23468

Directorate of Intelligence

~~Confidential~~

CIA | SOV | 88-10058 | 23468

# USSR: Natural Gas— Fuel for the 1990s

A Research Paper





~~Confidential~~

SOV 88-10058
August 1988

Copy

| | |
|---|---|
| **Warning Notice** | Intelligence Sources or Methods Involved (WNINTEL) |
| **National Security Information** | Unauthorized Disclosure Subject to Criminal Sanctions |

| **Dissemination Control Abbreviations** | | |
|---|---|---|
| | NOFORN (NF) | Not releasable to foreign nationals |
| | NOCONTRACT (NC) | Not releasable to contractors or contractor/consultants |
| | PROPIN (PR) | Caution - proprietary information involved |
| | ORCON (OC) | Dissemination and extraction of information controlled by originator |
| | REL... | This information has been authorized for release to... |
| | WN | WNINTEL - Intelligence sources or methods involved |

A microfiche copy of this document is available from OIR/DLB (482-7177); printed copies from CPAS/IMC (482-5203); or AIM request to userid CPASIMC1. Regular receipt of DI reports can be arranged through CPAS/IMC.

Classified by [redacted]
Declassify: OADR
Derived from multiple sources

All material on this page is Unclassified.

Directorate of
Intelligence

~~Confidential~~

# USSR: Natural Gas—Fuel for the 1990s

A Research Paper

This paper was prepared by
the Office of Soviet Analysis. Comments and queries
are welcome and may be directed to the Chief,
SOVA

*Reverse Blank*

# USSR: Natural Gas—Fuel for the 1990s


## Summary

*Information available as of 1 July 1988 was used in this report.*

Through most of the 1990s, gas will be the major fuel providing growth in Soviet primary energy production. Gas is to bridge the USSR's planned long-range transition from heavy reliance on oil to major emphasis on coal and nuclear power. At a time when costs of oil production are soaring, conservation efforts are mired, and the coal industry offers few prospects in the near term, gas offers marked advantages. It provides:

- Vast, proved reserves of high-quality fuel.
- High returns to investment in exploitation (albeit involving challenging technical problems).
- An existing, large expanding network of gas pipelines.
- Lower investment requirements and easier exploitation than coal and oil, especially for near-term benefits.

The Soviet gas industry has excellent potential for growth of supply into the mid-1990s and for stable output for many years thereafter. The availability of natural gas should enable the Soviet economy to escape a shortage in aggregate energy availability through the 1990s. Future production gains will come mainly from tapping huge gas reserves in West Siberia. The Yamburg field is the major development project for 1986-90, and additional gas will become available as deposits near Urengoy and on the Yamal Peninsula are developed and tied into the pipeline network.

Realization of this substantial production potential depends in part, however, on providing adequate investment and manpower resources to develop the West Siberian gasfields and, more important, on the ability of the domestic economy and export customers to absorb additional gas deliveries. The Soviet economy's capacity to absorb the lion's share of potential increases in gas production will depend on the implementation of a series of costly adjustments to rechannel existing patterns of energy use. These include:

- Completing a substantial expansion of the gas pipeline distribution system.
- Building more storage facilities to eliminate disruptions in supply during peak periods in winter.
- Increasing gas-for-oil substitution in the electric power industry by building new plants and bringing gas to new areas not now supplied.
- Increasing the use of gas as a boiler fuel in the industrial, commercial, and household service sectors of the economy.

To accommodate increasing gas production, the Soviets plan some 58,000 kilometers of gas pipeline construction for 1986-90, compared with the 48,000 planned for 1981-85. Moscow continues to import large volumes of materials and equipment for the pipeline program, particularly large-diameter pipe and heavy-duty winterized pipelayers. In the future, Moscow may need to step up imports of high-capacity gas pipeline turbines because the domestically developed 16- and 25-megawatt turbines have proved to be of low quality and poor reliability.

The need to provide increased investment and manpower comes at a time when these resources are in high demand by other priority activities. Gorbachev's industrial modernization program, for example, calls for increased access to many of these same resources. And within the energy sector itself, rising claims on investment resources will be made by the oil, coal, and nuclear power industries. Because oil will remain the USSR's prime source of hard currency earnings for the forseeable future, the effort to maintain oil production will continue despite soaring costs of production. Past deficiencies in coal industry improvement will delay the time when coal can supplant other fuels in many uses, while the investment requirements of the nuclear power industry have also increased since the Chernobyl' accident

Nonetheless, the technical problems that must be solved and the competition for investment resources are not likely in themselves to prevent the Soviets from achieving their planned expansion of gas production and carrying out the necessary pipeline construction. We estimate that gas production will increase by 20 percent between 1987 and 1990 and could grow by another 30 percent if demand warrants such an increase. By 1995, West Siberian fields probably will provide three fourths of Soviet gas productio

The outlook for gas demand, particularly after 1990, is uncertain. The electric power industry might be able to substitute gas for fuel oil and add gas-burning capacity to increase consumption by 50 percent. Further increases are possible in the industrial, commercial, and household services sectors if local pipelines are built. Much of Soviet industry has already converted to gas, and further expansion of industrial use can be expected to parallel future growth in industrial production, including the extent to which the petrochemical industry expands

The prospect for export demand is much less favorable. The extent to which Eastern Europe could absorb more gas as a replacement for oil deliveries is problematic, because many of the region's countries primarily need light oil products such as diesel fuel from the USSR. Nevertheless, the Soviets are increasing the capacity for delivering gas to Eastern Europe with the construction of the new "Progress" pipeline from Yamburg to Uzhgorod. The pipeline should be in partial operation by 1989, but we believe that East European demand for gas will not develop sufficiently to achieve the originally planned rates of delivery until well into the 1990s.

Opportunities for boosting Soviet sales of gas for hard currency during the next few years are uncertain. Increased gas sales to the West to offset lower earnings from oil will be difficult to achieve because of sluggish energy consumption growth in Western Europe and strong competition from other oil and gas producers, which have driven down the price of gas. Moscow's option of boosting gas exports would fade if West European oil and gas markets remain soft well into the 1990s because of intense interfuel price competition between oil, gas, and nuclear power (and if development of Norway's giant Troll gasfield proceeds as planned). However, if less nuclear power is generated in Western Europe than now planned and total energy demand strengthens, gas exports could again become an avenue for the Soviets to generate substantial increments in hard currency revenues. Recent policy shifts away from nuclear power to natural gas have been made in Italy and Sweden following the Chernobyl' disaster

## Contents


| | Page |
|---|---|
| Summary | iii |
| Scope Note | ix |
| The Growing Importance of Natural Gas | 1 |
| Impetus for Future Demand | 1 |
| Domestic Requirements | 1 |
| Export Demand | 3 |
| The Special Importance of Gas | 4 |
| Soviet Ability To Supply the Gas | 5 |
| Vast Reserve Base | 5 |
| Production Capability | 5 |
| Shifting Geographic Focus | 8 |
| The Role of Large-Bore Gas Wells | 12 |
| Pipelines—Essential Complement to Production | 13 |
| Potential Constraints | 13 |
| Investment Requirements | 15 |
| Storage Facilities | 15 |
| Regional and Local Gas Distribution Facilities | 20 |
| Outlook | 20 |

Scope Note

This evaluation of the Soviet natural gas industry completes our three-year review of the USSR's main energy-producing industries—oil, natural gas, coal, and nuclear power. The longer term issue of investment trade-offs between energy production and conservation was also analyzed. Published studies on Soviet energy have included:

- DI Research Paper SOV 86-10051, November 1986, *Soviet Oil Production Through 1990: Hard Choices Ahead.*
- DI Research Paper GI 86-10074X/SOV 86-10049X, November 1986, *Arctic Petroleum Development: Western Capabilities and Soviet Needs.*
- DI Research Paper SOV 87-10032X, June 1987, *The Soviet Nuclear Power Program After the Chernobyl' Accident.*

Future work on Soviet energy will examine the outlook for oil output in the Caspian region, production prospects of small oilfields in West Siberia, potential transport constraints to continued oil and gas development in West Siberia, and Moscow's long-term energy policy options. This paper examines the adequacy of the USSR's reserves of natural gas and Soviet industry's ability to play its assigned role in producing and transporting gas. The paper also addresses the ability of the domestic economy and export markets to absorb prospective increases in gas production

# USSR: Natural Gas—Fuel for the 1990s

## The Growing Importance of Natural Gas

Soviet gas consumption doubled from 1975 to 1987, buoyed mainly by large increases in use by the chemical industry (up 173 percent), electric power plants (up 213 percent), and compressor stations on gas pipelines (up about 640 percent) (see table 1). The rapid expansion in use of gas was facilitated by its clean-burning characteristics and the relatively simple technological requirements for its combustion.

Industrial consumption of gas rose from about 148 billion cubic meters ($m^3$) in 1975 to 256 billion $m^3$ in 1987 and accounted for 40 percent of domestic use. The growth of gas consumption by the chemical industry reflects a rapid expansion in output of gas-based chemicals in recent years. About 80 percent of the gas consumed by the chemical industry is for feedstock—gaseous or liquid petroleum-derived hydrocarbons from which gasoline, fuel oil, and petrochemicals are produced; only about 20 percent is used directly as fuel. Gas use by ferrous metallurgy has risen by about 39 percent since the mid-1970s, both as a partial substitute for metallurgical coke and as a source of energy for various steelmaking operations. And the massive expansion of the gas pipeline network has caused increasing use of gas as a power source for long-distance pipeline transport of gas. We estimate that about 10 percent of "apparent" annual gas consumption is now used as compressor fuel for pipeline operations.

Electric power plants remain the largest consumers of gas. Their share of apparent consumption reached 33 percent in 1987. Despite the sharp increase in gas use by power plants, however, the amount of fuel oil consumed in the electric power industry has decreased only slightly in recent years. Much of the increased use of gas has offset shortfalls in coal output and provided for above-plan electricity generation rather than displacing oil.

