these meters will be small, about 3 meters by 3 meters (9 square meters). Crew size will vary from 2 to 6–7 workers.

- Residential meters will be installed above ground on the gas riser connected to the gas distribution main. At apartment blocks these meters may be installed in alcoves or similar locations adequately ventilated and sealed to prevent any gas leakage from entering the building.

Operations and Maintenance

Operations and maintenance at these locations include meter reading once per month and turning meters off and on during extended vacancies between occupancies.

Residential meters may be removed and checked or replaced once in 5 or 10 years depending upon regulatory requirements to recalibrate the meters for accuracy.

Industrial and commercial meters will be checked for proper operation on a 1- or 2-year frequency depending upon size and type.

Master reading will be once per month for all meters, and may be performed by the individual owners, residents, commercial and industrial, under the present operating scheme.

Visitation to these installations for other purposes is essentially non-existent.

7.3 PROJECT OBJECTIVES

7.3.1 Elimination of Leaks

To replace degraded underground pipes in order to arrest existing gas leaks and prevent future leaks, enhance safety by preventing explosions, and reduce maintenance costs.

7.3.1.1 Replacement of submerged or inaccessible pipe

To replace and move submerged and inaccessible pipe to more accessible locations in order to enhance the safety of system operations by facilitating appropriate inspection and corrective maintenance techniques.

7.3.1.2 Cathodic Protection

To install a comprehensive cathodic protection system in order to:

- Extend the life of the existing system indefinitely.

- Reduce the electrical power consumption to 10 to 20 percent of the present annual consumption.

- Improve the public image and safety by reducing deterioration of and leakage from the system.

- Reduce leaks in order to reduce the costs for repair and replacement.
- Reduce the frequency of pipe replacement and street excavations.
- Reduce methane emissions into the atmosphere.

7.3.1.3 Construction, Maintenance, Test, and Leak Detection Equipment

To improve the capability of performing emergency construction work and scheduled and routine operation and maintenance tasks with greater efficiency and safety ; to improve the capability of detecting leaks in order to maintain a leak-free distribution system; to reduce release of natural gas to the atmosphere, and to reduce the amount of gas attributed to leakage by accomplishing the following:

- Providing present-day tools and equipment for accomplishing the required maintenance and repair procedures
- Reducing response time to emergencies caused by unauthorized excavations that rupture or puncture distribution piping
- Providing protective equipment for employees, including items such as work gloves, eye goggles, barricades, and toe protectors for use when operating pneumatic excavating and compaction tools.
- Providing new leak detection equipment that will reduce the time and costs required to maintain the existing equipment in a reliable working condition.
- Testing and calibrating equipment for cathodic protection operation and maintenance effectiveness thus ensuring performance of personnel assigned to inspecting cathodic protection systems.

7.3.2 Better System Controls—SCADA-Supervisory Control and Data Acquisition

To provide an accurate state of the art communication system that will transmit data on the status of gas flow in the distribution system on an on-line, real time basis. Instant availability and transmission of information on status of pressures, flow-rates, and security conditions at monitored locations will promote safety, and improve maintaining distribution pressures and delivery capacity with varying weather conditions. The ability to control operating pressures from a central control station will provide for operation of the system at the lowest pressure while providing required delivery capacity according to the season.

Load forecasting will allow the gas utilities to estimate future delivery requirements without setting arbitrary take-or-pay allocations which are counterproductive to gas conservation. Firm gas presently allocated that can be reallocated on a real-time basis will be available for other markets. For example, maintaining delivery to interruptible industrial customers who would otherwise be required to operate on alternative fuel would be possible. If the industrial customers must be curtailed, then the actual time of curtailment can be monitored.

7.3.3 Framework for Gas Conservation and for Increased Revenues—Installation of Meters at Unmetered User Locations

- To capture revenue from the individual users on the basis of actual gas consumed. Installation of meters at presently unmetered customers will allow for billing according to the actual use of gas.

- To conserve natural gas by increasing the price to comparable worldwide market value, thus promoting economy of use.

- To upgrade the sales meters of industrial consumers by replacing existing meters with meters of present-day standards, in order to improve metering accuracy.

- To provide gas meter testing facilities with state of the art electronic measurement of gas flow through meters for accuracy in calibration.

- To replace the arbitrary norms used now.

- To raise the standards for measurement of gas to equal world standards.

7.3.4 Improvement of Regional Air Quality and Reduction of the Greenhouse Effect

- To substantially improve regional air quality by reducing the reliance on alternative fuels (and by upgrading equipment in industrial plants and district heating plants).

- To reduce the potential for methane leaks into the atmosphere, thus reducing the greenhouse effect, which is substantially impacted by methane gas.

7.4 BASELINE DATA

7.4.1 Existing Conditions-Gas Distribution System

7.4.1.1 Pipeline System Characteristics

The development of the gas distribution systems in the four cities took place mostly in the 1950s. State Standard SNiP 2.04.08-87 defines the range of pressures for high, medium and low pressure systems which are currently in use at all four gas utilities:

High Pressure (HP) 1st category	6-12 Bars
High Pressure (HP) 2nd category	3-6 Bars
Medium Pressure (MP)	.05-3 Bars
Low Pressure (LP)	less than .05 Bars

Pipe wall thicknesses in use range from a minimum of 3 mm to a maximum of 10 mm, with 4 mm to 8 mm being the most commonly used by all four Gorgas companies. Similarly, pipe diameters range from 25 mm for low pressure application up to 700 mm for high pressure application. The average pipe diameter were given as follows:

	Ryazan	Saratov	Volgograd	Voronezh
HP system	200 mm	400 mm	700 mm	400 mm
MP system	225 mm	175 mm	100 mm	325 mm
LP system	125 mm	100 mm	100 mm	219 mm

All four gas utility piping systems are welded steel construction. Underground piping is wrapped with sections under cathodic protection. Aboveground piping is not wrapped and is generally <u>not</u> electrically isolated from the underground system. The aboveground piping is usually

attached to the outside of buildings at approximately ceiling height of the first story, and remains aboveground if it supplies gas to more than one building. The length of pipe installed above and below ground is summarized as follows:

	Ryazan	Saratov	Volgograd	Voronezh
Total Main length (km)	840	1634	1965	1634
Total Buried	692	738	1805	1399
Total Aboveground	148	896	160	235
Total HP	111	240	66	208
Total MP	112	19	545	211
Total LP	617	1375	1354	1215
Total under Cathodic Protection	806	558	803	449
% Buried Pipe under CP	86	76	44	32

Cathodic Protection

All four gas utilities were unable to provide length of pipe by diameter and wall thickness for any of the pressure systems. This information, however, is contained in thousands of individual project construction ("passport") files at each company.

7.4.1.2 Major Users of Natural Gas

Major users of natural gas are industrial plants, district heating plants, combined power generation-heating plants, and boiler houses. These users account for the following percentage of total use in the respective cities.

	Ryazan	Saratov	Volgograd	Voronezh
Total Sales, 1992 - mcm	2,077,500	1,684,800	3,642,000	4,428,723
Industrial - mcm	1,915,100	1,006,069	2,968,200	3,537,657
4.3 Industrial - % of total	92.2	59.7	81.5	79.9

7.4.1.3 Emergency Response Preparedness

All four companies have 24 hour emergency response service with a staffed dispatch center. Units are either dispatched by telephone, cellular phone, or radio. Generally, communications are good. Emergency response crews are usually not equipped to make permanent repairs. Such repairs are done by follow-up maintenance crews. The following summarizes the emergency response manpower for each city:

	Ryazan	Saratov	Volgograd	Voronezh
Total Manpower	37	50	116	82
Number of crews per shift	1	6	9	5
Maximum travel distance (km)	20	30	40	40
Maximum travel time (min)	25	35	45	45

128

7.4.1.4 Need for Pipe Replacement and Cathodic Protection

The cathodic protection system design is based on a government standard which specifies the requirements for cathodic protection, protection potentials, soil resistivity, and pipe protective coating. The coating system is a hot-applied bituminous coating. Pipe surface is wire brushed and primed.

All four utility companies use rectifiers (Cathodic Protection Stations) to protect what are essentially electrically continuous distribution systems. Because most service lines are not electrically isolated, each company's cathodic protection system is protecting not only its gas distribution system but any other system electrically connected to its gas distribution system. As a result, it is very difficult to control, monitor, and evaluate the effectiveness of the cathodic protection systems.

Therefore, the gas distribution piping should be isolated from other utility piping systems, and the cathodic protection equipment and controls should be modernized. Because of the existence of "drainage stations" used to drain the stray currents from streetcar rails, gas piping is bonded to other piping, i.e., the gas distribution piping network is electrically tied to other piping, such as water lines, communication lines, etc. This creates a large current requirement for cathodic protection without possibility of control of the current.

Pipe replacement is usually driven by a pipe's leak history. And most leaks are usually found through leak survey programs. Leak statistics at all four companies are directly related to their leak survey programs. None of the four companies perform mobile surveys. Each company performs walking surveys which either exceed or meet the minimum requirements of State Safety. Generally speaking, none of the four gas utilities are practicing aggressive leak survey management. This is compounded by the fact that their gas detection equipment often doesn't work. This most likely accounts for the extremely low number of leaks identified through the survey program. As a result of the interviews and system reconnaissance conducted for this study, there are indications that as the gas distribution system continues to age, leakage due to corrosion will accelerate for these reasons:

1. First generation pipe coating systems are showing signs of failure.

2. Underground piping, especially in the courtyard environment, is being replaced with aboveground piping because either the original installation was not properly protected and electrically isolated, or, third party excavation activities are creating similar problems.

3. Customers, because of increased electricity cost, have started grounding their electric meters to gas and other utility house piping, changing pipe potentials, and creating localized corrosion cells on the underground gas systems.

4. Approximately 25% of each gas utility's cathodic protection stations do not function and need to be replaced.

5. Buried pipe running adjacent to train tracks may be exposed to increase stray current. Meters and industrial/commercial house piping are owned by the customer. Ownership usually transfers at the property line or street valve. The meter/regulator train and all piping within industrial complexes are installed and maintained by the customer. Large industrial complexes usually have multiple metering locations. Master metering at the property line is not practiced.

7.4.1.5 Need for System Controls

None of the four gas utility companies has the capability of remote real-time monitoring of system pressure and flow conditions at any point on their distribution system, including the Gazprom supply points at the City Gate stations and major customer take off points. None of this information is telemetered back to their respective control rooms.

Chart recorders are used to record inlet and outlet pressure and some flow data at distribution pressure regulating stations. Chart recorders are also used to record static and differential pressure for orifice meter flow calculations at large industrial customer locations. These charts are reviewed weekly by the gas utility companies and then returned to the customer. Pressure data in the low pressure system at end-users is not normally recorded.

All four companies must depend on Gazprom to initiate pressure and flow changes to match distribution system demand changes and maintain safe system operating pressures under normal, design, and emergency conditions. None of the companies has the means to determine if a system component has failed or malfunctioned and therefore, they are unable to react in a timely and correct manner to make the system safe, minimize gas losses, and protect the public.

7.4.1.6 Need for Construction, Maintenance, and Operating Equipment

Construction and Maintenance

None of the four companies use clamps and sleeves to repair leaking mains and services. Pin hole leaks are peened over and welded. More seriously, leaking pipe is removed and replaced with welded pipe, no matter how small the piece. This is done as a "hot work operation." No isolation "hot tap" drilling equipment and service tapping equipment is used by any of the four companies. Instead, all connections and appurtenances are welded construction performed using the "hot connection" technique. No threaded fittings are used.

Operating Equipment

Presently, hydraulic modeling of gas pipe systems is done by Giproniigas, and then, only on a paid service basis. Models do not exist for the four Gorgas companies, and system modeling has never been performed on any of the gas utilities systems. The basic assumptions that are used to plan and design new projects have not changed in the past 40 years and are not validated once a project is completed. The hydraulic formulas and programs in use have not evolved with improvements from advanced technology. No modeling is performed for replacement and upgrade projects.

Network modeling capability is essential to properly carry out all aspects of new construction/replacement analysis and decision making, system capacity planning, upgrading, and, eventually, construction itself. Network modeling can easily and cost effectively deal with issues of long range planning, system upgrading, sanitation loading, emergency and contingency coverage, network simplification, supply restrictions, and much more.

Typically, modeling will identify the least cost option and reduce construction cost by at least 10%. Modeling will also identify potential system weaknesses and therefore potential service interruption, lost revenue, and damage cost.

Commercial software and compatible PC hardware are available that can efficiently and accurately model systems the size of the four gas utility companies. Most software is capable of supporting graphics. Model development can be done by either a third party or in-house. If model development is done in-house, additional software and hardware is usually required. Model development can be done in phases which will spread cost and manpower requirements.

7.4.1.7 Need for Meters and Metering Procedures

Currently, metering is limited to the industrial and commercial sector at each gas utility. Three types of meters are used: orifice, rotary, and turbine. Private homes and apartment units are not metered.

Rotary meter and meter prover technology has not evolved with improvements from advanced technology. No pressure or temperature adjustments are made either at the meter or in the billing process. Handling/shipment practices, poor quality replacement parts, and in some cases, poor maintenance facilities cumulatively contribute to poor rotary meter accuracy. There is no customer incentive to replace aging meter since the customer benefits from poor meter accuracy.

Industrial meters exhibit the following deficiencies:

1. Meter tubes are field fabricated when they should be machine fabricated to exact diameter, length, roundness, and roughness tolerances.

2. Meter tubes and orifice fittings are all welded construction precluding internal inspections for burrs, grease, roundness, roughness, diameter, protrusions, and tube cleaning.

3. Straightening vanes are not utilized where required.

4. Differential and static sensing lines are long and oversized when they should be of minimum length and diameter, and therefore are susceptible to leakage and line losses.

5. Charts and orifices are not properly handled and stored.

6. Charts are integrated with a hand held planimeter on a wood peg board. Each customer has his own planimeter, which he maintains and calibrates. It is impossible for the gas utility companies to control calibration standards and practices on these instruments.

7. Recording Chart equipment is calibrated with substandard test equipment owned, maintained and "certified accurate" by each customer. It is impossible for the gas utilities to control calibration standards and practices on these instruments.

The cumulative effect of these poor practices and substandard metering and calibration equipment can be very poor metering accuracy.

Private homes and apartment units are not metered. Typically, private homes have individual service lines connected to the gas distribution system. These service lines usually enter the private home aboveground. Apartment units are supplied gas for either cooking or cooking and hot water from a concealed riser system.

It has been estimated by the gas utility companies that each residential customer uses 3-5 times more gas than he pays for. Therefore, in addition to metering of unmetered customers, in order to capture all revenues corresponding to actual gas use, the entire metering system needs to be upgraded, at the gas receiving end and at the user end.

7.4.2 Physiography and Land Use

Of the five components of the proposed gas distribution system project, only pipe replacement, cathodic protection (including new test equipment), and new construction, maintenance, and operating equipment may have a measurable effect on the physical environment.

Because specific sites for these projects will only be known after completion of engineering studies in the next phase of the project, the large size of the areas encompassing the four cities, the great variation of the natural and man-made characteristics within them (e.g., the major differences between the left and right banks of the Volga), therefore, the general information about physical conditions in the study area presented in this EA is based only on available published materials. Meteorological and air quality data, were compiled from air pollution monitoring station reports in the four cities (by the St. Petersburg Geophysical Observatory).

It is anticipated that when specific construction sites are designated for pipe replacement (cathodic protection would not have a site-specific environmental effect but rather a cumulative effect on air quality), specific studies involving site reconnaissance by various disciplines will be conducted to describe baseline conditions for the project EAs to be prepared in each city. The same would apply once the specifies of the gas conservation projects are defined. A preliminary list of data which should be considered at that time is presented in Annex C attached to Appendix 7-A.

Volgograd

Physiography

This city, with a population of over a million, is situated on the comparatively high right bank of the Volga river where it changes course from South-South-westerly to South-easterly, leading to the land-locked Caspian Sea.

In 1952, a canal was built below the city connecting the Volga with the Don river. Then, in 1960, a hydro electric dam (2.5 million kW) was completed above the city at Volzhsky. These projects, by connecting the city to the industrial Donets basin of the Ukraine, completely changed the hydrology as well as the function of the city.

