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Prospects for Soviet Oil in the 1980s

A Research Paper

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Prospects for Soviet Oil in the 1980s

A Research Paper

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Office of Global Issues, and
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contributions from: the
SOVA; the
OIA; ar
IEURA. It was
coordinated with the National Intelligence Council
and the DCI Economic Intelligence Committee. (U)

Comments and queries are welcome

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Prospects for Soviet Oil in the 1980s [1]

Key Judgments

Information available as of 1 May 1983 was used in this report.

The Soviet Union has thus far averted the downturn in oil production that CIA had earlier predicted by virtue of an enormous, brute-force development effort that has tapped a petroleum reserve base larger in size than we previously believed. Production of oil and gas condensate now stands at 12.4 million barrels per day (b/d), and continues to inch forward, albeit at a rate of less than 1 percent annually. The cost of doing this has been high—the Soviet oil industry has calculated that the cost of producing a barrel of oil nearly tripled between 1970 and 1980—but we believe the Soviets will allocate enough investment resources to the oil industry to permit them to come close to if not meet their production target of 12.6 million b/d by 1985.

Beyond the end of the current five-year plan in 1985, however, the situation will probably become increasingly difficult:

- Outside of West Siberia only two major onshore producing regions, Komi and Kazakhstan, are not in decline, and both will remain relatively small producers throughout this decade. Promising offshore areas will contribute little before the 1990s.

- By the late 1980s, production at most of the supergiant and larger giant fields on which the Soviets have relied for the bulk of their oil over the past two decades will be declining rapidly. By 1990 the Soviets will need to produce 2-3 million b/d of new oil just to offset lost output from 12 of their largest oilfields.

- Though the remaining hydrocarbon resources of the Soviet Union are potentially among the largest in the world, the Soviets have already tapped or will soon have tapped most of their highest quality, favorably located oil reserves. Since the mid-1970s, well flow rates have steadily declined, and water cuts have rapidly increased even in oil-rich West Siberia, sure signs that the best reserves are being depleted and that the Soviets must work increasingly hard just to keep production from falling. To make matters worse, new deposits tend to be deeper, harder to drill, and more remotely located.

[1] The Defense Intelligence Agency (DIA) concurs with the production forecast for 1985. DIA does not agree with the estimated performance of the Soviet oil industry in the latter 1980s nor with the projected oil production level in 1990.

- Emphasis on maintaining high rates of production growth has resulted in Soviet failure to initiate the kind of exploration program that would be essential to proving up substantial new reserves, especially outside West Siberia. Consequently, potentially oil-rich portions of the Arctic, East Siberia, and even parts of West Siberia will contribute little significant new oil output until the 1990s.

- Though largely self-sufficient and highly sophisticated in terms of technical theory, the Soviet oil industry suffers from the same kinds of inefficiency, poor performance, and bureaucratic mismanagement that tend to plague other civilian sectors of the Soviet economy.

Though none of these sets of problems individually would preclude the Soviets from maintaining some growth in oil output over the rest of this decade, together they have dramatically raised the average and marginal costs of producing a barrel of crude. The Soviets plan to increase the oil industry's share of industrial investment from 12 percent in the previous five-year plan to 16 percent in the current plan, and by 1985 will be allocating to the oil sector about one-third of all incremental industrial investment funds. Our own estimates of investment requirements and analysis of past spending trends indicate that Moscow would have to increase investment in the oil industry from 8 billion rubles in 1981 to some 20-25 billion rubles in 1990 just to keep production at its present level. In an era of slow growth and tarnished performance in other key sectors of their economy, like agriculture, the Soviets, in our view, will be unwilling to sustain this pace of investment.

We do not believe the Soviets will get much relief from reductions in demand for oil. In 1990 internal requirements should rise to 9.5 or 10 million b/d, up from 8.9 million b/d in 1980 in spite of substantial gains in the substitution of gas for oil. The Soviets also export more than 3 million b/d of oil; two-thirds of this amount supplies Eastern Europe and other client states with roughly three-fourths of their oil needs; over one-third is sold on the world oil market, comprising the Soviets' principal source of hard currency. Even with careful domestic fuel management, completion of the Soviet pipeline for export of gas to Western Europe, and continued pressure on the other CEMA countries to reduce their liftings of Soviet crude, total unconstrained demand for Soviet oil should continue to hover between 12 and 13 million b/d through the rest of the 1980s.

Although a precise estimate is not possible because of lack of data, we do not believe that Moscow could, without extreme difficulty, wring much more than 500,000 to 1 million b/d out of projected total demand for its oil during this decade. Only gradual cuts in supply to Eastern Europe are possible until late in the decade when the Soviets will have gas available as a substitute for oil. The Soviets cannot afford substantial cuts in hard currency exports, which provide the foreign exchange to buy grain and technology, until natural gas begins to take some of the pressure off oil as an export earner toward the end of the decade. Finally, the structure of Soviet domestic oil consumption does not lend itself to substantial discretionary cuts in use, nor is there an effective price system to help reduce demand. Opportunities to substitute additional coal and gas for oil appear to be limited by strong competition for investment resources and inadequacies in the transportation network and refinery industry. To cover the potential supply shortfall, we believe the Soviets would have to turn to a program of conservation by fiat, coupled with additional unilateral cuts in exports to soft currency customers. Moscow's flexibility would be very limited.

The supply-demand outlook and the escalating investment costs present the Soviets with an increasingly serious oil challenge, albeit one that probably will prove manageable. The Soviets have several investment options available:

- They could continue to increase the total amount of economic resources going to the oil industry during the coming 12th Five-Year Plan but slowly reduce the rate of growth in this investment. This strategy would most likely result in production plateauing at about 12.5 million b/d by the middle of this decade and subsequently declining slowly to between 11 and 12 million b/d by 1990. Though such a program would still be expensive—investment and drilling effort would have to double between now and 1990—this course would be consistent with Moscow's past willingness to make the effort needed to avoid an energy crisis.

- With an enormous increase in investment, the Soviets could possibly hold production between 12 and 13 million b/d until 1990. Oil reserves are probably adequate, but we believe the costs of exploiting them could prove to be prohibitive: total investment and drilling would have to triple,

and the number of wells on artificial lift would have to roughly double. This option would be very expensive and, without windfall discoveries, would create a drag on other sectors of the economy.

- At the other end of the spectrum, the Soviets, if dogged by production problems and worse-than-expected geologic conditions in their oilfields and forced to shift investment rubles to other hard-pressed industries, could choose to sharply limit the growth of resources going to the oil industry after the end of this five-year plan. Such an approach, according to our calculations, could result in production peaking by 1985 and subsequently falling as low as 9 or 10 million b/d by 1990. This option would, in our view, create an unmanageable and potentially catastrophic gap between oil supplies and demand.

Though the situation might change, we believe the Soviets are now moving in the direction of the first option. Recent speeches by Andropov together with [ ] statements by senior spokesmen of the oil and gas industries, and the still-sketchy details of the Soviets' new 20-year energy plan, convince us that Moscow is feeling the energy investment pinch. These sources suggest that Soviet planners may gradually shift the energy investment balance from oil to the currently more cost-effective gas later in the decade. If this is the case—and it certainly would represent a very rational choice under the circumstances—we would probably see little, if any, further growth in Soviet oil output beyond 1985. Indeed, given the enormous and increasing effort the Soviets have been making since the late 1970s to keep production from leveling off, we would expect to see some decline by the end of this decade.

Barring a major shift in the oil market or change in energy technology, Moscow, in our view, would have a strong incentive to keep such a decline as small as possible. Other things being equal, production below 11 million b/d by 1990 would create a gap that would pose great difficulties for the Soviet and East European economies. Conversely, however, sustained oil production much above 12 million b/d over the rest of this decade might not be a prerequisite to faster economic growth.

In the final analysis, the oil policies the Soviets choose and the ultimate success of those policies will depend on many factors—the general state of the Soviet economy and key sectors like agriculture; the Soviet perception of the military balance; the state of the world oil market; the success of the development and export program for Siberian natural gas; Soviet success in substituting gas for oil in the domestic economy; and the stability and confidence of the new leadership. One thing, however, is clear: the Soviets face costly energy problems that will absorb much of their attention and resources through the rest of this decade.

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Preface

The Soviet Union, abundantly endowed with energy resources, is now the world's leading oil producer and a substantial net exporter of oil. As Soviet oil production has increased over the past three decades, so has Moscow's reliance on this resource. Oil has fueled national economic growth, and the expansion of key sectors of the economy is tied to its availability. The Soviets' ample domestic supplies of oil have allowed Moscow to provide the Council for Mutual Economic Assistance (CEMA) countries and other client states with low cost oil and to export crude oil and petroleum products to the West for badly needed hard currency. Petroleum has also become an essential element in the USSR's strategic position and a symbol of national pride. Thus, an accurate assessment of Soviet oil production prospects is central to an understanding of a number of larger economic, political, and military issues in the 1980s.

The number and the range of estimates made by governments, private industry, and academicians reflect the importance and difficulty of predicting Soviet oil production. Much of this interest was stimulated by the CIA estimate of 1977. In contrast to optimistic forecasts of continued growth made by a number of other individuals and organizations, the 1977 estimate asserted that Soviet oil production would soon peak and then decline rapidly. We now know that estimate underestimated both the size of the Soviets' petroleum reserve base and their capability and willingness to make the investment needed to keep oil output growing. Indeed, though the evidence is not conclusive, we believe that the unclassified release of the 1977 CIA estimate may have played a role in spurring Moscow to take these measures. Although Soviet oil production has yet to decline, many of the trends first highlighted in the 1977 estimate—as well as a number of new problems—have contributed to a slowdown in the rate of growth of Soviet oil production.

With the era of rapid oil production growth nearing an end, now is an appropriate time to reexamine the short- and long-term oil supply outlook for the USSR. This report assesses whether the Soviet Union can produce enough oil over this decade to satisfy its needs and those of its client states, and what the Soviets could do to avoid a serious supply problem. The principal focus of the analysis is on the physical resources of the USSR and the capabilities of the Soviet petroleum industry to exploit them. In

describing the dilemmas facing the Soviets, this report summarizes the findings of a number of building-block studies referenced in the text—including some that are available only in typescript form. The reader should consult those reports for a more detailed discussion of our analytic approach and supporting data. Moreover, this report addresses only superficially the broad economic, political, and military impact of a potential supply shortfall and Soviet efforts to avert such a shortfall. These issues will be treated in *Policy Implications of the Soviet Economic Slowdown*, scheduled for publication later this year.

Prospects for Soviet Oil in the 1980s

The Soviet Oil Challenge

The Soviet petroleum industry is one of the oldest in the world. Beginning with hand-dug wells in Baku in the early 1800s (figure 1), the USSR has risen to first place in world oil production, with an average output of 12.25 million barrels per day (b/d) in 1982.[2] It ranks second in exports at a level of nearly 3.3 million b/d, and is one of the few major industrialized nations self-sufficient in oil (figure 2). The era of rapid growth that characterized the Soviet petroleum industry since World War II, however, has now ended. Since 1979, although annual increments are still occurring, the rate of growth of oil production has been low

We do not believe that the current slowdown will be a temporary phenomenon, and numerous statements by Soviet officials in a position to know suggest that Moscow is of the same mind. According to our analysis and the Soviets' own statements, the roots of the slowdown lie in the deterioration of the quality and accessibility of the known oil reserve base, which is rapidly raising the costs of producing and transporting a barrel of crude.[3] These difficulties are compounded by the technical and bureaucratic deficiencies of the Soviet oil industry, whose technology lags as much as two decades behind that of the West. To make matters worse, [redacted] indicate that the Soviet Ministry of the Petroleum Industry (MPI)—through ineffective field development practices, poor planning, and plain bureaucratic bungling—is often unable to use effectively the technology it does have available.

[1] The Soviets include gas condensate—a liquid hydrocarbon produced in association with both oil and natural gas—with crude oil in production statistics. Gas condensate production is of growing importance and will probably provide most of the future increments in the growth of Soviet oil production. Throughout this report all crude oil production data includes gas condensate production unless stated otherwise.

[3] The term quality as applied to Soviet reserves refers to the characteristics of the oil—density, viscosity, and chemical composition—and of the reservoirs—size, depth, porosity, permeability, temperature, and pressure—which determine the speed, ease, and cost of oil extraction.

A slowdown or decline in production, however, would be no problem for the Soviets if oil exports were not so vital to their political and economic goals. Except under the most pessimistic supply-demand scenarios, the USSR is capable of meeting its own needs through the end of the decade. But with about one-fourth of their oil shipped to dependent states in Eastern Europe or sold for vital hard currency, the Soviets can ill afford to lose much of their oil export capacity during this decade. A substantial reduction in Soviet oil available for export—before foreign demand for West Siberian gas allows substantial substitution—could increase economic and political stresses in Eastern Europe and other client states that depend on Soviet energy and could deprive Moscow of as much as 50 percent of its hard currency earnings from commodity exports. In our view the immediate concern for the USSR, then, is not to avoid import dependency but to minimize the erosion of earnings and other benefits from oil exports.

[redacted] to avoid the difficult political and economic choices that an oil supply crunch could entail some time in the 1980s, the new Soviet leadership is struggling to formulate new long-term policies for the oil industry and the rest of the energy sector. These policy decisions will be essentially investment decisions—what portion of increasingly scarce investment funds to allocate to the energy sector and how to apportion these funds among the competing energy interests. We believe that the onus on the policymakers to make the correct decisions is great, because their choices could affect the future pattern of economic development and, hence, the health of the economy for decades.

Although the debate over long-term strategy is still going on, our analysis of Soviet press articles, data from a variety of [redacted] sources, and current five-year plan (FYP) goals indicate that decisionmakers have already come to terms

with the notion that the era of cheap and plentiful growth in oil supplies is over. They are now seeking ways to cope with a new reality—that increments to national oil production cannot be obtained without imposing severe technical and economic demands on the economy. We believe that acceptance of this new fact of economic life is reflected in Soviet oil-production goals for the 1980s. The 1985 goal is now set at 12.6 million b/d, an increase of only 570,000 b/d over 1980 output and an average annual increase of less than 1 percent. This goal, already reduced from an upper limit of 12.9 million b/d when the plan was first announced, could be scaled back even further in 1983, the third year of the 11th FYP. An official goal for 1990 will not be available until 1985, and it will be determined by the performance of the oil sector over the next three years. In an energy forecast submitted to the UN Economic Commission for Europe in 1980, the Soviets projected their 1990 production would fall between 12.3 and 13.8 million b/d. We believe, however, that the rising costs of oil production will force the Soviets to set a goal at or below the low end of this range.

For a reduced level of production to meet their needs, the Soviets must alter the energy economy of the country through oil conservation and the substitution of other fuels for oil. They are attempting to do just that. The conservation program, however, hampered by the nature of the Soviet economic system and the structure of energy demand, has had little effect to date, and appears to offer limited help through the rest of the 1980s. The fuel substitution program, particularly the substitution of natural gas for oil, offers a more promising alternative. The current FYP calls for investment in the natural gas industry to rise by 150 percent, and the Soviets are apparently willing to spend the rubles needed to increase the production of gas from their nearly unlimited resource base, to build the necessary pipelines, and to convert capital equipment to gas. At the same time, the coal industry, whose reserves are also more than ample, is suffering from an array of technical problems that the Soviets have yet to remedy. The real challenge for the oil industry in the short run, then, is to maintain production at the current high levels until natural gas can begin to cover a potentially serious oil gap arising near the end of the decade.

The Reserve Base

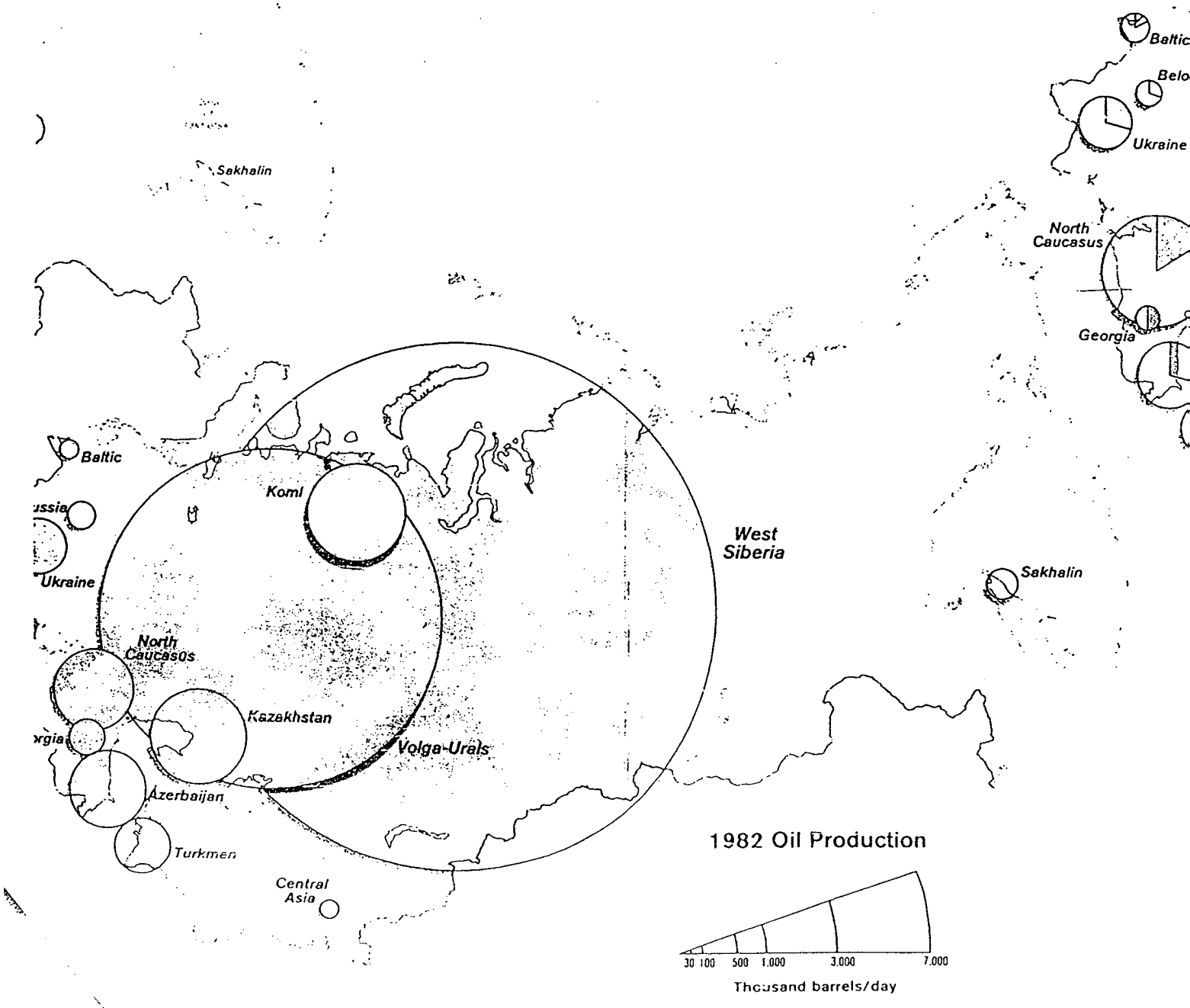
The fact that the Soviet Union has risen to first place in world petroleum production is a testament to the size of its reserve base, which by most estimates is among the largest in the world. A number of major potential hydrocarbon-bearing regions of the country are in remote areas and remain virtually unexplored, and exploration of offshore areas other than the Caspian is just beginning.