In the household/municipal services sector, consumption of natural gas, mainly for cooking, more than doubled during 1976-87, although its share of apparent consumption remained at about 12 percent. Soviet press reports indicate that piped or bottled gas (including liquefied petroleum gas) has become available to about 70 percent of all dwellings nationwide.

## Impetus for Future Demand

The USSR plans to rely heavily on natural gas to facilitate a transition in its energy-supply structure during the next 20 years and is capable of large increases in production. We believe that demand for gas by the domestic economy and by export customers will be the key determinants of future production levels.

*Domestic Requirements.* No forceful, coherent program for energy conservation has yet materialized in the USSR—and, with the demands on management resources resulting from Gorbachev's economic reform program, no such program is likely to significantly affect Soviet energy consumption in the next five to 10 years. Further, as the economy grows, energy will grow with it. The investment requirements for energy production will also be rising, leading to heightened competition among energy producers for scarce investment resources. As a result, the outcome will probably differ from the energy growth pattern set forth in Moscow's Long-Term Energy Program (see inset).

The coal and nuclear-energy industries will not be able to provide for the sizable growth in primary energy supply in the late 1990s that had been earlier assumed by Soviet planners. The Chernobyl' accident introduced a complex set of considerations that has slowed nuclear power development, and improvements in coal industry facilities are lagging, in part because of inadequate investment. Oil production is becoming

[1] See footnote a in table 1.

Table 1
USSR: Production, Trade, and Consumption of Natural Gas

*Billion cubic meters*

| | 1975 | 1980 | 1984 | 1985 | 1987 |
|---|---|---|---|---|---|
| Production | 289.3 | 435.2 | 587.4 | 643 | 727.4 |
| Net exports | 17.0 | 56.1 | 66.3 | 66 | 82.7 |
| Apparent consumption [a] | 272.3 | 379.1 | 521.1 | 577 | 644.7 |
| Gas distributed for consumption [b] | 261.9 | 346.7 | 462.8 | 510 | 568.0 |
| Electric power [c] | 68.7 | 91.1 | 156.9 | 180 | 214.7 |
| Industry: | 148.4 | 190.6 | 223.1 | 239 | 256.3 |
| Chemicals | 21.0 | 36.4 | 48.2 | 52 | 57.4 |
| Ferrous metallurgy | 34.4 | 40.4 | 44.9 | 47 | 47.7 |
| Nonferrous metallurgy | 5.9 | 7.0 | 8.3 | 9 | 9.7 |
| Machine building | 23.4 | 29.1 [d] | 34.2 | 37 | 39.8 |
| Construction materials | 23.2 | 26.6 | 31.1 | 32 | 34.1 |
| Oil and gas | 21.3 | 26.7 | 29.6 | 33 | 36.9 |
| Other [e] | 19.2 | 24.4 | 26.8 | 29 | 30.7 |
| Household/municipal services [c] | 35.5 | 52.1 | 64.3 | 70 | 74.4 |
| Other [f] | 9.3 | 12.9 | 18.5 | 21 | 22.7 |

[a] Differences between "apparent" consumption and gas distributed for consumption are accounted for the most part by gas used as fuel in compressor stations on long-distance pipelines.
[b] Because data on gas storage are not available, this table has not been adjusted for additions to and withdrawals from storage.
[c] Ministry of Power and Electrification use only.
[d] Including light and food industries.
[e] Mainly cooking.
[f] Includes construction, agriculture, transport, and losses.

ever more investment intensive; and, if—as we expect—oil production begins to decline in the 1990s, increased efforts to free oil for export to hard currency markets are probable

The gas industry, in contrast, appears well positioned to supply fuel both to meet increased domestic demand and expanded exports. From the supply viewpoint, gas production probably could be increased up to 250 billion m³ from 1990 to 1995 [1] without straining the absorptive capacity of both the domestic consumption and export delivery systems. Whether the domestic and export markets could absorb the increase is less certain but still possible. After allowing for pipeline compressor fuel, the electric power industry could absorb about 85 billion m³ of this increase—roughly three-fourths used to displace oil and the remainder as fuel in new gas-fired plants. A shift away from use of heavy fuel oil by power plants and boilers for central heating would need to be accompanied by an upgrading of oil refineries, however, so that a larger share of the average barrel of crude oil could be used to satisfy rising demand for light oil products. Much of Soviet heavy industry has already been converted to use of gas. Increasing the industrial use of gas, therefore, would depend heavily on the growth of industrial production and the concommitant growth in energy use, including the extent to which the Soviet petrochemical industry expands.

[1] Recent press reports indicate that eight to 11 large-diameter pipelines may be constructed from Yamal Peninsula during the 13th Five-Year Plan (1991-95), and a seventh pipeline is being built from Yamburg.

*Moscow's Long-Term Energy Program*

*In March 1984, Soviet energy planners set guidelines for energy supply and demand in the Long-Term Energy Program. Although the ambitious timetable set forth for implementing the program by the turn of the century is slipping in usual Soviet fashion, the logic of the program and its implicit diagnosis of future availability of the main fuels appear valid. But a smooth transition depends on timely, coordinated energy conservation and giant steps to increase production of coal and nuclear power. If—as is probable—these do not materialize fully, the capability of the gas industry to prevent emergence of an energy gap would be crucial to the economy.*

*Soviet energy planners seek to provide a "stable, high level" of oil production, at least through the early 1990s. For the longer term, they evidently foresee declining oil production (despite the likelihood of more discoveries) because the program notes a shift from "oil" to "liquid fuels" (explicitly including methanol and synthetic fuels).*

*According to the Soviet scenario, gas production is to roughly double from 1985 to the 1995-2000 period and then level off. Its share of primary energy supply is expected to increase from 36 percent in 1987 to about 40 percent in 1990 and will probably continue to grow in the following decade. Meanwhile, nuclear power production is slated to more than quadruple its still relatively small share of primary energy supply, and heavy investment is to be made in the coal industry. After the turn of the century, when oil production will almost certainly be declining and gas is being produced at a high level, needed increments to the primary energy supply are scheduled to come mainly from nuclear power and open pit coal. During the entire period under consideration, Moscow foresees progress in reducing the energy intensity of the economy—measured by the ratio of total energy consumption to national income—through increased conservation.*

*Export Demand.* Although Soviet planners have some ability to influence the domestic consumption of gas, they have little flexibility to affect demand in Western markets. Soviet gas exports have increased 50 percent since 1980, and further growth through 1990 is likely (see table 2).[1] But decisions affecting additional subsequent purchases of Soviet gas in Eastern and Western Europe will depend on many complex and unrelated factors, including economic conditions and political considerations in the various consuming countries as well as the availability and price of alternative energy supplies. Because oil is readily substitutable for gas in many uses, continued weakness of the world oil market reduces the potential demand for new Soviet gas. Finally, the West European market is experiencing strong interfuel competition between nuclear fuel, oil, gas, and coal suppliers, as well as keen competition between the individual oil and gas producers.

The extent to which Eastern Europe could absorb more Soviet gas—and the rate at which it could absorb the gas as a replacement for oil deliveries—is problematic; what many of the region's countries primarily need is light oil products such as diesel fuel from the USSR. Nevertheless, the Soviets are increasing the capacity for delivery of gas to Eastern Europe with the construction of the new "Progress" pipeline from Yamburg to Uzhgorod. This trunkline—being built with East European participation—is intended to deliver 22 billion m³ per year of additional gas. Pipelaying was completed this year, and the pipeline could be fully operational in 1991. We believe, however, that East European gas demand will not develop sufficiently to require the planned amount of delivery until well into the 1990s.

[1] The Soviets' most recent gas sales contract was concluded in February 1986 with Turkey. Deliveries began in June 1987 and will increase from 1.5 billion m³ in 1988 to 6 billion m³ in the mid-1990s. Agreements in principle for Soviet gas were reached with Greece, Sweden, and Spain in 1987.

[2] The "Progress" pipeline could carry as much as 30-32 billion m³ of gas per year if equipped with a full complement of compressors, which would provide at least 8-10 billion m³ of spare capacity. If gas demand in Western Europe increases, the Soviets could easily use this capacity to boost exports via the Czechoslovak transit pipeline system. The capacity of this system, which was about 53 billion m³ per year in 1984, is to be increased to 68 billion m³ by 1989 according to a Council for Mutual Economic Assistance publication. About 60 billion m³ of this capacity would be available for transmission of Soviet gas to Western Europe.

Table 2
USSR: Exports of Natural Gas

*Billion cubic meters*

| | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1990 [a] |
|---|---|---|---|---|---|---|---|---|---|
| Total | 56.5 | 60.8 | 62.3 | 65.7 | 68.8 | 68.7 | 79.2 | 84.3 | 112 |
| Eastern Europe | 31.5 | 32.2 | 33.8 | 40.3 | 36.8 | 38.3 | 41.2 | 43.7 | 54 |
| Bulgaria | 4.6 | 4.5 | 4.5 | 5.5 | 5.5 | 5.0 | 5.7 | 6.1 | 8 |
| Czechoslovakia | 8.3 | 8.5 | 9.0 | 11.1 | 9.3 | 11.0 | 10.6 | 10.6 | 11 |
| East Germany | 6.5 | 6.4 | 6.5 | 7.8 | 6.4 | 7.0 | 7.0 | 7.0 | 8 |
| Hungary | 3.8 | 3.8 | 3.7 | 4.5 | 3.9 | 4.0 | 4.7 | 4.8 | 6 |
| Poland | 5.3 | 5.3 | 5.6 | 6.0 | 6.0 | 5.7 | 7.1 | 7.5 | 11 |
| Romania | 1.5 | 1.5 | 1.5 | 2.1 | 2.0 | 2.0 | 2.5 | 3.3 | 4 |
| Yugoslavia | 1.5 | 2.2 | 3.0 | 3.3 | 3.7 | 3.6 | 4.0 | 4.4 | 6 |
| Western Europe | 25.0 | 28.6 | 28.5 | 25.4 | 32.0 | 30.4 | 38.0 | 40.6 | 58 |
| Italy | 7.0 | 8.1 | 8.6 | 7.5 | 7.7 | 6.0 | 8.0 | 8.6 | 14 |
| France | 4.0 | 4.7 | 4.2 | 4.0 | 6.0 | 6.8 | 9.3 | 8.8 | 12 |
| West Germany | 10.7 | 11.8 | 10.5 | 10.0 | 13.5 | 12.4 | 15.5 | 16.9 | 22 |
| Austria | 2.4 | 3.2 | 4.4 | 3.2 | 4.0 | 4.2 | 4.0 | 3.9 | 5 |
| Finland | 0.9 | 0.8 | 0.8 | 0.7 | 0.8 | 1.0 | 1.2 | 1.6 | 2 |
| Turkey | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.8 | 3 |
| Estimated hard currency revenue *(billion US $)* | 2.7 | 4.0 | 3.7 | 3.2 | 3.8 | 3.8 | 3.6 | 2.7 | NA |

[a] Estimated.