The series of hydro-electric dams built in the 1960s converted the Volga into a string of lakes. This has slowed the flow of water from the source to the Caspian to about a tenth of what it was, causing problems for fish and for navigation, with serious algae growth and hazards from storms (particularly for rafting of logs in the lakes). On the land, flooding has been controlled and ground-water raised in many places. Volgograd and Saratov are both affected by this condition.

The city is also at another physical junction, at the southern edge of the Central Russian uplands of sedimentary rocks on the right bank of the Volga, while on the left bank it is approximately at sea-level. Just beyond the edge of the city, the Volga breaks into many branches as it wends its braided, meandering way to the Caspian, below sea level.

In 1926, when the city's name was changed from Tsaritsyn to Stalingrad the population was only 150,000. When the name was changed again in 1961 to Volgograd, it was about 500,000. Since then, it has doubled again, probably due to its strategic position commanding routes to the Black and Caspian Seas and up-river to the industrial middle Volga and the Moscow region.

Soils

The soils on the right bank of the Volga are generally fertile black earth, and the vegetation is steppe, whereas on the left bank, away from the actual flood plain, the vegetation is of semi-desert scrubs and the soils are often saline and infertile.

Land Use

The unique characteristic of Volgograd's land use is its linear form—it spreads for 80 km along both sides of the Volga, with a mix of industrial, commercial, and residential uses. Although the city is industrialized, there is still a significant amount of agriculture close to other uses. Fruit and vegetables, as well as grain are grown on the outskirts of town.

The major industries are aluminum production and chemicals, which use hydro-power from the nearby station, as well as coal from the Donets basin, and oil and gas from the middle Volga. The major industries are the factories producing the following products: steel; building materials; oil refinery equipment, centrifugal oil pumps, gas separators, heat exchangers auxiliary gas heaters and small boilers; aluminum; drilling equipment; a greenhouse growing tomatoes, cucumbers, peppers, and other vegetables; protein vitamin concentrates; red brick; and food processing.

Meterorolgy and Climatology

The climate in the region is dry and continental with hot summer temperatures about 30°C and cold winters well below freezing. The annual average temperature is 7.5°C with an annual mean rainfall of 408 millimeters. Prevailing winds are from the northeast, especially during winter months, and from the west and norhwest during other times of the year.

Air Quality

The air quiality in Volgograd is affected principally by emissions from industrial sources and vehicles in the region. The estimated annual pollutant emissions in 1991 for the area were:

Particulate matter	-	29	ktonnes
Carbon monoxide	-	87,819	ktonnes
Nitrogen oxides	-	25.3	ktonnes
Nonmethane hydrocarbons	-	67.7	ktonnes

Principal industrial sources of air pollution in the region are from machinery construction, iron and steel manufacturing, aluminum production, petrochemical plants and fossil fueled power plants. Main stationary sources of discharge are industrial boilers—39.8%, power plants—16.3%, non-ferrous industries—13.2%, machine building and metal industries—7.9%, petroleum and chemicals—6.7%

Ambient air quality measurements were taken at nine monitoring stations in the region. The measured annual average levels in 1992 were compared with permitted levels. These comparisons, which are shown in Table 7-1, incidate that permissible levels of particulae matter (dust) and formaldehyde were exceeded on average throughout the area. Average levels for the other measure pollutants were below acceptable limits.

Saratov

Physiography

This city of over 900,000 people is located on a high bluff of the Volga half-way between the larger cities of Samara and Volgograd.

Similar to Volgograd, Saratov straddles the junction between the higher, wetter, more populated and longer-settled Central Russian uplands on the right bank of the Volga and the drier

less developed lowlands on the left bank to the east. In the 1960s, the city was given a strong economic stimulus by the development of the large oil and gas deposits to the north and by the construction of two very large dams at Volgograd ,whose back-up reservoir extends past Saratov, and at Balakovo, seventy miles to the north. Saratov, like Volgograd, is affected by the change of the Volga into a chain of water reservoirs, and its pollution due to major industrial activity.

The Saratov Oblast is regarded as one of the most polluted areas in Russia. The Institute of Geography of the Russian Academy of Science reports that the mid-Volga River area, including Saratov (Volgograd and Ryazan are also affected) is now characterized by the following environmental conditions: depletion and pollution of groundwater, soil erosion, alteration of topography by mining activities, air pollution; deforestation, and degradation of forest areas.

Soils

Saratov lies in the middle of the steppe-blackearth belt which stretches from the Danube delta to Central Siberia. This soil is loamy, of uniform texture, and well drained.

Land Use

Saratov was a comparatively prosperous city during the existence of the Russian Empire. In 1935, the railroad crossed the river connecting Moscow with Central Asia, and Saratov became the lowest bridging point on the Volga. In the old "Soviet Union", it lay near the center of gravity of the population. Although this is no longer the case, it is in a strategic location with respect to communications and resources for agriculture and industry. The major industries in Saratov are producing nitron chemicals including fibers, nitrite acrylic acid, and other products; rubber products; reinforced concrete; glass; refrigerators; dry ice and ice cream; red and white brick; and food processing, including margarine, mayonnaise, and other fat products. Saratov is still also a major agricultural center, Spring wheat being the chief crop, with cattle ranching and fruits as other important products.

Meterorolgy and Climatology

The climate in Saratov is dominated by continental flow with warm summers and cold winters. The coldest temperatures occur in January with a monthly mean temperature of -11.1°C, and the warmest month is July with a mean temperature of 22.9°C. Winds average at 4.4 m/s blowing predominantly from the northwest and occassionally from the south. Precipitation average 390 mm occurring mainly in the summer.

Air Quality

Air emissions in the region are dominated by heavy industry such as petrochemical, oil refining, machine construction and glass. The estimated emissions for 1991 in Saratov are given below:

Particulate matter	-	4.2	ktonnes
Sulfur dioxide	-	30.4	ktonnes
Nitrogen oxides	-	9.6	ktonnes
Carbon monoxide	-	57.5	ktonnes
Nonmethane hydrocarbons	-	44.6	ktonnes

Most of the industrial facilities are concentrated in the southern and northwestern districs of the city. Automobile exhausts account for approximately 40% of the total emissions in the region.

Ambient air concentrations, which are monitored at 5 locations throughout the city, show that levels of many pollutants are above the permissible levels. Table 7-2 summarizes the measured levels in the region during 1992. They show that NO_2 levels exceed the Russian standard, as well as HF, NH_3, benzo(a)pyrene and phenol. However, measured levels of SO_2, particulate matter, and CO are below the standards. The ambient air data reflect the high level of heavy industry located in the area.

Voronezh

Physiography

This city of some 900,000 people is situated on the high right bank of the river which bears its name, a navigable tributary of the Don, which it joins 15 miles downstream.

Soils

Voronezh is, unlike Volgograd and Saratov, in the fertile "wooded steppe" zone of European Russia, which has the best combination of blackearth soil and good climate. Its natural vegetation is a mixture of grassland and deciduous trees, with fertile blackearth and reliable rainfall (about 25 inches annually) and enough heat to ripen a wide range of crops reliably.

Land Use

As settlement infiltrated south into this region, it became a center of the most densely populated rural part of Russia, known as the "Central Chernozem belt." It was also centrally situated between Moscow and the industrial region of the eastern Ukraine and a railroad hub. Voronezh has one of the earliest nuclear plants in Russia.

The center of town, which has many educational institutions, is laid out on a grid-iron pattern, broken only near the river by ravines carved in the steep bank. The chief industries in Voronezh are aluminum; building materials; locomotive maintenance plant; food processing (including machinery for these operations), ceramics, locomotive maintenance, brick, and excavation equipment.

Meterorolgy and Climatology

The climate in Voronezh is slightly lmilder than Ryazan, with the coldest month averaging -9.3°C and the warmest month averaging 19.9°C. The region is hilly with wind speeds that average 4.4 m/s and predominant directions from the southeast and west during the spring and fall months, respectively. The annual rainfall averages 508 mm.

Air Quality

Air emissions in the region are moderately high, being dominated by the petrochemical industry, machine construction and fossil fueled power plants. Annual emissions in Voronezh for 1991 are given below:

Particulate matter	-	7.9	ktonnes
Carbon monoxide	-	91.5	ktonnes
Nitrogen oxides	-	12.5	ktonnes
Nonmethane hydrocarbons	-	5.7	ktonnes

Ambient air quality was monitored by four stations in the region for up to seven months during 1992. The measured pollutants, which are reported in Table 7-3, show relatively high levels.

The mean levels for particulate matter, nitrogen dioxide, formaldehyde and benzo(a)pyrene exceed the standards. However, sulfur dioxide levels are below the standard.

Ryazan

Physiography

This city of over half a million people lies on the right, higher, bank of the Oka river, a tributary of the Volga. The area north of the river (left bank) forms an extensive swampy depression known as the Meshchera, which is thinly populated and largely forested, where some reclamation has been carried out since the late 19th century.

Soils

The soil in Ryazan is appreciably poorer than in Voronezh. It is in the "mixed forest zone" with podzolic brownearths and glaciated often waterlogged land.

Land Use

This city is within the Central Industrial Region which has developed because of the presence of the capital nearby and the existence of lines of communication. Ryazan, connected by rail, water and pipeline with all the main regions of the country, has grown very rapidly, and is now ten times as large as it was in 1926. The major industries in Ryazan are automobile components; Electronic devices; color metal manufacturing and reprocessing, metal forging, and a tannery plant.

The Institute of Geography of the Russian Academy of Science attributes the severity of environmental pollution in the central industrial area to high densities of population and urbanization with intensive industrial activity, high levels of automobile pollution as well as agricultural activities.

Meterorolgy and Climatology

Ryazan is located in the interior of Russia with a climate that is dominated by contental air flow. Temperatures are slightly cooler than the other regions with an annual average of 3.9°C, a monthly low average of -11.1°C in January and a monthly high average of 18.8°C in July. Winds predominate from the west and southwest with an average speed of 4.9 m/s.

Air Quality

The principal sources of air pollution are from petroleum refineries, petrochemicals, cardboard production, machine construction and fossil fueled power stations. Emissions for the region are reported below:

Particulate matter	-	10	ktonnes
Sulfur dioxide	-	17.5	ktonnes
Nitrogen oxides	-	17.9	ktonnes
Carbon monoxide	-	41.6	ktonnes
Nonmethane hydrocarbons	-	38.5	ktonnes

There are four ambient air monitoring stations in the area. However, ambient air measurements were available for only a few months in 1992 at two stations. The measured levels, which are reported in Table 7-4, show that the standards may be exceed for NO_2, formaldehyde, and phenol.

The General Plans for the cities are still considered to be confidential by the Russian authorities and were therefore not released for use in this report.

7.4.3 Demographic Data

Population growth data and data on the total number of apartments, household size and apartment were obtained. Reliable income data was not available.

Projections on population were provided by Goskomstata and the Center for International Research, U.S. Census Bureau. Projections of the number of apartments are derived from the population projections and discussed in Section 3.

Population

The 1992 population for the four cities is as follows:

Ryazan	525,000
Saratov	907,000
Volgograd	1,003,000
Voronezh(oblast)	2,475,000 (900,000 reported for the city)

The projections follow projections for Russia as a whole, with an annual change ranging from 0.24% in 1993 to 0.21% in 1999.

Apartments

The number of apartments in each city in 1992 are as follows:

Ryazan	165,836
Saratov	295,000
Volgograd	305,232
Voronezh(oblast)	1,043,501

Households

The household size is 3.17 for Ryazan, 3.07 for Saratov, 3.28 for Volgograd, and 2.37 for Voronezh. The average apartment size is the same for all four cities: 40 square meters.

7.5 ENVIRONMENTAL ASSESSMENT REQUIREMENTS

World Bank Operational Directive 4.01

The World Bank has determined that this is a Category B project.

Most small scale rehabilitation, maintenance, and upgrading projects are designated Category B. The anticipated impacts are considered to be less than Category A impacts. Few if any of the impacts are considered to be irreversible, and they are not as sensitive, numerous, major, or diverse as Category A impacts. Also, remedial measures can be more easily designed. Preparation of a mitigation plan suffices for most Category B projects and the report may be included in a separate chapter of the project feasibility study.

Russian Federation Environmental Protection Legislation

According to RSFSR Law on Environmental Protection No. 2060-1, adopted 19 December, 1991, Section V, Articles 36, 37, and Section VI, Articles 40, 42, and 43, an Environmental Assessment is required for this project under the category of "rebuilding of

facilities." Ecological and other related implications of a project must be considered in "remodeling or technically refurbishing" facilities. An EA is also required if foreign equipment is introduced. During construction and operation, the project sponsor is responsible for implementation of all the mitigation measures specified in the Environmental Assessment.

Russian Federation regulations implementing RSFSR Law on Environmental Protection, no. 2060-1, adopted December 19, 1991 are as follows:

- "On Approval of the Status of Gosudarstuennoi Ecologichesikoi Ekspertize" (SEIAR) N 942, September 22, 1993
- "Temporary Instruction on Ecological Evaluation Within Preproject and Project Documentation" (with 10 attachments) and a List of "Major Legal, Normative, and Methodological Materials, Recommended for Application when Substantiating Ecological Safety of Objects of Economic and Other Activity", July 16, 1992
- "On State Ecological Expertize (SEIAR) of preproject and project documentation", circular by the Minister, MEPNR, August 7, 1992
- "On State Ecological Expertize (SEIAR) of Enterprises with Foreign Investment", Instruction by MEPNR and RAICD, May 21, 1993

A complete list of major laws, regulations, and programs relevant to the EA is presented in Annex B attached to Appendix 7-A.

7.6 SIGNIFICANT IMPACTS ON THE ENVIRONMENT

No significant impacts are anticipated to result from the project. For the purpose of full documentation and disclosure, the impacts which have been considered are described below and mitigation measures for them are proposed in Section 7.8. In the subsequent EAs to be prepared for the pipe replacement and construction, maintenance, and operating equipment projects by the four cities, additional impacts may be identified on the basis of site-specific conditions. In addition, more precise impacts on regional air quality and the greenhouse effect will be identified when the specific conditions for the gas conservation projects are known.

7.6.1 Potential Adverse Impacts

Construction Impacts

Pipeline replacement will result in short term construction related impacts. This would include traffic circulation, air quality, odor, soil erosion, water quality, fish movement, noise and public safety risks.

Traffic Circulation and other Public Activities

There will be a potential temporary disruption of traffic movement, consisting of delays due to increased traffic on local roads and detours due to excavation at road intersections. Disruption of recreational activities may also occur, for example, if the pipe replacement area coincides with a public park or recreation area, a school, or another public use.

Air Quality

Construction activities will create dust during clearing and grading activities, during trench digging and while moving soil. However, these dust emissions will result in only localized air quality impacts, because most of the particulate matter will settle out immediately downwind of

the source. Localized dust emission impacts can be mitigated by applying water sprays to the construction area.

The exhausts from construction vehicles will emit chemicals that are precursors to photochemical smog formation. These emissions will have a more regional impact, because of the long atmospheric reaction times to form smog. However, these emissions will be very small when compared to other mobile and industrial source emissions of the region. Therefore, the impacts on the area will not be significant.

Old pipe segments will be purged of gas after new sections of main are installed. Blowdowns release natural gas to the atmosphere. Because natural gas is lighter than air, it will rise quickly, mix, and be diluted to a level at which it would not be a concern to human health.

Odor

Gas venting will result in odor near blowdown sites. Under certain climatic conditions the vented gas may drift in sufficient concentrations to be detected over a substantial distance. The duration of delectability in these cases is usually from a few minutes to an hour.

Odors can also be emitted from exhausts on the diesel construction equipment. However, these impacts will only be localized and temporary, usually occurring during vehicle acceleration.

Soil Erosion

In hilly areas there would be a potential for increase in soil erosion as a result of the pipe replacement activities.

Water Quality

Some of the pipe replacement locations may cross rivers, streams, and reservoirs. If old degraded pipes are not removed and disposed of properly this could result in degradation of water quality.

The release of hydrostatic test wastewater could also result in an impact on water quality.

Barrier to Fish Movement

There may be a need to replace 5-6 km of pipe in the Voronezh River. Trenching in the rivers may result in a temporary barrier to fish movement.