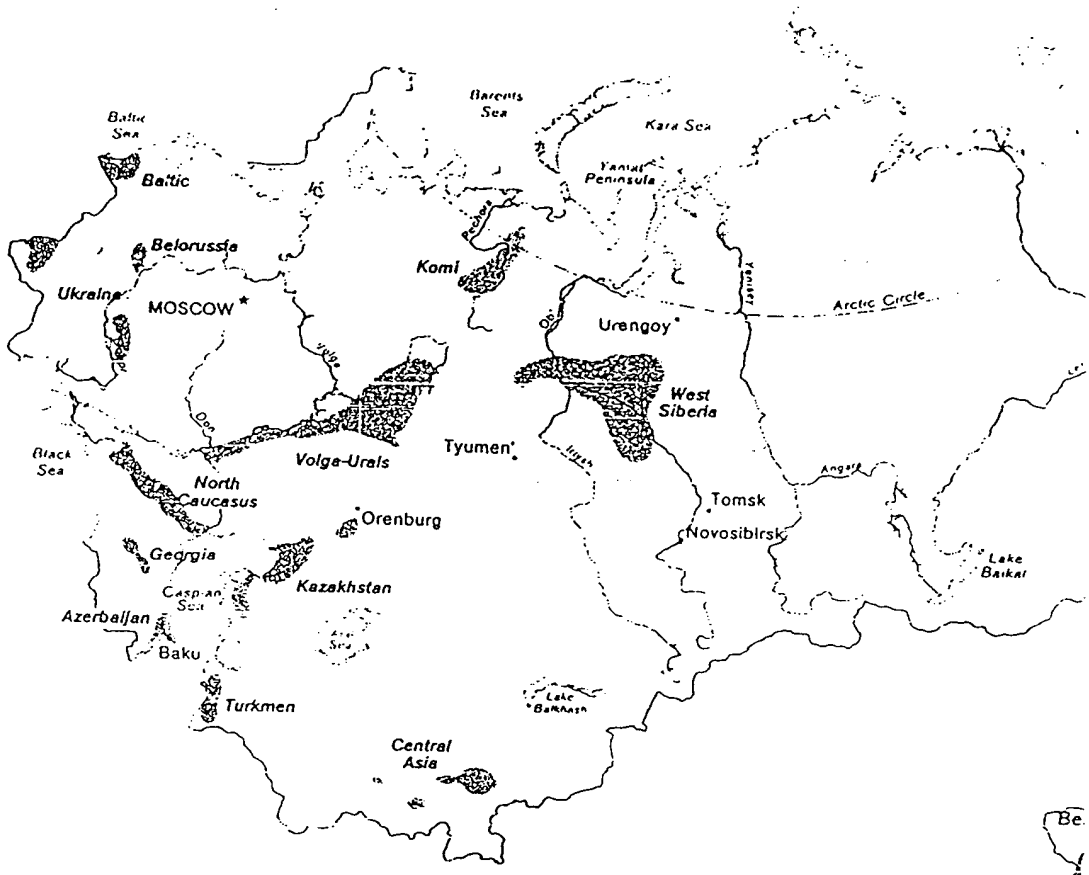
The reserve base is located in 15 major and numerous minor oil and gas provinces scattered throughout the country (figure 1). Perhaps the most noteworthy feature of the distribution of Soviet oil is the relationship between the location and size of the oil-bearing basins and the location of Soviet economic activity. With the exception of the Volga-Urals region, the economic and population heartland in the west contains mostly minor oil-bearing basins. The large sedimentary basins that will provide the USSR with most of its oil for the rest of this century are in the lightly populated northern and eastern sections of the country, where environmental conditions are severe, economic infrastructure lacking, and development costs high. Thus, as the Soviet economy and its demand for oil have grown since World War II, the Soviets have been forced to move their search for oil into remote regions farther from the centers of petroleum demand.

The Soviets have concentrated their development efforts on a single region at a time to provide needed growth in oil supplies. As Baku, the earliest center of major extractive activity, declined after World War II, the Soviets moved north and east into their "Second Baku," the Volga-Urals Basin. The Volga-Urals provided large annual increments of growth for two decades and is still the second-largest producing area, accounting for 27 percent of national oil output. Production from the basin is now declining rapidly as major fields and reserves become depleted.

When it became apparent that the Volga-Urals would no longer be able to provide large annual increments in oil output, the oil industry began to shift its search

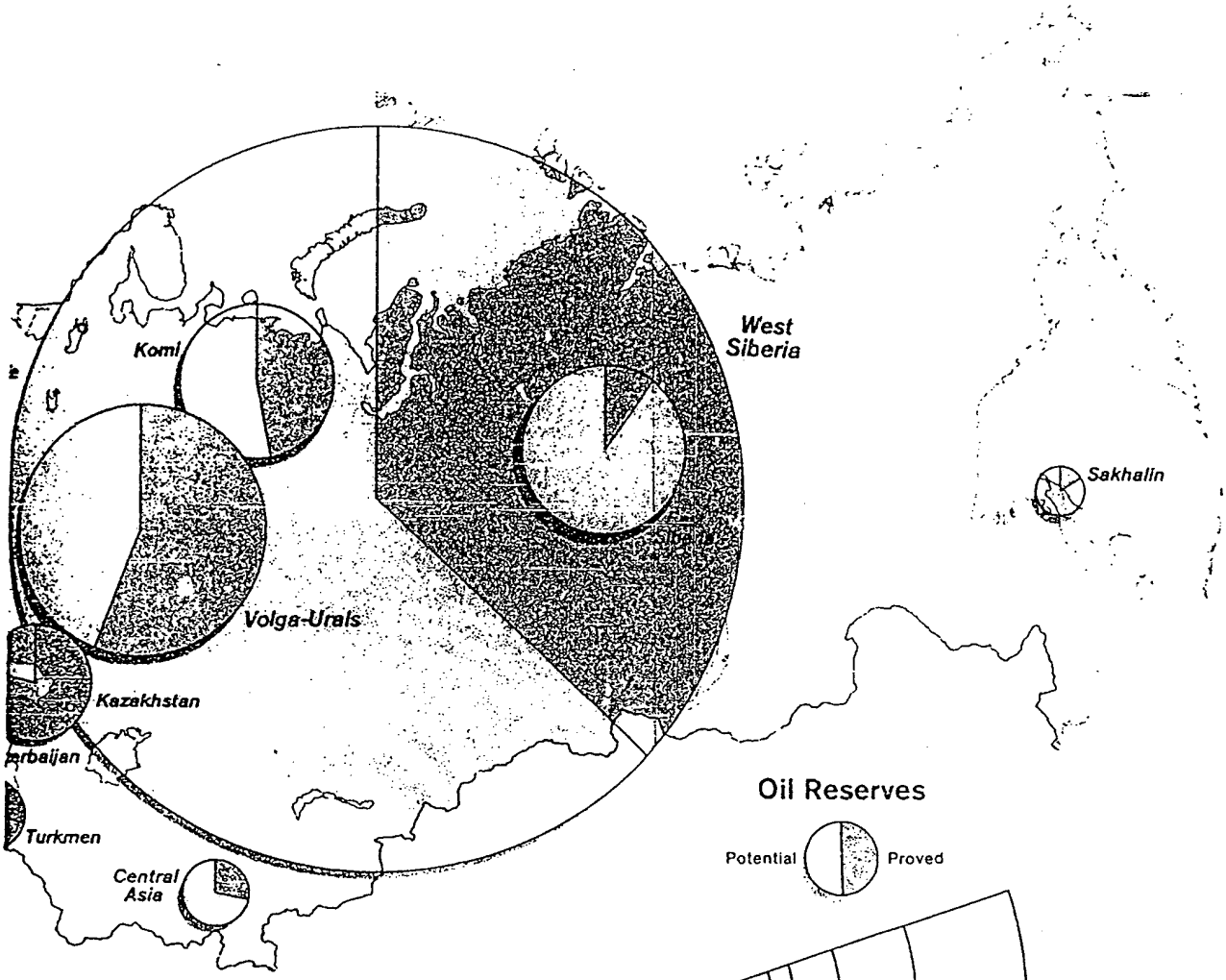
Figure 1
Soviet Union: Oil Production and Reserves





Oil Producing Regions

The United States Government has not recognized the incorporation of Estonia, Latvia, and Lithuania into the Soviet Union. Other boundary representation is not necessarily authoritative.



Data shown represent the midpoint between low and high reserve estimates. (see Table 2)

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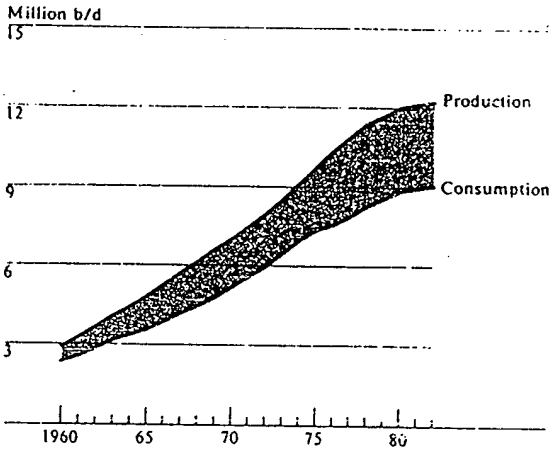
Figure 2
Soviet Union: National Oil Production, Consumption, and Exports



for new oil to the remote and environmentally hostile West Siberian Basin in the early 1960s. This prolific basin provided most of the growth in the 1970s, and will be, according to Soviet statements and our own analysis, the leading producing region into the 1990s. It now accounts for 58 percent of national oil output, and the Soviets expect this share to rise to more than 63 percent by 1985 and even higher by the end of the decade. Although West Siberia contains the richest known hydrocarbon deposits in the country and production is expected to increase for several more years, the rate of growth has slowed. Some segments of the Soviet oil industry are now arguing openly that the time is ripe to shift the focus of exploration activity into virgin regions of the country such as East Siberia and offshore basins in the Kara and Barents Seas. The Soviets acknowledge that production from these areas, however, will not be a factor until the next decade.

Reserve Quantity

The size and potential of its petroleum reserve base puts the USSR in an enviable position compared to other industrialized nations, but potential oil reserves hold little significance for the immediate oil supply problem. Because of the lag between the time a deposit is discovered and the time development begins—according to Soviet statements and our own analysis, not less than four to five years and sometimes seven years or more for fields in remote areas—production in the 1980s will depend almost entirely on hydrocarbon-bearing structures that have already been discovered and whose reserves can be rapidly exploited by delineation and development drilling.

Estimating the actual size of the Soviet reserve base presents a formidable analytical task. Since 1947 Moscow has treated the size of its oil reserves as a state secret, publishing only occasional, fragmentary, and inconsistent data. Our last official data point [redacted] indicated that at the end of 1975 Moscow probably estimated its proved reserves to be about 70 billion barrels, and regarded them as adequate in quantity if not quality. Another problem is the USSR's reserve classification system, which is not only different from that used in the West but has changed over time. Moreover, an estimate of the size of the reserve base through the 1980s—whether by the Soviets or the United States—cannot be static: it must allow for depletion of known reserves, for increments to reserves from exploration and development drilling, and for improvements in Soviet recovery technology. Finally, any estimate of mineral reserves is based on a number of highly subjective judgments and should be treated with caution (see inset page 6 and figure 3 and inset page 7 and table 1).

West Siberian Reserves. Because West Siberia is so central to Soviet production in the 1980s, we performed an intensive basin analysis of the region, focusing on the middle Ob' sector where the Soviets are increasingly concentrating their oil production

Reserves: Definitions and Terminology

The Soviet system of reserve classification is much different from that used in the West. The Soviet reserve categories—A, B, C_1, C_2, D_1, and D_2—are based primarily on the degree of exploration and delineation drilling that has been carried out, and cannot be directly equated to the Western categories of proved, probable, and possible reserves, which are based more on prevailing economic and technological factors:

- *In our analysis, the term "proved reserves" corresponds roughly to the Western definition, reserves that geological and engineering data demonstrate with reasonable certainty to be recoverable under existing economic and operating conditions. The nearest direct comparison to Western "proved reserves" in the Soviet system is the concept of "explored" or "commercial" reserves, which include the Soviet A and B categories plus 30 percent of the C_1 category. Our geologic analysis, however, indicates that this percentage is too high for C_1, and we would include only 10 percent of Soviet C_1 reserves as proved.*
- *Our "potential reserves" category, which includes both probable and possible reserves by Western definition, roughly corresponds to the Soviet "prospective reserves," and in this assessment represents our estimate of the recoverable portion of the remaining C_1 reserves and of the C_2, D_1 and D_2 categories*

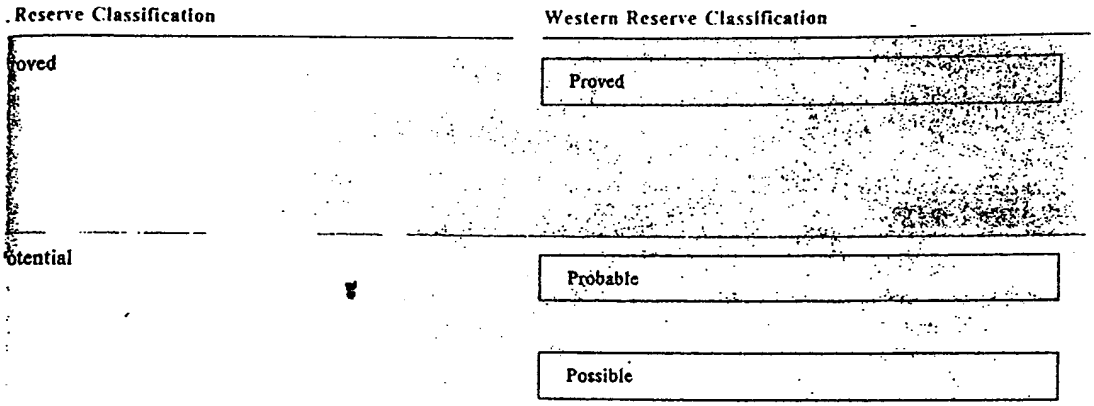
activity.[4] Based on this geologic analysis, we believe that the size of the reserve base in West Siberia will not by itself be a constraint on production growth from that region during this decade. We estimate, for example, that the middle Ob' region alone may have originally contained as much as 240 billion barrels of oil in place. Our engineering analyses of Soviet recovery techniques at major Soviet fields in the region indicate that the Soviets probably will achieve an

Table 1
Estimates of Soviet Oil Reserves

	Billion Barrels
Petrostudies, 1979 (Sweden)	150
EXXON, 1979, Proved and Probable (United States)	92
Petroleum Economist, 1980 (United Kingdom)	66
European Petroleum Yearbook, 1980 (West Germany)	95
Petrole Information, 1980 (France)	66
The Economist Intelligence Unit, Proved and Probable, 1980 (United Kingdom)	102 to 110
Defense Intelligence Agency, Accessible and Producible, 1981 (United States)	80 to 85
World Oil, 1982 (United States)	85
Myerhoff and Associates, 1982 (United States)	43.5
US Geological Survey, 1982, Proved and Probable, (United States)	135
ARCO, 1982 (United States)	60+
Oil and Gas Journal, 1982 (United States)	63

average recovery efficiency of about 30 to 40 percent for the middle Ob' deposits as a whole. Assuming the Soviets find and exploit these resources efficiently, they could expect to ultimately recover perhaps some 85 billion barrels of oil

According to Soviet data, more than 15 billion barrels in the middle Ob' region have already been extracted, leaving by our estimate a potential 70 billon barrels of ultimately recoverable oil in that region alone. Not all of this oil would be available to the Soviets in this decade or even in this century. Producing it would require a massive exploration and drilling program and more scarce investment resources than the USSR—or any other country—would be able to muster. From geologic [ ] analyses [ ], however, we can confirm that the currently producing deposits alone contain at least 15 billion barrels—and probably much more—that qualify as proved reserves by strict Western definitions. Of the remaining 55 billion barrels, an estimated 25



VED
illed and well explored reserves that are in—or are about to be —active production. Includes Soviet A + B + 10 percent of C_1 tegories and is roughly equivalent to the Western proved tegory

ENTIAL
ie amount of remaining reserves, in our judgement, that will be covered if the oil is discovered and exploited. Includes 90 rcent of Soviet C_1 plus $C_2 + D_1 + D_2$ categories and is equivalent the Western probable and possible categories

PROVED
Reserves which geological and engineering or drilling data demonstrate to be recoverable under existing economic and operating conditions

PROBABLE
Incompletely defined reserves estimated to occur:
- In known producing areas
- As extensions of known pools
- In undiscovered areas within known oil-bearing geologic trends
- Recoverable under exis ig economic and operating conditions

POSSIBLE
Inferred reserves estimated to occur:
- In undiscovered areas analogous to other known oil-bearing areas
- Recoverable under existing economic and operating conditions

Reserve Calculation Methodology

We used a variety of techniques to estimate Soviet proved and potential reserves, depending on the data available and the size and importance of each individual region.[a]

Middle Ob'—Estimating Approach

For the middle Ob' region, which currently provides approximately 95 percent of West Siberian oil output and nearly 60 percent of the national total, we assembled a team of geologists, engineers, and industry specialists to perform an intensive basin assessment. Techniques the US oil industry would use to estimate oil in place and potential oil recovery were applied to data available from

[redacted] Soviet open literature [redacted]

[redacted]

Proved and Potential Reserves

In simple terms, our approach to estimating oil in place and both proved and potential reserves of the middle Ob' region was as follows:

- *We identified and measured the areas of potential hydrocarbon-bearing structures by correlating* [redacted] *surface geology with Soviet maps of the subsurface geology.*
- *Next, using data* [redacted] *analysis of drilling and production activities, we determined whether the Soviets knew these structures were oil bearing.*
- *We then used* [redacted] *reporting to identify the relative productivity (that is, well flow rates and recovery potentials) of each oil-bearing zone.*
- *Finally, we extended the productivity data from known to potential oil-bearing structures to estimate oil in place and proved and potential reserves.*

Level of Confidence

Basin assessments of hydrocarbon-bearing potential tend to be optimistic when based principally on geologic data. To compensate, we tried to be conservative in assigning productivities and recovery rates and in inferring the actual presence of oil. Our results fall approximately within the middle of the range of the estimates done in recent years by other government agencies, private firms, foreign countries, and the Soviets themselves.

We are most confident of our judgments of Soviet proved reserves in the middle Ob'. We are less certain about the accuracy of the estimate of potential reserves. In both cases, however, because of our conservative approach, we believe that the true amounts of oil in place and potential reserves are more likely to be greater—rather than less—than we have estimated.[c]

Other Regions—Estimating Approach

Proved Reserves

A lack of data precluded a similarly detailed analysis of reserves in the rest of the Soviet Union. For Komi, Kazakhstan, and other areas in West Siberia where data are relatively plentiful, we calculated proved reserves via a modified volumetric-geologic approach similar to the one used in the middle Ob' analysis. For each of the remaining producing regions, we calculated proved reserves as the product of current annual production and an estimate of the

[a] *A more detailed description of our reserve calculation methodologies is available to interested readers. To obtain copies* [redacted] *contact Office of Global Issues, 351-5006. (U)*

[b] *This approach is similar to the one that we developed to assess prospects at major oilfields. See* [redacted] *November 1978 Project CHALLENGE: USSR Feasibility Study Report.*

[c] *Several known oil-bearing structures outside of the major uplifts were not included because of the lack of data. Some of these structures have potentially large oil resources and are now being developed.*

reserves to production (R/P) ratio.[4] Estimates of individual R/Ps were purposely kept on the conservative or low side to be consistent with the approach used in the middle Ob' analysis.