The Special Importance of Gas

In Moscow's Long-Term Energy Program, gas emerges as the "swing fuel" in two senses. Through most of the 1990s, it will be the major fuel providing growth in Soviet primary energy production, bridging the transition from heavy reliance on oil to major emphasis on coal and nuclear power. Gas can provide much of the badly needed flexibility in the adjustment process—both with respect to the amount of energy and the timing of availability—to cope with possible shortfalls in oil output, in coal and nuclear power development, and in energy conservation.

Gas has marked advantages over both oil and coal in terms of investment requirements and ease of exploitation (from extraction through combustion and the delivery of energy to end users). Soviet investment costs for maintaining current world record levels of oil output have been soaring as a consequence of the high rates of depletion in a large number of existing giant fields and the poorer quality of the new fields being tapped. (The fields are located at great distance from consuming centers and are difficult to exploit, and the well flows are low.) The coal situation is characterized not only by past neglect in terms of investment but also by a host of problems related to the low quality of much of Soviet coal. The bulk of the coal planned for exploitation in the next quarter century has relatively low energy content. It also presents difficult problems—many of them still unresolved—with regard to combustion as well as transportation because the coal is either transported directly by rail or after conversion to electric power, to consuming centers thousands of kilometers away.

In contrast, natural gas provides vast proved reserves of high-quality fuel, high returns to investment in exploitation (albeit involving challenging technical problems), and a large, expanding gas pipeline system. One large-bore gas well can produce as much energy in one day as 30 new oil wells, a marked advantage in terms of investment and manpower requirements. Gas utilization does not present the combustion and energy transmission problems that plague much of Soviet coal development. With total primary energy investment—including pipeline construction—already about one-fifth of total new fixed investment in the economy, and the agroindustrial complex continuing to swallow up one-third of investment, Moscow might well decide to amend its pattern of domestic fuel consumption by obtaining even more energy from gas and taking more vigorous steps to conserve energy to throttle back increases in oil investment

Table 3
USSR: Natural Gas Reserves, Production, and Reserves-to-Production Ratio

| | End-of-Year Reserves[a] (billion m³) | Production (billion m³) | Reserves-to-Production Ratio[b] (in years) |
|---|---|---|---|
| 1965 | 3,564 | 127.7 | 28 |
| 1970 | 15,750 | 197.9 | 80 |
| 1975 | 25,800 | 289.3 | 89 |
| 1980 | 30,000 | 435.2 | 69 |
| 1981 | 34,000 | 465.3 | 73 |
| 1985 | 34,000-42,000 | 643.0 | up to 65 |

[a] Reserve data shown include A, B, and C1 categories. These Soviet categories correspond generally to Western categories of proved, probable, and possible reserves.

[b] The reserves-to-production ratio is the reserve base divided by annual production. This ratio is used by planners at the national, regional, and local levels as a basis for investment and development decisions.

One 1981 Soviet petroleum industry publication carried an estimate of 34 trillion m³. Other Western observers, especially Cedex, a Paris-based journal, believe reserves to be as much as 42 trillion m³. We consider it likely that the Soviets have added to proved reserves an amount roughly comparable to production in recent years. The last published Soviet reserve estimate appeared in *Razvedka i Ekspluatatsiya Gazovykh i Gazokondensatnykh Mestorozhdeniy* 1981. No. 1, p. 3.

## Soviet Ability To Supply Gas

### Vast Reserve Base

The Soviet Union is endowed with the world's largest natural gas reserves, last shown in Soviet publications as 34 trillion m³ in 1981 (see table 3). Recent Western sources cite estimates of up to 42 trillion m³.[1] The high ratio of reserves to production suggests that, even in the unlikely event that no new reserves were added between now and the year 2000, gas reserves would be roughly equivalent to over 20 years' production at the rate of 1 trillion m³ per year. Nearly 80 percent of Soviet gas reserves are found in Tyumen' Oblast in West Siberia (see figures 1 and 2 and inset). Other sizable deposits are located in the Turkmen and Uzbek Republics (over 3 trillion m³) and in Orenburg Oblast and the Pre-Caspian Depression (at least 2 trillion m³).

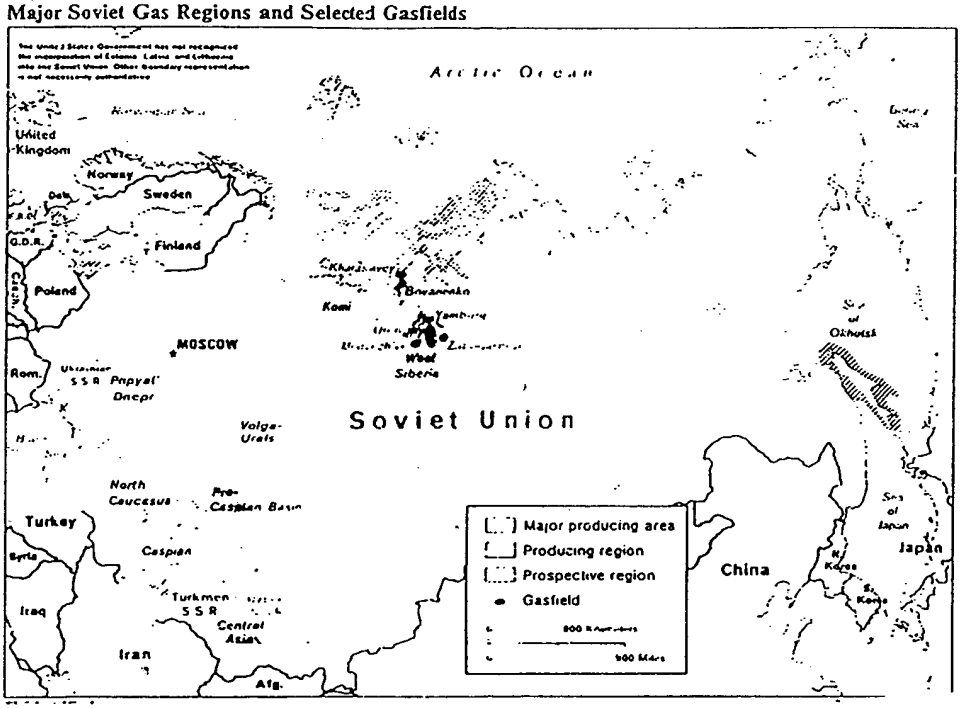
Production in the Turkmen and Uzbek Republics and in Orenburg Oblast accounted for most of the growth in gas output during the 1970s but has been roughly stable for the last five years. Development of two new giant deposits—Sovetabad in the Turkmen Republic and Shurtan in the Uzbek Republic (each with up to 1 trillion m³ of reserves)—should enable production in these regions to stabilize or grow slightly in the 1990s. East Siberia, the Soviet Far East, and the offshore Arctic may also possess huge reserves, but those regions have been explored only slightly and have produced very little gas. The older reserves in the Ukraine and the North Caucasus have been heavily exploited for more than two decades and are substantially depleted.

### Production Capability

Among the major fuels, only gas has posted substantial rates of growth of output (6 to 10 percent) in the USSR in recent years. Moscow's efforts to expand natural gas production in the face of declining growth

[1] The Soviet Gas Minister was asked the size of current gas reserves at the International Gas Union Congress in June 1988, and he replied that this figure, like that for oil reserves, is now regarded as a state secret. Prior to this Congress, the French Cedex publication released a Soviet gas reserve estimate of 42 trillion m³.