Construction Noise

There will be a temporary increase in noise levels during construction. Trucks, bulldozers, and welding equipment will be required for grading, trenching, pipe laying, and back-filling. These pieces of equipment produce noise levels of 70-85 dBA at a distance of about 15 meters. These noise levels are not higher than ambient levels in urban locations in daytime, and therefore the temporary incremental increase in noise levels is not considered to be significant.

Gas venting usually takes about an hour. Venting is required at both ends of the replaced pipe section. Ventings will take place occasionally over the term of the pipe replacement program. Because the duration of the noise is only one hour this is not considered to be a significant impact. Nevertheless mitigation measures are recommended to inform nearby residents and commercial establishments of the time of venting in advance.

Increased Public Safety Risks

The old pipes that will be removed will be purged of gas and then removed. The pipes that are abandoned in place will be cut, capped, and filled with inert nitrogen gas to eliminate future risks. Therefore no potential for increased public safety risks is foreseen.

Economic Impacts

It has been estimated that in 1993 the average personal income in Russia was approximately 24,000 rubles a month. (Reliable government statistics are not available). Most residential gas consumers spend about 48 rubles, or less than 1% of their monthly income on gas. By the year 2,000 as part of the implementation of this project, the price of gas will be raised to closely approximate its value on the world market. At that time the equivalent price of gas for an individual consumer per month would be $3.6 or 3,600 rubles (assuming $1=1,000 rubles). It is assumed that real salaries in Russia will grow as well, and that this amount would represent not more than 3-5% of salary which is the average cost of gas in developed countries worldwide.

7.6.2 Potential Beneficial Impacts

Reduced Methane Leak Potential

Replacement of deteriorated pipes, installation of a cathodic protection system and new testing equipment will substantially eliminate gas leaks and result in two impacts:

- Increase in public safety by reducing the risk of explosion due to undetected leaks
- A cumulative beneficial impact resulting from the reduced potential for release of methane to the atmosphere, thus reducing the greenhouse effect. Since methane emissions produce a greenhouse signal that is 20 to 50 times greater than carbon dioxide for equivalent emissions, it is the second most significant greenhouse gas being emitted by man's activities.

Potential for Gas Conservation

Increased efficiency in the delivery of gas through the reduction in the potential for leaks, through pipe replacement, cathodic protection and new testing equipment, better system controls through installation of SCADA, and the combination of upgrading and new metering and a change in pricing policy will result in gas conservation. This will make more natural gas available to accommodate future population growth. As market forces create a greater external demand for gas at higher prices, increased sales made possible by conservation of gas will result in an increase in an economic benefit to the Russian economy.

Improvement in Regional Air Quality

Because of the greater availability of natural gas as a result of greater efficiency in its use, there is the potential that coal and oil use will decrease as natural gas use increases. This will result in considerable reductions of emissions of particulate matter, sulfur dioxide and nitrogen oxides leading to an improvement in air quality. As a result of implementing the gas energy conservation projects (through upgrading of equipment in industrial plants and district heating), the total yearly emissions of NOx in the four cities would be reduced by 1,064 tons and total emissions of CO_2 (particularly important for reduction of the greenhouse effect) would be 82,620 tons. These are considered to be beneficial impacts.

240

7.7 PROJECT ALTERNATIVES AND THEIR IMPACTS

In addition to the proposed project, five project alternatives were analyzed in the gas distribution system rehabilitation study, including the No Project Alternative. The environmental impacts of each alternative are described herein.

Alternative 1: Industrial Energy Conservation Projects

This Alternative is characterized by the following conditions:

- Loans would be made by the World Bank for industrial efficiency projects meeting the World Bank's economic criteria. These projects would involve institution of measures which would increase the efficiency of use of natural gas in the large industrial plants in the four cities. This goal would be accomplished by projects of the following types: replacement of existing boilers with modern versions; installation of heat exchangers; automatic controls for furnaces; installation of refractory lined stacks with heat recovery equipment; replacement of production equipment with modern equipment that can use gas more efficiently, for example insulation and sealing of kilns; installation of condensate return equipment; insulation of above ground piping, installation of heat recovery wheels in kilns; replacement of CO_2 recovery equipment; replacement of inefficient burners at boilers with high efficiency burners with associated controls, and other similar retrofit projects.

- The central hot water and heating system would remain in operation and continue to serve all existing customers

- The gas distribution system would remain operational and would be expanded, as necessary, to serve the growing needs of the population, using current practices, procedures, and equipment.

This Alternative would have a limited but noticeable effect on overall gas demand and thus result in some gas conservation. The extent to which it would result in a significant amount of conservation would depend on the number of industrial plants in which projects would be implemented.

This Alternative would result in a significant improvement in air quality because the new burners and recovery equipment would reduce the amount of NO_x and CO_2 escaping into the atmosphere. However, if no improvements are made to the gas distribution system, the adverse impacts resulting from continuation of current gas distribution construction, maintenance, and operating practices would continue. Namely, continuation of leaks and release of methane into the atmosphere, continuation of safety risks to the public, and loss of revenue from inaccurate metering.

The activities required to implement this project would all be contained within the industrial plants, and therefore there would be no short term construction impacts on surrounding activities.

Alternative 2: Elimination of Residential Gas Cookers

This Alternative assumes that the World Bank would make loans for energy conservation projects meeting the Bank's economic criteria to industrial plants as in Alternative 1. Also, the following conditions would apply:

- The central hot water and heating system would remain in operation continuing to serve all existing customers

- The gas distribution system would be retired in those areas where gas is used exclusively for cooking. Gas cookers are replaced with electric cookers.

Replacement of gas cookers with electric cookers in those areas of the low pressure gas distribution system where gas is used exclusively for cooking would have practically no discernible effect on overall gas demand because of the relatively small share of overall consumption that these cookers represent.

In order to implement this alternative, additional electric generators would have to be installed, or the present generators will have to produce more electricity. In either case, the gas used for producing electricity for the electric stoves will be about three times greater than the gas used for gas stoves. This would result in increased emissions from the electric generating plants. This is considered to be an adverse impact.

In the long term, there would be less need for cathodic protection and pipe replacement because gas pipes leading to residential users would be abandoned, and thus there would be less short term construction impacts.

Alternative 3: Installation of Boilers in Apartment Complexes

This Alternative assumes that loans would be made for industrial efficiency projects meeting the World Bank's economic criteria, and in addition:

- The central hot water and heating system would be retired in those areas where conversion to a gas based local system is more cost effective

- The gas distribution system would remain operational and be expanded, as necessary, to serve the growing needs of the population.

Retirement of the central heating and hot water system in those areas where conversion to a gas based system is more cost effective than upgrading the central heating and hot water system would lead to a dramatic shift in gas use from the district heating sector to the residential sector.

Because of the proximity of the heat source to the customer, heat loss would be reduced. This would also result in reduction of gas use and therefore in gas conservation.

Due to better, more individual controls at apartment blocks, heat and hot water would be delivered more efficiently and would make the system more reliable as well as add to the comfort of consumers.

Installation of new boilers would have some short term construction period impacts.

This Alternative would result in bringing the emissions from boilers at the central hot water and heating plants closer to the residential users. This is considered to be an adverse impact.

The impacts of implementing the energy conservation projects in the industrial plants and continuation of the gas distribution system in its present practices would be the same as described in Alternative 1.

Alternative 4: Elimination of Gas Stoves and Installation of Boilers in Apartment Complexes

This Alternative is a combination of Alternatives 2 and 3 and therefore it would result in a combination of the impacts of those alternatives. Emissions would increase under this Alternative because of the increased emissions from the electric generating plants.

Alternative 5: The No Project Alternative

Under the No Project Alternative, there would be no international loan money provided for industrial projects that are designed to improve gas use efficiency in the four selected cities. Future changes in gas consumption would be driven solely by the underlying economic and demographic changes. Also, under this Alternative:

- The central hot water and heating system would remain in operation continuing to serve all existing customers
- The gas distribution system would remain operational and would be expanded as necessary, to serve the growing needs of the population using current practices, procedures, and equipment.

The No Project Alternative would preclude the rehabilitation of the gas distribution system for more efficient and economically viable gas delivery.

Although pipeline leaks and cathodic protection inspections and pipeline replacement would continue as at present, the lack of a systematic up to date program for leak surveys, leak detection equipment testing, and the unavailability of modern equipment for construction and maintenance, in combination with continued aging of the pipeline system, would result in exacerbation of the current deficiencies of the system.

Without the potential for increased revenues that would result from better system controls, metering of currently unmetered residential and commercial users, and barring an associated equitable pricing policy, potential economic benefits to the gas utility companies and possibilities for gas conservation would be lost.

Any short term adverse impacts of construction activities such as excavation of streets, dust and noise during construction, etc., would be postponed to a future date because the condition of pipelines will continue to deteriorate. Continuation of leaks will continue the loss of natural gas resources due to increased undetected leaks of methane to the atmosphere. This would also continue to contribute to the greenhouse effect and be a potential increased safety risk to the public.

7.8 MITIGATION MEASURES

Implementation of cathodic protection systems and SCADA, purchase of new equipment for construction, maintenance and operation, and metering are not anticipated to result in adverse impacts. The origin and specifications for the new equipment for the gas distribution system and the energy conservation projects will not be known until vendors are selected after competitive bids are received. Therefore, three types of mitigation measures are proposed: construction mitigation measures for pipe replacement, enhancement of environmental management capability, and public involvement during the construction process.

7.8.1 Construction Mitigation Measures for Pipe Replacement

7.8.1.1 Protection of Other Utilities

Prior to construction, the location of other utilities underground and above ground in the vicinity of the pipe must be identified and permits from local authorities obtained. During construction all the other utility lines must be protected. Each utility should remain in full operation during construction. All ditches must be returned to their original condition or better.

7.8.1.2 Construction Safety

World Bank Requirements

The project sponsor is required to obtain the two volumes "Encyclopedia of Occupational Health and Safety" published by the International Labour Office in Geneva, Switzerland. Pertinent information on safety procedures during construction should be disseminated to all levels of personnel involved in the project. Some of the safety hazards of concern to the World Bank include the following: dangerous machines with moving parts that can mutilate and kill; electricity; ergonomic factors—physiological and psychological stresses of the human body; eye protection; falls; fires and explosions; heat or cold stress; moving and lifting equipment; noise; vibrations; and combinations of several of these hazards which can exacerbate the danger and injury.

Russian Federation Requirements

Construction should be performed according to the following Russian Federation laws, instructions and regulations dealing with environmental protection and occupational Safety Regulations:

- Instructions of SNiP 2.04.08-87: "Gas Supply" and "Safety Rules for Maintenance of Gas Utilities"
- Russian Federation Health and Safety Regulations in the Gas Industry, 20 October, 1991
- Norms for Safety in Construction Industry, 1991
- Safety Rules and Norms in the Construction Industry. Noise Protection, July 1, 1978
- Federal Standard GOST 12.1.003-83
- SNiP 2.05.06-85, Section 9, Environmental Protection for Pipelines
- SNiP 3.05.02-88, Building Code Gas Supply
- The State Committee for Safe Performance Supervision in Industrial and Mining Sectors, Safety Rules in Gas Industry
- GosGorTechNadzor, Safe Operation of Reservoirs which are under pressure
- RosStroyGas, Operation Regulations in Gas Industry, Health and Safety Regulations, July 1, 1992

Each city has its own occupational safety regulations. Construction procedures should be in conformance with all city regulations that apply.

Construction should be in conformance with the World Bank Occupational Health and Safety Guidelines, September, 1988, General Guidelines for Industrial Projects, and Oil Pipelines.

Relevent sections of these guidelines are presented in Annex E attached to Appendix 7-A.

7.8.1.3 Construction Procedures

Research of Pipelines

No excavation should be undertaken until detailed research on the existing underground structures is completed by a qualified pipeline engineering concern. All underground structures, their sizes, locations, depths, materials carried, and ownership shall be identified, in order to prevent damage from external sources and damage from construction activities to existing underground facilities.

Pot holing

Pot holing is the advance digging in area to locate underground structures. The digging is performed carefully by hand if necessary when a pipeline is near. Pot holing should be used whenever it is necessary to locate the position of underground structures.

Protection of Existing Drainage Patterns

At stream or river crossings, new pipeline should be buried at least 3 meters under the scour line.

Erosion Control

In hilly areas where there is a potential for erosion, an erosion control plan should be prepared to keep stripping of vegetation to a minimum, control the velocity and direction of the runoff, protect slopes, stabilize soil, and reestablish native vegetation in natural areas. SNiP 2.05.06-85, Environmental Protection for Pipelines, Section 9.2, specifically requires erosion control measures.

Dust Control

The construction area should be sprayed with water to control dust.

Construction Noise

Prior to venting of gas as part of pipe replacement operations, notice should be given to surrounding area residents and commercial and industrial establishments. The approximate time for venting and the anticipated noise level should be disclosed at that time. Construction activities should take place only during the daytime, and should conform to city noise ordinances and regulations, as applicable. Safety Rules and Norms in the Construction Industry, Noise Protection, and Federal Standard GOST 12.1.003-83 should be followed in all construction activities.

Treatment of Removed Old Pipes

The old pipes that will be removed should be purged of all gas and then removed. Pipes that are abandoned in place should be cut, capped, and filled with inert nitrogen gas to eliminate future risks.

Water Quality

The hydrostatic test water should be drawn from nearby sources, pressurized in the pipe, tested for contamination, and then discharged to an existing waterway. General guidelines for hydrostatic testing are included in the World Bank Technical Paper Number 154, Environmental Assessment Sourcebook, Volume III, Guidelines for Environmental Assessment of Energy and Industry Projects, 1991, p. 291.

Solid Waste

All solid waste generated at the construction site should be removed from the site and deposited at an approved solid waste disposal facility.

Toxic Soil

It is not anticipated that toxic materials would be used for construction activities. However, because of the possibility of the existence of past deposits of toxics as a result of industrial or military activities, the potential for such conditions should be investigated prior to construction, and construction activities should be carried out according to the best practices of health and environmental safety, which may involve clean up of any existing contamination.

Construction Inspectors

The gas utility in each city should designate inspectors to perform regular inspections of construction activities to ensure that the contractors are following proper construction procedures (for example, that backfilling is performed to prevent settling, and that streets are restored to former conditions), and that they are taking precautions in conformance with Federal and local occupational health and safety provisions.

Fire Protection and Emergency Response

An Emergency Response Plan should be prepared for the project prior to construction. The Environmental Coordinator would be responsible for preparing the plan, managing its implementation and reviewing it as necessary. Proper safety and fire fighting equipment should be provided at the construction sites and arrangements should be made in advance with emergency response teams in the area. Personnel should be trained in the use of safety equipment and periodic drills should be given in emergency procedures. Safety reminders should be issued to all staff periodically, and visitors to the construction site should be briefed on potential hazards and necessary safety precautions.

The Emergency Response Plan should contain an Emergency Organization Chart, with the names and home phone numbers of responsible personnel; an emergency communication network to supplement the main network, storage, maintenance and testing procedures for emergency equipment; training schedule for personnel, emergency control procedures; resident evacuation; arrangements made with local fire fighting force, police, and hospitals; and restoration procedures in case of an upset.

Continuation of Vehicular Circulation

The following methods should be used to ensure that vehicular circulation is not disrupted during construction: detour of traffic around the construction area; direction of traffic along one-half of the roadway, and routing of traffic across temporary trench bridging. Detours should be properly signed and personnel should be deployed to direct traffic if necessary.

Vehicular Safety During Construction on the Road and on the Construction Site

All Federal and local laws dealing with vehicle safety during construction should be adhered to, to avoid the possibility of increase in vehicular accidents as a result of the addition of trucks carrying construction equipment on the road. The construction area should be appropriately signed to alert motorists and pedestrians. Temporary lighting and personnel should be deployed to direct traffic if necessary, to ensure safe movement around the construction sites.

Future Maintenance

Future maintenance activities should be undertaken on a regular basis as follows:

- Periodic checks of cathodic protection equipment to ensure proper operation and effectiveness of corrosion protection
- Maintain active participation by other agencies to ensure that notice is given by them prior to excavating in the vicinity of the gas system pipe
- Annual leak surveys
- Maintenance of valves, regulators, and metering devices according to regular schedule

Mitigation Measures Monitoring

Monitoring of the implementation of mitigation measures should occur before, during, and after the pipe replacement has taken place. Monitoring should encompass all the mitigation measures required as conditions of the project to ensure that they have been properly executed. Monitoring should be the responsibility of the Environmental Coordinator in each gas utility .