Potential Reserves

Potential reserves for all regions outside the middle Ob' were estimated with the same volumetric-geologic methodology described above.

Level of Confidence

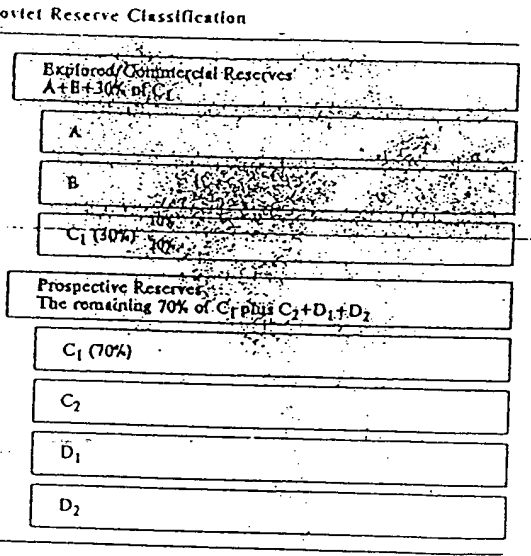
Here again, we are more confident of the accuracy of our proved reserve estimates, primarily because the accuracy of the R/P estimates benefited from historical reserve data provided [redacted]. The accuracy of the potential reserve estimates cannot be expected to exceed the accuracy of the data used in the volumetric-geologic equation. We were forced to estimate many of these inputs, and consequently our potential reserves estimate may vary from reality by plus-or-minus 30 to 40 percent. Since these inputs were kept conservative, we believe our estimate is more likely to be on the low side.

The Soviet View

[redacted] Soviets' own reserve data for the year 1975. These data both give us a one-year snapshot of what the Soviets believed their reserve base to be and tend to confirm our view of its size. According to this data, at the end of 1975 Soviet "explored" reserves—A plus B plus 10 percent of C_1—totaled some 70 to 80 billion barrels. Since that time, some 34 billion barrels have been produced, leaving some 36 to 46 billion barrels plus whatever reserves the Soviets have been able to prove up subsequently through exploration and development drilling. Under a pessemistic scenario, in which the Soviets found new oil to replace only 50 percent of oil produced, the Soviets would still be carrying as "explored" or proved some 53 to 63 billion barrels of oil, very much in line with our estimate of roughly 50 to 70 billion barrels

[4] The R/P ratio expresses the relationship between total remaining proved reserves and annual production. It is a commonly used measure of the adequacy of the reserve base of an oil-producing entity.

Figure 3
Soviet Union: Reserve Classification System



"A" Category Reserves:
- Geologically and geophysically examined in detail
- Delineated by exploratory and production wells drilled over the whole deposit
- Engineering data demonstrate recoverability
- Represent reserves in current production

"B" Category Reserves:
- Geologically and geophysically examined in detail
- Evaluated by drilling to a degree adequate for development planning
- Engineering data demonstrate recoverability
- Represent on-hold reserves or unused producing capacity

"C_1" Category Reserves:
- Represent reserves adjacent to "A" and "B" categories
- Geologically and geophysically evaluated
- Verified by minimal drilling (1 to 6 drill holes)
- Engineering data demonstrate partial recoverability; an average 30 percent will shift to "B" and then "A" categories

"C_2" Category Reserves:
- Presumed to exist, based on favorable geologic and geophysical data analogous to that for areas containing verified reserves
- Some will shift to higher categories

"D_1" Category Reserves:
- Speculative reserves presumed to exist on the basis of geologic analogy with oil-bearing reference areas
- Some will shift to "C_2" category

"D_2" Category Reserves:
- Speculative reserves presumed to exist on the basis of geologic analogy with an oil-bearing reference area
- Less geologically and geophysically evaluated than "D_1" category
- Some will shift to "D_1" category

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billion lie in fields now being developed or in deposits well explored by the drill bit. These same [ ] analyses indicate that much of this oil could be produceable as the decade progresses if the Soviets made the effort—and, indeed, the Soviets probably consider most of these 25 billion barrels as proved. Consequently, we believe that during this decade the Soviets will have available for production a base of proved reserves of some 25-35 billion barrels from the middle Ob' region alone. Most of the remaining 30 or more billion barrels of potential reserves lie in largely undrilled but geophysically explored structures and would not, in our judgment, be available for production until the 1990s or later

North of the middle Ob' study area, the Soviets have not yet been able to conduct an extensive exploration and development effort. Our low proved reserve estimate, 0.5 to 1.0 billion barrels, reflects this lack of effort rather than pessimism over the long-term potential of this area. South of the middle Ob', in Tomsk Oblast, the Soviets have been active since the 1960s with much less success than in the middle Ob'. Tomsk probably contains some 1.0 to 1.5 billion barrels of remaining proved oil reserves, mostly in deeper Mesozoic deposits. The Soviets have discovered substantial reserves of much deeper Paleozoic oil in Tomsk and Novosibirsk Oblasts. Although this area contains some 5-8 billion barrels of potentially produceable oil, we do not think the Soviets will be able to do much with these reserves in this decade.

In addition to the crude oil reserves, West Siberian condensate reserves are substantial, an opinion held by both Soviet and Western oil experts. Based on published data from the Soviet Gas Ministry, we estimate the current proved gas condensate reserves associated with oil to be on the order of 136-272 million tons, with little growth expected over the rest of the decade. Recently published Soviet data indicate the presence of 547-818 million tons of condensate reserves associated with gasfields, primarily the supergiant fields in northern West Siberia. We expect large additions to this region's proved condensate reserve total of some 683-1,090 million tons—or, very roughly, 7 to 11 billion barrels [5]—as exploratory and delineation drilling increas

[5] On the average, 1 ton of condensate is roughly equivalent to 10 barrels of oil. The conversion factor used by the Soviets varies widely from year to year and field to field.

Non-West Siberian Reserves. In contrast, the reserve situation west of the Urals and in minor producing regions is precarious at best. We know from Soviet data that reserves in the critical Volga-Urals Basin are falling rapidly, and we estimate that the proved reserve base there has probably dropped below 10 billion barrels. Reserve additions in Komi and Kazakhstan—the only areas outside West Siberia scheduled for any significant production growth—have not yet lived up to Soviet expectations, at least in part because of large shortfalls in exploratory drilling. Reserves in the other producing regions are too small to have much of an effect on the national total in this decade

Total Reserves. Given the uncertainties associated with estimating Soviet oil reserves, it is foolhardy to attempt to arrive at a precise estimate. Taken together—the promise of West Siberia, the disappointments in Komi and Kazakhstan, and the deteriorating situation in other producing regions—we estimate Soviet proved reserves at the beginning of 1983 to be in the range of 50 to 70 billion barrels (table 2). This amount is in the lower half of the range of estimates made by [ ] analysts of the Soviet oil industry, and is comparable to what analysis of data [ ] suggests the Soviets estimate their own oil reserves to be

Reserve Quality

Numbers do not tell the whole story in an analysis of the Soviet reserve situation. A reserve base must be accessible and of a quality that permits exploitation without undue technical and economic costs. The Soviet oil industry faces growing problems on both counts. In the middle Ob', our geologic analysis indicates that the Soviets will find decreasing reserve quality—slightly deeper reservoirs with lower porosity, permeability, and flow rates—as they begin work in deposits farther from the earlier centers of production.[6] Moreover, based on our analysis and the Soviets'

[6] Porosity is the percentage of rock bulk volume occupied by open or pore space in which oil can accumulate. Permeability is a measure of the ease with which fluids move through this pore space.

Table 2
Estimated Soviet Oil Reserves
31 December 1982

Billion barrels

Region	Proved Reserves [a]	Potential Reserves [b]
West Siberia		58 to 78
Middle Ob'	25.0 to 35.0	
Northern West Siberia	0.5 to 1.0	
Tomsk	1.0 to 1.5	
Condensate	7.0 to 11	
Volga-Urals	7.5 to 10.5	6.5 to 7.5
Komi	3.0 to 3.5	1.5 to 5.8
Kazakhstan	3.0 to 3.5	0.8 to 0.9
East Siberia (developed areas only)	0.5 to 1.0	3.0 to 11.0
Georgia	0.2	under 0.2
North Caucasus	0.8 to 1.0	2.5 to 7.0
Baltic	0.1	0.2 to 0.8
Sakhalin	0.1 to 0.2	0.1 to 0.6
Azerbaijan	0.6 to 0.8	1.5 to 2.0
Turkmen	0.4 to 0.6	0.9 to 1.5
Central Asia	0.4 to 0.5	0.9 to 1.3
Belorussia	0.1 to 0.2	0.2 to 0.5
Ukraine	0.4 to 0.5	0.9 to 1.2
Total	50.6 to 70.8	77.3 to 118.3

[a] Includes only drilled and well-explored reserves that are in—or are about to be in—active production.
[b] All other reserves, including those that are partially explored or geologically inferred.

own expectations, the remoteness of these new locations, both from the oil consuming centers in the European USSR and from existing middle Ob' infrastructure, will accelerate the already high costs of development.[redacted] Many of the same infrastructure and cost problems will occur in Komi and Kazakhstan, where the Soviets are working very hard to increase the size of the proved reserve base

[redacted]

In other areas west of the Urals, the reserve base—although favorably located near existing oil producing, refining, and transportation centers—is declining rapidly in quality. New deposits being discovered in the critical Volga-Urals, for example, are smaller, more scattered, and deeper, with lower quality oil.

The Reserve Base for the 1980s

Although problems of quality and accessibility continue to grow and will intensify the challenge of development, we do not think that reserves by themselves will seriously constrain Soviet oil production in this decade. Continuation of production through 1990 at the present rate of more than 12.4 million b/d, for example, would result in the subtraction of more than 36 billion barrels of oil from our estimated proved reserve base of 50-70 billion barrels nationwide. With the proving out of 5-15 billion more barrels of potential reserves in the middle Ob', the expansion of gas condensate reserves in West Siberia, and minor additions west of the Urals, the Soviet proved reserve base would still be at least 30-40 billion barrels at the end of the decade

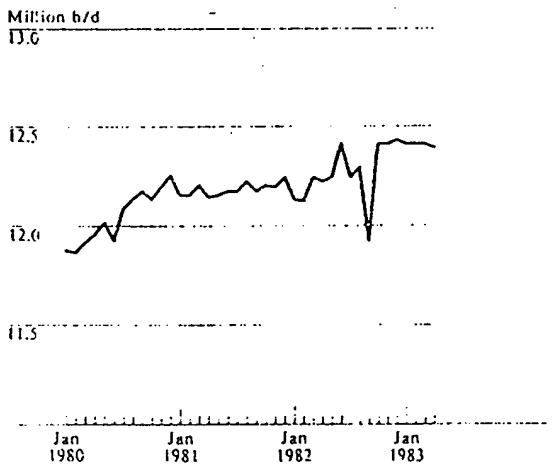
We also believe the Soviets are reasonably content with their reserve situation for the 1980s. Although they plan to increase exploratory drilling meterage by about 30 percent nationally and by nearly 100 percent in West Siberia during this FYP, the national increase in absolute terms will be small, less than 8 million meters. We would expect to see a much larger increase planned if the Soviets believed reserves were in danger of dropping below the amount needed to achieve future output targets. Furthermore, although the Soviet planning system is far from perfect and there have been instances of gross miscalculation, we do not believe that development drilling and crude oil output would be planned at levels that the Soviets believed to be completely beyond the bounds of feasibility unless they were attempting to mislead the rest of the world. Finally, we know

[redacted] that production from West Siberia is still growing—a sign[redacted], that substantial amounts of new reserves are continuing to be proved up

There are, however, indications of Soviet concern over the long-range reserve outlook, as indicated by numerous discussions in the press of the declining reserves-to-production ratio. A generally accepted principle in the oil industry holds that production must be backed up by an adequate ratio of proved reserves to production if steep declines in future output are to be avoided. Our analysis of Soviet reserves and production data indicates that this key indicator of future production possibilities is falling as a result of the overemphasis on production drilling in the 1970s, the poorer quality of new reserves, and decreasing finding rates of new oil. If the Soviets do not succeed in reversing this downward trend, they will probably run into reserve constraints on production in the 1990s

The presence of a large proved and potential reserve base is not a guarantee of future production increases. The Soviets must also be willing to devote an increasing share of limited investment resources to the oil industry and be capable of applying the level of managerial and technical expertise needed to develop and produce this reserve base. The nature and location of their present and future reserves will severely test both of these requirements. To the west of the Urals, equipment needs, technology demands, and costs will multiply as the Soviets move to exploit the lower quality deposits. In West Siberia, these problems as well as infrastructural and logistic demands—roads, housing, electric power, timely delivery of supplies—will require huge upfront costs before oil starts to flow.

Figure 4
Soviet Union: Monthly Oil Production



Production Possibilities

Current Production

Future oil production for the Soviet Union or any other country is impossible to predict without establishing a number of reference points that become increasingly tenuous the further one moves from the present. Over the remaining three years of the 11th FYP, Soviet oil production will be determined largely by the size and quality of known deposits, as well as by investment and field development choices that have, for the most part, already been made and are known to us. In the last half of this decade, however, Soviet production levels will increasingly depend on unknown and hard-to-predict variables like future exploration success and investment decisions that might be influenced by external political and economic factors

In 1982 the Soviet oil industry reported an average daily production rate of 12.3 million barrels. For the past 36 months, daily output, while still inching upward, has varied by less than 5 percent, fluctuating between 11.8 and 12.4 million barrels, as reported monthly in the Soviet press (figure 4). From all indications the sharp drop in September of 1982 and subsequent equally sharp recovery in October do not portend any major changes in the pace of Soviet oil production, but reflect the consequences of a fire and lengthy power outage that disrupted activities in a high percentage of West Siberian deposits

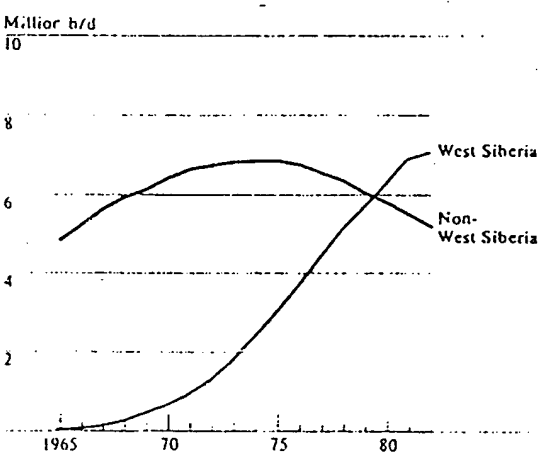
Though still growing, Soviet oil production has not reached plan goals for some time. The Soviets failed to make either the original or revised targets for the end of the last FYP, and have not equaled or exceeded an original annual target since 1972. Plans have been revised downward to the point where the 1985 Plan goal of 12.6 million b/d is no higher than the original target—later revised downward—for 1980. The present 1985 goal, already lowered from an original high of 12.9 million b/d, represents planned growth of less than 1 percent per year

These small increases have been possible only because the Soviets have been able to keep West Siberian production growing—from 6.2 million b/d in 1980 to an estimated 7.1 million b/d in 1982, a 6.3-percent average annual increase (figure 5). West Siberia's share of national output is now 58 percent, and should continue to grow throughout this decade. Other than West Siberia, only two major regions of the USSR are currently able to boost production—the Komi region, in the northern European USSR, and Kazakhstan, on the eastern shore of the Caspian Sea—and neither are adding production increments large enough to offset significant declines elsewhere. These three growth areas, together with the declining Volga-Urals region, produce more than 90 percent of Soviet oil and will largely determine Soviet production possibilities in the 1980s

Aside from West Siberian crude oil production, the only major bright spot for the Soviets has been the growth of gas condensate production. We know from [redacted] Soviet data that condensate output is growing at a current annual rate of about 10 percent compared to the less-than-1-percent growth of oil and condensate combined. Condensate still provides less than 5 percent of Soviet oil output, but the Soviets expect that most, if not all, of any growth in oil production will probably come from condensate. Their optimism is based on the immense reserves of natural gas and condensate in the northern gasfields of West Siberia. The Soviets hope to recover as much as 4 million tons of condensate from the Urengoy field alone by 1985.

Oil production in all other major Soviet producing regions is now stagnating or declining. Volga-Urals production has declined by more than 1 million b/d—

Figure 5
Soviet Union: Regional Oil Production



or 25 percent—since its peak in 1975. The drop was largely the result of a decline at the supergiant Romashkino oilfield, the leading producer in the region and the second largest field in the country. Altogether, oil production in these declining areas slipped by more than 1.7 million b/d between 1975 and 1982.

Production Problems

In simple terms we believe that the current oil-production slowdown can be attributed primarily to a number of poor strategy choices made by Soviet planners in the 1970s. The high growth in production since World War II was largely the result of the discovery and exploration of a series of large giant and supergiant fields.[4] In the 1950s and 1960s the

[4] Oilfields with recoverable reserves greater than 500 million barrels are considered giants. To rank as a supergiant, a field must contain recoverable reserves of at least 5 billion barrels

Soviets were able to look to the Volga-Urals and the massive fields of Romashkino and Arlan and to Kazakhstan, site of the Uzen oilfield. By the 1970s, just as production growth from the western USSR was beginning to taper off, the Soviets were fortunate to receive a needed boost in production from the mammoth fields of the West Siberian Basin—such as Samotlor, Fedorovo, and Mamontovo

During the 1970s, however, the then-promising reserve situation and the Soviet emphasis on maximizing current production led planners to slight exploration and delay development of potentially rich but more remote oil-bearing basins. In 1983, with national oil output more than 12.4 million b/d and most major producing areas outside of West Siberia in decline, a third "windfall" is not in sight, and neither we nor the Soviets expect one to appear in time to provide an easy offset to the waning performance of the mature oil-bearing regions. Moreover, data

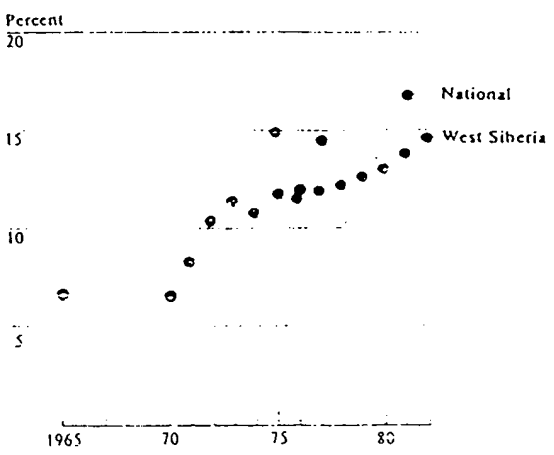
combined with our engineering analysis of a number of key Soviet fields suggest that the emphasis on current production and plan fulfillment in the 1970s also led to field development practices that, while maximizing output quickly, often resulted in reservoir damage and rapid declines once peak production was reached.

engineering analysis indicate that this problem is particularly acute in the Volga-Urals region and in the more mature fields of West Siberia.

The way the Soviet economy and bureaucracy operate, these decisions on development and exploration strategy tended to respond to immediate needs and pressures. But their consequences have collectively made the current challenge facing Moscow far greater than it might have been. For now, the Soviets find themselves with a reserve base of deteriorating quality and many deposits with continuing production problems. To make matters worse, Soviet planners were slow in anticipating these trends, and often delayed until the last minute allocating the increased inputs of manpower, equipment, and infrastructure needed to assure continued production increases.

The Soviet oil industry is now confronting these problems in the field in the form of declining capacity from old wells and lower initial flows from new wells.