Figure 1
Major Soviet Gas Regions and Selected Gasfields

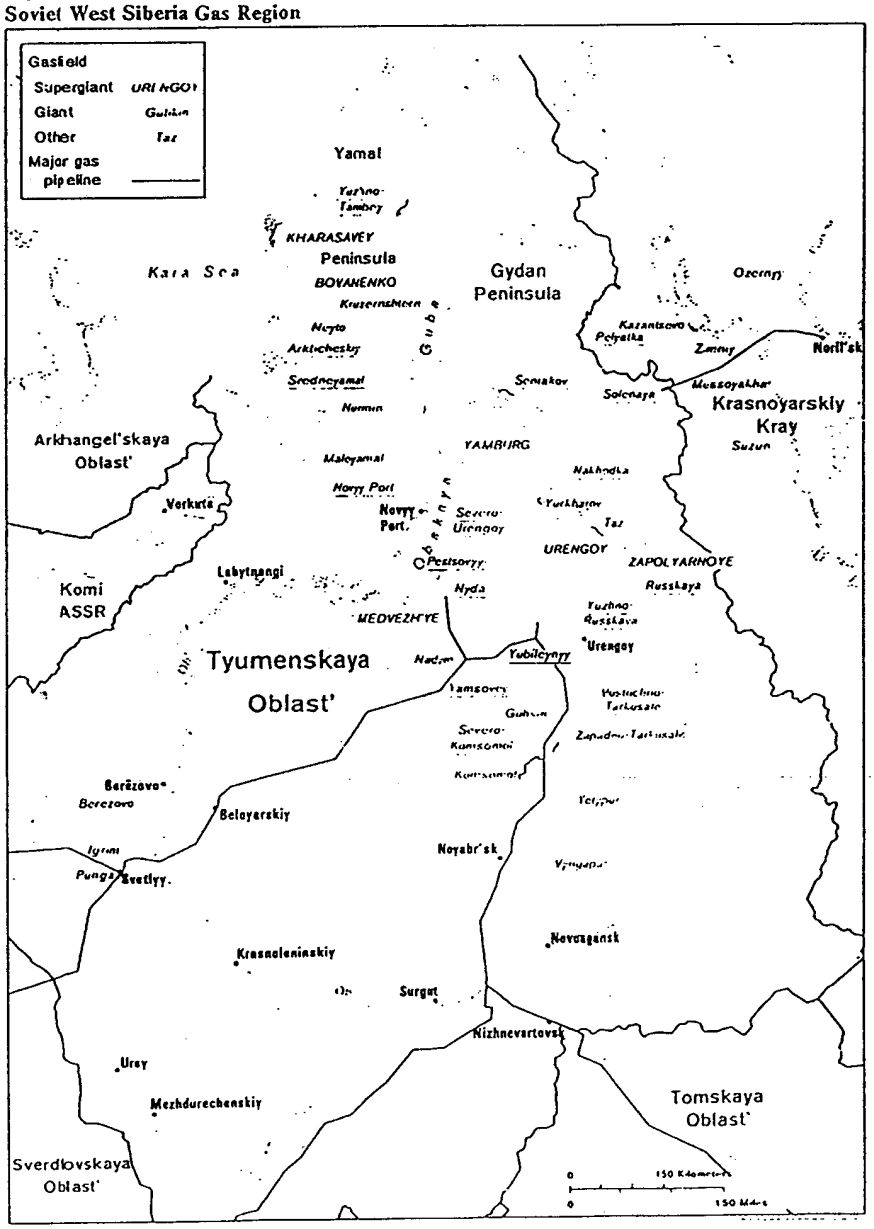



in oil and coal production have brought about a rise in natural gas output from 435 billion m³ in 1980 to 727 billion m³ in 1987, making the USSR the world's largest gas producer (see figure 3).*

* The USSR publishes two data series on natural gas production, both calculated at standard atmospheric pressure of 760 mm of mercury. The first series, used in tables relating to energy production and use in the USSR alone, evaluates the volume of gas produced at a temperature of 20 degrees Celsius; the second, used by the Soviets in international comparisons, evaluates the volume at 0 degrees C. Thus the volume of gas produced in 1985 is reported in plan fulfillment reports and in the domestic section of the annual statistical handbook as 643 billion m³ (20 degrees C). But in the section of the statistical handbook dealing with international comparisons, it is reported as 599 billion m³ (0 degrees C).

Because of the country's vast natural gas reserves and the Gas Ministry's established record of boosting output, we believe that increases in gas output at an average annual rate of 6 percent can readily be achieved between now and the mid-1990s. Attaining these production growth rates will involve the development of one or two new giant gas deposits every five years. The Soviets plan to let gas output level off in the mid-to-late 1990s, probably within the range of 1,100-1,200 billion m³ per year, and remain at that level until about the year 2020. Such a plan appears feasible: each large field should be able to produce 40-50 billion m³ annually for 20 to 25 years from each trillion m³ of gas reserves. From time to time, smaller fields will be developed to maintain output and to cover demand in local areas to maximize utilization of installed pipeline and distribution systems

Figure 2
Soviet West Siberia Gas Region



*Tyumen' Oblast Gasfields: The Biggest and Best*

*Urengoy—the world's largest gasfield—and Yamburg together contain 10-12 trillion m³ of natural gas. The seven major Tyumen' gasfields listed below account for more than half of the country's reserves. The two largest fields will provide most of the growth in gas production in the next few years. At least 18 trillion m³ of the estimated explored gas reserves in the Tyumen' Oblast are in shallow Cenomanian (Upper Cretaceous) reservoirs at depths of 650 to 1,300 meters. Another 6 trillion m³ are found in much deeper Valangian (Lower Cretaceous) reservoirs at depths of 2,200 to 3,700 meters. The Valangian gas pools are less prolific producers, but they are rich in natural gas liquids (NGL)—estimated to contain at least 1 billion tons of ethane, propane, and butanes. On average, large-bore Cenomanian gas wells can each produce 1.5 million m³ daily of gas that are 93 to 98 percent methane (the "natural gas" of commerce) for sustained periods. The Valangian wells may produce about one-third as much gas per day, and the methane content is lower (83 to 88 percent) because of the high NGL fractio*

| Field | Year of Discovery | Reserves (billion m³) |
|---|---|---|
| Urengoy | 1966 | 6,000-8,000 |
| Yamburg | 1969 | 4,000 |
| Zapolyarnoye | 1965 | 2,500 |
| Bovanenko | 1971 | 2,300 |
| Medvezh'ye | 1967 | 1,500 |
| Kharasavey | 1974 | 1,000 |
| Vyngapur | 1968 | 300 |

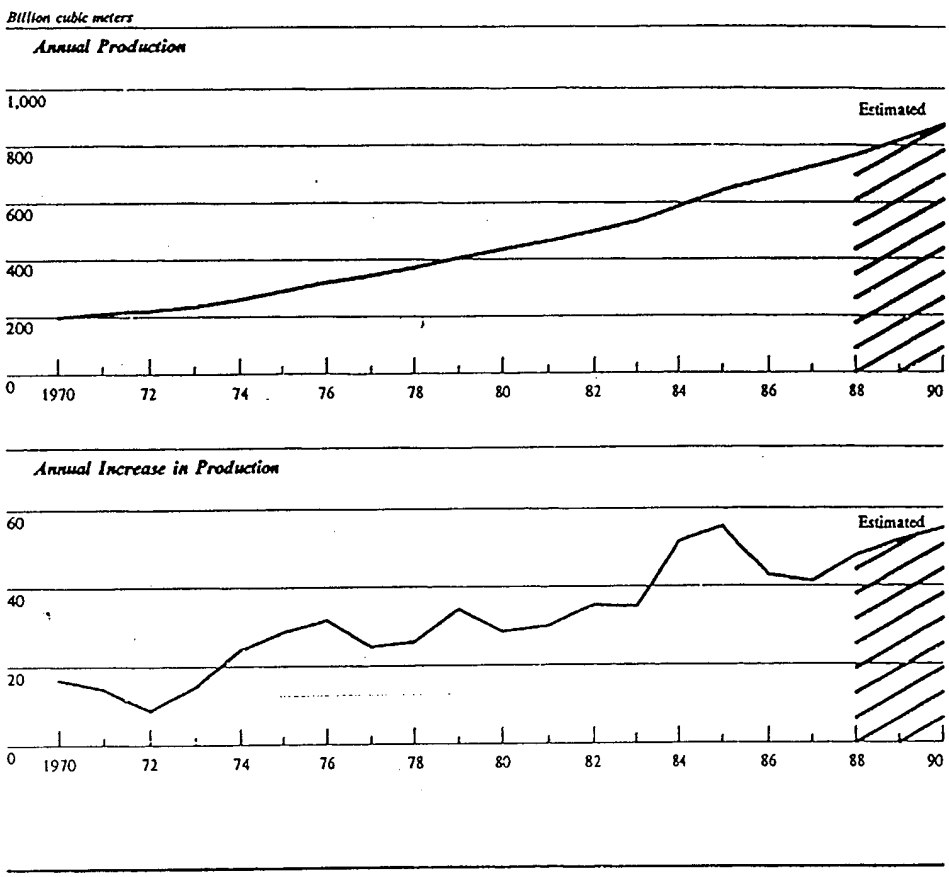
*Shifting Geographic Focus.* Like other major gas producers, the USSR has relied on a small number of very large fields to ensure the growth of gas production. In the 1960s, Shebelinka in the Ukrainian Republic, Gazli in the Uzbek Republic, and Vukhtyl in the Komi Republic fueled most of the rapid growth in gas supply. The Shatlyk, Achak, Naip, Gugurtli, and Kirpichli fields in the eastern region of Turkmen Republic provided the increases posted during the first half of the 1970s. During the last half of that decade, Orenburg, located southwest of the Ural Mountains, and Medvezh'ye—the first of the supergiant West Siberian natural gas deposits to be developed—came on line. By 1980, Orenburg was producing 48 billion m³ per year, and Medvezh'ye contributed another 70 billion m³.

Since the mid-1970s, West Siberia has replaced Central Asia as the industry's main base for expansion. Since its startup in 1978, the huge Urengoy field has provided most of the increase in West Siberian output. Medvezh'ye, Vyngapur, and Urengoy together accounted for over 50 percent of Soviet gas production in 1985, with a combined output of 345 billion m³. The Yamburg field, the major development project on the agenda for the 1986-90 Five-Year Plan, is scheduled to produce 195-200 billion m³ in 1990.

Moscow is stressing development in northern West Siberia because of the numerous large gasfields waiting to be tapped. After Yamburg, additional gas will become available as the Zapolyarnoye, Yubileynyy, and Gubkin deposits near Urengoy and the Bovanenko, Kharasavey, and Kruzernshtern fields on the Yamal Peninsula are developed and tied into the pipeline network. But development of these northern fields will require increasing allocations of investment and manpower to cope with several difficulties:

- The location of these fields some 3,500 km from the centers of industry and consumption in the European USSR has required development of an immense gas pipeline system that, by 1990, will cost some 60-70 billion rubles.
- As production moves northward from Urengoy to Yamburg and subsequently onto the Yamal Peninsula, permafrost will continue to present increasingly difficult technical problems in field development and in pipeline construction and operations. Highly specialized insulation techniques are required to prevent settling and misalignment of drilling and processing equipment as well as breaks in pipelines.