7.8.2 Enhancement of Environmental Management Capability

In order to ensure that the project mitigation plan is executed effectively, the environmental management capability of the gas utility companies in the four cities should be enhanced as follows:

- Organizational changes should be instituted as follows:

  A new position of Environmental Coordinator should be established within each gas utility company. The position would include responsibility for ensuring that the mitigation measures incorporated in this project are carried out according to the technical details, descriptions, and operating procedures specified in this EA and following project specific EAs, that monitoring of mitigations and reporting procedures are carried out properly, and that funds allocated for implementation of mitigation measures are used for their intended purpose.

- If an appropriately trained person is not available to fill the position of Environmental Coordinator in the short term, the Chief Engineer or his deputy should assume the position in addition to his other duties until a qualified professional is available.

- A staff development program for environmental compliance should be instituted as follows:

  - Training of engineers in potential environmental impacts related to gas distribution system rehabilitation and operation, and means for preventing or mitigating the impacts, and in preparing environmental compliance plans and emergency response plans for projects.

  - Training of construction personnel in preparing construction environmental control plans prior to construction and in recognizing and abetting potential environmental problems in the field.

  - Periodic review with all engineering and construction personnel of the environmental and occupational health and safety regulations applicable to gas distribution system engineering, construction, and operation activities.

- Technical Assistance Program

  In order to keep the newly appointed Environmental Coordinator in each city current with developments in the environmental field, particularly with respect to gas distribution systems, environmental personnel should periodically be scheduled to visit with counterparts in various World Bank countries, to attend relevant technical conferences in Russia and abroad, and receive funding for courses and seminars on relevant environmental topics offered in the universities in their own cities.

- Equipment Support for Environmental Management

  In order to facilitate the work of environmental coordinators in the gas utility companies and the personnel in the Environmental Committees in the four cities, the following equipment should be supplied:

  - Computers, including hardware and software for developing an up-to-date data base for environmental information, monitoring systems, and visual simulation
  - Environmental and gas distribution standards and procedures translated into Russian
  - Fax machines
  - Noise meters
  - Air filters

7.8.3 Public Involvement During Project Implementation

A public involvement program should be conducted as part of the project for the general public and the commercial and residential establishments that would be affected by the short term construction impacts of the project. The program should be planned to inform the public about the purpose of the project, the short-term adverse impacts that may be anticipated, the mitigation measures that will be undertaken to reduce these impacts, and the long term benefits of the project. The program should begin prior to start of construction and continue until the completion of the construction period.

This program should include press releases , distribution of hand-outs, community forums and meetings, and site tours in areas to be disturbed. Citizen concerns and suggestions for added mitigations of environmental impacts should be incorporated in project procedures.

7.8.4 Implementation, Schedule and Cost of Mitigation Measures

7.8.4.1 Implementation Responsibilities

Construction Mitigation Measures

Implementation of the construction mitigation measures will be the responsibility of the engineering contractor for the project, and subsequently of the construction contractor. Adherence to the mitigations will be specified in the bid documents for these contractors, and the gas utilities will assign inspectors and environmental monitors for the duration of the project to ensure that they are carried out.

Program for Enhancement of Environmental Capability

Implementation of the organizational changes will be the responsibility of the gas utility companies.

Implementation of the training program the will be the responsibility of the Ministry of the Environment, in cooperation with the Ministry of Fuel and Energy. Each ministry will appoint a joint-project coordinator for the program. The coordinators will screen candidates from recommendations made by the cities for training, will supervise all travel arrangements, and will monitor progress after completion of the training.

A counterpart coordinator will be designated in the U.S.[1] to supervise training activities there. This coordinator will be responsible for implementation of the program as planned. Each trainee will have a mentor for the duration of the training. The mentor will be responsible for follow-up, guidance, and support to the trainee while he/she is in the U.S. Mentor services will be pro bono.

7.8.4.2 Schedule

The designation of environmental coordinators in the gas utility companies should take place at project inception.

Gas Utility Personnel

One person will be designated for training at each gas utility. This person will spend a total of three months in the U.S. The first month will be spent during the engineering phase, in the first 6 months of the project. The second month will be spent just prior to start of construction. The third month will be spent after construction is completed.

Environmental Committee Personnel

One person will be designated for training from each city's Environmental Committee, one person from the Ministry of Fuel and Energy, and one person from the Ministry of Environment. Each person would spend two months in the U.S. "shadowing" environmental program staffs in various cities and industries.

---

1 U.S. is assumed to be the country for training for cost estimating purposes. Training could be carried out in other World Bank countries which are active in environmental control.

249

Equipment

Equipment will be delivered to the gas utility companies and the city environmental committees at the completion of training for their personnel.

7.8.4.3 Cost of Mitigation Measures

No additional costs are calculated for construction mitigation measures because highest and best engineering and construction practices would incorporate all of the measures recommended above as part of the project cost. The cost of the public involvement program will be included in the project specific EAs to be prepared at a later phase.

Environmental Management Capability

	Year 1	Year 2	Each Subsequent Year
Environmental Coordinator			
Salary	$8,000	$8,000	$8,000
Utilities	12,000	12,000	12,000
Subtotal	$20,000	$20,000	$20,000
Apartment	$8,000	$8,000	
Car	12,000	12,000	
Subtotal	$20,000	$20,000	
Training Program			
4 persons for three months @ $2,500 per month per person	$15,000	$15,000	
6 persons for two months @ $2,500 per month per person	15,000	15,000	
Out of country coordinator (consultant)	5,000	5,000	
Travel (18 trips total @ $3,000 ea)	27,000	27,000	
Other Expenses	5,000	5,000	
Subtotal	$67,000	$67,000	
Equipment			
Computers (10 units)	$30,000		
Fax Machines (8 units)	8,000		
High Volume Filters or RAM(4 units) (real time aerosol monitors)	12,000		
Subtotal	$50,000		
TOTALS	$157,000	$107,000	$20,000

7.9 DOCUMENTS CONSULTED

Environmental Assessment Manual, Russian Federation, updated in 1992

Gosstroy, Construction Norms and Regulations,

Gosstroy, Safety Rules and Norms in the Construction Industry, Noise Protection, July-1,1978

Russian Federation Health and Safety Regulations in the Gas Industry, October 20, 1991

Institute of Geography, Russian Academy of Science, White Book Paper on Environment for 1991, Moscow, 1992.

RosstroyGas, Operation Regulations in Gas Industry, Health and Safety, October 20,1992 Regulations

RSFSR Law on Environmental Protection No. 2060-1, adopted December, 1991 Section V, Articles 36, 37, and Section VI, Articles 40, 42, and 43

Safety Rules in the Gas Industry, June 1,1989

SNiP 2.05.06-85, Section 9: Environmental Protection for Pipeline Projects

SNiP 3.05.02-88, Building Code Gas Supply

Temporary Instruction for Environmental Assessment in Pre-project and project materials, July 15,1992

The World Bank, Occupational Health and Safety Guidelines, September 1988

The World Bank, Operational Directive, Manual Transmittal Memorandum 4.01: Environmental Assessment

The World Bank, Technical Paper Number 139, Environmental Assessment Sourcebook, Volume I, Policies, Procedures, and Cross Sectoral Issues, pp. 55-62, 175.

The World Bank, Technical Paper Number 140, Environmental Assessment Sourcebook, Volume II, Sectoral Guidelines, December, 1991, pp. 153-167.

The World Bank, Technical Paper Number 154, Environmental Assessment Sourcebook, Volume III, Guidelines for Environmental Assessment of Energy and Industry Projects, 1991, pp. 36-62.

7.10 MINISTRIES AND OTHER GOVERNMENT AGENCIES CONSULTED

Ministry of Fuel and Energy
Eugeny V. Minaev, Chief, Environmental Protection and Natural Resources Management Department

Ministry of Environment and Natural Resources
Sergei A. Bourtsev, Deputy Director, State Department of Environmental Assessment and Review
Svetlana Golubova, Technical Specialist

Permanent Commission for Ecology, Saratov
Vitaly N. Yeryomin, Chairman

Committee for Ecology and Environment Control, Voronezh
Nadezhda V. Storozhenko, Chairwoman

Gorgas, Voronezh
Larisa Sokolova, Occupational Safety Engineer

City Committee for Protection of the Environment, Volgograd
Vasili Shevchenko, Deputy President

City Committee for the Protection of the Environment, Ryazan
Vladamir Voronov, Phd., Director

City Administration, Ryazan
Sergei Safonke, Deputy Chief City Sanitary Doctor

E.A. Maximov, Chief Federal Sanitary Doctor of Ryazan

7.11 ENVIRONMENTAL ASSESSMENT PREPARERS

Bechtel

Irina Perlis Torrey, A.I.C.P., EA Manager
Robert Vranka, Air Quality Specialist

Subcontractors

David Hooson, PhD, Geography Department,
University of California, Berkeley

Dr. Emma Bezuglaya,
St. Petersburg Main Geophysical Observatory

Table 7-1

Measured Ambient Air Pollutant Concentrations for Volgograd in 1992

Pollutant	Annual Average Concentration ($\mu g/m^3$)	Permissible Level ($\mu g/m^3$)
Particulate Matter (Dust)	220	150
SO_2	17	50
CO	1,200	3,000
NO_2	40	40
HF	4	5
NH_3	30	40
Formaldehyde	8	3
Benzo(a)pyrene	6×10^{-4}	1×10^{-3}

Source: Dr. Emma Bezuglaya, St. Petersburg Main Geophysical Observatory, October 1993.

Table 7-2

Measured Ambient Air Pollutant Concentrations for Saratov in 1992

Pollutant	Annual Average Concentration ($\mu g/m^3$)	Permissible Level ($\mu g/m^3$)
Particulate Matter (Dust)	90	150
SO_2	6	50
CO	1,900	3,000
NO_2	100	40
NH_3	30	40
Formaldehyde	20	3
Benzo(a)pyrene	1.7×10^{-3}	1×10^{-3}
Phenol	5	3

Source: Dr. Emma Bezuglaya, St. Petersburg Main Geophysical Observatory, October 1993.

Table 7-3

Measured Ambient Air Pollutant Concentrations for Voronezh in 1992

Pollutant	Annual Average Concentration ($\mu g/m^3$)	Permissible Level ($\mu g/m^3$)
Particulate Matter (Dust)	280	150
SO_2	5	50
CO	700	3,000
NO_2	50	40
NH_3	7	40
Formaldehyde	8	3
Benzo(a)pyrene	2.2×10^{-3}	1×10^{-3}

Source: Dr. Emma Bezuglaya, St. Petersburg Main Geophysical Observatory, October 1993.

Table 7-4

Measured Ambient Air Pollutant Concentrations for Ryazan in 1992

Pollutant	Annual Average Concentration ($\mu g/m^3$)	Permissible Level ($\mu g/m^3$)
Particulate Matter (Dust)	150 [a]	150
SO_2	3 [b]	50
CO	3,000 [a]	3,000
NO_2	80 [a]	40
Phenol	7 [a]	3
Formaldehyde	5 [a]	3
Benzo(a)pyrene	$9xx10^{-3}$ [b]	$1x10^{-3}$

[a] Data for only 7 months
[b] Data for only 3 months

Source: Dr. Emma Bezuglaya, St. Petersburg Main Geophysical Observatory, October 1993.

Section 8

TABLE OF CONTENTS

8. FINANCIAL ANALYSIS OF LOCAL GAS COMPANIES 1

8.1 INTRODUCTION 1

8.1.1 Scope of Work 1

8.1.2 Approach 1

8.2 FINANCIAL ISSUES 2

8.2.1 General Company Conditions 2

8.2.1.1 Revenue-Driven Profitability 2

8.2.1.2 Conservation vs. Allocation of Supplies 2

8.2.1.3 Investment for Growth 3

8.2.1.4 Inflation 3

8.2.1.5 Salaries 4

8.2.2 Scenario Analyses 4

8.2.2.1 Assumptions 5

8.2.2.2 Observations 8

8.3 ADMINISTRATIVE ISSUES 10

8.3.1 Company-wide Issues 10

8.3.1.1 The Absence of a Business-Oriented Focus. 10

8.3.1.2 The Absence of a Marketing Function 11

8.3.1.3 Procedures to Reconcile Sales Volumes and Revenues 11

8.3.1.4 Reliance Upon Manual Procedures 12

8.3.1.5 Absence of Analysis 12

8.3.1.6 Business and Management Training 12

8.3.2 Company Specific Issues 13

8.3.2.1 Ryazangorgas. 13

8.3.2.2 Saratovgorgas. 14

8.3.2.3 Volgogradgorgas. 15

8.3.2.4 Voronezhoblgas. 16

8.4 INSTITUTIONAL CHANGES 16

8.4.1 Structural Interdependence 16

8.4.1.1 Ministry of Fuel and Energy 16

8.4.1.2 Gazprom 17

8.4.1.3 Rosgaz 18

8.4.2 Legal and Regulatory Content 19

8.4.2.1 Gas Supply Allocation 19

8.4.2.2 Prices 20
8.4.3 Privatization 21
8.5 SUMMARY AND RECOMMENDATIONS 22
Table 8-1 Prices for Natural Gas 24
Table 8-2 1992 Data Base 25
Table 8-3 Summary of Scenario Results 28
Table 8-4 Selected Operating Statistics 29

Section 8

FINANCIAL ANALYSIS OF LOCAL GAS COMPANIES

8.1 INTRODUCTION

8.1.1 Scope of Work

The scope of work for the Financial Analysis included the following tasks:

1. A financial analysis of the four local gas distribution companies ("LDC")

   - Ryazangorgas, Ryazan
   - Saratovgorgas, Saratov
   - Volgogradgorgas, Volgograd
   - Voronezhoblgas, Voronezh

   in order to analyze the financial viability of each company under a range of scenarios.

2. An organizational evaluation of each company to address the adequacy of controls for the proper and efficient use of loan proceeds.

3. An institutional analysis to identify the changes which will be necessary to support the transformation of the companies into joint-stock companies.

8.1.2 Approach

The approach in completing the assignment was as follows:

1. An initial data request was sent to each of the companies in Russia. (This questionnaire is included as Appendix 8-A.)

2. Accountants and gas industry consultants visited each LDC at each company's headquarters in Russia. These visits included reviews of responses to the data requests, examinations of company records, detailed interviews with management and key employees regarding operating and management policies and procedures and inspections of facilities in the company of other Project Team members. (A list of those visits appears as Appendix 8-B.)

3. Financial data were compiled and presented in the form of projection statements which are based on the representation of LDC management and do not include evaluation of the assumptions underlying the projection. The Project Team has not examined the projection and, accordingly, does not express an opinion or any other form of assurance on the projection statements or assumptions.

4. Meetings were also held with key individuals at related governmental associations at their offices in Russia to understand the organizational structure of the gas industry in Russia and the interrelationship between those associations and the LDCs being studied. (See Appendix 8-B.)

5. Upon the conclusion of field work (Items 2 through 4, above), a formal report was prepared.

8.2 FINANCIAL ISSUES

8.2.1 General Company Conditions

In the course of this study, the Project Team observed a number of general conditions common to each of the four distribution companies. These are discussed in the following subsections:

8.2.1.1 Revenue-Driven Profitability

Currently, both gas prices and margins are established beyond the control of the LDCs. Furthermore, these rates are established at the same level for all companies throughout Russia, regardless of their location or the actual costs incurred in providing service to customers at their various geographical locations.

As shown in Table 8-1, the price to LDCs for purchasing natural gas was established at 10,499 Rubles ("Rb.") per 1000 m^3 effective August 15, 1993; the selling price was set at 11,961 Rb. After deducting the Value Added Tax ("VAT"), the mark up is about 1,100 Rb. of which 100 Rb. is directed to Rosgaz' stabilization fund. This system keeps each company's margin at 10% of the selling price for 1993 and thereafter. Inasmuch as the LDCs are driven by revenue, not efficiency, the only way for the company to raise its profits is to increase the volume of gas sold and its total revenues.

The companies also distribute LPG, whose price is tied to oil prices. These substantially higher prices result in losses at the local gas company level which must be covered by subsidies provided from the budget of the Ministry of Fuel and Energy.