Figure 6
Capacity Decline Rates



forcing the Soviets to drill more wells and pump more fluid to obtain a smaller proportion of oil in return. Each year the production capacity from old wells falls, and in order to maintain existing production levels some amount of new-well production must go on line to offset this decline. In recent years this rate of capacity decline has increased and, according to the Soviets, today stands at more than 15 percent annually—meaning that about 2 million barrels per day of new oil are needed annually to keep production at the current level (figure 6). Lower new-well flows are exacerbating this problem. We know

that average well flows are now only 130 b/d nationwide and 475 b/d in West Siberia (figure 7). This drop in average well output can be attributed to the watering out of old wells and to the lower average flow rates of new wells entering the well stock—a manifestation of the relatively poorer quality of most new reserves

Figure 7
Average Well Flows

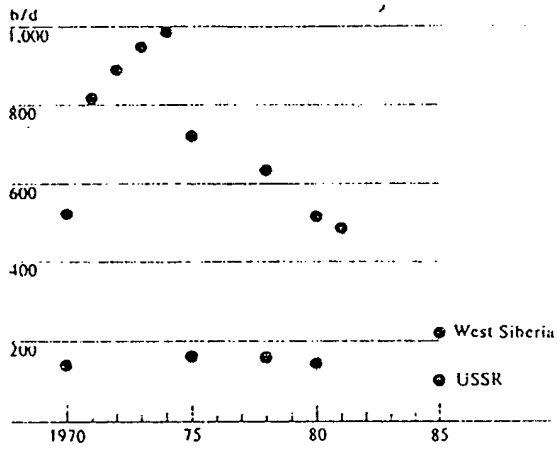
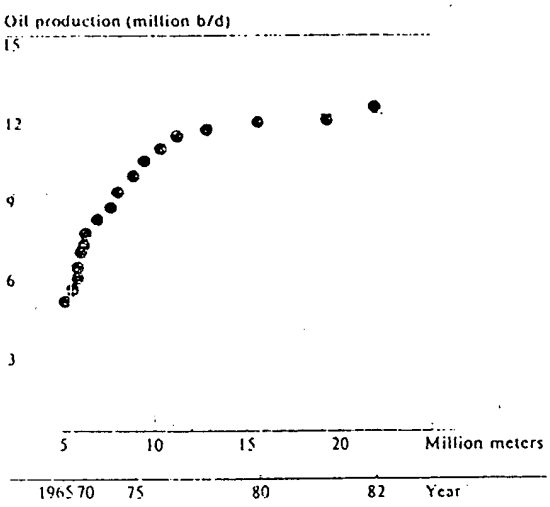


Figure 8
Decreasing Returns to Drilling



As a result the Soviets now must increase production drilling annually just to keep output steady. Figure 8, drawn from Soviet open source data, illustrates the dilemma: oil production increases as drilling increases but at a decreasing rate. The severity of the problem was summed up by the Soviet Oil Minister, who stated that for the 1976-80 period the oil industry had to drill wells able to produce 8 tons of oil just to get a 1 ton net increase in oil production, with the other 7 tons (88 percent) going to offset the depleted capacity from old wells. In the 1981-85 period some 95 percent of new capacity will go to offset depleted capacity

Capabilities To Meet the Challenge

How successful the Soviets will be in coping with these challenges during the rest of this decade will depend in large measure on the technical capabilities of their oil industry. These capabilities are mixed.*

The USSR's first-place position in world oil production appears to us to be primarily the result of an abundant resource base and sheer persistence rather than of any technical and managerial virtuosity on the part of its oil industry, which for many years has suffered from equipment shortages, technology shortcomings, and lagging productivity and efficiency. Indeed, though accorded high-priority status in the civilian sector, we find the oil industry to be troubled by many of the same problems that afflict other Soviet industries.

Faced with a deteriorating reserve base and investment constraints in the 1980s, key segments of the oil industry will clearly need to improve their performance and efficiency if the Soviets are to avoid a production decline. Moscow has been attempting to accomplish this with an across-the-board program of foreign equipment purchases and domestic technology enhancements. In our judgment, this program has met with some success and will result in continued but uneven improvements in this decade that will help prevent a drastic production downturn. In light of the inefficiencies and inflexibility of the Soviet economic system, we do not, however, expect the Soviet program to result in the kinds of fundamental changes in

*See appendix, "Capabilities of the Soviet Oil Industry," for a more complete description of these strengths and weaknesses.

Table 3
Apparent Strengths and Weaknesses of the Soviet Oil Industry

Technical Capability	Current Status	Potential for Near-Term Improvement
Planning and management	Better than most other civilian industries.	Some administrative changes under way, but impact is questionable.
Technology (general)	Theoretical knowledge rates strong; application is weak.	Aggressive modernization and Western acquisition program but assimilation still a problem.
Exploration	Technologic level is 10 years behind the United States.	Soviets would need to shift some emphasis away from development and production.
Drilling	Reasonably good for shallow work; weak for deep work because of equipment limitations.	Improvements in technology and equipment will be offset in part by increasingly difficult geologic conditions.
Production methods	Field technology is generally 10 years behind the United States; highly dependent on Western technology for advanced artificial lift and enhanced oil recovery.	Improvement would depend on substantial availability of Western equipment and on willingness of Soviets to modify some field development practices.
Offshore	Soviet experience is very limited.	Rapidly improving as a result of infusions of Western and Japanese technology.
Pipelines (oil)	Relatively strong.	Oil pipeline construction must compete with a high-priority gas pipeline effort.
Refining	Current refining system is marginal in capacity terms and does not deliver an optimal product mix.	Improvements are coming slowly and will depend on availability of Western equipment for secondary refining.

the petroleum industry that would allow production to continue growing through the rest of this decade without a disproportionate increase in cost and expense.

Strengths Versus Weaknesses. Although we would not rate the Soviet oil industry as being without at least some significant limitations on every front, the Soviets are clearly more capable in some areas than others. Table 3 summarizes our best current judgments—buttressed by data from industry experts, our own engineering analysis, and data [redacted]—of the capabilities of eight critical segments of the Soviet oil industry.

On the positive side, the Soviet oil pipeline system appears adequate to support planned production rates through the end of this FYP if additions now planned for West Siberia are completed on schedule. We rate the overall quality of planning and management in the Soviet oil industry as well as Soviet capabilities in the areas of petroleum technology, exploration, offshore operations, and refining as either marginal or weak relative to those of Western oil industries. None of these, however, are likely by themselves to impose critical constraints on current Soviet oil production in the 1980s if the Soviets move ahead with planned improvements. Failure by the Soviets to continue upgrading their capabilities in these areas, however, would be an important signal of their inability or unwillingness to keep increasing oil production. Moreover, we do not believe that the Soviet strengths in these areas are—or will be in this decade—sufficient to compensate for weaknesses in the others.

On the negative side, two areas of weakness stand out, and, in our view, promise to constrain Soviet efforts throughout this decade. One key weakness is Soviet drilling capability. Over the past 10 years or so Soviet drillers have reported large annual gains in meterage drilled, thus helping to keep production growing, but they have consistently fallen far short of planned goals

and productivity targets. Soviet technical literature and [redacted] indicate that the main problems have been the relatively mediocre quality of Soviet drilling equipment and poor execution in the field. Soviet capabilities in production methods are even weaker. Overall, we would rate Soviet oilfield technology and recovery practices as about 10 to 20 years behind those of the United States, and the Soviets remain highly dependent on Western designs and equipment for advanced artificial lift systems and enhanced oil recovery. Moreover, Soviet production practices have tended to emphasize achieving high-volume production rates rapidly at the expense of more balanced field development and larger ultimate recovery. Improvements in both drilling and production methods have been slow, and the Soviets have generally opted for corrections that increased the level rather than the quality of the effort.

Prospects for Success. The Soviets are now moving ahead with a broad range of programs to upgrade the capabilities of their oil industry, streamline the planning and management system, and increase efficiency. We know [redacted] that Moscow is expanding its already aggressive programs for acquiring Western equipment and technology and for enhancing domestic capabilities to manufacture large volumes of higher quality oilfield equipment such as drill bits and pipe. We expect many of these programs to meet with some success.

The real issue, however, is whether these improvements can be made quickly enough to offset the disturbing trends confronting the industry. By 1990, for example, we estimate the average flow rate of new wells will have fallen by 20 to 50 percent. We also expect that the average national watercut, currently about 60 percent, will have risen by at least 10 or 15 percentage points. The pressure will be on the Soviets to deliver accelerating rates of increase in drilling meterage and fluid lift capacity just to offset the production declines occurring nationwide and at key fields. Based on the Soviets' past record, we believe it will be extremely difficult and very costly in investment terms for them to do this. In our view the improvements now being made by the Soviets are likely to occur too late and in less critical segments of the oil industry, and thus will not obviate the need for an intensification of the brute-force development approach on which Moscow has relied to keep production growing, however slowly, since the late 1970s.

Consequently, in estimating Soviet production possibilities for the rest of this decade, our analysis reflects an assessment that the negative trends now facing the oil industry can at best be stabilized or moderated somewhat and, indeed, are more likely to continue at the same pace as in recent years. Thus, the gains Moscow is most likely to achieve will come from increases in the inputs—the factors of production—rather than from any major increases in efficiency. Data [redacted] convince us that this is how the Soviets also see the task, particularly in the critical drilling industry.

Estimating Approach

Although the problems facing the Soviets are national in scope, we have divided our analysis of Soviet production possibilities along regional lines—with West Siberia on one side and the other producing areas taken as a whole on the other. West Siberia is now the dominant Soviet producing area, and it is also the only major producing region with strong prospects for growth during this decade. We consequently chose to examine it in great detail, using not only relatively simple reserves analysis and decline curve analogies with other producing regions but also statistical and planning models. Information [redacted] not generally available for other producing regions—permits a more detailed approach and allows us to incorporate data on investment (drilling and wells) and field conditions (decline rates and well flows). (See inset page 1)

In contrast, oil output from the rest of the country—where all but two of the principal regions are in decline—is falling, and future production can be estimated by fitting standard decline curves to production data since the 1975 peak. We also estimated gas condensate production separately. A growing share of condensate yield comes from gasfields rather than oilfields, and is not directly related to drilling or other investment measures for the oil industry. We

Production Forecasts: A Methodological View

We used a variety of methods to estimate future Soviet oil production levels because of the inherent uncertainty of production estimating and because no single methodology is applicable in all instances. For example, some methods are more suitable for fields or regions that exhibit increasing production, while others work better on declining fields or regions.

The most precise method of estimating oil production is detailed field and reservoir engineering analysis, which looks at geologic and operating characteristics of individual fields and their past production histories in depth, and then models the field to project future production possibilities under alternative development scenarios. Ideally we would like to apply this method to all current and emerging Soviet oilfields, and then simply sum the individual forecasts to estimate national oil production. Unfortunately, sufficient data on most fields are not available, and, even if they were, the cost of carrying out the analysis would be prohibitive.

Because of the impossibility of applying the field-by-field engineering approach to the entire USSR, we used several other estimating methods. In regions of the USSR where the majority of fields have reached maturity and production is well documented and already falling, we have applied simple decline curve analysis. The validity of the decline curve approach relies on the fact that, once production at an oilfield has peaked, subsequent production generally follows an observable and predictable rate of decline that can be described mathematically with a regression (trend) line and used to predict future performance at the field. In producing regions where most—if not all—fields have peaked, we can plot a composite decline curve for the area as a whole. This is standard engineering practice and typically yields good results.

In regions of the country—principally West Siberia—where production is currently growing, we used four separate approaches that yield convergent results:

- *We inferred production by extrapolating R/P ratio series based on our highest and lowest estimates of proved reserves.*
- *On the basis of our reserve estimates and the Soviets' experience in more mature oil-producing regions, we hypothesized a series of possible peak years and associated production rates, and then declined production at rates based on historical trends for other areas.*
- *We made individual estimates of capacity-decline rates, the number of new wells, and well flows, and substituted these values into a formula—similar to the one used by the Soviets for planning purposes—where production capacity is the sum of start-of-year capacity plus net change in production capacity over the year.*
- *We developed a series of statistical estimating equations that relate annual changes in production to essentially the same variables described above via a multiple regression model.*

Data to support these approaches come from a variety of [redacted], *our own geologic and engineering analyses and field studies,* [redacted] *and open Soviet statistics.*

None of these methods yield entirely satisfactory results. We prefer the latter two approaches, however, because of their ability to account statistically for the more critical variables that will affect output.

An appendix—"Soviet Oil Production Forecasts: A Methodological View"—presenting the detailed results obtained by the four methodologies is available [redacted]

prepared our condensate estimates by fitting growth curves, analyzing Soviet expectations, and performing engineering calculations of the amount of condensate possible in Soviet gas reservoirs (see inset page 18 and figure 9 and inset page 21 and figure 10)

In addition, we performed reservoir engineering analyses of 12 key Soviet oilfields—including all the supergiants and many of the large giants in the USSR. In virtually all major oil-producing countries, a few giant or supergiant fields produce most of the oil, with the balance of production coming from many small fields. The Soviet Union is no exception: Samotlor, Romashkino, and Fedorovo, the three top ranking fields, accounted for about 35 percent of 1982 production. Though we lack the data to model enough key fields to permit a nationwide estimate based only on reservoir analysis, this specific technique has provided a key source of supplementary field data and a useful check on the regional production estimates (see inset page 23 and figure 11).

Forecasts

West Siberia. West Siberia is the region the Soviets are counting on to hold their oil industry together for at least the rest of this decade. This is the region where they plan to expend the bulk of new oil industry investment. Based on our calculations, we expect West Siberian production to continue growing through at least 1986 and possibly until the end of the decade, though the latter would be a very expensive proposition.

At the current pace of development—and assuming planned investment levels are carried through—we believe that West Siberian production for 1985 will approach or reach the target of 7.9 million b/d. After 1985 production growth in West Siberia could slow appreciably, with output probably peaking in the late 1980s. By 1990, under what we view to be the most likely circumstances, West Siberian production would range roughly between 7 and 8 million b/d. Our forecast assumes that the Soviets approach their 1985 drilling plans in Siberia and continue to increase drilling in the last half of the decade at the same rate as during the first half, and that field conditions are no worse than Soviet statements or our geological studies suggest them to be. In the extreme cases, if the Soviets could triple drilling meterage in West Siberia

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Non-West Siberian Regions

Declining Regions

Other than West Siberia, Komi, and Kazakhstan, all major Soviet oil-producing regions are in decline. Production from these declining regions—the Volga-Urals, Belorussia, Ukraine, Azerbaijan, North Caucasus, and Central Asia—fell by a total of 1.2 million b/d from 1976 to 1980, with a further decline of 1.4 million b/d planned for the 1981-85 period. These declines will continue through the late 1980s, although their rates may slow. Substantial efforts—drilling, pump installation, and well maintenance—are necessary even to hold the declines to planned levels. During this FYP, for example, some 30 percent of Oil Ministry development drilling is planned for the declining regions. If these efforts are reduced, the production decline will be steeper.

Volga-Urals

The Volga-Urals region, which includes eight individual oil-production associations, accounts for 85 to 90 percent of production from these declining regions. Production began in the Volga-Urals during the 1930s, but growth in oil output did not start to accelerate until the late 1950s when the supergiant Romashkino field and several other major deposits were developed. The decline of these major fields, coupled with delays in developing smaller, lower quality deposits, caused regional production to peak in 1975. We expect Volga-Urals production to drop nearly 2 million b/d below peak by 1985 and to fall an additional 600,000 to 700,000 b/d by 1990.

Stable Regions

Several producing regions—Georgia, Sakhalin, and the Baltic—have been able to stabilize production or post slight increases. These regions accounted for only 1 to 2 percent of 1981 production, less than

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250,000 b/d. Aside from offshore Sakhalin (discussed below), little change is anticipated for these regions in the 1980s.

Growth Regions

Of the three major growth regions—Komi, Kazakhstan, and West Siberia—only West Siberia provides more than 5 percent of national production. Nevertheless, given the soaring marginal cost of oil, Komi and Kazakhstan merit careful evaluation.

Komi

Komi, despite repeated disappointments, remains one of the Soviets' hopes for the 1980s. Although the region appears to have substantial resources—we have identified 52 oil and gas fields and at least 25 potential fields—development has been slowed by the extreme arctic environment and the heavy and paraffinic oils that are characteristic of the region. Nevertheless, the Soviets are committed to developing the oil and gas condensate reserves of the region. The number of active drill rigs in Komi is far out of proportion to its contribution to national oil production. We believe that Komi has an outside chance of meeting its 1985 plan goal of 500,000 b/d but that declining condensate production, lagging injection programs, poor infrastructure and supply, and competition from West Siberia will limit growth prospects in the late 1980s.

Kazakhstan

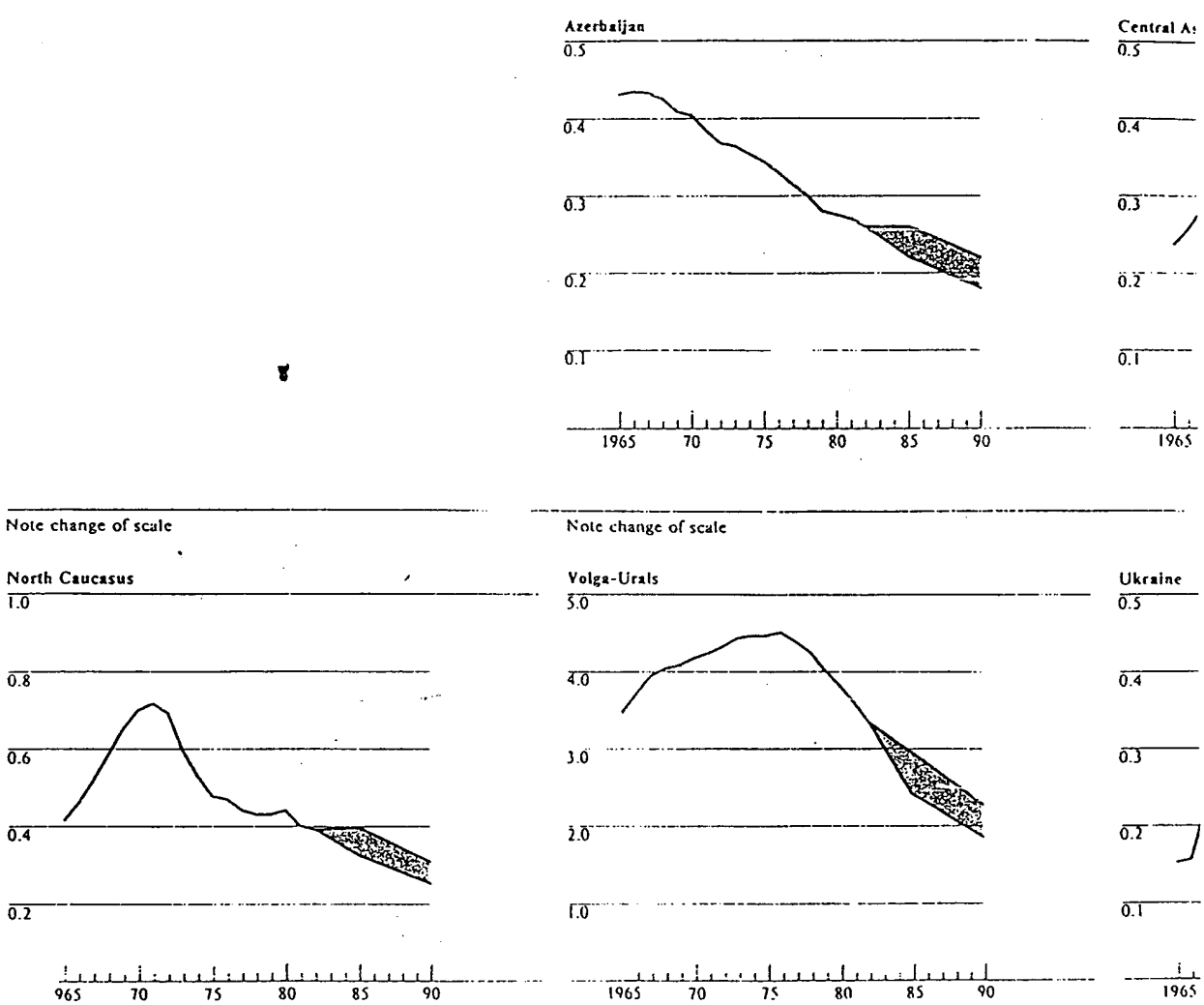
Kazakhstan's production comes primarily from three areas: the Mangyshlak Peninsula, dominated by the giant Uzen field; the Buzachi Peninsula, with several deposits of very heavy oil; and the Emba region, the source of early Kazakh production. Kazakh oil producers face some of the most difficult conditions in the USSR: the highly paraffinic Uzen oil has long bedeviled Soviet oilmen, and the heavy Buzachi oil must be produced by expensive EOR methods; a more recent discovery, the Tenghiz oilfield, has extremely high sulfur and CO_2 content. In addition, labor turnover is a problem, a result of some of the harshest weather conditions in the Soviet Union. Our analysis indicates that the Soviets will be unable to achieve more than slight increases in Kazakh production through 1985, with stable production or slight declines later in the 1980s.