Figure 3
USSR: Natural Gas Industry Development, 1970-90



*Deep drilling operations at Urengoi*

*Pipeline trenching excavator*

*Moving a drilling rig to new wellsite*

*The new cliff for gas workers at Novyy Urengo.*

*Gasfield Glasnost'*

*The glowing statistics of rapidly increasing gas production in West Siberia tend to obscure living conditions and operating practices that would be considered intolerable in the United States. A Soviet television documentary highlighted the difficulties and privations of workers and their families in Novyy Urengoy, located just below the Arctic Circle. Housing varies from small prefabricated structures shaped like large oil tanks lying on their sides to cramped apartments in nine-story concrete buildings. Three families were shown sharing an apartment, with "three equal housewives" vying for use of the kitchen. Social and cultural facilities were described as grossly inadequate and thus a contributing cause to juvenile delinquency.*

*The documentary extended its criticism to local gasfield operations, stressing the desire of the general director of the production association responsible for the area to fulfill gas development plans while disregarding the city's needs. The narrator noted that much work at production sites remains incomplete and wonders if the mistakes of the oil industry (against which General Secretary Gorbachev railed in his September 1985 Tyumen' speech) are being repeated: "the deposit has been brought up to design capacity, yet it turns out that here at the operating sites there is a need to mercilessly tear at the gas horizons in order to conform to plan figures." The video and commentary show flaming flare towers, where 30 percent of the valuable ethane content of gas from the deposit is being lost because of inadequate planning for its use.*

*Exploiting the Pre-Caspian Sour Gas Deposits*

*Development of the sour gas deposits of the Pre-Caspian Basin requires specialized equipment, technology, and operating experience, as well as skill, both in the drilling of wells and the processing of output. Up to 50 percent of the gas from these reservoirs is made up of toxic and corrosive contaminants such as hydrogen sulfide and carbon dioxide. Because of their great depths—often 5,000 meters—the Pre-Caspian reservoirs have bottom-hole pressures and temperatures much higher than those encountered in Tyumen'.*

*The conditions encountered in sour gas drilling and processing call for use of highly specialized—and expensive—equipment. On many wells, blow out preventers capable of handling pressures of up to 15,000 pounds per square inch are needed. To cope with the corrosive environment, stainless steels are called for in drill pipe, casing and tubing, gathering systems, and the processing plants that strip hydrogen sulfide and carbon dioxide from the gas.*

*A high order of technical skill and performance is needed not only in drilling but also in the vast amount of "plumbing" work in assembling gathering systems and processing equipment. The Soviets apparently lack some of the skills and experience needed for safe and efficient deep drilling under conditions such as those encountered in the Pre-Caspian Basin. They are also notably slack in the exercise of quality control in critical assembly work. As a result, drilling in the area proceeds at about one-third the pace achieved by US drillers working on comparable wells, blow outs have occurred, and leaks of toxic gas have resulted in fatalities.*

- Tapping northern Tyumen's immense gas reserves will pose difficult logistic problems until roads, communications, and utilities, as well as housing and other social infrastructure, are provided (see inset)

Less importance is attached by the Soviets to the deep Astrakhan' and Karachaganak sour gas deposits in the Pre-Caspian Basin (see inset). Each of these fields should be producing 5-6 billion m³ of sour gas annually—plus 2-4 million tons of condensate by 1990. The combined gas output for this region should reach 25 billion m³ by 1995, and it could rise to 38 billion m³ by the year 2000 (see table 4).

Table 4
USSR: Regional Production of Natural Gas, 1975-2000

*Billion cubic meters*

| | 1975 | 1980 | 1985 | 1990 a | 1995 a | 2000 a |
|---|---|---|---|---|---|---|
| Total | 289 | 435 | 643 | 875 | 1,100-1,200 | 1,100-1,200 |
| West Siberia | 40 | 156 | 370 | 600 | 820-920 | 835-935 |
| Urengoy | | 50 | 255 | 325 | 300-400 | 300-375 |
| Yamburg | | | | 150 | 200 | 200-225 |
| Medvezh'ye | 32 | 70 | 72 | 68 | 65 | 60 |
| Vyngapur | | 16 | 16 | 17 | 15 | 13 |
| Middle Ob' oilfields a | 4 | 16 | 22 | 35 | 35 | 32 |
| Bovanenko | | | | | 130 | 130 |
| Kharasavey | | | | | 70 | 95 |
| Messoyakha | 4 | 4 | 5 | 5 | 5 | 5 |
| Volga-Urals | 33 | 65 | 65 | 60 | 54 | 50 |
| Komi Autonomous Republic | 19 | 19 | 18 | 15 | 12 | 10 |
| North Caucasus | 23 | 14 | 10 | 10 | 6 | 5 |
| Far East | 2 | 2 | 2 | 5 | 8 | 10 |
| Ukraine-Belorussia | 69 | 53 | 46 | 45 | 40 | 30 |
| Pre-Caspian Basin | 4 | 4 | 5 | 10 | 25 | 38 |
| Astrakhan' | | | | 3 | 9 | 20 |
| Karachaganak | | | 1 | 3 | 9 | 12 |
| Oilfield gas | 4 | 4 | 4 | 4 | 7 | 6 |
| Central Asia | 89 | 109 | 114 | 117 | 121 | 108 |
| Turkmen Republic | 51 | 70 | 77 | 86 | 90 | 80 |
| Uzbek Republic | 37 | 38 | 36 | 30 | 30 | 27 |
| Other | 1 | 1 | 1 | 1 | 1 | 1 |
| Azerbaijan | 10 | 13 | 13 | 13 | 14 | 14 |

a Estimated.

*The Role of Large-Bore Gas Wells.* Soviet gas production has benefited from a major innovation—first tried at the Medvezh'ye gasfield in the early 1970s—which involves drilling extra-large-diameter gas wells. These wells can produce up to 1.5 million m³ of gas daily—nearly three times as much as a normal well. By reducing the total number of gas wells drilled, this method permits a rapid buildup in output with minimum inputs of scarce capital and labor.

The use of large-bore wells, however, also involves substantial risks. If local permeability is poor, cones of low pressure may form around well bores, causing water encroachment and leading to lower ultimate recovery of gas. (An excessive or sharp loss of reservoir pressure usually draws in the formation and

surrounding ground waters and can lead to a reduction in the flow of gas.) Advanced water encroachment has already been detected along the eastern slopes in the shallow reservoirs of Medvezh'ye and Urengoy.[7] Continued overproduction of the development wells at Urengoy in 1986 and 1987—probably to meet production targets in the face of drilling delays at Yamburg—has aggravated this problem, prompting remarks in the Soviet press about repeating mistakes of the same kind made at the Samotlor oilfield in the 1970s.

**Pipelines—Essential Complement to Production**

To accommodate increasing gas production, the Soviets plan some 58,000 kilometers (km) of gas pipeline construction for 1986-90, compared with the 48,000 km completed during 1981-85 (see figure 4).[8] In part because new gas production is planned to come largely from the Yamburg field some 300 km north of Urengoy, the amount of 1,420-mm-diameter pipeline to be laid will be roughly 4,000 km greater than the 20,000 km constructed during 1981-85. A total of six new transcontinental trunklines are to be built from Yamburg via Urengoy to consuming centers in the Western USSR and to export terminals. A seventh pipeline from Yamburg to supply Omsk, Kemerovo, and Novosibirsk in West Siberia had been mentioned in the Soviet media, but little has been heard about this project recently (see table 5)

Transporting gas from the new, remote Arctic or.-shore gasfields on the Yamal Peninsula will pose challenges even greater than those being encountered in building pipelines from Yamburg. These pipelines must not only traverse a much longer route over permafrost but also will require installation of long underwater segments spanning th mouth if the Ob' River.

[7] The drilling of deep large-bore gas wells to extract gas with a high NGL content may not be feasible, because these fractions tend to liquefy and collect at the bottom of larger diameter wells, causing a reduction of the gas flow. For the NGL-rich reservoirs at Urengoy, Yamburg, and other Tyumen' gas deposits, wells of standard diameter are probably easier and faster to drill and can improve condensate recovery.

Since 1980 the USSR has been laying large-diameter gas pipelines from West Siberia to the European USSR at an average rate of one per year. Moscow continues to import large volumes of materials and equipment for its gas pipeline program, particularly large-diameter pipe and heavy-duty, winterized pipelayers. The Soviet development of 16- and 25-megawatt industrial gas turbines (GTN-16 and GTN-25)—and, more important, the 16-megawatt aeroderivative gas turbine (GPA-Ts-16)—doubled annual gas turbine production in terms of rated capacity and eased the shortage of high-capacity gas turbines. In terms of quality, however, these turbines have fallen far short of expectations, proving to be of low quality and poor reliability.[9] Because Soviet-built 16- and 25-megawatt gas turbines are scheduled to provide about one-half of the aggregate power needed on the Yamburg pipelines, Moscow may need to import more high-capacity turbines or rely more heavily on the less suitable 10-megawatt gas turbines and some 12.5-megawatt electric motors.