The companies, purchasing gas within a monopolistic environment under such restrictive controls, does not have the opportunity to design rates which would encourage increased sales. Its financial health is, therefore, entirely dependent upon the captivity of its customers and the revenue generated by tpayment of established rates for gas service.

Addressing this vestige of the controlled economy is clearly beyond the scope of this project. Nonetheless, the inability of the companies to set market-based prices–a primary function of the successful competitor–adversely affects each company's future profitability. As noted above, it is essential that the companies begin thinking of themselves as merchants of a commodity rather than as providers of an allocated resource. Indeed, such thinking–the specific transformation of each company into a consumer-oriented enterprise–and its accommodation within a price de-controlled environment is a prerequisite for each company's longer-term profitability.

8.2.1.2 Conservation vs. Allocation of Supplies

Under the current system of national gas allocation, savings in gas usage during any year will result in reduced allocations during the following year. The company has no opportunity to redirect these volumes of gas and sell them to other customers.

Each year the company requests volumes of gas to be delivered by Gazprom. These requests are detailed by annual and quarterly volumes required and constitute a take-or-pay order by the company with penalties imposed for actual takes which exceed this amount.

If the company and/or its customers are able to reduce their consumption of gas, this conservation will not reduce their cost of gas except that, under the Conservation Decree of April

1993, the company may share in the revenue to be received by Gazprom from selling this "released" gas to export customers.

Even if this unused gas can readily be resold outside of Russia, the benefit of this resale will accrue to the company for one year only. Under current allocation procedures, any reduction in usage will be reflected in the following year's allocation.

8.2.1.3 Investment for Growth

At each of the companies there is an absence of meaningful investment for growth and expansion of the enterprise. Formerly, capital for development of the distribution system was provided by the central authorities consistent with their responsibility to allocate natural gas resources. In the privatized environment, the distribution companies must now assume this responsibility.

An important test for the viability of any enterprise is whether or not it can generate sufficient funds from internal sources and reinvest those funds in plant and equipment which will keep the business functioning. As shown below, none of the companies can pass this test:

	Current Assets	Current Liabilities	Current Ratio
Ryazan	240,908	224,696	1.1
Saratov	540,998	478,875	1.1
Volgograd	241,456	203,586	1.2
Voronezh	1,301,006	1,304,107	1.0

Thousands of 1992 Rubles

Each company does set aside an amount equal to current depreciation for reinvestment; however, this sum is grossly inadequate for the longer term viability of the enterprises. Depreciation is calculated relative to the installed cost of the company's assets adjusted once, in 1992, for inflation. The rapid pace of inflation since 1992 makes this calculation meaningless as a determinant of the capital which should be reinvested.

Although a more realistic investment is strongly recommended, it is also understood that, because of the fixed prices which the companies must charge, it is unlikely that the companies can generate adequate funds for reinvestment from their current cash flows.

8.2.1.4 Inflation

It must also be noted that inflation in Russia effectively eliminates the ability of each company to retain and to accumulate earnings. Again because of the fixed rates which the companies are obliged to pay and pass on to their customers, the resulting revenue-driven cash flows are inadequate to generate meaningful net incomes after payment of salaries, employee benefits and related employment taxes. The recent decree which calls for an indexation of gas costs to monthly increases in inflation is an important step in matching the buying power of a company's revenues closer to each company's actual level of expenses. Nonetheless the companies remain virtually defenseless in relating current costs to market prices.

A further exacerbation of the dilemma is each company's billing gap. This gap, typically 30 to 60 days between the time that a bill is issued and the time that funds are either received by the company or credited to the company's account, permits a critical devaluation of revenues. Inflation, currently in the range of 15 to 30 per cent per month, can reduce revenues by

35 to 82 per cent over a 60 day period with disastrous consequences for companies whose net incomes are roughly 2.5 to 6 per cent of revenues.

8.2.1.5 Salaries

Compensation levels of employees at various companies varies among enterprises in the same cities. Companies which pay salaries in excess of approved levels are required to pay an Excess Salary Tax of 39 per cent on the higher salaries. The significance of this observation is that, in order to justify the payment of higher salaries, along with the additional taxes they generate, the companies must seek to "right size" their staffs and salaries to optimally cost-effective levels. This item, as well as other controllable costs, must be addressed in an overall program to minimize deductions from inflation-eroded fixed-rate revenues.

8.2.2 Scenario Analyses

The following cases, identified by the World Bank, were analyzed for each company:

Case 1 Scenario 1 of the Project Team's demand forecast. Losses occur between purchases and sales as calculated by the Bechtel Project Team based upon their field observations and calculations. The following new projects would be undertaken:

SCADA
Network Analysis
Cathodic Protection
Leak Detection
Pipe Replacement

Case 2 Scenario 1 of the Project Team's demand forecast. Purchases equal sales. The following new projects would be undertaken:

Commercial Meters
Private Home Meters
Industrial Meters
Apartment Meters
Test Equipment

Case 3 Scenario 1 of the Project Team's demand forecast in which there are no industrial efficiency projects, no conversion of cookers, and no substitution of local boilers for district heating. Purchases equal sales. The following new projects would be undertaken:

SCADA
Network Analysis
Cathodic Protection
Leak Detection
Pipe Replacement
Commercial Meters
Private Home Meters
Industrial Meters
Apartment Meters
Test Equipment

Case 4 Scenario 5 of the Project Team's demand forecast which includes industrial efficiency projects, conversion of cookers, and substitution of

local boilers for district heating. Purchases equal sales. The following new projects would be undertaken:

SCADA
Network Analysis
Cathodic Protection
Leak Detection
Pipe Replacement
Commercial Meters
Private Home Meters
Industrial Meters
Apartment Meters
Test Equipment

Analyses of these cases are summarized below (See Section 8.2.2.2, Observations) and detailed computer projections are presented in Appendix 8-C.

8.2.2.1 Assumptions

The Project Team evaluated the financial viability of each company relative to the projects being proposed by the Study Team. This evaluation was predicated upon the following assumptions as directed by the World Bank:

a) Residential and industrial gas prices were initially set to increase from August 1993 price levels to US$40 (in 1993 dollars) per thousand cubic meters by January 1, 1996. Thereafter prices would rise at the rate of inflation. Residential prices would be adjusted at six month intervals; industrial prices would be adjusted monthly. The elesticity of demand was considered by Benjamin Schlesinger & Associates in the development of the demand scenarios.

b) All forecasts are expressed in nominal rubles. Forecasts of international and Russian inflation, as well as the US$/Ruble exchange rate were provided by The World Bank as shown in the tables illustrating "Monthly Gas Cost Calculations" (see Appendix 8-D).

c) The internally-generated funds of each company would be used to fund the domestic-source portion of each proposed project as well as duties and taxes associated with all portions of each proposed project.

d) During the period 1994-1997—i.e. the years of investment in the proposed projects—net profit (if any) is retained. Beginning in 1998, 50% of the net profit is paid out as a dividend.

e) The foreign-source portion of each proposed project would be funded by The World Bank in U.S. dollars at the interest rate of 10 per cent per year. The loan tenor will be 17 years. During the first 5 years only interest will be paid by the gas companies in Russia. Loan repayments will be made in equal installments over the subsequent 12 years.

f) Payroll expenses, plus non-discretionary consumption funds in 1992 which have been reclassified as operating expenses, are revalued to mid-1993 levels; in subsequent years this amount is increased by local inflation.

g) The forecast of accounts payable assumes the same ratio as December 1992 payables to 1992 expenses; the forecast of accounts receivable assumes the same

ratio as December 1992 receivables to sales forecast for December 1992. No allowance has been made for bad debts.

h) The forecast margin between wholesale and retail gas prices is to remain a constant percentage throughout the forecast period.

i) The percentages shown in the following table indicate the percentage of gas which is lost and/or unaccounted-for gas:

	Ryazan	Saratov	Volograd	Voronezh
RESIDENTIAL				
All Scenarios				
1993	1.4%	1.5%	1.0%	1.4%
1994 - 2002	0%	0%	0%	0%
INDUSTRIAL				
Scenario 1				
All Years	1.4%	1.5%	1.0%	1.4%
Scenarios 2,3,4				
1993	1.4%	1.5%	1.0%	1.4%
1994	1.05%	1.125%	.75%	1.05%
1995	.7%	.75%	.5%	.7%
1996	.35%	.375%	.25%	.35%
1997 - 2002	0%	0%	0%	0%

j) Natural Gas Sales Revenue –
Calculations for each year are based upon estimates of demand as provided by Schlesinger & Associates and forecasts of gas prices based upon inflation factors provided by The World Bank. The calculation of Gas Prices is shown in Appendix 8-D.

k) LPG Revenues –
Calculations for each year are based upon constant 1992 demand and current prices for LPG escalated by each year's annual inflation factor.

l) Other Revenues –
Actual for 1992 is reevaluated for 1993; estimates for subsequent years are the resulting 1993 values escalated by the cumulative annual inflation factor from 1993.

m) Gas Purchases –
Forecast of demand as provided by Schlesinger & Associates.

n) Production Costs –
Ratio of actual for 1992 to sales is applied to sales in each forecast year.

o) Subsidies –
Actual as reported for 1992; forecasted as the difference between LPG receipts and expenses.

p) Taxes –

Tax	Rate	Application
Excess Payroll Tax	39%	Applies to salaries in excess of approved levels. Assumed in these analyses to apply to 50% of all salaries.
Corporate Income Tax	32%	Tax on profits.
Property Tax	1%	Tax basis is assets.
Value Added Tax	20%	Applies to foreign source project costs; recaptured in subsequent two years. Applies to gas costs. Calculated as the difference between VAT included within the selling price and the VAT included within the purchase price. For example: If sales price including VAT is 2000, gas cost = 1667 (i.e., 2000 / 1.2) and VAT on sales = 333 (i.e., 2000 - 1667). If purchase price including VAT is 1200, by the same calculation gas cost = 1000 and VAT on purchases = 200. The company's VAT liability is, therefore, = 133 (i.e., 333 - 200).
Road Tax	.4%	Tax basis is sales margin.
Duties	5%	Applies to foreign supplies.

q) Cash –
Actual for 1992 is reevaluated for 1993; estimates for subsequent years are the resulting 1993 values escalated by the cumulative annual inflation factor from 1993.

r) Short-Term Investments –
The positive difference between "Cash and Short-Term Investments", which is determined by the Cash Flow Statement, and "Cash".

s) Materials & Equipment –
Actual for 1992 is reevaluated for 1993; estimates for subsequent years are the resulting 1993 values escalated by the cumulative annual inflation factor from 1993.

t) Other Assets –
Actual for 1992 is reevaluated for 1993; estimates for subsequent years are the resulting 1993 values escalated by the cumulative annual inflation factor from 1993.

265

u) Reevaluation and Depreciation of Fixed Assets –

(a) Beginning Value of Assets
(b) = (a) Reevaluated to current year's price level.
(c) = New Investment
(d) Ending Value of Assets (Gross) = (b) + (c)

(e) Beginning Accumulated Depreciation
(f) = (e) Reevaluated to current year's price level.
(g) = Current Depreciation
(h) Ending Accumulated Depreciation = (f) - (g)

(i) Net Book Value of Assets = (d) - (h)

v) Other Funds (Excluding Charter) –
Actual for 1992 is reevaluated for 1993; estimates for subsequent years are the resulting 1993 values escalated by the cumulative annual inflation factor from 1993.

w) Charter Fund –
Actual value for 1992 is kept constant in all forecast years.

8.2.2.2 Observations

Appendix 8-C includes pro-forma financial statements and supporting schedules for each of the scenarios described above. The results of the financial analysis, detailed by those schedules, appears in Table 8-3.

These financial schedules are not the result of a formal audit in accordance with generally accepted international auditing standards, neither do they express an opinion about the financial viability of the companies. The observations of the consultants who visited the companies, reviewed company records and interviewed company personnel are presented elsewhere in this text. Nonetheless, the financial schedules included herein set forth a projected financing plan for the future funding of prospective system rehabilitation projects at each of the LDCs within the context and assumptions of this assignment.

Observations with regard to each scenario and the financial viability of each company under each scenario are as follows:

a) Scenario Observations

Case 1

Under this scenario, external funding requirements range from 37 to 71 billion rubles, represent 64 to 68 per cent of project costs. Over the period 1998 to 2002, Ryazan, Saratov and Volgograd are projected to earn 6.1%, 10.2% and 6.2% relative to net reevaluated assets. Voronezh is projected to be unprofitable during this period, i.e., minus 1.3% net income to net assets.

Case 2

Under this scenario, external funding requirements range from 41 to 82 billion rubles, representing 63 to 75 per cent of project costs. Over the period 1998 to 2002, Ryazan, Saratov and Volgograd are projected to earn 8.3%, 15.1%

and 13.2% relative to net reevaluated assets. Voronezh is projected to be unprofitable.

Case 3

Under this scenario, external funding requirements range from 78 to 146 billion rubles, representing 69 to 71 per cent of project costs. Over the period 1998 to 2002, Saratov is projected to be profitable with its net income equal to 3.2% of its net reevaluated assets. Volgograd is expected to earn .3%, Ryazan is projected to break even and Voronezh is projected to be unprofitable.

Case 4

Under this scenario, external funding requirements are the same as in case 3. Over the period 1998 to 2002, Saratov is projected to be profitable with its net income equal to 3.6% of its net reevaluated assets. Volgograd is expected to earn .6%, Ryazan is expected to earn .5% and Voronezh is not projected to be unprofitable.

b) Company Observations

Ryazan

In 1992, Ryazan's net income—i.e. before distributions—was 58% of its net assets. In the first two cases, its ability to service a debt of between 37 and 41 billion rubles is such that, measured against significantly reevaluated assets, its ratio of net income to net assets drops to the range 6.1% to 8.3%. Higher gas prices could increase this ratio; however, this would require annual increases above the rate of inflation.

Under cases 3 and 4—which requires the company to service a debt of 78 billion rubles—its net income falls to 0% and .5% of net assets respectively. These cases are not viable at this company under the given set of assumptions.

Saratov

In 1992, Saratov's net income—i.e. before distributions—was 20% of its net assets. In the first two cases, its ability to service a debt of between 58 and 63 billion rubles is such that, measured against significantly reevaluated assets, its ratio of net income to net assets falls to the still profitable range of between 10.2% and 15.1%.

Under cases 3 and 4—which requires the company to service a debt of 121 billion rubles—its net income falls to 3.2% and 3.6% of net assets respectively. Higher gas prices could increase this ratio; however, this would require annual increases significantly above the rate of inflation.

Volgograd

In 1992, Volgograd's net income—i.e. before distributions—was 24% of its net assets. In the first case, its ability to service a debt of 71 billion rubles is such that, measured against significantly reevaluated assets, its ratio of net income to net assets falls to 6.2%. Higher gas prices could improve this ratio; however, this would require annual increases above the rate of inflation.

In case 2, servicing a debt of 57 billion rubles would allow Volgograd's net income to be 13.2%.

Under cases 3 and 4—which requires the company to service a debt of 128 billion rubles—its net income falls to .3% and .6% of net assets respectively. These cases are not viable at this company under the given set of assumptions. Higher gas prices could increase this ratio; however, this would require annual increases significantly above the rate of inflation.

Voronezh

In 1992, Voronezh's net income—i.e. before distributions—was only 5% of its net asset value. Each of the cases worsens this poor condition and yields unprofitability. Case 1 requires a debt of 64 billion rubles and would produce a net income to net assets ratio of -1.3%. Case 2 requires debt of 82 billion and produces a net income to net assets ratio of -.4%. Cases 3 and 4 require debt of 146 billion and produce ratios of -3.4% and -2.4% respectively. None of these cases is viable under the given set of assumptions.

8.3 ADMINISTRATIVE ISSUES

8.3.1 Company-wide Issues

Although each of the companies studied have been successful enterprises within the context of their state ownership and direction, the Project Team notes five significant administrative deficiencies at each company. These deficiencies are of concern in that they adversely impact the performance of each distribution company and will likely prevent the companies from operating successfully in a market-oriented environment.