Offshore

The Soviets also have substantial offshore oil and gas potential. Aside from Sakhalin, most of the more promising offshore areas—the Barents and Kara Seas, for example—are only now being explored, and substantial oil production will not be realized until the 1990s. We estimate that production could begin from offshore Sakhalin in 1987, but rise to only 40,000 b/d by 1990 and to some 80,000 to 90,000 b/d by the mid-1990s.

hat even this 1990 number may be overly optimistic. In the less promising areas like the Baltic, some oil has been discovered and is being produced, but the Soviets expect little growth. Exploration in the Black Sea has turned up primarily gas. There is no indication that new oil production from deeper Caspian Sea areas can do more than compensate for falling production from older, shallower deposits. Thus we believe that offshore production can do little more than hold today's rate of 200,000 to 250,000 b/d through the mid-1980s, rising perhaps to 300,000 to 400,000 b/d by 1990, depending on Soviet success in deeper areas of the Caspian.

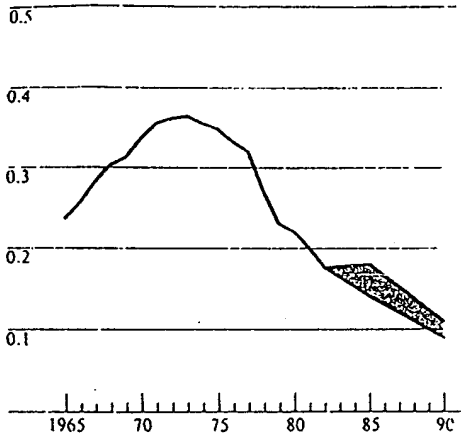
Figure 9
Oil Production From Declining and Growth Regions



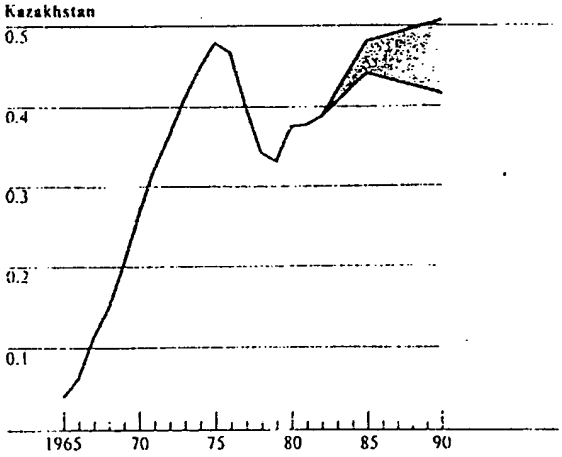
Growth

Million b/d

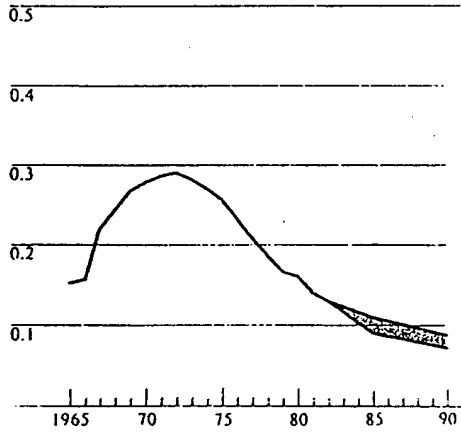
Central Asia



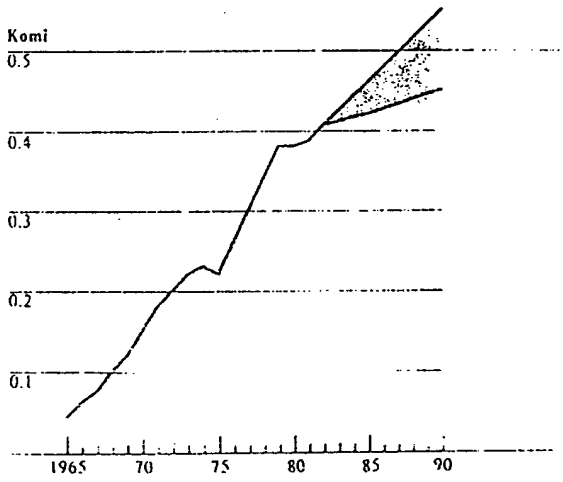
Kazakhstan



Ukraine



Komi



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Gas Condensate

Gas condensate, also called natural-gas liquids, is a hydrocarbon occurring either in natural-gas or oil-associated-gas reservoirs of great depth and high pressure. Condensate is normally in the vapor phase, but condenses as reservoir pressure is reduced during extraction. Processed components of condensate such as propane, butane, and pentane are important energy resources used as petrochemical feedstocks, motor gasoline, "bottled gas," and raw materials for other industrial uses. Since the early 1970s the Soviets have added condensate output to that of crude when reporting figures for total oil production.

Reserves

Data are sparse on Soviet condensate reserves, but both Soviet and Western oil experts believe the reserves are substantial. We estimate them to range from 1.6 to 2 billion tons; they are widely distributed in the USSR, with numerous deposits in West Siberia, Komi ASSR, western Kazakhstan, Central Asia, and the Ukraine. Soviet sources indicate, however, that at least 40 percent of total condensate reserves are in West Siberia, primarily in the immense North Tyumen gasfields. Based on available data [ ] recently published Soviet reports, we estimate current proved oil-associated gas condensate reserves in West Siberia to range from 136 to 272 million tons, with indications of another 547 to 818 million tons of condensate reserves associated with gasfields.

Current Production Trends

Significant production of condensate was not achieved until the early 1970s, when the Soviets first began to add condensate totals to their crude oil production output. By 1975 production had risen to 9 million tons, with some 5.7 million coming from two condensate fields—Vuktyl in Komi ASSR and Orenburg in the southern Urals. Since that time national and regional condensate production figures have not been provided by the Soviets. We estimate, based on Soviet open-source data and recently acquired production data [ ] that current Soviet condensate output now ranges from 20 to 23 million tons, with some 10 to 11 million tons provided by the Ministry of the Gas Industry and another 10 to 12 million tons produced by the Ministry of the Petroleum Industry.

Growth has been steady, but the Soviets have encountered numerous problems in expanding their condensate output. Condensate development has long taken a back seat in investment allocations, with the oil and gas ministries preferring instead to concentrate on easier and more rewarding oil and natural gas production. Consequently, a large percentage of both oil-associated condensate and condensate available from gas production has been lost because of inadequate processing capacity and inefficient field recovery techniques. Until very recently the Soviets have lagged badly in developing their gas-processing facilities and increasing their condensate recovery totals.

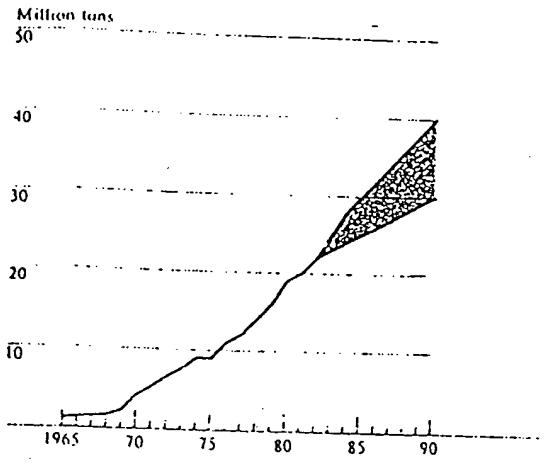
The USSR is now attempting to upgrade the capabilities of its condensate industry and has set ambitious production goals for the 1980s. We expect to see substantial production increases from West Siberia,

Central Asia, western Kazakhstan, and possibly Komi ASSR. The Soviets hope to recover about 4 million tons from Urengoy field alone by 1985, and to transport it by a major condensate pipeline that will link up with Surgut and, according to some reports, extend westward to the Volga-Urals. Two other major gas condensate fields, Astrakhan on the Volga River and Karachaganak in northwestern Kazakhstan, are slated to provide together some 3 to 4 million tons of condensate production by 1985.

Production Possibilities for the 1980s

For several reasons—the rising importance of condensate, its leverage on future oil production, the fact that most condensate is derived from natural gas, and the contrasting growth trends between condensate and crude oil—we have chosen to estimate gas condensate production separately and add these estimates to crude production to derive an overall oil estimate. Our analysis of Soviet plans, statements, and pipeline and processing capacity, and our engineering calculations on the condensate content of future Soviet natural gas production indicate that condensate production should continue to grow at the rate of 1 to 3 million tons a year. Annual output should approach 25 to 30 million tons by 1985 and some 30 to 40 million tons by 1990. The Soviets' ability to prevent rapid declines in condensate production at older oilfields and gasfields is the critical unknown in the gas condensate equation, and will determine whether production reaches the low or high end of our estimate.

Figure 10
Soviet Union: Gas Condensate Production



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Key Fields: An Engineering Analysis

In any country a few key fields usually account for most of the oil production. This is especially true in the USSR, whose production has historically benefited from the early contributions of Baku, from Romashkino and Arlan in the 1960s, and Samotlor in the 1970s. Consequently we have examined in great detail the future production possibilities of 12 of the USSR's largest fields, comprising the four largest fields in the country and eight large deposits in the critical West Siberian Basin.

Our Approach

The Soviets have for some time published only fragmentary and often conflicting production data for major oilfields. To overcome this problem, we have developed a number of predictive geologic, reservoir engineering, and [redacted] methodologies. These methodologies utilize available Soviet open-source scientific data, [redacted] and allow us to estimate with some precision the reserves, current production, and future yields of Soviet oilfields under alternative development scenarios. We are quite confident of the accuracy of the short-term production estimates and of the general trends our approach reveals. These detailed field analyses are useful as analogs for other Soviet fields, and also provide us with an excellent understanding of the strengths and weaknesses of Soviet oilfield development practices.

Findings

Our engineering analyses reveal that:

- *The 12 large fields in our sample contributed about 45 percent of total Soviet oil production in 1982. Production from these fields is now declining at an average annual rate of 5 percent per year; their contribution to national oil production could fall to 35 percent in 1985 and as low as 25 percent in 1990.*
- *By the end of this decade, even under the best of circumstances, the Soviets will need to produce at least 2-3 million additional b/d of oil from other deposits—an amount greater than total Soviet oil exports to Eastern Europe and at least two-thirds of Mexico's current oil production—just to compensate for the anticipated decline of these fields.*
- *The supergiant Samotlor, the driving force behind West Siberian production growth for a decade, peaked at 3.2 million b/d in 1980. Our analysis indicates that this critical field produced 2.8 million b/d in 1982 and will decline by as much as 10 to 15 percent or more annually, through most of the rest of this decade.*
- *The second-generation West Siberian fields—such as Fedorovo, Mamontovo, Lyantor, Agan, and Severo-Varyegan—which the Soviets expect to provide production increments in the wake of the Samotlor decline, will peak in the mid-1980s. By 1990, seven of the eight West Siberian fields we analyzed will be in decline.*
- *According to our analysis the Soviets seriously mismanaged the fields in our sample, resulting in irreversible reservoir damage in many cases. The track record of the petroleum industry at difficult-to-develop fields such as Uzen in Kazakhstan has been particularly poor*

Conclusions and Implications

Our engineering analyses reinforce much of what the Soviets themselves have been saying about the problems facing the oil industry in the rest of the decade as well as some other problems we have highlighted in this paper:

- *The Soviets have stated repeatedly that they must develop a large number of smaller fields later in this decade, one of the primary reasons for the rising costs of oil production. Our engineering analyses confirm that the contribution of larger fields will fall rapidly in this decade [redacted] the Soviets, particularly in the middle Ob', are moving to*

develop many of the small fields. We find no evidence of the discovery and development of any new supergiant or large giant fields.

- *Soviet oilmen are indeed facing the problem of decreasing reserve quality, requiring more sophisticated and costly recovery techniques. In Kazakhstan—where they are trying to slow the decline of the damaged Uzen field, and at nearby Kalamkas, the source of most of the new production in Kazakhstan—they are attempting with limited success to institute thermal recovery methods on a large scale. Our geologic analysis of the newer West Siberian fields indicates that well flow rates will continue to decrease as the Soviets move farther away from the older established producing areas.*

- *Our survey of key fields helps confirm the fact that the Soviets can do little to halt the rapid decline of older producing regions. Romashkino and Arlan, which account for 32 percent of production from the large Volga-Urals producing region, will continue in steep decline unless the Soviets attempt costly and risky enhanced recovery techniques.*

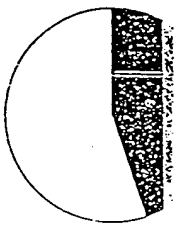
- *Soviet technical literature has emphasized the need for better and more cost-effective field development practices. Our analysis indicates that the Soviets have plenty of room for improvement in this regard; and if the Ministry of the Petroleum Industry changes some of its more controversial procedures, newer fields could sustain longer production peaks and significantly improve the Soviet oil outlook later in this decade.*

- *The 11th FYP calls for large increases in drilling and in installation of pumps and gas lift in West Siberian fields. Our engineering analysis confirms that this effort will be pivotal if the Soviets are to keep West Siberian production growing.*

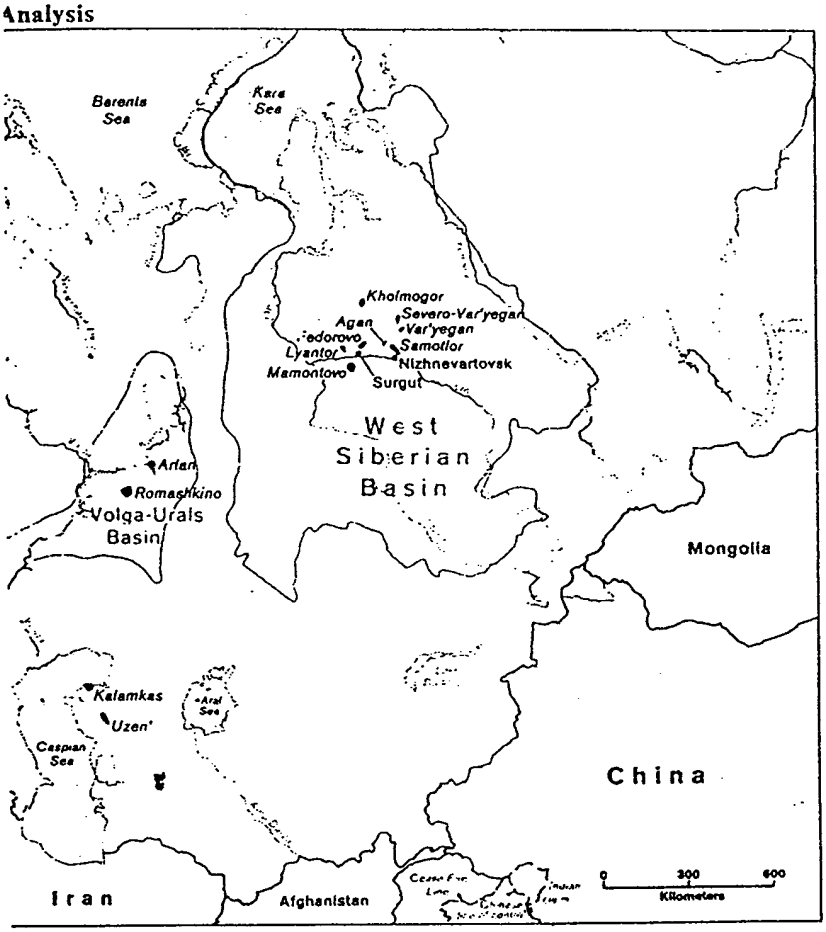
Figure 11
Soviet Union: Key Oilfield

National Production: Share

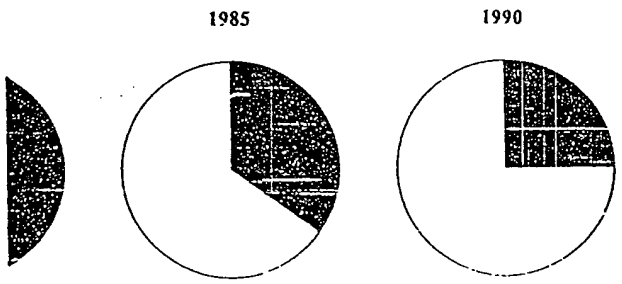
1982



Analysis



of Key Fields



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between now and 1990, production could approach 9 million b/d. Conversely, if the Soviets either chose or were not able to at least double drilling between now and 1990, West Siberian production could peak in the mid-1980s and fall as low as 6 million b/d by 1990.

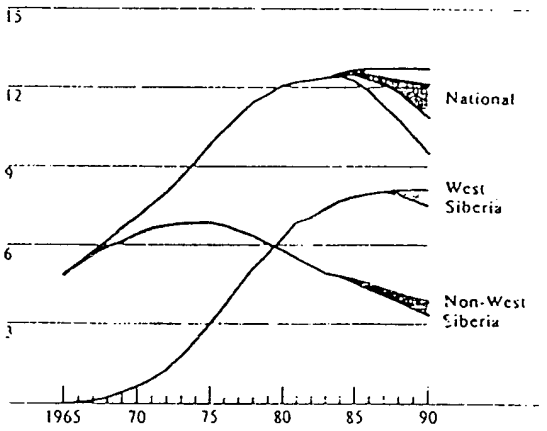
The extent of Soviet success in West Siberia will depend in large measure on their ability to continue developing smaller fields to replace the supergiant Samotlor. The rapid growth in oil production from West Siberia in the 1970s was made possible by this single key field. At its peak in 1980 Samotlor produced more than 3.2 million b/d—just over one-half of West Siberia's total production. Today, production from the original Samotlor reporting unit is declining; in 1982 the field produced about 2.8 million b/d, and by 1985 production could be about 2.0 million b/d, according to our engineering analysis. Thus far the Soviets have been able to draw more than enough production from newer fields in West Siberia like Fedorovo to make up for losses from Samotlor, but this is an increasingly costly proposition.[10]

of Soviet drilling activity indicates that the Soviets have high hopes for fields and geologic structures in the new Noyabr'sk production association in the northern part of the middle Ob' region. Our geologic analysis indicates that this area does have the potential for giant fields. The discovery and rapid development of another Samotlor, or even a Fedorovo, though possible, does not seem likely in this decade.