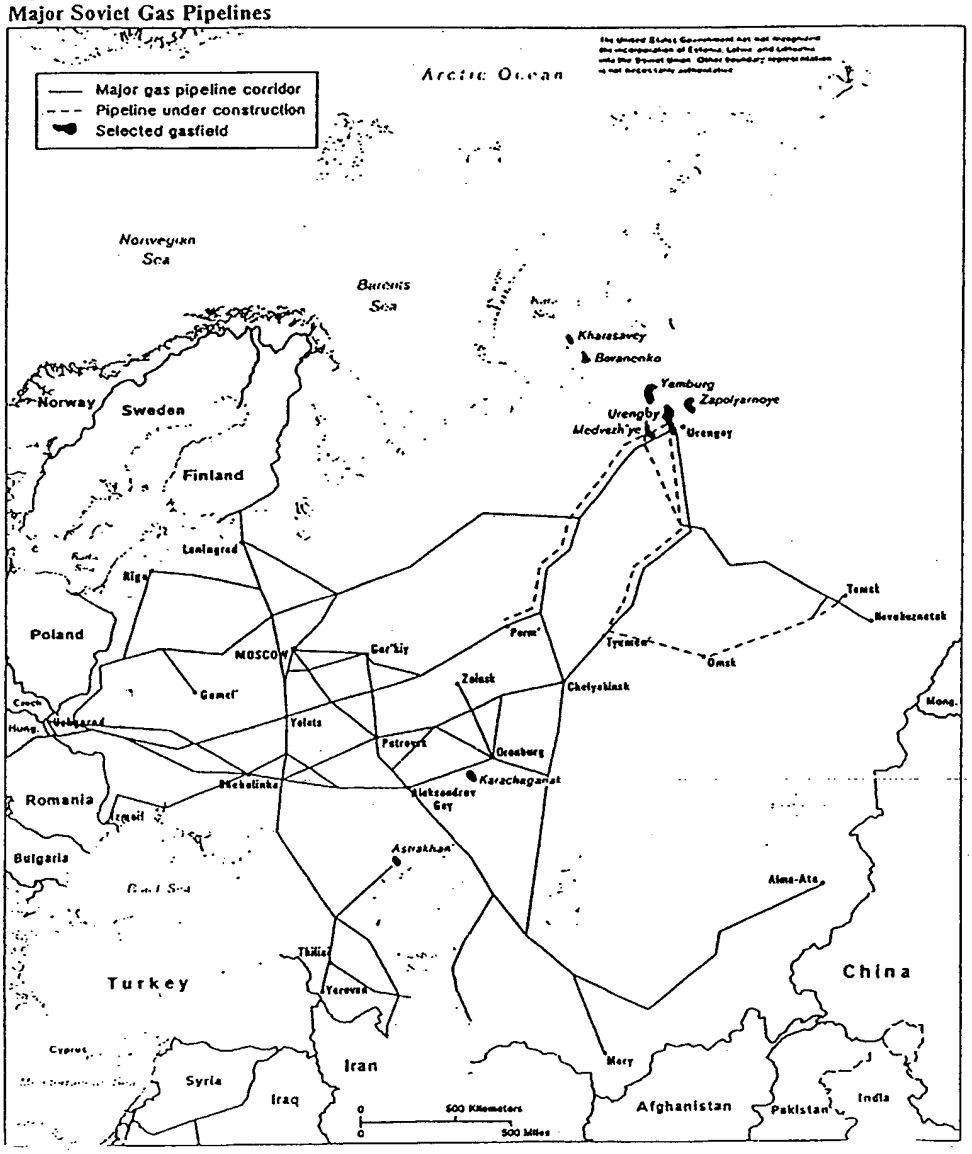
**Potential Constraints**

A number of economic adjustments will be required on both the demand and supply sides to attain the two-thirds increase in gas production we believe to be achievable by 1995. The greater use of gas requires not only large expansion of the gas distribution system, with increasing emphasis on new local distribution networks, but also additions or changes of equipment by gas consumers. All of this will entail substantial investment, on both the production and consumption ends.

Much of the gas-for-oil substitution in the electric power industry that has already occurred has been based on the availability of facilities equipped to burn either fuel. Using more gas in the industry will mean constructing new plants, bringing gas to areas not now supplied, and eliminating delays in extending lateral

[9] Soviet writers blame design flaws, low-quality inputs, and poor assembly practices.

Figure 4
Major Soviet Gas Pipelines



pipelines to areas where power plants are now being built. Some of the planned power plants are to be sited in northern West Siberia, where terrain and weather conditions will raise construction costs. Increasing gas consumption in the household/municipal services sector is not technically challenging but can be disruptive and time consuming. The principal requirement will be to set up local gas distribution networks in areas not now served.

The requirement for increased equipment, manpower, and skilled management for expanded production and use of gas comes, however, at a time when these resources are also in high demand by other priority activities. Gorbachev's industrial modernization program, for example, calls for increased access to many of these same resources. Within the energy sector, moreover, rising claims on investment resources will be made by the oil, coal, and nuclear power industries. For the foreseeable future, oil will remain the USSR's prime source of hard currency earnings; accordingly, the effort to maintain oil production will continue despite soaring marginal costs of production. Past deficiencies in coal industry investment will delay the time when coal can supplant other fuels in many uses. The requirements of the nuclear power industry have also increased since the Chernobyl' accident

Investment Requirements

Gas industry investment, including the cost of gas pipelines, will continue to increase, but at a much slower rate than investment in the oil industry (see table 6). As the center of gas production activity shifts farther north and production from Pre-Caspian gasfields increases, the investment costs for attaining greater output will increase more than proportionally. In the mid-to-late 1990s, however, a planned leveling off of gas production should drastically reduce the requirement for further investment in transcontinental pipelines. Most gas-related investment will then be limited to the drilling of new gas wells and field gathering lines.

Although the current dramatic boost in investment and manpower allocations needed to sustain oil-industry output may lessen availability of resources for some gas projects in the near term, it will probably not endanger longer term goals.

We estimate that total investment in gasfield development and pipeline construction during 1986-90 will be roughly 59 billion rubles. According to the Soviet press, planned investment for 1986-90 is to include the construction of 56 gas-processing plants, 24,000 km of 1,420-mm pipelines, 34,000 km of other gas transmission lines, more than 300 compressor stations, and needed infrastructure (see table 7).

Harsh conditions and, initially, the almost total lack of infrastructure at Yamburg—together with the high-cost activities associated with development of deep sour gas deposits in the Pre-Caspian Basin—lead us to estimate a one-third rise in investment for gas extraction and processing (including that necessary to offset depletion). Soviet concern with escalating costs was clearly evident when plans for a workers' city at Yamburg were scrapped in late 1985 and the Gas Ministry decided to reduce permanent staff at the gasfield and fly in workers from other regions for two-week shifts. In addition, the average cost per km of the planned six transcontinental pipelines from Yamburg to the western USSR will be slightly higher than that of those laid in 1981-85 because of the permafrost conditions in the first 200 to 300 km from Yamburg (see inset). Construction of a seventh pipeline from Yamburg is now being considered to deliver gas to the Novosibirsk region and Central Asia

Storage Facilities

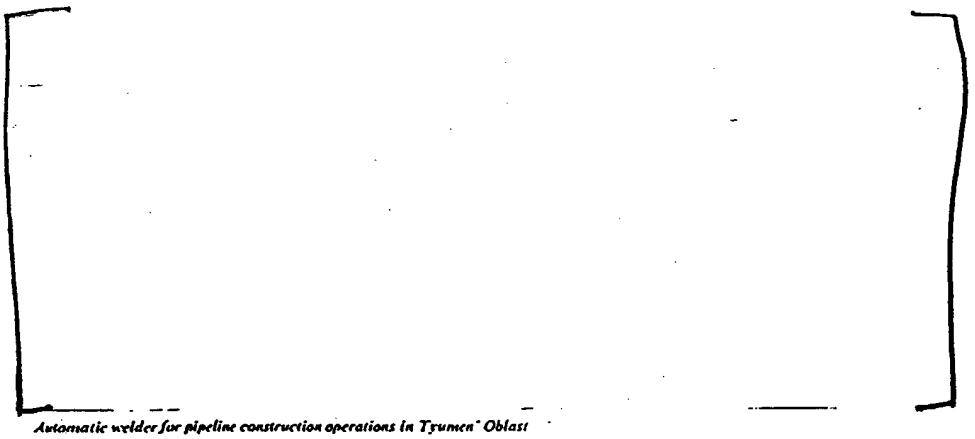
Because gas use fluctuates widely on a seasonal basis, favorably sited gas storage facilities are an economical alternative to the construction of pipeline capacity to accommodate gas demand during peak periods of use. Where gas pipeline capacity constrains a gas system's ability to meet peak demand, storage facilities must be located close to the major gas-consuming centers. In the Soviet Union, however, most of the economical sites—abandoned oil and gas deposits and salt formations—are far removed from these centers, which are concentrated in the European USSR

Following positive results from pilot gas storage projects in abandoned oilfields in the Volga-Urals region, gas storage projects were launched in the 1960s near Moscow and Leningrad. These projects, which sought

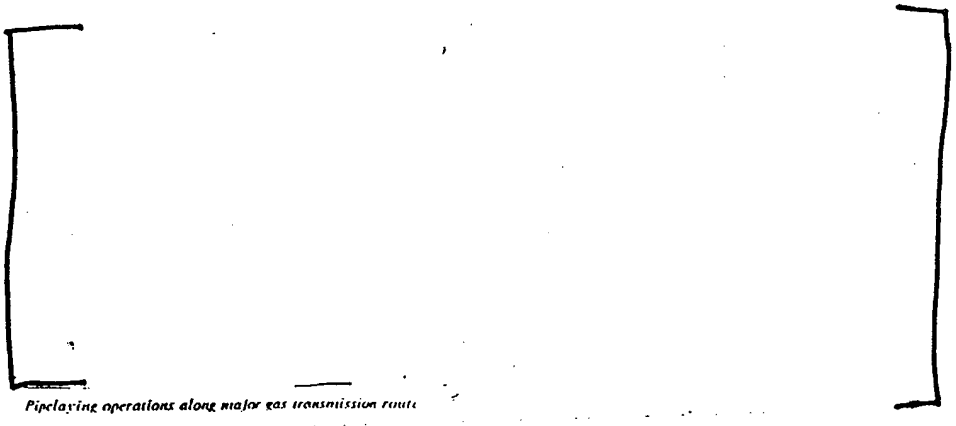
Table 5
USSR: Major Gas Transmission Pipelines From West Siberia