The identification of these deficiencies is, of course, a criticism derived from a market-oriented bias. It is important to make note of this perspective inasmuch as the following observations and recommendations are not necessarily criticisms of past practices but suggestions as to how these companies should restructure themselves to operate successfully in a new business environment.

8.3.1.1 The Absence of a Business-Oriented Focus.

Within the controlled-society, the role of the natural gas distribution company was, literally as the title implies, to act as an agency distributing an allocated resource. Within that context, the focus of the enterprise needs only to be a "regime"–broadly speaking, an infrastructure–in place to achieve the objective of providing that societal benefit without regard to the consequences of profit and loss.

As Russian society restructures such that competitive forces exert pressure upon virtually all economic transactions, the utility–particularly after privatization–will find itself under growing pressure to provide customers with low-cost services while, at the same time, providing owners with reasonable returns on their investments.

Procedures which were established to exert control must be modified to reflect the need for cost efficiency. Staff levels must be examined so that the staff and salaries are "right sized" for a cost-efficient operation.

In summary, the companies must focus their thinking and, therefore, reshape their organizations such that decisions regarding operations as well as management policies and

procedures will reflect the goal of being merchants of an economic commodity rather than as distributors of an allocated resource.

8.3.1.2 The Absence of a Marketing Function

Although each company has a "sales" department, the function of that department is limited to coordination of filing the gas demand application, preparing the necessary contracts and documentation and including the potential gas demand within the company's upstream nomination for gas supply. This department needs to take a more pro-active role in soliciting or encouraging new customer service.

Currently, potential customers are required to persuade the company of their need for gas. In addition they are required to pay all costs of connecting their homes and businesses to the distribution grid. Cost benefit analyses are not conducted to determine whether the potential sales would justify such an investment by the company.

Each of the companies makes a concerted effort to provide its customers with a necessary service. Nonetheless, in order for the companies to be successful in an increasingly market-oriented environment, the role of the service-provider must be subordinated to the tasks of anticipating and meeting the service needs of customers. In this effort, the utility must become a partner with its customers in developing and implementing improvements to service that are perceived within the marketplace as being meaningful to the consumer.

8.3.1.3 Procedures to Reconcile Sales Volumes and Revenues

At each of the companies, there are careful procedures in place for the generation of bills and for the monitoring of purchases by the utility. These procedures are, however, entirely separate functions and there is no mechanism in place for their reconciliation except at the company's senior level where such details are unlikely to be the focus of attention. The result of this separation is that the company does not know with a high degree of confidence whether the variance between purchases and sales is due to losses from the pipeline infrastructure, from billing discrepancies or from other causes, including theft of service.

A critical aspect in any business is the monitoring of inventories. This function is no less important for a natural gas utility, although the function is complicated by the situation which exists in Russia where, in many cases, gas is sold at flat rates relative to assumed norms or standards of usage.

Typically, the natural gas consumption by residential customers in Russia is not metered. Norms have been calculated to represent a customer's typical or expected usage based upon the size of the area to be heated, the number of gas-consuming appliances, the number of people in the home, etc. A bill is issued to this customer, regardless of actual usage, based upon this standard. The decree issued in September, 1993 delegated the calculation of these norms to the local authorities although the Ministry of Fuels and Energy and Rosgaz would continue to share the responsibility for developing an appropriate methodology. While this decree moves the calculation of norms closer to the customer and the specific requirements of the service territory, the use of norms remains a method of estimating rather than accounting for gas usage.

It is recommended that each company's accounting procedures be modified to include a system for reconciling purchases with sales. This reconciliation must be done early enough during the flow of accounts for problems to be isolated and addressed in a regular and timely manner. It is important to note that the value of this reconciliation will increase significantly over the near term as gas prices rise toward market-clearing levels.

8.3.1.4 Reliance Upon Manual Procedures

It was observed that the bookkeeping procedures at each company are labor-intensive and heavily dependent upon manual calculations. The wider introduction of personal computers, including local area networks, would expedite billing and other accounting procedures. It can be argued that the cost of the computer is disproportionate to the relatively low salaries of employees who currently are processing the accounts manually. Nonetheless, it must also be recognized that the computer can support the preparation of forecasts and other analyses which support the company's effort to be profitable and which the "redundant" employee may be trained to conduct.

A related observation is that, with the absence of a computer, many critical files are being maintained in their original form on, for example, unprotected and readily-accessible cupboard shelves. The possibility of losing these files to fire, for example, is an unacceptable business risk which could be reduced by proper computer-assisted information processing and storage procedures.

8.3.1.5 Absence of Analysis

It is essential for the growth and competitive success of a market-oriented business that management decisions be supported by a wide variety of sophisticated analyses. With the present system of manual data processing, it is unrealistic to expect a significant level of financial analyses. The broader introduction of computer technology, as recommended above, will facilitate the conduct of these analyses and the appropriate training of employees in the development and use of and management information systems techniques must be a high priority at each company.

8.3.1.6 Business and Management Training

In order to address each of these deficiencies, each of the companies must actively implement programs of business and management training at all levels throughout their respective organizations. Although the staffs of these companies have competently undertaken their various responsibilities within the scheme of resource allocation, there is clearly a need for all to have formal training in the both the philosophy and the skill of running market-oriented businesses. Management's immediate focus should be in the following basic subject areas:

- Developing corporate strategies
- Implementing of business plans
- Using accounting procedures as business-planning tools
- Organizing efficient business structures

Throughout each company there is a need for training in the following areas:

- Developing a customer-focused business orientation
- Learning to use automated data processing equipment
- Understanding market-oriented business principles

Initially this training may likely come from sources outside Russia. However, training from external sources is only an interim stage in the system's transformation. As an increasing number of enterprises within Russia complete the transformation to a market-orientation and gain experience in the skills identified above, they should be able to provide domestic-source training to the utilities. Furthermore, in developing training programs, each company must identify employees who will, in turn, become teachers of other employees. Training programs must be designed in the expectation that they will ultimately be self-sustaining.

8.3.2 Company Specific Issues

Selected operating statistics are presented in Table 8-4 and further discussed as follows.

8.3.2.1 Ryazangorgas.

Ryazangorgas sells more than 2 billion cubic meters of natural gas each year using a pipeline network of 840 kilometers (220 km are of high and medium pressure). Two city power plants consume about 60% of total gas supplied by the company. The company employs 450 people.

Ryazangorgas is significantly different from the other LDCs which were studied in both their managerial and operational approaches. The company is currently finishing the process of reorganizing into an independent Joint Stock Company ("J.S.C."). This process differs from that in order in other cities as follows:

In 1990, Ryazangorgas reorganized itself as a leasehold enterprise as an intermediate step on the way towards privatization. A private management group leases the assets and right to use them from its owner, the city of Ryazan. At that time, lease payments were about 500,000 Rubles per year. This is the only such arrangement among LDCs in Russia although there are no legal constrains preventing others from using this method. Under this arrangement the company's buildings, transport services and technical services were put in a lease-purchase agreement, while the gas pipelines were left in a 50-year lease agreement and still belong to the city.

The company now would prefer to acquire the pipeline network, but the city is reluctant to sell it. The Gorgas, i.e., LDC at the city level (See discussion in Section III.C, below.), is considering retaining ownership of each section of pipe when it installs replacement sections in the city owned system; the company calculates that it can take over the entire system in 50 years by this piecemeal method.

Currently Ryazangorgas is comfortable with this leased assets based approach because it provides the opportunity to achieve complete independence from Rosgaz. Although there are no plans to move in this direction, the restructuring of gas pricing along cost-of-service lines would require a more substantial asset base than this arrangement of leases would support.

Ryazangorgas's operations are also distinguished by the advanced degree of its computerization. They have computerized many aspects of operations including materials inventory, depreciation of fixed assets, payroll, general register, sales revenues, cash on hand and cash in banks. The employees in the accounting department work directly on the computers, although tax reporting forms are still completed manually by the chief accountant. The company has 50 computer programs as compared with typically 3 to 4 programs in other gorgases, and carries them as intangible assets on the balance sheet; none of the other enterprises visited in the course of this investigation carried any intangible assets.

Ryazangorgas determined from their own cost analyses that gas service to households is a loss center. During 1992 about 30% of gas delivered to the residential customers remained unbilled because of low usage norms which haven't been changed since 1964. This is very similar to other places. The company is considering the possibility of installing meters in the households to encourage customer responsibility for consumption, but management's interest has cooled with the realization that, at present prices and volumes, the payback period on the meters could be as much as 100 years.

Another important problem in Ryazangorgas is the billing procedure itself. In the current situation, most of industrial and all commercial and residential customers actually receive their gas supplies on credit, and billing occurs at the end of the month. Gorgas leases billing and

27

related data processing services, which adds another 30 days to its collection schedule. Given that funds are often "delayed" during process and by the banks, the company typically loses from 50 to 70 days worth of inflation before collecting its revenue.

Because Ryazangorgas, not unlike the other companies, has substantial amounts in delayed payments, the company has reached an informal agreement with gas transmission companies such that penalties for late payment are levied only in those months when the Gorgas' back debt exceeds 150 million rubles. In those months when fines are levied, they are levied on the full amount of debt. Accordingly, Ryazangorgas regards any payable on which it can delay, as essentially an interest free loan from gas transmission company. Each month it purposefully calculates the amount of its accounts payable which needs to be paid in order to maintain the sum it owes at or below the 150 million ruble level.

Ryazangorgas has an impressive, professional management, with a clear vision of building the business and will to change. Most notably, rather than redistributing all available profits to employees in the form of monthly bonuses, as is done in each of the other three gorgases, Ryazan has made significant capital investments in 1992. They built a new facility to house a repair shop, warehouse space and some administrative offices. They also purchased some new transportation equipment, built new apartment houses for employees and invested in agriculture.

Significantly, most of Ryazangorgas' management joined the company within the last three years, i.e., during its reorganization. By contrast, in the other three LDCs, the managers have all been at the company for most of their careers; many were extremely conservative, fearing innovation and wishing to preserve the status quo.

8.3.2.2 Saratovgorgas.

Saratovgorgas employs 547 people, which is comparable with other companies visited. The company's operations are mainly consistent with Rosgaz directives. It provides a portion of its revenues for the subsidy of unprofitable gas companies in the Oblgas[1] and makes payments, as required, to various Rosgaz funds. Nonetheless, the management of Saratovoblgas declined to meet with the Project Team, indicating thereby an increasing tension between the Gorgas and Oblgas which derives from the desire of Saratovgorgas to be privatized separately from the Oblgas and to become an independent gas company.

Within the City of Saratov, it is unlikely that industrial gas consumption can be increased over the near term. Usage for power generation–which currently consumes 52.7% of the total gas supply in Saratov–could be increased by 25% if plants switch entirely to natural gas, i.e., do not use residual fuel even under peak demand conditions.

Ten of Saratov's twelve largest gas customers, including power stations, have "permanently" delayed payments for gas consumed. Saratovgorgas does not impose penalties upon these customers, assuming that the uncollected bills will not damage the gorgas' potential profits. In turn, the company has reached an agreement with the gas transmission company such that it will not be charged penalties for these delays. Nonetheless, current banking procedures–as well as the terms of gas supply contracts–allow the transmission company to take all available cash from the Gorgas bank account in payment for outstanding accounts. Accordingly, the discrepancies between Accounts Receivable typically requires the expenditure of what would otherwise be net income.

The level of computerization in Saratovgorgas is higher than in Volgograd or Voronezh. The company has developed a number of its own software programs and handles all gas accounting

---

1 The functional inter-relationship between the regional gas company, known as an "oblgas", and a city gas company, known as "gorgas" is discussed in Section 8.4 of this report.

in house. Although it saves time and expenses by these in-house procedures, the control of gas and money flows is separate and, therefore, ineffective.

In Saratov the natural gas pipelines network is the oldest in Russia. The first pipelines were installed in 1945. Today the network consists of 1665 kilometers of pipes including 260 kilometers of high and medium pressure, and only 77% of all underground pipes do have cathodic protection. At the same time in 1992 all funding allocated for network repairs was less than 2% of company's net income. As in the other Gorgases, Saratovgorgas' management uses only depreciation as a source for reinvestment and distributes the income in all possible forms of benefits.

Saratovgorgas, as most of other LDCs, is still run as a "not for profit" organization lacking the ability to define long and short term company goals with clarity. Cost-benefit and other economic evaluations would help to focus management attention upon appropriate fiscal objectives. In the absence of these tools, management is incapable to deal with an inflationary economic environment and escape from its reactive mode.

8.3.2.3 Volgogradgorgas.

Volgogradgorgas serves a city which stretches along the Volga river for more than 100 kilometers. Most of the industrial customers are large factories, and 75% of gas supply is purchased by 32 customers. The pipeline network consists of 1965 km with 517 km under either high or medium pressure. About 50 km of pipe lacks cathodic protection.

Relations between the Gorgas and the Oblgas are deteriorating mainly because the gorgas is privatizing independently. The company no longer has any financial relationship with the oblgas which, lacking revenues from an industrial base, is in an extremely weak economic position.

All large customers report their consumption by telephone each day and, every five days, provide charts for checking. Despite these reports, most of the payments are delayed. In summer the number is from 7 to 10 large customers; in the winter this number typically doubles. Delays in receiving payment from these customers can generate accounts receivable in excess of the company's net income.

Most of the electricity in the Volgograd area is supplied by the huge hydro-electric generating station. Unlike the other gorgases, which typically sell 50% of their supplies to power generation, Volgogradgorgas does not have a large power station in its customer base.

Billing and processing of accounting for gas supplies to residential (excluding private homes) and some commercial customers except private homes is leased to a computer services company; as in Ryazan this out-sourcing delays the processing of these bills and complicates control. Within the company, all accounting is performed by hand. Employees in the economic and accounting departments do not share database and economic analyses are done only by the deputy manager of the company.

Volgogradgorgas is the most "aggressive" in distribution of all available profits to the employees. Salary levels there are the second highest among the city's industrial enterprises and three times higher than the country's average level. Having twice the number of employees–934–than other gorgases with similar amounts of gas supplied, Volgogradgorgas must pay a substantial portion of its profit as an "Excessive salary tax". For example in August of 1993 company's net income totaled in 80 million rubles. Of this sum, 30 million was paid in "excessive salary tax"; 35 million as special bonuses to employees and only 15 million remained as available for equipment purchases or reinvestment.

8.3.2.4 Voronezhoblgas.

Until February of 1993 Voronezhgorgas was a separate entity similar to the companies in Ryazan, Saratov and Volgograd. It chose to be incorporated within the Voronezhoblgas privatization scheme and now is one of twenty operating divisions within Voronezhoblgas. All of these operating companies have their own balance sheets and income statements, which are sub-accounts of the oblgas balance sheet and income statement. Oblgas is the only entity to prepare forms for presentation to the tax inspectorate.

Using the second variant of the privatization program, 51% of the ownership of Oblgas is allocated to workers and management and 49% to the state. The state ownership is 43.7% to the Federal government, 1.5% to the Oblast, and 3.8% to districts and towns of the Voronezh region.

The management of Voronezhoblgas is considering the opportunity to have a swap agreement with Gasprom.[2] Although the number of shares exchanged will be small, financial interest in each other's business will secure cooperation between the gas transmission and distribution companies.

As with any gas distribution company serving many residential customers in rural areas, Voronezhoblgas heavily depends on supplies to the industrial users to keep company profitable. The difference between Voronezh and the other four regions is that sales to the power plant in Voronezh accounts for only 25% of the region's total gas consumption. Another 22% of the supply is sold to a large fertilizer plant in the south of the region. There are 30 large industrial gas customers, 10 of which are considered as major. Altogether they consume 60% of total gas supply. As at the other companies, most of these customers delay their payments for several months. In total the amount owed to the Voronezhoblgas usually equals the monthly payment of oblgas to the gas transmission company; because of inflation, the oblgas loses permanently about 15% of that money. And as everywhere else, Voronezhoblgas cannot use bank credits because of extremely high commercial interest rates.

The situation with bill processing in Voronezh is better than in other places since it takes only 7 to 10 days for the company to receive payments. Processing is leased to a computer company at a charge of 2% of the revenues. This arrangement makes it difficult to exert control over amounts charged and paid for; it takes more than a month for the Oblgas to receive all documentation from all participating parties.