Non-West Siberia. On the whole, the Soviets hold no hopes of increasing total production outside West Siberia during this decade. They are, however, counting on increased production from Komi and Kazakhstan—the only major non-West Siberian regions showing any appreciable growth in percentage terms—to help slow the rate of decline of non-West Siberian production. Soviet plans call for production of 4.7 million b/d of oil outside West Siberia in 1985, an average annual decline of more than 3 percent from 1982. This contrasts with the 5- to 6-percent annual declines between 1980 and 1982 and suggests that the Soviets hope to slow the rate of decline—though the task may not be easy. We expect based on

[10] Sc

Figure 12
Soviet Union: Oil Production Forecasts



the decline rate analysis (see inset page 18) that, at best, the Soviets may be able to reach their plan of approximately 4.7 million b/d in 1985 and slow the decline adequately to keep production at around 4 million b/d in 1990. We expect non-West Siberian production to fall to around 4.6 million b/d in 1985 and to between 3.3 and 3.8 million b/d by 1990

National. Our calculations, summarized in figure 12, yield a range of possibilities for Soviet oil production between now and the end of this decade. Our forecasts for the years through 1985 cluster closely enough to suggest that, assuming the Soviets follow through with their current development plans, they should come very close to, if not meet, their announced production target nationwide of 12.6 million b/d. A shortfall greater than several hundred thousand b/d, though possible, would be unlikely

Beyond 1985, the range of possibilities opens up considerably, with the forecasts varying according to what estimating methodologies and assumptions about investment and geologic conditions are used:

- Analysis based on the likely magnitude of the Soviets' current base of proved reserves provides what is essentially a bounding set of estimates, and suggests that production can, at best, grow slowly, to no more than 13 million b/d by 1990. At worst, these reserves would provide a basis for production at a level no less than 9 million b/d by that year.

- Use of decline curve analysis for West Siberia—with Soviet experience in the Volga-Urals region serving as the paradigm—provides similar results and suggests that national production will begin to decline by the middle of this decade and stand somewhere between 10 and 12 million b/d by 1990.

Neither of these estimates explicitly incorporates key variables indexing level of effort or changing field conditions. When these considerations are introduced into the calculations, the forecasts still remain well within the same range:

- Substituting realistic high and low estimates of investment and geologic indicators—drilling, capacity decline rates at old fields, and new well flows—into a planning formula similar to one Soviet economists use suggests that, at best, Soviet production will remain stable at its current level through the end of this decade or, at worst, begin to decline shortly and fall to a point between 9 and 10 million b/d by 1990.

- Statistical modeling, using similar values for these key variables, indicates that production is unlikely to increase beyond 13 million b/d or to fall below 11 to 12 million b/d by 1990.

There is, of course, no single correct answer. But, when we adjust our methodologies to incorporate what now appear to be the most likely values for the principal investment and geologic variables, we conclude that by the middle of this decade Soviet oil output will have probably reached a plateau and could subsequently begin to fall to between 10 and 12 million b/d by 1990. Somewhat higher and lower production paths are possible, but depend on assumptions that, based on current indications, appear overly optimistic or pessimistic in terms of Soviet capabilities and the geologic conditions the Soviet oil industry will increasingly be facing.

We believe that Moscow will choose an investment path calculated to keep output between 11 and 12 million b/d at the end of the decade. Based on our estimates of the likely range of unconstrained demand for Soviet oil—that is, domestic needs plus export requirements—the Soviets would be hard pressed to cope with the shortfall that would occur were production to drop below 11 million b/d by 1990. In view of their oil reserves and the capabilities of the oil industry, it appears almost certain that the Soviets would take steps to avoid such a shortfall.

Whatever happens, investment—in the form of more money, manpower, drilling, and equipment—will be the key. And, the costs will be substantial, as illustrated in table 4. The Soviets will need to double their overall level of investment simply to keep production from falling below the range of 9 and 11.5 million b/d by 1990. Conversely, they will probably need to triple overall investment to ensure output remains at or near current levels.

Potential Surprises. Our projections of future national oil production possibilities are based on current Soviet plans and our assessment of likely future Soviet capabilities, on the geology of areas now being developed or explored, and on the Soviets' record of dealing with oil production and exploration problems in the past. Though our production possibility estimates allow for what appears to us to be the most likely combinations of circumstances, we cannot rule out the possibility of a surprising development that might greatly alter each of the supply scenarios, particularly those comprising what we believe to be the most likely cases. A favorable combination of developments could make it much easier for the Soviets to keep output at about 12 million b/d during this decade. An unfavorable combination, however, could work to pull production below 11 million b/d by 1990.

Table 4
Soviet Investment Options

	1982	1990 Requirement	
		Low Production (*9-11.5 million b/d*)	High Production (*12-13 million b/d*)
Oil Ministry drilling (*million meters*)	23.3	30-40	50
Drilling brigades	1,400	1,800-1,900	2,100-2,200
Oil Ministry Work Force	400,000	500,000-550,000	610,000-620,000
Total wells	90,000	160,000-170,000	170,000-180,000
Wells on artificial lift	78,000	150,000	160,000
Investment (*billion rubles*)	8-9	18-20	24-28

On the positive side, the Soviets could identify another Samotlor-class supergiant field. Our assessment of the middle Ob' region of West Siberia indicates the possibility of several very large undrilled structures with supergiant potential. If such a field were favorably located and developed on a crash basis, it could reverse by the end of the decade many of the negative trends in oil production that have been occurring over the past few years. Even if not in a class with Samotlor or even Fedorovo, a single large field would be much easier and cheaper to develop than a number of small fields, and could give Soviet oil production an unexpected boost in the late 1980s. Much has been made in the Western press of Soviet failure to find large fields, and there have been no indications that any of the new fields reported in the Soviet press are of this size. All things considered, we discount the likelihood of such a discovery but cannot rule it out.

An unexpected stimulus could raise production by the end of the decade if the Soviets reverse past policies and open up the country, as China has recently done, to exploration and development by Western companies through traditional joint-risk ventures. The companies could provide technology, equipment, and even skilled labor in return for a share of any future oil produced. Ideologic considerations aside, joint ventures would appear to be economically attractive to the Soviets, particularly in offshore areas requiring state-of-the-art technology. Even assuming the willingness of Western firms to participate and the availability of equipment, the Soviets would have to make this decision very soon, or the inevitable time lags between negotiations and production would prevent any significant output in this decade. For the Soviets to pursue such a course for onshore oil development, a major—and unanticipated—reversal in the thinking of the leadership would have to occur.

On the negative side the recent leadership changes in the Soviet Union could result in energy policy shifts that would cause our projections to be too high. Brezhnev was a powerful advocate of West Siberian oil and gas development, and little is known about new General Secretary Andropov's loyalty to this policy. Albeit unlikely in view of Soviet oil needs, the possibility exists that, under Andropov's stewardship, the leadership might attempt to cut back the oil industry's share of investment substantially and to

allocate more funds to other fuels, to vigorous conservation and substitution programs, and to other capital-short sectors of the economy. We believe—given the inertia of the energy sector, the likelihood of stiff bureaucratic resistance, and the long leadtimes involved in changing established energy policies—that the effects of such a major policy change would not be felt until the 12th FYP, beginning in 1986, at the very earliest.

Outlook for the 1980s: Implications and Alternatives

The USSR has managed thus far to avoid the precipitous downturn in production that this Agency had previously predicted. This was made possible—in the face of increasingly difficult logistic, environmental, and technologic problems—by a large reserve base and by the willingness on the part of the Soviet Government to commit itself to a brute-force development program. If our analysis of Soviet oil production possibilities and capabilities is correct—and we believe it is not too different from the Soviets' own assessment of their situation—this approach is now yielding rapidly diminishing returns. The rate at which the Soviets must pour resources into their oil industry is soaring disproportionately, creating a major drag on other sectors of the economy. In short, the marginal cost of keeping oil production relatively stable—indeed of preventing it from falling—is becoming enormous, and the limits of growth are now visible.

We do not believe that Moscow will be able to continue on this course much longer, probably not far beyond the end of this FYP, and will most likely feel compelled to accept some decline in production in order to moderate the increase in the flow of resources to the oil industry. The still sketchy details of the Soviets' new 20-year energy plan together with a number of recent statements by senior government officials, most notably [redacted] GOSPLAN, [redacted] of the oil industry, [redacted] of the Academy of Sciences, and Andropov himself, lead us to believe that the leadership is preparing to do this, possibly when the 12th FYP is announced. [redacted] has been particularly frank about the high costs of oil production and the need to increase investment in the gas and coal industries.

Though a number of scenarios are possible—depending on the international climate, the health of other key sectors of the economy, and the political self-confidence of the new leadership—in our judgment Moscow will pursue a gradual approach to the problem. We believe the Soviets will attempt to avoid any sharp drop in oil production, and will opt to back off as slowly as possible from the increasing rate of growth in oil investment that has characterized their recent efforts. How large the resulting drop in oil production and how serious its consequences would depend not only on the timing of the decision but, more importantly, on how fast production costs continued to mount and domestic energy consumption and hard currency needs continued to grow. Consequently, as oil production prospects dim, Moscow will need to seek an acceptable tradeoff among three major objectives:

- Satisfying domestic energy needs while keeping the economy growing.
- Gaining badly needed hard currency to buy grain and Western technology.
- Keeping Eastern Europe solvent and politically stable.

Supply Side Remedies and the Price of Growth

Specifically, we do not believe that—barring the unlikely discovery and rapid development of several accessible Samotlor-class fields—the Soviets will be able to support continued growth in oil output throughout this decade. Indeed, simply maintaining the level of current output may already be becoming prohibitively expensive. Accordingly, supply-side remedies can, at best, moderate a decline but not reverse it during this decade.

The Dilemma of Rising Costs. The principal cause of rising costs is the deteriorating quality of the reserve base—in the form of declining well flows, rising water cuts, and the less favorable location of new reserves. These factors increase drilling and fluid lift requirements and drive up production costs. Drilling, for

example, accounts for 40 to 50 percent of oil production costs according to Soviet sources. As operations move to the north and east away from the centers of economic activity, drilling costs per meter of well rise from 200 rubles in the middle Ob' region of West Siberia, to 500 rubles at the Arctic Circle, and to 1,600 rubles on the Yamal Peninsula, reflecting the relative remoteness of these locations, the need for stronger and more expensive climate-capable equipment, and the associated higher repair and replacement costs.[1]

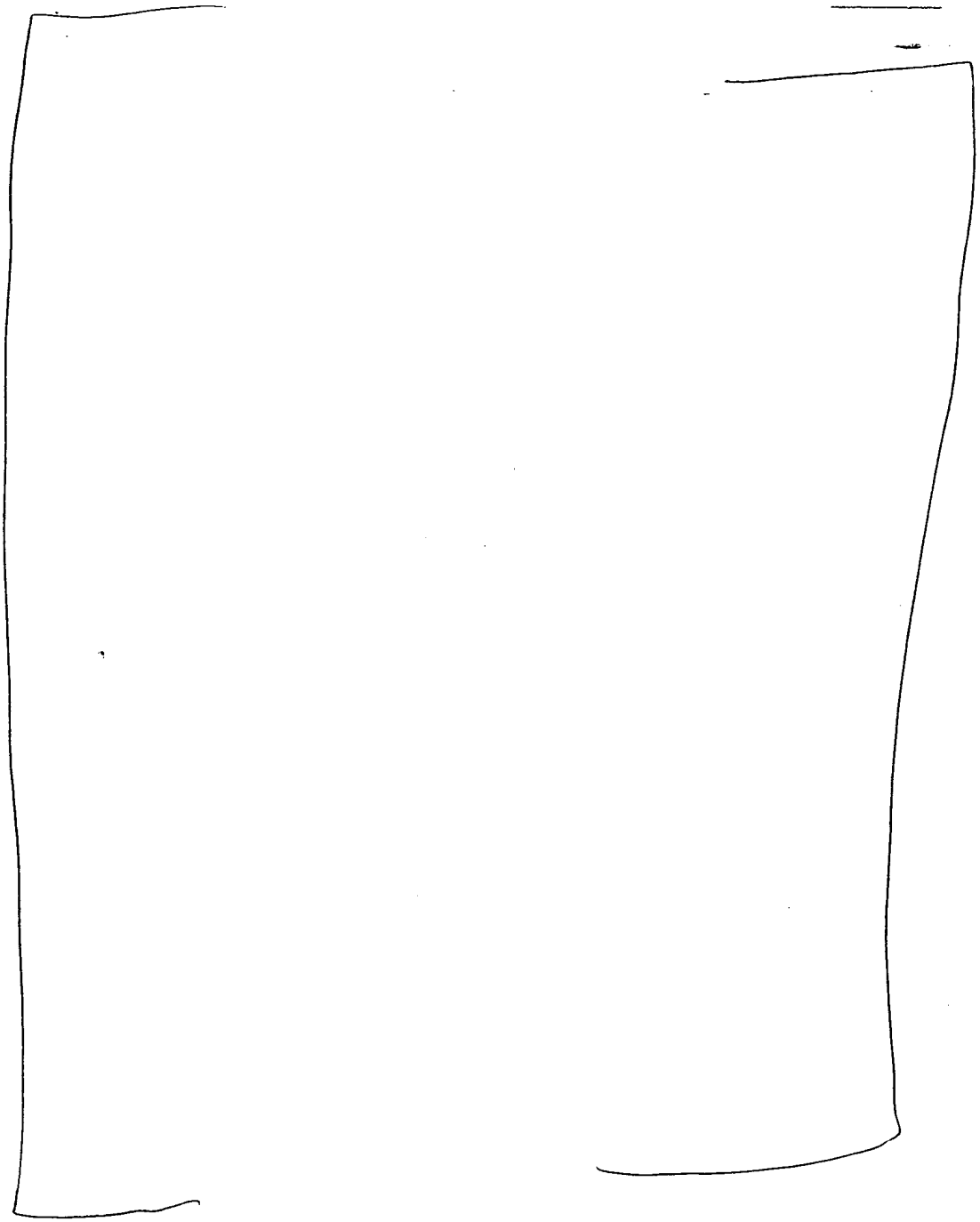
Though oil operations in West Siberia have always been very expensive, the payoff has been substantial in the past because of the very high well flows initially found in supergiant fields like Samotlor and Fedorovo. Today, however, [ ] confirm that well flows in most parts of West Siberia have fallen sharply, and watercuts have increased from their early levels. Accordingly an increasingly smaller percentage of the well stock is free flowing, raising the requirements for expensive and repair-intensive artificial lift equipment such as pumps and gas lift. To make matters worse, increased water injection raises the amount of fluid separation equipment required and, hence, associated costs. Nonetheless, achieving production increases in an existing field by intensifying drilling is far more expensive. [ ] stated that at the Soviets' largest field, Samotlor, the added cost of producing an incremental ton of oil by pumping was 1.25 rubles, while that by drilling was 14.1 rubles.

Soviet sources have reported that these changing operating conditions have caused oil production costs to triple over the past decade: from 1971 to 1975 the average cost of producing 1 ton of oil was 35 rubles; by 1981 the average cost had risen to 100 rubles. Other Soviet industry experts have estimated that deteriorating operating conditions doubled the cost of producing an incremental ton of oil from the Ninth FYP to the 10th FYP, and they expect these costs to accelerate even faster during the 11th and 12th FYP.

[1] This and all subsequent references to ruble costs from Soviet sources are for illustrative purposes only and should be considered only as relative measures of effor

The high cost of oilfield development and production is an increasingly contentious issue in the Soviet Union. Oil experts frequently use cost-based arguments for or against development of more remote regions, deeper drilling of existing deposits, use of enhanced recovery methods, and exploration of offshore areas. At the same time efforts to contain and reduce oil-related costs are much in evidence. The Soviets hope, for example, that the higher quality drill bits coming from their US-equipped plant at Kuybyshev will increase the meters drilled per bit, thereby reducing both time and cost. They are developing a new field, Sutormin in West Siberia, using several cost- and time-reducing methods [ ] Wells are being drilled on 80-well pads to ease the cost of drill site infrastructure, site preparation, and rig setup and tear down. Infrastructure costs will possibly be reduced further by a novel roadbuilding technique using compacted material dredged from the lakes to form roadbeds. The field is also utilizing modular skid-mounted gathering units—instead of larger, permanently installed facilities—to gather oil from the wells for treating and shipment

Increasing the Inputs. All things taken together, the rapidly mounting costs of producing oil are forcing Moscow to allocate an increasing share of the investment pie to the oil industry. From the perspective of the state budget as a whole, oil industry investment represented 14 percent of Soviet industrial investment in 1980. During the current FYP ending in 1985, the Soviets plan to increase the share of industrial investment going to the oil industry to 16 percent, compared to only 12 percent in the previous plan, with oil receiving some 6 percent of all investment monies for the economy as a whole and about one-third of all incremental industrial investment. Though we cannot identify the precise breakpoint, we do not believe that the Soviets can continue to increase the allocation going to the oil industry in view of the dismal performance of their agricultural and industrial sectors. Moscow, for example, invested 8 billion rubles in its oil industry in 1981, an increase of 18 percent over 1980. Based on our estimates of investment needs and past spending levels, it would have to triple its current



annual investment by 1990 in order to hold oil production at current levels through the next FYP. With slow economic growth and many competing claims on investment resources, a commitment of this size must appear extremely costly to Soviet planners.

Consequently, we believe Moscow's options for avoiding or minimizing a shortfall in oil availability are limited. Actual investment requirements are difficult to quantify, but our preliminary calculations suggest that keeping production growing, even slowly, beyond 1985 could be prohibitively expensive in terms of resources required:

- By 1990 drilling requirements would nearly triple, with sharp increases for more rigs, bits, and drill pipe.
- Even allowing for productivity improvements, the number of production workers and drillers would have to increase by 80 percent.
- As water cuts continued to rise, the Soviets would need to lift and separate a minimum of 20 million b/d of water by the end of this decade.
- At least 90,000 more wells would need to be put on some form of artificial lift.
- At the same time the associated costs of exploration and infrastructural development—housing, roads, electrification, and transport—would have to rise accordingly.

Taken individually, achievement of no single requirement is beyond the Soviets' means. But when all of these resource requirements are added together, the additional cost to the economy becomes staggering.

At the lower end of the production spectrum, there is little relief for the Soviets. Our own economic analysis of the Soviet economy coupled with data [redacted] indicate that maintaining the level of resources going to the oil industry is already a drain on the Soviet economy. Based on our estimates, however, the Soviets would have to hold investment at levels implied by the 11th FYP for 1985 just to keep oil production from falling below 9-10 million b/d by 1990.

On balance we believe the Soviets will opt for a middle course and begin to moderate the increase in the flow of new investment to oil. Exactly when and to what degree this occurs will depend on a variety of factors that cannot be accurately predicted:

- The state of the Soviet economy in general and the performance of key sectors, like agriculture.
- The Soviet perception of the military balance and the associated requirement to increase—or decrease—the flow of resources to defense.
- Global economic conditions and the state of the world oil market.
- Prospective sales of gas to Western Europe and Soviet success in increasing natural gas production and substituting gas for oil both domestically and for export.

We expect this investment path to keep average production close to 12 million b/d over the 12th FYP, with total output beginning to decline in the latter half of the 1980s and most likely standing somewhere between 11 and 12 million b/d by 1990. Barring a catastrophe of some sort, we judge this to be an attainable goal, providing that the Soviets can continue to make some increases, albeit smaller than in the past, in oil industry investment. The effort required, however, would still be greater than the one the Soviets are now making—with most of the risks on the down side—and the outcome would be far from certain.