| Pipeline | Length (kilometers) | Route | Status | |
|---|---|---|---|---|
| | | | Pipelaying | Compressor Stations |
| Urengoy-Gryazovets | 2,280 | Urengoy-Nadym-Punga-Ukhta-Gryazovets | Completed in 1981 | Operational in 1983 |
| Urengoy-Yelets (Urengoy-Center I) | 3,400 | Urengoy-Krasnotur'insk-Pomary-Yelets-Dikan'ka | Completed in 1984 | Operational in 1986 |
| Urengoy-Yelets (Urengoy-Center II) | 3,022 | Same as above but terminates at Yelets | Completed in 1985 | Operational in 1985 |
| Urengoy-Uzhgorod (Siberia–Western Europe) | 4,451 | Urengoy-Pangody-Krasnotur'insk-Gornozavodsk-Mozhga-Pomary-Pochinki-Yelets-Kursk-Il'intsy-Bogorodchany-Uzhgorod | Completed in 1983 | Operational in 1985 |
| Urengoy-Petrovsk | 2,740 | Urengoy-Nadym-Punga-Krasnotur'insk-Nizhnyeya Tura-Moskovo-Syzran'-Petrovsk | Completed in 1981-82 | Operational in 1983 |
| Urengoy-Novopskov | 3,346 | Urengoy-Nadym-Punga-Krasnotur'insk-Nizhnyaya Tura-Moskovo-Syzran'-Petrovsk-Balashov-Kalachevka-Novopskov | Completed in 1982 | Operational in 1984 |
| Yamburg-Yelets-Kremenchug (Yamburg-Yelets I) | 3,650 a | Follows route of Urengoy-Yelets pipelines | Completed in 1985-86 | Operational in 1987 |
| Yamburg-Yelets (Yamburg-Yelets II) | 3,150 a | Follows route of Urengoy-Yelets pipelines | Completed in 1988 | Limited Operation |
| Yamburg-Uzhgorod (Progress) | 4,605 | Follows route of Urengoy-Uzhgorod pipeline | Completed in 1988 | Limited Operation |
| Yamburg-Gor'kiy-Mozdok (extension of Yamburg-Yelets I line to North Caucasus) | 3,100 a | Will probably follow route of Urengoy-Yelets pipeline as far as Pomary and then through Gor'kiy and Murom to Yelets, then south to Mozdok and the North Caucasus pipeline grid | Completed to Mozdok early 1988 | Limited Operation |
| Yamburg-Tula-Kiev (Yamburg-Tula II; also referred to as Yamburg-Center II) | 3,700 a | Will probably follow route of Urengoy-Yelets pipeline | Started in late 1987 | NA |
| Yamburg-Volga River area (Yamburg-Povolzh'ye) | 2,600 a | Will probably follow route of Urengoy-Petrovsk pipeline | Under construction | NA |
| Yamburg-Omsk-Tomsk | NA | NA | Under construction | NA |

a Estimated.



*Automatic welder for pipeline construction operations in Tyumen' Oblast*



*Pipelaying operations along major gas transmission route*

*Urengoy gas plan*

Table 6
USSR: Investment in Production of Major Forms of Energy

*Billion 1984 rubles*

| | 1976-80 | 1981-85 | 1986-90 [a] |
|---|---|---|---|
| Total | 92.6 | 138.5 | 238 |
| Gas [b] | 29.0 | 46.0 | 59 |
| Oil | 29.3 | 50.3 | 120 |
| Coal | 11.4 | 13.5 | 18 |
| Electric power | 22.9 | 28.7 | 41 [c] |

[a] CIA projections. The oil investment estimate reflects the acceleration in the number of new fields planned and the substantial increase in drilling meterage from that originally planned.
[b] Including estimates of investment in gas pipeline construction.
[c] Pre-Chernobyl' estimate.

Table 7
USSR: Estimated Investment for Natural Gas Production Processing, and Gas Transmission Pipelines, 1976-90

| | 1976-80 | 1981-85 | 1986-90 |
|---|---|---|---|
| Production (end of period, billion m³ per year) | 435 | 643 | 875 |
| Net additions to annual capacity (billion m³) | 146 | 208 | 232 |
| Gross additions to annual capacity (billion m³) [a] | 180 | 270 | 300 |
| Major gas trunkline construction (kilometers) | 32,200 | 48,000 | 58,000 |
| 1,420-mm-diameter pipelines (kilometers) | 10,600 | 20,000 | 24,000 |
| Other pipelines (kilometers) | 21,600 | 28,000 | 34,000 |
| Compressor stations (number completed) | 174 | 231 | 300 |
| Total compressor capacity, end of period (megawatts) | 18,000 | 43,000 | 68,000 |
| Total investment in gas industry complex (billion rubles) | 29 | 46 | 59 |
| Gas extraction and processing, all phases (billion rubles) | 11 | 16 | 21 |
| Additions to gas transmission pipeline system (billion rubles) | 18 | 30 | 38 |

[a] Includes new capacity needed to offset depletion of old capacity.

to store gas in aquifers (shallow water-bearing formations) met with only partial success. By 1975, according to a former gas minister, some 65 percent of the gas being stored was in depleted petroleum reservoirs far removed from the Moscow and Leningrad industrial centers and thus poorly located for supplying gas during periods of peak demand [20]

Recognizing the advantages of gas storage for supplying peak demand, the Soviets planned a 170-percent increase in storage volume during 1976-80, which would allow about 500 million m³ per day to be withdrawn. After 1976, however, the Soviet media (including gas-industry journals) gave few specific details on the subject of gas storage capacity and withdrawal rates. Plans for 1986-90 stated only that storage capacity was expected to double. But there is clear evidence that gas available for withdrawal has continued to be inadequate to meet peak seasonal demand. In many winters, deliveries of gas to export customers were reduced, and some domestic industries were ordered to use secondary fuels to ensure gas supplies to priority consumers, including the urban/household sector.[a]

[a] During the severe winter of 1986-87, the Soviet press mentioned the growing importance of gas storage for meeting demand during peak periods, but did not provide information on the type, capacity, or location of storage facilities. In late 1987, however, *Izvestiya* reported that 53 billion m³ of gas were stored underground in preparation for the coming winter [21]

The slow development of gas storage capacity contrasts sharply with the rapid expansion of gas production. In typical Soviet fashion, the production and transport of gas were stressed at the expense of ancillary facilities. The gas industry was scoring remarkable successes in field development, and the pipeline construction industry was mastering the techniques for laying large-diameter pipe. We believe that these successes probably influenced Soviet officials to scale back storage plans in the belief that expansion of the pipeline network would provide sufficient excess capacity to meet anticipated surges in demand. As a result, current storage capacity will have to be expanded substantially if gas is to penetrate further into new domestic markets. This can be done most efficiently by using abandoned oil and gas deposits in

*Estimating Capital Investment in Gas Transmission Pipelines*

*The gaps in published Soviet data on gas pipeline construction, both with respect to pipeline length and costs, are substantial. Part of the problem involves contradictory data; for example, one source may state a length of pipeline commissioned during a given time period while another cites a different length. Investment costs for pipelines, moreover, are not reported; instead, the Ministry of Construction of Petroleum and Gas Industry Enterprises usually publishes only the value of construction and installation work for its activities as a whole.*

*These published totals include not only those for gas and oil pipelines, oil products, and related equipment, but also housing and other infrastructure serving the oil and gas industries. The outlays for infrastructure probably constitute about 10 percent of the ministry's total work. Of the construction and installation work by the ministry which amounted to 29.5 billion rubles in 1981-85 and was projected at about 40 billion rubles in 1986-90, some 18.6 billion rubles and 23 billion rubles, respectively, have been identified by the ministry as being related to gas rather than to oil or other programs. When these data are adjusted by available ratios between outlays for construction and installation work and total capital investment in construction of major gas pipelines, the estimate for investment during 1981-85 is 29 billion rubles and for 1986-90 is 36 billion rubles.*

*Another approach to estimating investment in gas pipelines is to multiply costs per km (on the basis of Soviet pipeline construction experience) by the length of pipelines constructed. We use factors of 1.1 million rubles per km for 1,420-mm pipelines and 0.25 million rubles per km for smaller pipelines built in 1981-85. To account for the added costs that are being incurred between Yamburg and Urengoy, we increase the average cost factor to 1.2 million rubles per km for 1986-90. These calculations yield investment estimates of about 29 billion rubles for 1981-85 and 37 billion rubles for 1986-90.*

*Residualized investment data reported for the transportation and communications sector result in an estimate of about 34 billion rubles for oil and gas pipeline investment in 1981-85. On the basis of the relative length and size of the oil and gas pipelines constructed, the implied investment from this residual for additions to the gas pipeline system is roughly 30 billion rubles for 1981-85.*

*Finally, researchers at the Center for International Research, US Bureau of the Census, have estimated investment in gas pipelines of about 25 billion rubles in 1981-85 and 33 billion rubles in 1986-90. Their calculations are based on estimates of pipeline length installed in 1981-85 and per-kilometer costs of gas pipeline construction in 1986-90 somewhat lower than those we used.*

*We estimate that roughly 30 billion rubles of capital investment was made in the gas pipeline system during 1981-85. During 1988-90 roughly 38 billion rubles of investment will be required to expand the pipeline system to accommodate planned increases in gas production, given the added length of major pipelines and the potential for unforseen problems with permafrost as gas production shifts northward to Yamburg*

the North Caucasus, Ukrainian, and Volga-Urals regions of the European USSR.

**Regional and Local Gas Distribution Facilities**

During 1981-85, Soviet plans called for construction of 48,000 km of gas pipelines, of which about 15 percent would be distribution lines directed to cities for power plants, industry, households, and services. Specific information on the construction of local-distribution pipelines is sparse, but it appears that the effort was successful as judged by the 47-percent rise in gas distributed for consumption in the domestic economy during 1981-85.

Extension of the network of lateral and local gas distribution pipelines permitted rapid increases in gas use in industry:

- Total industrial gas use rose by some 50 billion cubic meters during 1981-85.
- By 1985, gas consumed by thermal electric power plants, primarily in the Volga-Urals region and West Siberia, had almost doubled from that used in 1980.
- The expansion of chemical production in West Siberia, the Volga-Urals, and the Ukraine resulted in a 43-percent growth in natural gas use by the chemical industry.
- Gas accounted for a growing share—almost 30 percent in 1985—of total fuel requirements for ferrous metallurgy.