Industrial and residential gas consumption in Voronezh is expected to remain at a similar level without significant changes. With no military customers and economically sound industrial users, the changing economic conditions in Russia should not have an adverse effect on Voronezhoblgas. The area of possible development in gas supplies is the residential sector in small towns and remote districts. The oblgas does not have the financial capability to encourage rural gasification projects.

8.4 INSTITUTIONAL CHANGES

8.4.1 Structural Interdependence

8.4.1.1 Ministry of Fuel and Energy

Currently all energy related activities, except for nuclear energy, are under the responsibility of the Ministry of Fuel and Energy. Under this Ministry–although theoretically at

---

2 The organization and function of Gasprom, the monopoloy supplier of natural gas to the oblgases and gorgases, is discussed in Section 8-4 of this report.

the same level–there are two major gas companies: A. O. Gazprom ("Gazprom") and A. O. Rostroigazifikatsiya ("Rosgaz"). Both have recently been reorganized as J.S.C.s.[3]

8.4.1.2 Gazprom

Gazprom, although reorganized, has retained virtually the same organizational structure despite the economic turmoil of recent years. It is now the largest gas company in the world, responsible for all aspects of the Russian gas industry except distribution. Its span of control includes gas exploration and development, production and processing, as well as transportation through a network of high pressure pipelines. This pipeline network serves export markets as well as distribution companies throughout Russia.

Being the operator of all economically feasible gas fields, underground gas storage, and the owner-operator of all gas transmission facilities in Russia, Gazprom enjoys a monopoly position in the industry which enables it to determine Russia's gas development strategies and gas pricing policies. Furthermore, with direct access to the Council of Ministers, i.e., bypassing even the Ministry of Fuel and Energy, the Ministry is often found in a reactive position with regard to Gazprom's initiatives.

During the Project Team's meetings with Gazprom's management, discussion was focused on the following issues:

1. The industry's current situation and development strategies in all major fields of company activities
2. Gas supply-demand trends and forecasts
3. Economic conditions and gas pricing strategies
4. Energy conservation
5. Export opportunities.

Gazprom's internal gas sales are organized such that all of its enterprises remain profitable. At each point of sale, i.e., from producing enterprise to transmission company to LDC, each Gazprom company recovers all of its costs in addition to charging a markup. This system gives Gazprom the opportunity to keep complete control over main-line gas flows throughout Russia as well as for export and enables Gazprom to exercise considerable influence over Russia's gas pricing policies.

Today, all major gas fields in Russia are producing at maximum output levels. Also, because of the effectiveness of new technologies, the new fields, which Gazprom puts into operation every year typically reach this stage of full production within 2 to 3 years. This means that additions to gas supply are capable of covering decreases due to depletion of old fields. Combined with substantial gas reserves in underground storage resulting from several recently warm winters, the balance between new development and depletion provides Gazprom with the capability to meet internal gas demand as well as to meet export requirements. Furthermore, while limits are imposed upon the LDCs, there are several gas exchanges in Russia, which sell undistributed volumes of gas within the country as well as in some spot markets for export.

---

3 Gasprom became a J.S.C. in February 1993; Rosgaz became a J.S.C. in August 1993, during the course of this study.

It is important to understand that Gazprom is in a position to cover all of the country's gas needs now and in the future. There is no indication of any gas shortages for internal supply, as well as for export need. With access to the transmission system and with all underground storage completely under Gazprom's control, it is doubtful that LDCs will get access to third party gas supply in the near future. Also, since the limits, or allocation, of gas supply to the distribution companies are determined by Gazprom for each year, any gas saved by the distribution company will actually remain as Gazprom's property.

Financially, Gazprom is fully capable of handling its maintenance needs and of providing for additions in gas supply, keeping gas consumption in Russia at current levels. The current situation provides Gazprom with a time window to accumulate funding and equipment which will be required for the development of new fields in northern Siberia when, within the next few years, the depletion rate of older fields will be accelerating. Currently, most major investments planned by the company for the near term are export related.

8.4.1.3 Rosgaz

Rosgaz is an intermediary agent between Gazprom's gas transmission companies and industrial, commercial and residential customers in the regions. It operates through 71 gas distribution companies ("Oblgas") at the regional ("Oblast") administrative level. Each Oblgas operates through a number of city and district gas companies ("Gorgas" and "Mejraygas", respectively). Some of these companies–typically those located in industrial cities–are jurisdictionally independent gas companies; most of the companies located in small towns and rural areas are, however, simply departments of the Oblgas.

Being responsible for the local gas distribution system in the country, Rosgaz has the following objectives:

- Determining the strategy of system improvement, including safety measures
- Providing the common technical and investment policies
- Coordinating the development of new technologies
- Participating in gas demand forecasting
- Participating in gas distribution operations
- Developing local gas supply systems
- Developing new capabilities for gas equipment manufacturing
- Developing the new norms and standards of gas consumption
- Coordinating local companies investment policies
- Participating in gas pricing determination
- Personnel training programs
- Providing services to local companies on the commercial basis
- Other commercial and foreign economic activities

216

Only two years ago Rosgaz started building an economically viable company. Prior to that time it was one of the economically weakest organizations in the Soviet industrial management. As with any other institution, it was a not-for-profit organization having no decision-making authority over purchasing, sales and other expenditures. Belonging to the government, it was required to give up all of its revenues to the federal and local budget.

Although this system provided that the financial needs of this company were to be covered from state and local budgets, the budget was inadequate even to support the safe operation of the distribution systems.

Organizationally the system was structured vertically with all gas distribution companies at the regional level reporting to the gas distribution department of the Ministry of Municipal Affairs ("Minjilkomhoz") in Moscow for strategic development, equipment, material supplies, internal structure and safety policies issues. All other activities of local companies were under the control of local governments, with companies functioning organizationally as the local government's gas department. This dualism was an effective tool for the state to benefit from the revenues of the LDCs, but it did not provide an effective funding mechanism for the LDC.

In 1991, when the collapse of the Soviet Union caused restructuring of most of governmental activities, Rosgaz was created with gas departments reporting along a vertical chain of command independent from state and local governments. New companies reported directly to the headquarters in Moscow. Rosgaz has 71 companies at the oblast level, each of which in turn have from 10 to 30 local distribution companies, depending upon the size of the region. In industrial cities these companies are the Gorgases; in other areas they are the Mejraygases.

Under the new system, the ability of Rosgaz to influence the decisions of local companies is reduced substantially; the former system of vertically distributing material supplies, investment funds and staffing limits no longer exists. Managements have since gained almost full control over their LDCs and enjoy a heretofore unknown degree of independence in their decisions.

It is not surprising, therefore, that some of the local managers see little benefits in privatization; defensively, they perceive the imposition of a Board of Directors as the reinstatement of control over their newly-gained decision-making independence.

8.4.2 Legal and Regulatory Content

Rosgaz has two major objectives in its activities which have significant impacts on the gas distribution system's legal and regulatory context: (a) gas supply allocation system (gas limits) and (b) pricing.

8.4.2.1 Gas Supply Allocation

Currently, in October of each year, the LDCs collect applications from each customer for following year's supply. The total of these applications is forwarded from the city or district companies to the Oblgases which, in turn, combine them for the region and send a regional application to Rosgaz. Rosgaz combines all applications and sends its total required amount to the Ministry of Fuel and Energy. In parallel, Gorgases and Oblgases send their applications for the required amounts to Gazprom's transmission company. Following negotiations among the Ministry, Gazprom and Rosgaz, the final amount of gas which Gazprom should provide in the following year is established and the companies throughout Russia are informed of this decision. Typically, the final volume is 3 to 5% less than in the previous year, and this decrease is allocated by Rosgaz to all local companies. This is the only time that Rosgaz participates in the allocation of gas limits because supply contracts are signed at the local level directly between Oblgases or Gorgases and gas transmission companies.

For now the possible influence of Rosgaz on the allocation of gas limits is also limited by flat demand for gas and the ability of Gazprom to supply it. Greater independence by the local companies in dealing directly with the gas transmission companies will decrease the role of Rosgaz in the process of gas allocation.

8.4.2.2 Prices

Prices have been and will be, for several years into the future, determined by the State Pricing Committee of the Russian Federation. This function will remain an important political tool for the government with Gazprom and Rosgaz, the major initiators of price increases, playing important roles in this process.

Prior to August 15, 1993, prices were increased only occasionally as a result of substantial efforts by Gazprom and Rosgaz. Prices for residential customers were kept at lower levels than costs of gas supply. After August 15, residential prices will be set to cover all expenses and industrial prices will be indexed to the rate of inflation. Subsequently, industrial prices should be indexed monthly; residential rates will be indexed twice a year. If inflation continues at the same rate, the next indexation of gas prices is expected in December. The price will still be established at the same level for the whole country without regard to differences in costs incurred.

Inasmuch as the gas provided to the residential customers–about 5% of total consumption–is not metered, customers are billed according to the norms of consumption. These norms are based upon the size of a customer's house or apartment, the number of people living there and the number and rated capacity of their gas-burning appliances. These norms are different for each region, determined by the local gas companies and approved by the local governments.

Even though the price of gas is increasing, the profitability of the gas companies is unaffected. The purchasing and selling gas prices are changing in parallel and their mark-up remains at the same percentage rate of total selling price.

Gas companies are burdened by the heavy taxes which fund the Russian economy. LDCs are subject to an excess salary tax of 39% on salaries above a standard rate set by the government, an income tax of 32% of net income, a property tax of 1% of assets, a road tax of 0.4% and a VAT of 20%.

The local government's fiscal department requires the company to pay taxes on the revenues which would be received from sales at rates established by the government. This gives the LDCs no flexibility in pricing the gas. Sales at higher than governmental prices are illegal and sales at lower prices–which will produce revenues to be taxed as though they were generated by the higher, state-established rates–would be costly for the LDC.

Another important fiscal issue is the provision for charging penalties. Gas companies can charge penalties from customers for usage of gas in amounts above established limits. For each use, the customer could be charged five times the price during the winter and 1.5 times during the summer. Eighty per cent of collected penalties are given to the local fiscal office rather than to the company, which is only allowed to retain the actual price for the gas supplied.

Although the local gas distribution companies are interested in increasing the gas sales to raise revenues, they have neither flexibility nor marketing tools for adjusting or controlling demand through pricing, credit discounts, penalty charging or the quality of services. The LDCs are, therefore, entirely reactive to customer requests and needs, having neither control over gas supply nor any inclination to expand their customer base. Given the exogenous constraints of the current legal and regulatory structure, improvement of managerial, operational and control procedures at the LDC level will not materially improve this financial condition.

Prices for gas should be freed using a different rate of increase for industrial and residential customers. Currently, industrial prices will increase relative to inflation; over the near term, however, these prices could increase more rapidly than inflation and reach export levels within 2 to 3 years. Residential prices will be subsidized for a much longer period. Since pricing of gas is a politically sensitive issue in Russia, governmental concern will most probably affect the pace of price increases.

8.4.3 Privatization

According to the current privatization law, gas companies could be privatized under one of two models. Under the first variant, employees and management of the company would buy 40% of shares. 38% of remaining shares go to the municipalities, i.e., local government, and 22% to the federal government, i.e., the State Property Fund. As was noted in the discussion of Voronezhoblgas (Section 8.3.2.4, above), the actual division of shares amongst state and private owners is within these guidelines but the result of specific and often complex negotiations.

Under the second variant, employees and management would buy 51% of the shares, with 38% going to the local government and 11% to the State. There are several proposals for allocation of the state and municipally-owned shares but none of them have become a reality. Rosgaz is, for example, trying to convince local governments that the Gorgas' shares belongs to them and should be transferred to the Oblgas so that the latter could regain almost complete control over the Gorgas. This scheme has not yet succeeded. After three years, shares belonging to the state and municipalities should be sold to the public under procedures to be established by the State Property Fund. During that three year period all dividends will be reinvested in the business.

Such a privatization program is not intended to bring capital to the company. The proceeds to be realized from employees will be negligible because the assets of the company are evaluated at book value, which reflects original costs, and, in 1992, a one-time indexation for inflation. Furthermore, of that low value approximately 50% would be "sold" for vouchers which have been distributed, free of charge, among the population. Also, the remaining proceeds from sales of government owned shares will go to the state and local budgets, but not to the company.

Rosgaz became a J.S.C. according to Presidential decrees #721 of July 1,1992 and #1559 of December 8,1992. According to these Decrees, Rosgaz affiliates could be privatized, i.e., become a J.S.C. at the oblast level and all Gorgases and Mejraygasses should become departments of the Oblgasses. The State Property Committee of the Russian Federation ("GKI") issued an "Explanation to the Law", however, allowing local companies to be privatized at the city level as well. This "Explanation" has created a great problem for Rosgaz.

The current structure of gas prices is that residential customers are subsidized by industrial users, who pay much higher prices for gas. In each region only those Gorgases, which serve industrial customers in their cities, are profitable. Other gas companies, which primarily serve only residential customers in rural areas, are highly unprofitable.

For example, in the Saratov region, while only 4 of the 17 companies in the oblast are profitable, the profits of those 4 could exceed all of the losses in the region. Similar situations exist throughout Russia. If the local gas distribution company is privatized at the regional level as it is in Voronezh there would be no financial problems for Rosgaz to run the system. However, if the Gorgases are privatized separately from Oblgases difficulties are created for Rosgaz.

Firstly, some of Gorgases (e.g., in Ryazan) do not consider themselves as a part of Rosgaz and act accordingly with complete independence. Secondly, along with the profitable companies in its system, Rosgaz will have the financial responsibility of supporting a number of highly unprofitable companies.

In the Volgograd and Saratov regions, Gorgases are being privatized separately from the Oblgases. In the Saratov region, there are gas companies serving other industrial cities, which could keep the Oblgas profitable even without Saratovgorgas. In the Volgograd region, however, there are no such opportunities and it is unlikely that, on its own, Volgogradoblgas could survive financially.

Rosgaz strongly opposes the privatization of the Gorgases arguing that profits are not earned by Gorgases and caused only by special gas price structures, a situation which will reverse itself when residential and industrial prices reach equilibrium.

Rosgaz would prefer to deal with the 71 Oblgases in Russia rather than the more than one thousand separate Gorgases and Mezraygases throughout the country. The management problem would greatly exceed the capabilities of its single headquarters in Moscow.

8.5 SUMMARY AND RECOMMENDATIONS

Price Waterhouse evaluated the financial viability of each company relative to projects being proposed by the Study Team. Four scenarios reflecting groups of proposed projects and selected demand projections were evaluated using assumptions as to inflation and gas cost provided by The World Bank. The results of that analysis indicate that the burden upon each company which the projected debt service will impose will significantly reduce each company's current level of profitability. These results are detailed in Appendix 8-C and discussed in Section 8.2 above.

Although each of the companies has been a successful enterprise within the context of its charter, five significant administrative deficiencies were noted at each company. These deficiencies are:

1. The absence of a business-oriented focus.

2. The absence of a marketing function.

3. Inadequate procedures to reconcile sales volumes and revenues.

4. Excessive reliance upon manual procedures.

5. The absence of management and financial analysis.

These deficiencies, which are discussed in Section 8.3 above, adversely impact the performance of the companies and will likely prevent them from operating successfully in a market-oriented environment. Correction of these deficiencies will require the development and implementation of business and management training at all levels throughout the organizations.

Institutional issues are discussed in Section 8.4, above. These issues are grouped into three categories:

1. Structural independence, which relates to the roles played by the Ministry of Fuel and Energy, Gazprom and Rosgaz in the Russian system of gas transmission and distribution, and to the effects of those roles upon the companies under study.

2. Legal and Regulatory Context, which relates to the legal framework within which natural gas supply is allocated throughout Russia and by which prices are set.

3. Privatization, which relates to the models under which the government-owned utilities may become joint stock companies, and to the effects of those transformations.

The following recommendations are derived from these analyses and discussions:

1. The volumes of gas received in 1993 by each LDC participating in the project, should be guaranteed by the Ministry for subsequent years so that any results of energy conservation activities would not adversely affect LDC's ability to receive gas from the transmission company.

2. After they have purchased gas from the transmission companies, the LDCs should be considered as owner of that gas with the unrestricted right of resale to any other party. If any of the customers of the LDC do not use all of the gas which has been allocated to them, or gas savings accrue from other sources, LDCs should have the right to sell that gas to other customers at market prices. This recommendation implies that LDCs must prepare themselves to participate in open market transactions.