The Demand Side

In the final analysis, the adequacy of Soviet oil supplies during this decade will depend in large measure on the level and structure of demand for Soviet oil and the ability of the Soviets to manipulate that demand.[12] Since the mid-1950s the Soviets have been able to produce as much oil as they needed internally, with an ample share left over for export. By definition then, domestic oil consumption, and hence requirements, always equaled total oil production less net exports and stock changes. In such an environment the Soviet economy has become increasingly dependent on oil, which now accounts for 35 to 40 percent of energy use and ranks as the USSR's most important energy source.

[12] The Agency as well as several outside scholars are now undertaking major studies of the Soviet energy demand. Some of these will appear later in 1983.

In round numbers, the Soviets consume about 9 million barrels of oil daily, with the bulk going to transportation, industry, electricity, and agriculture. The Soviets export another 3.2-3.3 million b/d, with about 2.3 million b/d of that shipped to Eastern Europe, Cuba, and other soft currency buyers and the balance sold on the world market—mainly to France, the Netherlands, Italy, and West Germany—for hard currency.[13] On the whole, Soviet oil satisfies 85 percent of the oil requirements of the non-Soviet CEMA countries. The hard currency sales component is also extremely important. Oil—which earned the Soviets about $12.2 billion dollars in 1981—is now the largest single source of Soviet foreign exchange and yields Moscow a greater return than any other export item.

Because of the difficulties inherent in decoupling supply from demand in the Soviet context, future oil requirements are tricky to estimate. Based on analysis of open-source material and data including planning documents, we believe that total demand for Soviet oil, unless further constrained by production or outside events, will continue to grow throughout the rest of this decade. Though precise estimates are difficult to make and must be treated with extreme care, we calculate that total domestic demand for energy will rise from about 24 million b/d oil equivalent (b/doe) to about 27 million b/doe in 1985, and to slightly more than 29 million b/doe by 1990. Allowing for projected growth in supplies of other energy sources and for anticipated substitution among them, internal requirements for oil would grow slightly, to about 9.5-10 million b/d in 1990.[14] Soft currency deliveries of Soviet oil, on the other hand, are unlikely to grow beyond the current levels—and will probably shrink. Since the late 1970s, the Soviets have put pressure on Eastern Europe and Cuba to reduce their liftings, and have also imposed several unilateral reductions on deliveries to CEMA countries. Hard currency demand for Soviet oil—or more properly, projected Soviet requirements to earn hard currency from oil—will depend on a number of variables that are nearly impossible to anticipate such as the state of Western markets for Soviet nonenergy exports, the world oil market, and the quantity of gas sold to Western Europe.[15] But, assuming that the current gas pipeline project is completed and European customers take all the gas to which they are entitled and that all other factors remain about the same (or change in a fashion to balance one another out), by 1990 Moscow would need to export only one-half the oil it does now to maintain the 1981 level of total hard currency earnings. Combining all these estimates, unconstrained total demand for Soviet oil would probably remain somewhere between 12 and 13 million b/d over the rest of this decade.

When our estimates of total unconstrained demand are compared with the likely range of Soviet oil production, it is clear that the Soviets should be easily able to satisfy their oil requirements through 1985. In the latter half of the decade, however, Moscow could face a potential oil supply shortfall of several hundred thousand to several million b/d, depending on what investment path it chooses for the oil industry during the 12th FYP. In the most likely supply case, we would expect that the Soviets would need to compensate for a shortfall of about 500,000 million b/d. Though a distressing prospect from a Soviet standpoint, this is not, in our judgment, an unmanageable gap.

Distributing Any Shortfall. Analysis of the demand side of the equation highlights the real crux of the Soviets' oil dilemma. Under no likely set of circumstances, even the most dismal ones, would the Soviets fail to produce enough oil to satisfy their domestic needs during this decade. Rather, their problem occurs at the margin, where they might be forced to choose between earning hard currency, and maintaining stability in Eastern Europe without aggravating an already tense domestic energy situation. During the first half of this decade the Soviet oil problem will be largely one of hard currency. The pressure will not be off oil as a revenue earner until the late 1980s,

when sales of Siberian gas to Western Europe should be well on line. Until then, the Soviets will likely try to distribute any oil supply shortfall over domestic consumption and soft currency sales.

On the domestic side Moscow would need to look to conservation and substitution to do the job, but its track record on both of these has been poor to date. Our projections of internal consumption already assume some additional conservation as well as interfuel substitution, particularly gas for oil. On the whole we believe the Soviet options for additional decreases in oil consumption over this decade are very limited, amounting to, in very rough numbers, perhaps 500,000 b/d of oil by 1990, or about 5 percent of current use

The factors that will limit Soviet success in achieving significant oil savings via conservation or substitution of other fuels for oil are reasonably clear:

- The structure of Soviet oil consumption does not lend itself to substantial discretionary cuts or to rapid adjustments to changes in supply levels. Unlike the United States, for example, the Soviet Union burns little gasoline in personal transportation and related uses. Instead, the bulk of oil use is concentrated in public transportation, electrical generation, agriculture, and heavy industry, where consumption rates are determined by the size and condition of the physical plant and capital stock.

- Despite some improvements since the 1960s, including substantial increases in energy prices, the role of petroleum product prices in enterprise decisions does not encourage efficient use and will not help to ration oil during a supply shortfall. The Soviets are well aware of this problem, as their economic literature indicates, but they have been unable to correct it.

- Interfuel substitution is sharply constrained by inadequacies in the distribution network for gas and coal, and by the limited ability of the refinery industry to alter its product mix. Moreover, major oil users like agriculture and heavy transport are not equipped to use fuels other than oil. Finally, development of both coal and nuclear power production is lagging behind plan.

- Gas can be easily substituted for fuel oil in power generation, and the Soviets have ambitious plans for doing this over the rest of the decade. The heavy fuel oil (*mazut*) that would be saved, however, is already oversupplied on world markets, and would be a relatively poor money earner. Moreover, without substantial additions and changes to their current refining units, the Soviets could not further process much more of it for other uses.

In the long run, of course, with appropriate improvements in the national capital stock and refinery product mix, as well as with further adjustments in rationing arrangements, the Soviets could significantly moderate their oil use. In the shorter run—through the better part of this decade—most oil savings would have to be achieved by administrative fiat. In a country where oil and electricity are still frequently not metered and "misappropriation" often costs industries 10 percent of their annual fuel allotments, slowing the rate of growth of consumption appreciably will be difficult.

In any case, the process of demand adjustment is slow. Economists agree, for example, that the impact of the oil supply disruptions of the 1970s is still working its way through Western economies. Adjustment to reduced supplies in the USSR probably is unlikely to proceed much faster.

On the soft currency side, the Soviets will have to decide if they want to risk the cost—both political and economic—of reducing oil deliveries to Eastern Europe. Though Romania receives little oil from the Soviets, the remaining Warsaw Pact clients depend on Moscow for 90 percent of their oil imports. Eastern Europe's desperate external financial problems would preclude, in the near term, making up for Soviet cutbacks by going to the world market. Thus, attempts by the USSR to squeeze even as little as a total of 100,000 b/d from its East European clients would diminish the area's economic prospects. Cuts greater than 200,000 b/d could risk driving some East European economies into absolute decline. The 10-percent cut imposed in 1982 on Czechoslovakia, the

German Democratic Republic, and Hungary was one of the principal factors that drove average economic growth in these countries below 1 percent

With several years to adjust, the Soviets have several options that would give the East Europeans some alternatives to Soviet oil. They could supply more gas to Eastern Europe, or they could arrange barter deals with other oil producers.[14] If such substitutes are available and if the East Europeans reach their goals for conservation and nuclear power production, they might be able to withstand cuts as large as 500,000 b/d without suffering severe declines in economic growth

All things considered, we believe Moscow could cope with a gap between domestic production and total demand of as large as 1 million b/d during the late 1980s. The task would not be easy and would place a further strain on the Soviet economy and those of its client states, particularly in Eastern Europe. In our judgment, however, managing a substantially larger supply shortfall with demand-side remedies could well prove more economically and politically difficult than allocating enough new investment to the oil industry to produce the additional oil needed to narrow the gap.

The Oil Market Factor. One variable that could either help or hurt the Soviets in their efforts to deal with a supply shortfall will be the state of the world oil market. During the 1970s Moscow benefited from rising real prices for oil. Since 1981, however, when the world oil market began to soften, the Soviets have been forced to sell increasing amounts of oil simply to prevent hard currency earnings from falling. Though industry forecasts do not lead us to expect any increase in the real price of oil over the next few years, it is probable that oil and gas prices will begin rising again later in the decade. This would be strongly to the Soviets' advantage, particularly if the gas pipeline to Western Europe is operating at full capacity. Under no circumstances would we see the Soviets entering the world oil market as a buyer during this decade except possibly to support financially strapped client states.[15] Soviet reductions in oil deliveries could, however, force the other CEMA countries to increase their liftings from Free World sources.

Looking Ahead

Moscow faces an increasingly serious challenge over the rest of this decade in coping with a potential drop in oil production while at the same time trying to regain an acceptable level of economic growth. Based on our foregoing analysis, the oil problem is a serious one, particularly because of its ramifications for investment allocations and hard currency earnings and the unpleasant trade-off decisions it presents for the leadership. Though we do not believe that Soviet oil prospects for the rest of this decade are in and of themselves sufficiently poor to halt economic growth, they could, when combined with economic problems in other sectors, cause considerable damage.

On a more positive note the USSR should have a reasonable opportunity to avoid an oil-fueled crisis providing it can moderate production declines, on the one hand, and gently reduce the rate of growth in demand on the other. Continued success of the West Siberian gas development program, combined with more skillful management in the other sectors of the economy, will be critical to the process.

We believe the Soviets are now in the process of formulating a concerted attack on their oil problems for the rest of this decade. Within the next year or two, we should begin to see a number of indicators that point to the seriousness with which they perceive their dilemma and to the approach they will try to use to solve it. These should include:

- Unexpected changes in investment and oil production goals for the 12th FYP. Our best judgment at this time is that the Soviets will move to reduce somewhat the rate of growth of new investment in the oil industry and to accept some decline in production. A reduction in the production target for 1990 of more than 1 million b/d from the 1985 goal would indicate that Moscow believes itself to be in serious trouble.

[14] For example, Moscow might send arms to Libya or Syria, who in turn would send oil to Cuba, Vietnam, or Eastern Europe, or some of the USSR's LDC customer

[15] Some cross-border oil trade, particularly with Iran, probably will continue for the purposes of efficiency

- Gradually increasing efforts to cultivate Western sources of supply for drilling and artificial lift equipment, for oilfield technology, and to improve domestic manufacturing capability.

- A drive to increase secondary refining—specifically cracking—capability so as to avoid a shortage of lighter products (gasoline, kerosene, and diesel fuel) in the event of a crude oil production decline.

- Expansion of oil pipeline capacity in Western Siberia to accommodate increased production goals for that region—or, conversely, failure to add capacity currently planned.

- Continuing pressure on Eastern Europe and other soft currency importers of Soviet oil to reduce liftings, combined with a search for alternative sources of supply—perhaps through barter and arms trade agreements—for these countries.

- More stringent goals for domestic energy conservation combined with tougher penalties for waste and theft of oil.

- Adoption of a political and economic posture that would encourage Free World, particularly LDC, oil producers to limit supplies, thus raising prices to the West.

- A heightening of the debate between those advocating increased exploration and those favoring high near-term production goals, with the advantage probably continuing to go with the latter group.

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Appendix

Capabilities of the Soviet Oil Industry

Planning and Management

Responsibility for making and implementing Soviet oil policy extends through an official hierarchy and parallel informal network from the highest party and government officials in Moscow to the individual work crews in the field (figure 14).[16] At the apex of this hierarchy is the Politburo of the Communist Party of the Soviet Union (CPSU), which has final responsibility and ultimate authority for determining basic oil policy. Because the breadth of its responsibility encompasses the entire spectrum of Soviet foreign and domestic policy, the Politburo considers oil policy only sporadically and often in the context of larger issues. Among Politburo members, only Aliyev, Tikhonov, and Dolgikh appear to have a strong and continuing interest and responsibility in this policy area. Therefore, although the Politburo retains approval authority over policy, it must rely on others for much of the input into these decisions. Most of the high-level policy initiatives and plan formulation takes place just below the Politburo in:

- The Secretariat of the Central Committee of the CPSU, which monitors plan fulfillment and policy implementation for the Party.
- The Presidium of the USSR Council of Ministers, which exercises operational control over the Ministry of the Petroleum Industry (MPI) and other energy ministries as part of its larger task of overseeing the entire economy. The State Commission for Reserves (GKZ), subordinate to the Council of Ministers, also exercises substantial control over the oil industry through its power to certify reserves and approve drilling plans and production practices at individual oilfields.
- The State Planning Committee (GOSPLAN), which makes both long- and short-range plans for the oil sector as part of its national planning effort.

Responsibility for detailed planning and management and the implementation of oil policy is shared by some 17 or more separate government ministries and a host of research and advisory institutes. Four ministries—Geology, responsible for locating new petroleum reserves, the Petroleum Industry, the Gas Industry, and the Construction of Petroleum and Gas Industry Enterprises—do the bulk of this work, with the additional ministries providing often-critical support facilities, equipment, or funds

As might be expected with so many separate bureaucracies involved, the Soviet oil sector, from top to bottom, is not efficiently managed. We believe that the gerontocracy in the Politburo has been too rigid and conservative to provide creative leadership on energy policy initiatives. Shifts in oil policy have been small and incremental, reflecting the Soviet style of planning. On occasion, however, the leadership has shown itself to be capable of making much sharper changes when confronted with a crisis. In 1978 growing leadership awareness of the mounting problems associated with meeting oil production targets and the very real potential for a downturn in oil production led to a decision to reallocate vast sums of investment capital into the rapid development of the West Siberian oil and gas fields. Similarly, the leadership unilaterally and apparently without prior warning reduced oil exports to Eastern Europe in 1981 and again in 1982.

Moreover, during the Brezhnev era policy was decided by consensus, often difficult to obtain because Politburo members are linked by background and personal connections to different and competing energy constituencies which operate according to their perceived

[16] See for [redacted]

self-interest. With the death of Brezhnev, consensus and constructive change may be even more difficult to achieve, at least for some time. In any event the Andropov regime will be constrained by bureaucratic inertia in the energy sector, by the same economic and foreign policy considerations that led to the current policies, and by the highly institutionalized nature of the Soviet decisionmaking process, which tends to generate similar decisions regardless of who makes them.

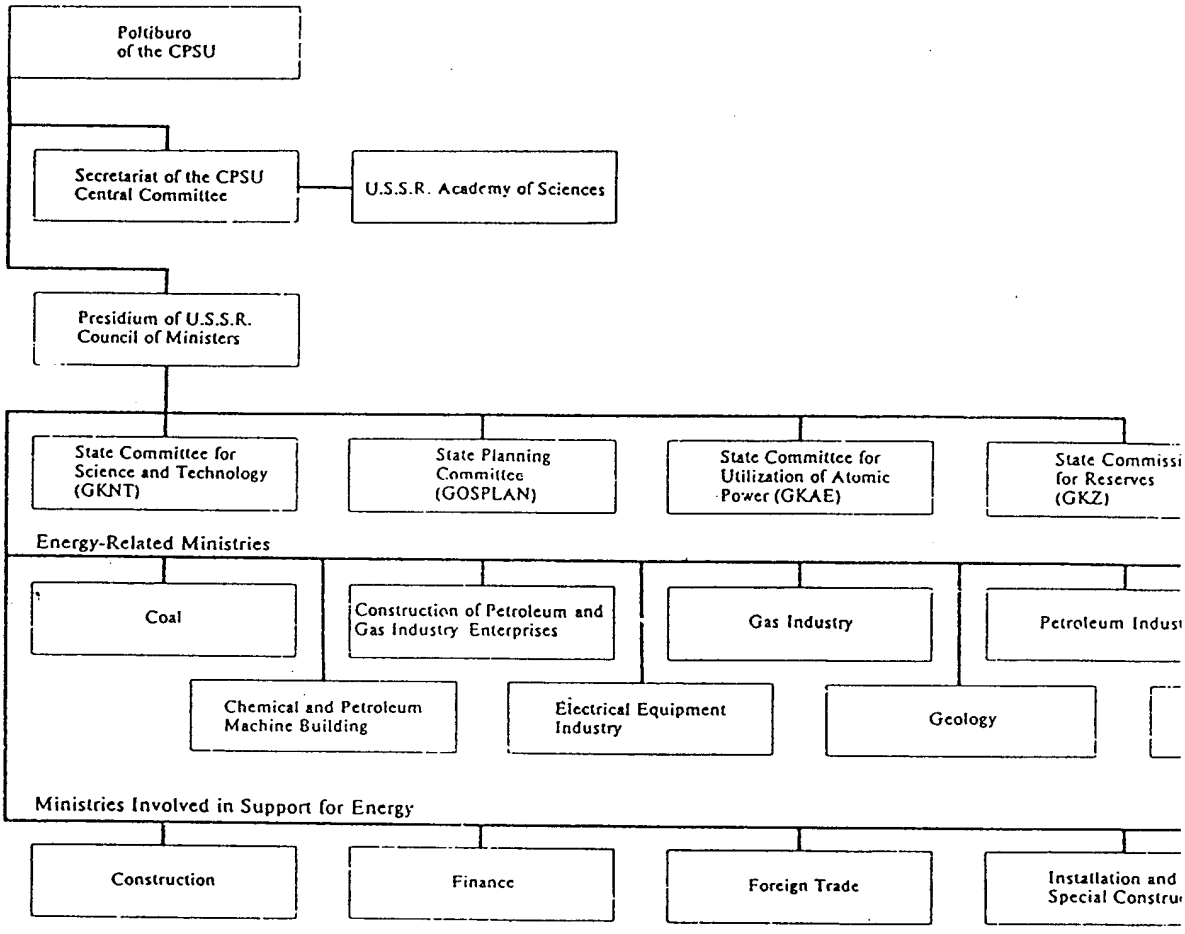
The working-level planning and management bureaucracy suffers from all the problems endemic to the Soviet system, including a cumbersome and rigid planning process that discourages initiatives by managers and centrally planned price and performance criteria that do not reflect costs or allocate resources effectively. The system also emphasizes output and plan fulfillment rather than efficiency, which tends to reduce productivity and raise investment needs, as well as favoring short-term gains at the expense of long-run benefits. But, in our view, perhaps the most far-reaching problem is the absence of a dominant central organization—with authority that cannot be circumvented—to settle disputes. The lack of a coordinated nationwide master plan and an all-powerful organization to direct it causes a host of related difficulties. Management strategies are diverse, power and authority diffused, and ministries battle each other over jurisdiction and funds. With no mechanism for coordination or lateral communication, one ministry's failure echoes down the supply chain, forcing adjustments and inefficiencies.

At the receiving end of all these deficiencies is the MPI, forced to deal with many problems not of its own making. The MPI and its subordinate organizations, charged with meeting or exceeding often unrealistic output goals, often have to use counterproductive short-term production practices at the expense of long-term production, and are also hampered by the lack of cooperation from other ministries[redacted] late arrival of critically needed equipment or support infrastructure, for example, is one of the primary reasons for development delays at new deposits in West Siberia—where the MPI is dependent on the Ministry of the River Fleet for supplies, on the Ministry of Construction of Petroleum and Gas Industry Enterprises for much of the infrastructure, and on the Ministry of Power and Electrification for electricity.