No reliable information is available on the length or extent of the gas pipeline network to households and municipal services. However, this sector is the third largest user of natural gas, accounting for about 13 percent of gas distributed for domestic consumption. An increase of 18 billion m³ in gas use by this sector in 1981-85 must have required a substantial expansion of local gas distribution networks.

Although many of the measures needed to implement increased distribution and use of gas are not challenging in a technical sense, their implementation will undoubtedly run afoul of the many perils of the Soviet bureaucracy. With its heavily layered system of decisionmaking and coordination, Moscow is unlikely to smoothly achieve shifts in the pattern of fuel supply and use. The woes of a program for large-scale use of gas as a motor fuel provide a cameo portrait of the Soviet system in action (see inset). Despite its inefficiencies, Moscow has, during the 1980s, provided for a remarkable expansion of gas production, transport, and use and—not without difficulties—will almost certainly continue to provide for the same through the mid-1990s.

## Outlook

For the remainder of this century, natural gas will provide the major source of growth in the USSR's energy supply. Plans for 1990 call for gas output to reach 835-850 billion m³. On the basis of the gas industry's current performance, we believe that output of 875 billion m³ is more likely. For the longer term, we believe that the comparatively high returns to investment in gas industry will lead Soviet planners to allocate sufficient resources to increase gas production to 1,100-1,200 billion m³ in 1995 and to be able to maintain output at that level into the next century, despite investment and manpower requirements that appear relatively inefficient compared with those employed in the West.

With gas providing most of the growth in future energy supplies, the Soviet economy will face costly adjustments in adapting patterns of energy use to the changing proportions in availability of specific fuels. If problems do arise, they are likely to stem from the inability of the Soviet economy to absorb the increase in gas production that the industry could supply by the mid-1990s. Greater use of gas will require further expansion of the transmission, lateral, and local gas pipeline networks. Moscow must also build more storage facilities to overcome the reluctance of enterprises to rely more heavily on gas because of fears that their supply may be interrupted during peak demand periods in the winter. As production activity increases at Yamburg and on the Yamal Peninsula, both field development and pipeline transportation will be more difficult. Substantial investment will be required; the amount will depend in part on whether the Soviets obtain Western equipment and expertise to cope with Arctic conditions. To ensure enough resources for the gas sector, the Soviets probably will hold back investment from the coal industry.

*Natural Gas for Transportation*

*Large-scale use of compressed natural gas and liquefied petroleum gas as motor fuel is being advocated by prominent members of the Soviet regime, but the planning, research and development, and industrial establishments are dragging their feet.* Pravda *reports that at a September 1987 CPSU Central Committee conference, "Second Secretary" Yegor Ligachev emphasized the importance of improving the energy balance by reducing the amount of oil used to produce certain types of fuel. Vladimir Dolgikh, party secretary in charge of energy, stressed the need to accelerate the conversion of motor vehicles to use natural gas. This conversion is seen by the leadership as desirable not only for its effect on the pattern of fuel use but also for its potential to reduce atmospheric pollution, particularly in cities with large numbers of motor vehicles*

*According to the press report of the Central Committee conference, the program for using compressed gas as transport fuel is beset with problems and delays. Indeed, the process is described as "amateurish and haphazard":*

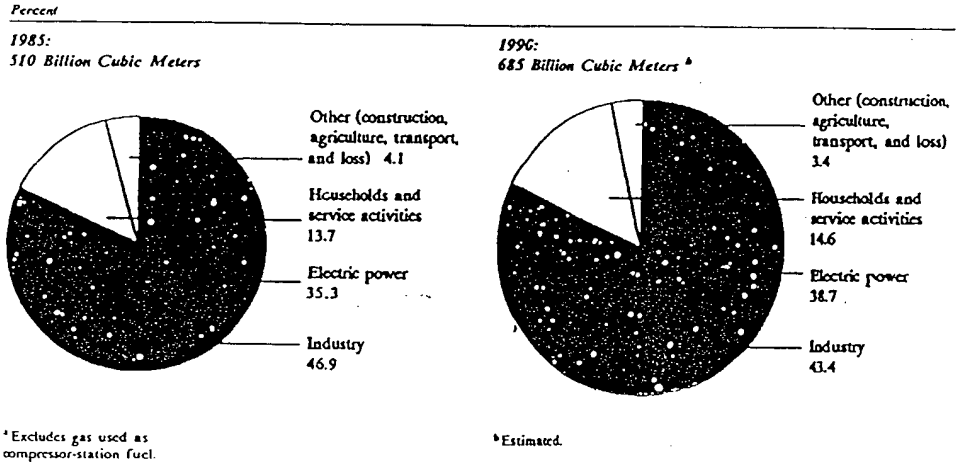
- *Certain ministries, party organs, and enterprises are failing to attach proper significance to resolving the problem.*
- *Academic and scientific organizations are little involved, and the research and design organizations are extremely slow to produce specifications for gas filling stations and for conversion of transport vehicles to use of gas.*
- *The machine-building ministries are failing—with respect to both quantity and quality—to produce the needed equipment (such as compressors, gas cylinders, and pressure regulators).*
- *Construction of gas filling stations is lagging, and where they exist, the stations are operating at only 30 percent of capacity.*
- *Vehicles and equipment designed for use of gas fuel are often supplied to regions where there are no gas filling stations and no plans to build any*

Despite the many factors that complicate new production and raise the cost of Soviet gas, meeting growing energy demand by use of other fuels is even more complicated and expensive. For example, oil refineries need to be upgraded increasingly by installation of catalytic cracking units so that heavy fuel oil released from various uses by interfuel substitution or conservation measures can be processed into needed light products such as gasoline and diesel fuel.[11] Expansion of low-grade coal output calls for development and widespread introduction of improved combustion equipment and alternative technologies for the transportation and use of energy derived from coal

We estimate that total gas distributed for domestic consumption (excluding fuel for compressors to transport gas via pipelines) will reach about 685 billion $m^3$ (11.1 million barrels per day of oil equivalent) in 1990 (see figure 5). They may be able to increase power industry gas consumption from about 180 billion $m^3$ in 1985 to as much as 265 billion $m^3$ in 1990 by eliminating constraints on power-plant use of gas during the winter, installing new gas-fired boilers at industrial and commercial sites, and converting more oil- and coal-fired power plants to gas. Beyond 1990, increasing industrial use of gas will depend heavily on growth in industrial production and the concomitant growth in energy use.

The outlook for boosting Soviet sales of gas for hard currency during the next few years is bleak. Increased gas sales to the West to offset lower earnings from oil will be difficult to achieve because of sluggish energy consumption growth in Western Europe and strong competition from other energy sources, as well as from oil and gas producers, which have driven down the price of gas (see inset). Moscow's option of boosting gas exports would fade if West European oil and gas prices remain soft well into the 1990s because of intense interfuel price competition between oil, gas, and nuclear power (and if development of Norway's giant Troll gasfield proceeds as planned). However, if less nuclear power is generated in Western Europe

Figure 5
USSR: Gas Distributed for Domestic Consumption[a]




[a] Excludes gas used as compressor-station fuel.

[b] Estimated.

than is now planned and total energy demand strengthens, gas exports could again become an avenue for the Soviets to generate substantial incremental hard currency revenues. Nevertheless, the USSR will probably remain able to export gas to Western Europe at costs and selling prices below those of its competitors.

Although contractual deliveries of gas to West European countries could expand to as much as 58 billion $m^3$ in 1990, France, West Germany, and Italy have the option of curtailing these deliveries by up to 10 to 20 percent. This gives them the opportunity to reduce the amount of gas taken at full price and to purchase additional volumes in the "spot" market at lower prices.

Soviet natural gas sales to the West should continue to expand slowly in periods when gas is priced to undersell fuel oil. Recently, the Soviets have succeeded in signing up new buyers in Greece, Turkey, Spain, and Sweden; however, only small volumes are involved in each case. Combined sales to the above markets will do little to enhance hard currency revenues. The West European market for home heating oil remains a big potential outlet for natural gas. Natural gas is also expected to penetrate further into the industrial heating and thermal-power markets. Although the Soviets will probably continue to sell the world's lowest cost gas until well into the next century, there are competitors—Norway, the Netherlands,

*Soviet Gas Pricing and Marketing Policies*

*Although the Kremlin is reported to have halted oil sales several times during 1986 in the face of falling prices, it continued to push gas sales. Late that year, Moscow was selling gas at a contractual price of $70 per thousand m³ or less, drastically lower than the floor price of about $190 per thousand m³ expected when the Siberia-to-Western Europe gas export pipeline began delivering gas in 1983.*

*During the past few years, a "spot gas market" has developed in Western Europe. During the summer months of low seasonal demand for gas, for example, the Soviets—and to a lesser degree the Dutch—have pushed extra gas onto the market at prices heavily discounted from prevailing contract prices. In December 1986, gas was sold on the spot market at prices only half those in effect for contract sales. The "rolled-in" average price of all gas purchased by the various national distribution firms is probably lowered by about 10 percent annually as a result of this strategy. In the summer, large West European buyers store some of the gas for winter peak needs and funnel some low-cost gas to domestic fertilizer manufacturer.*

*The issue of price is likely to remain a central issue in West European gas consumers' choice of suppliers even though the agreement with Norway to proceed with development of its Troll deposit assures Norwegian gas a larger role.[a] Gas prices in Western Europe are, however, still well above Soviet costs for producing gas, and Moscow's strongly competitive gas pricing will probably enable it to maintain market share in the face of rapidly falling energy prices.*

*[a] There is, however, continuing ambivalence in West European gas demand-and-supply relationships. An illustrative case is the late 1986 dispute in the French-Norwegian Troll negotiations. Norway offered all Troll gas buyers the option of increasing gas deliveries—without paying a premium—to meet surges in demand. But the terms would have limited the ability of Gaz de France to adjust contract volumes upward when it renews its contracts with the USSR and Algeria and would have prohibited France from increasing spot gas purchases. France held out until the Norwegians dropped the requirement.*

and, to a lesser degree, Algeria—available to fill any potential gas-supply gap in Western Europe over the next 15 years.