3. If the LDCs (and their customers) require gas in excess of their allocations, the LDC should have the right to compete with all potential suppliers, e.g., gas exchanges. transmission companies, etc., through aggressive pricing and should be taxed only on the basis of actual revenues.

4. If any customer is delinquent in payment for gas provided by the LDC, or if any customer takes delivery of gas from the LDC in excess of its allocation, the LDC should have the right and timely ability to discontinue service to that customer and/or to charge penalties without disbursement thereof to other parties. (It is currently the practice for LDCs to give any revenues derived from penalties to the local government)

5. Having substantial problems with late payments, LDC should have the unrestricted rights to offer discounts to customers who are willing to advance money to the LDC for gas to be supplied. The LDC should develop an effective strategy for encouraging large customers to participate in such arrangements.

6. Assuming that the current gas pricing strategy will remain in effect, Rosgaz and Giproniigas, with the participation of local governments, should develop and implement the methodology for correcting the LDCs markup to reflect local conditions including the LDC's customer profile and the size and condition of its network as well as geographical, climatological and other relevant conditions.

7. As gas prices for industrial customers rise toward export levels, the LDCs should have the right and opportunity to purchase some or all of their requirements directly from the gas producing company or other suppliers in direct competition with the transmission company.

Table 8-1

Natural Gas Prices
(Rubles per 1,000 cubic meters)

	1990 Purchase/Sales	1991 Purchase/Sales	1992 Purchase/Sales	1993 Purchase/Sales	Governmental Number	Decrees Dates
Residential	40 / 50					
		40 / 50			# 55	12-19-91
			206 / 260			
				300 / 600	# 29	1-1-93
				600 / 2,000	#678	7-13-93
Industrial	40 / 50					
		40 / 50			# 55	12-19-91
			206 / 260		# 381	5-18-92
			940 / 1,100			
				3,600 / 4,000	# 29	1-1-93
				7,900 / 9,000	# 687	7-13-93
				10,499 / 11,961	# 687	7-13-93

Table 8-2

1992 Data Base

	Ryazan 1992	Saratov 1992	Volvograd 1992	Voronezh 1992	Notes:
INCOME STATEMENT (Rubles x 1000)					
OPERATING INCOME					
Total Sales Revenues	1,747,019	2,025,403	3,597,549	3,525,955	(2)
Other Revenues	2,245	2,822	4,020	19,101	(3)
TOTAL OPERATING INCOME	1,749,264	2,028,225	3,601,569	3,545,056	
OPERATING EXPENSES					
Cost of Gas and LPG	1,135,982	1,709,700	2,447,017	2,395,496	(2) (4)
Payroll (Wages & Bonus)	70,050	41,268	123,610	201,650	(5)
Production Costs	52,411	62,379	107,926	176,298	(6)
TOTAL OPERATING EXPENSES	1,258,443	1,813,347	2,678,553	2,773,444	
EARNINGS BEFORE TAXES, SUBSIDIES AND DEPRECIATION	490,821	214,878	923,016	771,612	
NON-OPERATING INCOME					
Subsidies				128,747	(7)
TOTAL NON-OPERATING INCOME	0	0	0	128,747	
DEDUCTIONS					(8)
Value Added Tax	385,665	83,720	792,292	771,303	
TOTAL DEDUCTIONS	385,665	83,720	792,292	771,303	
INCOME BEFORE INTEREST & TAXES	105,156	131,158	130,724	129,056	
INTEREST & TAXES					
Interest Expenses					
Taxes:					
Excess Payroll Tax	14,497	6,970	25,586	33,267	
Corporate Income Tax	33,396	64,943	41,816	41,298	
TOTAL INTEREST & TAXES	47,893	71,913	67,402	74,565	
NET INCOME	57,263	59,245	63,322	54,491	
DISTRIBUTIONS					
Accumulating Funds	40,441	18,201	5,619	32,793	
Consumption Funds:	16,822	10,001	57,656	11,843	(9)
Other		46,692	47	9,855	
TOTAL DISTRIBUTIONS	57,263	74,894	63,322	54,491	(10)
CHANGE IN RETAINED EARNINGS	0	(15,649)	0	0	

Source: Official Russian Statements for each company.

Unaudited - For Study Purposes Only

Table 8-2 (Continued)

1992 Data Base

	Ryazan 1992	Saratov 1992	Volvograd 1992	Voronezh 1992	Notes:
BALANCE SHEET (Rubles x 1000)					
ASSETS					
Current Assets					
Cash	58,981	223,965	47,997	95	
Short-Term Investments	17,843	300		48,377	
Cash & Investments	76,824	224,265	47,997	48,472	(11)
Accounts receivable		290,272	125,809	844,705	
Advances to Suppliers				16,535	
Group Companies		1,377	4,069		
Loans to Employees		7,061	1,302	2,504	
Other Debtors			48,198	109,401	
Prepaid Taxes				170,949	
Other		73		12	
Accounts receivable	153,761	298,783	179,378	1,144,106	(12)
Materials & equipment	10,323	17,563	12,947	67,063	(13)
Other assets	3,000	387	1,533	40,905	(14)
Total Current Assets	243,908	540,998	241,855	1,300,546	
Fixed assets					
Historical cost	293,943	544,513	1,248,789	1,919,208	
Capitalized Costs			1,542	72,537	(15)
Work in Progress	17,056	1,148	398	17	
Adusted Cost of Fixed Assets	310,999	545,661	1,250,729	1,991,762	
Less: Accumulated Depreciation	(212,548)	(243,740)	(983,749)	(846,313)	
Net Revalued Assets	98,451	301,921	266,980	1,145,449	
TOTAL ASSETS	342,359	842,919	508,835	2,445,995	
LIABILITIES & EQUITY					
Current Liabilities					
Accounts Payable	187,691	465,467	138,093	792,600	
Income of Future Periods			440	328,247	
Other Creditors	6,977	5,547	21,579	38,466	
Provision for Future Expenses	15,249	1,180	1	7	
Settlements With Budget	14,781	6,381	12,775	24,192	
Social Insurance Payable			14,662	26,105	
Subsidiaries				48,120	
Wages and Salaries Payable			15,155	42,309	
Other		300	882	3,618	
Total Current Liabilities	224,698	478,875	203,587	1,303,664	(16)
Long Term Debt					
Interim Financing		49	1,430	1,206	
Other Funds	99,934	296,328	286,011	1,099,999	
Interim and Long Term Liabilities	99,934	296,377	287,441	1,101,205	
Other Liabilities & Equity					
Charter fund	17,727	11,529	17,807	41,126	
Retained Earnings	0	56,138	0	0	(10)
Net Equity	17,727	67,667	17,807	41,126	
TOTAL LIABILITIES & EQUITY	342,359	842,919	508,835	2,445,995	

Source: Official Russian Statements for each company.

Unaudited - For Study Purposes Only

Table 8-2 (Continued)

1992 Data Base

Notes:

(1) Values refer to the gorgasses at Ryazan, Saratov and Volgograd and to the oblgas at Voronezh. Accordingly values for Voronezh reflect a far larger and more diverse service territory than the values of the other three companies.

(2) Totals include both natural gas and LPG revenues/expenses; detail of revenues and expenses is not provided in the Official Russian Statements; forecasts will reflect field estimates of 1992 sales volumes.

(3) Revenues from services other than the sale of gas and LPG.

(4) Cost of Gas and LPG = Total Operating Expenses as reported in the Offical Russian Statements less payroll costs and production costs (estimated as per note 6), which have been reclassified as separate captions.

(5) 1992 Employees and average compensation:

	Employees	Compensation (Thousand Rubles/Year)
Ryazan	450	156
Saratov	547	75
Volgograd	939	132
Voronezh	2,887	70

(6) Includes maintenance of pipeline network, cost of emergency services, maintenance of in-building gas network equipment, also general and administrative excluding salaries. Actual values were included in the Official Russian Statements for Saratov; values were estimated as 3% of sales at Ryazan and Volgograd Gorgasses and as 5% at Voronezh Oblgas based upon field interviews and observations.

(7) Subsidies from the State for losses incurred at Voronezh; all other companies were profitable.

(8) Depreciation is not reflected by the Official Russian Statements in the calculation of net income. Accumulated depreciation is as shown on the Balance Sheet with annual depreciation estimated as 1/30th of net revalued assets.

(9) Includes Social Security Funds, Pension Funds, Employee Funds and Other Bonuses.

(10) Except at Saratov where a Retained Earnings balance is maintained, it is the policy of each company to distribute all of its net profits.

(11) Variance in cash and investments is due to individual company policies, also levels of net accounts payable & receivable.

(12) Detail of accounts receivable was not provided by Ryazan in the Official Russian Statements. Differences amongst companies reflect variances in the number of customers at each company, the mix of customers and the payment behaviors thereof. Discussions with management suggest that a higher level of doubtful and uncollectable debts occurs at Voronezh.

(13) The higher level of materials and equipment at Voronezh reflects the larger service territory and the higher production costs at that company.

(14) Other assets includes miscellaneous investments in infrastructure not necessarily related to the distribution of gas and LPG. The higher value at Voronezh is indicative of the larger service territory, greater number of employees, the need for more extensive transportation networks, larger medical facilities, etc.

(15) The greater value of new construction (i.e. capitalized costs) reflects the need, in Voronezh, to develop the natural gas distribution infrastructure over a larger area this is served by the other companies.

(16) The large variance amongt the companies reflects Voronezh's inability to collect on its outstanding receivables and thus reduce its current liabilities. Another significant difference amongst the companies is indicated by the high level of prepayments at Voronezh. These prepayments reflect a flow-through of cash between Gazprom and customers who are served directly by Gazprom contracts.

Unaudited - For Study Purposes Only

Table 8-3

Summary of Scenario Results

Scenario/Description	Demand Forecast (a)	Proposed Projects (b)	Lost & Unaccounted for Gas (c) Residential	Lost & Unaccounted for Gas (c) Industrial	Ryazan	Saratov	Volgograd	Voronezh
Case 1	Case 1	SCADA, Network Analysis, Cathodic Protection, Leak Detection & Pipe Replacement	Factors Apply in 1993 Only Zero Thereafter	Factors Apply in All Forecast Years				
External Funding (Billions of Rubles)					37.1	62.6	71.1	64.1
External Sources = x% of Project					64.5%	66.2%	67.5%	64.2%
Net Income as a % of Net Reevaluated Assets Average over Period 1998 - 2002					**6.1%**	**10.2%**	**6.2%**	**-1.3%**
Case 2		Metering Projects Only		Factors Apply from 1993 to 1996 Only Zero Thereafter				
External Funding (Billions of Rubles)					41.4	58.1	57.3	81.9
External Sources = x% of Project					73.2%	75.3%	75.0%	72.9%
Net Income as a % of Net Reevaluated Assets Average over Period 1998 - 2002					**8.3%**	**15.1%**	**13.2%**	**-0.4%**
Case 3		SCADA, Network Analysis, Cathodic Protection, Leak Detection & Pipe Replacement, and Metering Projects						
External Funding (Billions of Rubles)					78.0	120.7	128.4	146.0
External Sources = x% of Project					68.8%	70.3%	70.7%	68.8%
Net Income as a % of Net Reevaluated Assets Average over Period 1998 - 2002					**0.0%**	**3.2%**	**0.3%**	**-3.4%**
Case 4	Case 5							
External Funding (Billions of Rubles)					78.0	120.7	128.4	146.0
External Sources = x% of Project					68.8%	70.3%	70.7%	68.8%
Net Income as a % of Net Reevaluated Assets Average over Period 1998 - 2002					**0.5%**	**3.6%**	**0.6%**	**-2.4%**
Net Income as a % of Net Assets 1992					58.0%	20.0%	24.0%	5.0%

Notes:
(a) Projections of Demand per Schlessinger & Associates
(b) Project costs estimated by Bechtel Project Team
(c) See Assumption 9 for detail

Table 8-4

Selected Operating Statistics

	Gas Volumes 100 Cubic Meters	Number of Major Customers	Customers Reporting Daily	Diagrams Provided by Customers	Customers Reporting Monthly	Homes Billed Monthly	Apartments Billed Monthly
Ryazan							
Industrial	2,989,164	10	130	77	1,015		
Residential	177,846					1,133	148,229
Total	3,167,010						
Saratov							
Industrial	2,989,164	12	60	250	1,133		
Residential	177,846					30,000	251,692
Total	3,167,010						
Volgograd							
Industrial	3,441,610	32	120	180	650		
Residential	151,737					34,000	259,100
Total	3,593,347						
Voronezh							
Industrial	3,900,000	30	90	44	243		
Residential	537,000					44,285	242,800
Total	4,437,000						

Section 9

TABLE OF CONTENTS

9. SUMMARY OF POTENTIAL INVESTMENTS 1

9.1 INVESTMENT SUMMARY 1

9.2 ENERGY CONSERVATION PROJECTS FUNDING 1

Section 9

SUMMARY OF POTENTIAL INVESTMENTS

9.1 INVESTMENT SUMMARY

Potential projects for the gas distribution companies have been identified for each of the four cities with investment requirements ranging from approximately $26 million for Ryazan to $46 million for Voronezh. In combination for each city, the sets of projects have estimated economic rates of return ranging from 26% in Ryazan to 37% in Volgograd. These benefits are largely measured in terms of conserved gas and deferred maintenance (which, though necessary to preserve existing assets, is not presently being carried out). Since these do not contribute directly to the distribution companies' ability to repay loans for the projects, adjustments to the sales margins of the four companies will be required, as described in Section 8.

It is understood that industrial projects will be financed by an intermediary fund for energy conservation. Since the benefits of these projects have been calculated solely on gas savings to the enterprises themselves, financially sound companies should have the ability to repay relatively short term loans. Of 52 projects considered in the survey, 34 were judged to have a rate of return in excess of 25%. These 34 projects would require an investment of approximately $26 million (US$ 1993). Approximately 32% of the total quantity of industrial gas consumption was included in the survey, so an estimate of the potential "market" for such loans could be as much as double this amount. However, since the ability of some companies to repay conservation loans may be compromised by uncertain business conditions, no extrapolation has been made in this report.

A considerably larger share of the district heating sector, including all the major heat-producing facilities, was surveyed than was possible for the industrial sector. As discussed in Section 5, a 20% rate of return was used at the cut-off point for selecting district heating projects. Some 28 of 43 projects considered in the survey fulfill this criterion. Approximately $42 million would be required to finance those 26 projects. Borrowers would be the district heating companies and the owners of cogeneration facilities.

The estimated investment requirements of "qualified" projects are as follows:

Total Investment Requirements, $000

	Distribution	Industry	District Heating
Ryazan	26,000	200	8,500
Saratov	38,000	4,000	10,800
Volgograd	40,000	5,200	13,700
Voronezh	46,000	300	9,000
Totals	150,000	9,700	42,000

Details are listed in the tables of the sections describing the individual sectors.

9.2 ENERGY CONSERVATION PROJECTS FUNDING

A number of energy conservation projects were identified in each city. It is recommended that these projects be funded through a loan made to the Russian Energy Savings Fund. The Russian Energy Savings Fund has the following three main functions:

1. Foreign economic relations

2. Projects review and analysis

3. Economics and finances

The Russian Ministry has signed a memorandum of understanding in September, 1993 to cooperate in areas of energy conservation. As per resolution No. 568, the Russian government guarantees repayment to Western companies through the Energy Savings Fund.

The Board of the Savings Fund:

1. Reviews all proposed projects on technical bases

2. Arranges financing for the approved projects

3. The Fund is used as a conduit for funds from the various ministries

4. The Fund makes soft loans to support projects that may seem unprofitable at the initial stage

5. The Fund operates at both the national and regional level

6. The Fund generates its budget from special fees charged to entities that use over 20,000 tons of fuel annually. Thirty percent of these fees are generated on the federal level and 70% on the regional level

7. Typically, the Fund lends money to qualified entities at 10 to 15% in rubles

The money loaned to the Energy Savings Fund for the energy conservation projects described in Section 5 and 6 would be given to the gorgas companies for financing of these projects. The gorgas companies will lend the money to the industries for implementing energy conservation projects. For projects that cost over $10 million, the World Bank will loan 60 percent and the balance will be furnished by local sources.