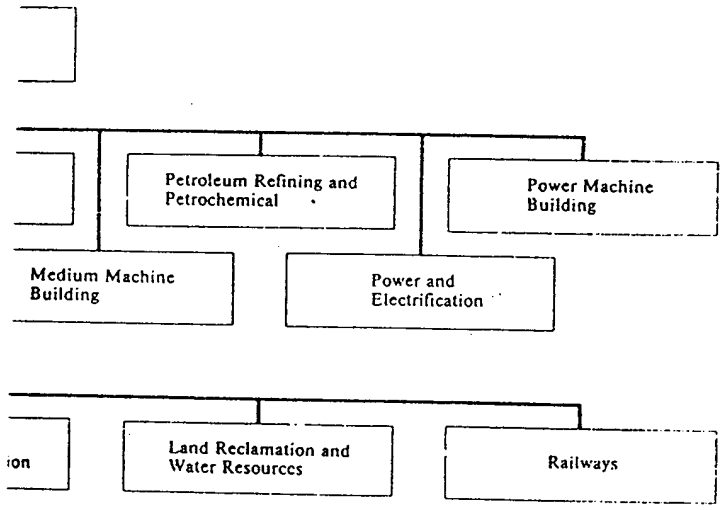
We see little chance of a fundamental overhaul of the petroleum sector any time soon. General Secretary Andropov has made much of the need for reorganization and managerial reform in energy production, but has yet to provide much in the way of specific guidance or structural change that would aid in this effort. The inertia of the system and the size and number of entrenched bureaucracies not only argue against radical change but almost guarantee that change will be implemented in small and incremental steps. The Soviet system places a premium on the achievement of consensus and avoidance of risk, ensuring that a conservative approach to solving the organizational problems of the oil industry will almost certainly win out over innovative but potentially disruptive ones.

We have seen numerous examples recently of the kinds of incremental changes likely to become more common as Soviet leaders search for greater efficiency in the oil industry. As part of a target programing effort to speed up solutions to top-priority social and economic problems, the Council of Ministers and Gosplan set up special interdepartmental commissions to monitor development of the West Siberian oil and gas complex [redacted] 1982 the Deputy Chairman of the Council of Ministers, the Deputy Chairman of Gosplan, and other high-ranking officials were engaged in a series of meetings to plan energy production targets and possibly to consider policy shifts in energy planning. In December, General Secretary Andropov proposed, and the Supreme Soviet Presidium submitted a plan to form a permanent commission on energy to supervise the work of the ministries and to call managers to task for wasteful use of resources. There are even indications [redacted] that the Council of Ministers is toying with the idea of reorganizing the oil and gas ministries into three ministries along regional lines. Though we judge

Figure 14
Energy Decisionmaking in the Soviet Union



SOURCE: Derived from Central Intelligence Agency, "Energy Decisionmaking in the Soviet Union," Aug 82


Petroleum Refining and Petrochemical
Power Machine Building
Medium Machine Building
Power and Electrification
Land Reclamation and Water Resources
Railways

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many of these to be cosmetic changes, they do underscore the increasing importance of West Siberia in the eyes of the Soviet leadership. Only if the bottom falls out from under West Siberian production would we anticipate major attempts at reform.

Technology

The Soviet oil industry has transformed itself from near total devastation during World War II into a largely self-supporting industry capable of leading the world in oil production—and has done so in spite of equipment and technology that generally suffer in comparison to those available in the West. The USSR's technologic problem, in our view, has lain not so much in know-how or design but in an inefficient and cumbersome economic system that has hindered both the production of high-quality oil equipment in the quantities needed and the efficient use of advanced techniques and equipment. Consequently, the performance of key segments of the oil industry, from exploration to drilling to refining, continues to be characterized by inefficiencies and lagging productivity.

The Soviets have in the past compensated for equipment shortcomings with imports, but they have done so only selectively to cover spot shortages or for particularly difficult applications. During the 1970s the USSR bought about $2 billion worth of Western oil equipment, which we believe was only a small portion of their total equipment requirements. These imports often had an impact far out of proportion to their cost, however, because they were used on the Soviets' largest and most critical projects

confirm that Moscow intends to continue to purchase Western technology and equipment and has developed a list of items it believes will be necessary to achieve oil production goals for the current FYP. The Soviets are looking to France, Japan, West Germany, the Scandinavian countries and, to a diminishing extent, the United States—which they now believe is an unreliable supplier—for the items they want. Based on a variety of recent Soviet discussion and our own detailed analysis of their needs, we believe these purchases will cluster into six broad categories:

- Exploration equipment.
- Drilling equipment and technology.
- Fluid-lift and oil-treatment equipment.
- Computers and automated control technology and equipment.
- Specialized offshore drilling and production equipment.
- Enhanced oil recovery technology and equipment.

We also expect the Soviets to continue to pursue methods other than outright purchases for acquiring Western technology. They regularly collect information on Western-developed technology and equipment through open and covert means. During the US embargo, for example, the Soviets tried through third parties, including the other Warsaw Pact countries, to acquire or copy denied equipment. They also use joint development projects similar to their Sakhalin Island agreement with Japan to obtain Western know-how and equipment—and these projects have the added benefit of not requiring large upfront payments of valuable hard currency.[19] Moscow, for instance, is currently pursuing a joint development scheme for the Barents Sea with several Scandinavian countries and France. For these joint projects to affect national oil output, however, the Soviets would have to overcome their past reluctance to grant foreign firms access to detailed oilfield data.

At the same time, the Soviets are attempting to alleviate equipment problems with an across-the-board effort to enhance domestic manufacturing capabilities. One critical problem being addressed is poor metallurgy, which results in short-lived drill bits, pipe, and pumps, and in resultant inefficiencies and delays in the field. Reports in the Soviet press claim, for example, that Soviet industry has developed a new technique for hardening drill pipe. If true, this process would help alleviate some of the stress problems that the Soviets have had with the drill pipe and make it

more suitable for rotary drilling.[a] The Soviets have also established a new offshore oil research institute to develop equipment and technology for the continental shelf. In addition, [redacted]—possibly as part of this effort to improve oil technology—the Soviet defense sector is becoming involved in research, development, and manufacture of oil exploration and production equipment.

By almost any measure the Soviet oil industry has raised its level of technology and equipment over the past few years, and we expect to see steady improvements over the rest of this decade. The domestic industry will continue to provide the bulk of Soviet oil equipment requirements, certainly for the current FYP. We believe that the Soviets will indeed try to go forward with many of their planned equipment purchases, but that the contribution of this Western technology will be held at the margin over the next few years. In the short term, production from difficult-to-develop fields and necessary increases in drilling and fluid lift will depend somewhat on Western equipment. In the longer run, the availability of foreign technology will be critical to finding and developing deeper, less accessible onshore reserves in the late 1980s and offshore reserves in the 1990s

The effect of these foreign purchases and technology improvements on oil output will ultimately depend on the ability of the oil industry to disseminate and apply them. Its track record, however, like that of other Soviet civilian industries, has been quite poor. Soviet oil research institutes and key industrial ministries have acquired state-of-the-art knowledge and have closely studied and tried to copy Western techniques and equipment. But they have subsequently experienced difficulty in transferring this knowledge to wide-scale use in the oilfields, largely because of what we believe to be systemic constraints—a disfunctional incentive-and-reward system and a reluctance on the part of managers to take necessary risks. Numerous reliable sources have reported startup and quality control problems in purchased oilfield equipment plants, for example, and delays in installing and problems in operating new equipment in the field are common. Though we see Soviet recognition of this problem and some preliminary attempts at solutions, we do not expect the kind of fundamental changes in the economic system that would allow Soviet oilmen to implement new and improved technologies on a timely basis or on a scale that would dramatically raise productivity and efficiency.

Exploration

Exploration is the key to future oil and gas production, but a successful exploration effort in the Soviet Union does not usually pay off in commercial production for four to seven years. In the 1970s the Soviets often sacrificed exploration for the sake of current production, especially in oil-rich West Siberia. They are attempting to improve the situation in the current FYP by calling for a 30-percent increase in exploration drilling nationwide and presumably a substantial expansion of other exploration efforts as well, but appear to have posted only modest gains thus far. The Soviet press nevertheless reports that exploration drilling for oil and gas is to increase by another 47 percent during the next FYP.

Soviet geologists are using a wide array of techniques in their exploration effort—satellite imagery to locate promising areas, regional and localized seismic surveys, geochemical mapping, and well logging. [redacted] indicate, however, that exploration progress is impeded by technological limitations in several key areas. Magnetometers and gravity meters used to perform regional surveys require highly sophisticated sensing technology and data processing capability. Soviet technology in this area lags considerably behind that available in the West. Remote areas, such as East Siberia and the offshore Arctic, will be difficult to explore without improved equipment. Inadequate seismic equipment forces the Soviets to continue to rely on techniques which can identify large geologic structures but lack the resolution to identify smaller more subtle traps. These techniques also yield poor

[a] In rotary drilling the entire drill string rotates, placing high stress on each section of the drill pipe. Because of an inability to manufacture enough high-quality drill pipe, the Soviet drilling industry pioneered the development of turbodrilling, in which the drill string does not rotate, but a turbine motor powered by the flow of drilling mud powers the drill bit. Turbodrilling works well in shallow, soft deposits but is not as efficient as rotary drilling in deeper, harder, and high-pressure formation

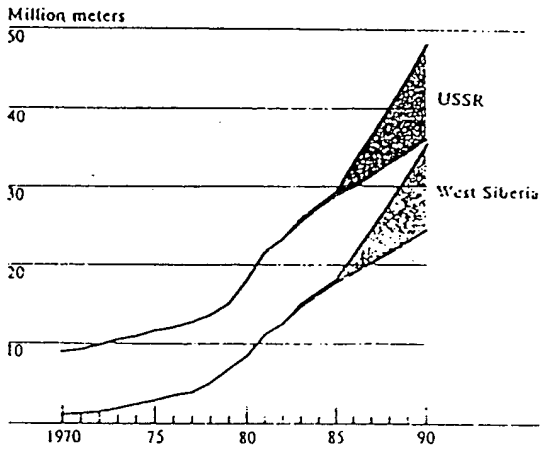
results below 3,000 meters, hampering deeper exploration. Moreover, the Soviets have generally lacked the computers and sophisticated software to process the seismic data into usable high-resolution form. [redacted] however, we believe that they are now beginning to make significant progress toward overcoming these technological limitations

Developmental and Exploratory Drilling

Given the apparent adequacy of the size of the reserve base, the performance of the Soviet drilling industry will be pivotal in determining output levels over the rest of this decade.[21] Development drilling—drilling wells to produce oil and inject water—will determine the amount of new production capacity; and exploration drilling—locating new fields and establishing the limits of previous discoveries—will determine the level of the proved reserves that are needed to sustain Soviet oil production through the end of this decade and into the 1990s.

Soviet drillers have received heavy criticism and much of the blame for the declining rate of growth in Soviet oil production. Both the Soviets and most Western analysts agree that the industry's leading problem has been the poor quality and inadequate quantity of drilling equipment—rigs, pipe, tool joints, bits, mud, and blowout preventers—combined with poor execution in the field. Because of the emphasis on meeting high-volume drilling goals, given the fact that the industry has been unable to produce sufficient quantities of high-quality drill pipe that can stand up to the stresses of rotary drilling, Soviet drillers have come to rely principally on turbodrilling. Though turbodrilling is a significant technologic achievement of the Soviet oil industry, it remains less efficient than rotary drilling for the deeper deposits and high stress conditions that the Soviets are increasingly encountering. Equipment problems are exacerbated by poorly trained and motivated crews, and logistic, planning, and operational difficulties. Despite these inadequacies, the Soviet Oil Ministry—through increased inputs of men and equipment—has managed to raise [redacted]

Figure 15
Oil Ministry Drilling



drilling meterage steadily over the past two decades, from 47.7 million meters during the 1961-65 plan to 72 million meters during the 1976-80 plan (figure 15). For the 1980s, however, the Soviets acknowledge that increases of this magnitude will not be enough. Soviet Oil Ministry plans call for drilling to grow to 131 million meters in this FYP, and the Soviets anticipate that requirements will rise even more steeply, possibly doubling, in the 12th FYP. According to the Soviets, these increases reflect the lower quality and greater depths of new deposits and the need to drill more wells to compensate for the increasing declines in capacity of the current well stock [redacted]

For the Soviets to meet drilling and oil output goals in this decade, we believe the drilling industry must both allocate its limited resources effectively and also

continue to upgrade the level of drilling technology. Specifically, the industry will need to:

- Allocate drilling efforts properly between development drilling and exploration drilling.
- Achieve a proper balance in drilling between West Siberia and the other regions.
- Achieve planned productivity gains in drilling; or, in the absence of these gains, provide sufficient additional inputs of labor and capital in the form of drilling brigades and equipment.

The Soviets are attempting, so far with mixed results, to accomplish all three tasks.

Development Versus Exploration

Soviet planners have long recognized the potential danger of overemphasizing development drilling at the expense of exploration drilling. The slow pace of exploration drilling in West Siberia is often singled out in the technical press and planning literature as an issue of special concern for long-term production possibilities. Yet the Ministry of Geology has managed only sluggish growth in exploration drilling for oil and gas during the first two years of the current FYP. Based on their past record—the Soviets completed 3.1 million meters of exploratory drilling in West Siberia in their 1971-75 FYP, and could reach only 3.6 million meters in the 1976-80 FYP—the original goal to triple exploration drilling in West Siberia during the current plan seems well out of reach, though we do not see this potential shortfall as a significant constraint on oil output until after the 1980s. Barring a major stroke of luck in discoveries or a quantum increase in exploratory drilling efficiency in West Siberia, however, the Soviets will probably pay for past neglect in the 1990s.

West Siberia Versus Other Regions

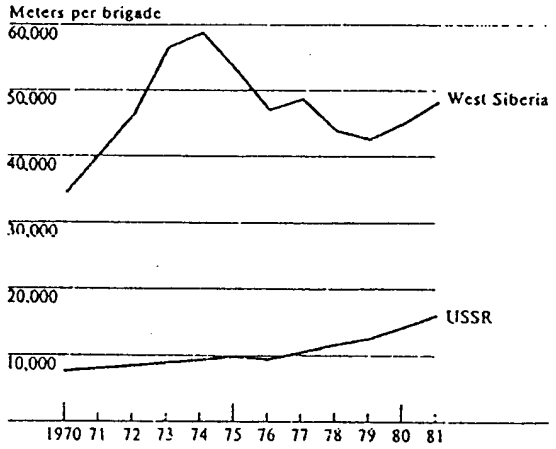
Although its share of exploration drilling remains small (some 20 percent), West Siberia's share of development drilling has risen rapidly, from 16 percent in 1970 to 54 percent in 1980, and a further increase to 69 percent in 1985 is planned through a major expansion of the number of drilling brigades and the use of expeditionary brigades flown in from other oil-producing regions. Indeed, the expeditionary crews alone are slated to contribute about one-third of 1981-85 drilling meterage in West Siberia, and this approach has already yielded big dividends for the Soviets. Largely because of better geologic conditions in West Siberia, the expeditionary crews are able to drill twice as fast there as in their home regions and complete wells with much higher flow rates. The Soviets, however, must balance these gains against the potential losses in the other regions, from which they hope to produce approximately 4.7 million b/d by 1985.

Productivity

The success of the Soviet drilling program this decade will hinge primarily on efforts to improve drilling productivity, defined by the Soviets as the number of meters a brigade can drill in a year. The increased drilling meterage, which Soviet oil planners believe necessary to reach oil supply goals, assumes ambitious productivity gains. The 1981-85 FYP, for example, calls for individual Oil Ministry drilling brigades to drill 60 percent more in 1985 than in 1980. If these gains are not realized, the planned inputs of manpower and equipment will probably be insufficient, and crude oil output will suffer, especially in the late 1980s

There is considerable room for improvement, as Soviet drilling productivity remains low by world standards. In 1981, for example, US rigs were 2.6 to 2.7 times more productive than Soviet rigs. A variety of factors determine productivity—equipment and technology, rock type and depth, and the hostility of the working environment—and all these, with the exception of equipment and technology, are getting worse for the Soviets by their own admission. Despite the worsening conditions, Oil Ministry drillers did manage to register some increases in productivity during the 1976-80 FYP period (figure 16). The reason for these gains, however, was not so much improved drilling practices as the increasing share of the drilling effort going to West Siberia. West Siberian drilling productivity, nevertheless, though still more than three times the Oil Ministry average, declined between 1974 and 1979 as drillers began working smaller deposits. This decline was reversed in 1980, and we expect that drilling productivity will continue to increase, assuming the Soviets are successful in making the improvements they now plan in drilling equipment, procedures, and support infrastructure

Figure 16
Oil Ministry Drilling Productivity



We have analyzed the factors affecting drilling productivity for the major categories of brigades. The effect of these productivity gains on drilling rates are summerized in table 5. These projections assume that Soviet drilling technology will continue to improve during the rest of this decade, that the Soviets will be successful in at least some of their efforts to correct limitations via the acquisition of Western technology and the expansion of the domestic equipment industry, but that worsening geologic conditions will impede these gains somewhat.

More specifically, based on our analysis of past trends and most likely future conditions, we believe the Soviets can achieve an increase in drilling productivity in West Siberia of 30 to 40 percent between now and 1990 through the use of higher quality drill bits, larger production pads, and, most significantly, improvements in the support infrastructure that could reduce rig downtime by 20 to 30 percent. Outside of West Siberia, prospects for productivity increases are poorer. Since 1970 the Soviets have been managing to raise productivity slightly by concentrating on infill drilling and work on easier-to-drill, shallow deposits. Beyond 1985, however, most of the ready gains from this approach will probably be exhausted, and the Soviets plan to turn to deeper drilling which, if anything, will tend to depress productivity.

If our analysis of future productivity gains is correct, both drilling and oil production goals could be in jeopardy unless the Soviets increase the number of brigades faster than planned (table 6). To reach 1985 goals for drilling and production, for example, we estimate that the oil industry will need approximately 1,600 drilling brigades, some 150 more than the number implied by Soviet productivity targets. Indeed, the Soviets now appear to be adding brigades faster than originally planned. If the Soviets attempt to maintain oil production at approximately the current level over the rest of this decade, development drilling, based on our projections of likely well flows, would have to grow from about 27 million meters in 1985 to some 45 million meters in 1990. Exploration drilling by the Oil Ministry would have to nearly double from 1985 to 1990. To reach these projected drilling levels, the Soviets would need to add about 800 more drilling brigades than existed in 1982—a very ambitious task, given the rising drilling requirements of the Geology and Gas Ministries.

Production Methods

In addition to increasing drilling, the Soviets also face challenges in extracting more oil from their wells.[11] Fewer Soviet oil wells flow freely today than in the past, primarily because of the rising amounts of water produced along with the oil. Soviet production engineers use water injection as a primary production technique in an effort to maintain original field pressures. Although the initiation of water injection early in a field's development enables the Soviets to boost well flows, limit the requirement for pumping equipment, and increase initial oil recovery, it also creates the need later on to lift large volumes of fluid

Table 5
Drilling Productivity

Meters per brigade per year

Type of Drilling Brigade	1980	1985 *	1990 *
Development			
Local West Siberian	47,000	55,000 to 60,000	60,000 to 70,000
Expeditionary brigades in West Siberia	40,000	45,000 to 50,000	50,000 to 60,000
Other regions	12,000	13,000 to 15,000	13,000 to 15,000
Exploration	4,200	4,400 to 4,500	4,600 to 4,800

* Estimated.

from the reservoir. Thus, the Soviets' aging stock of wells requires a rapidly increasing number of artificial lift systems such as sucker-rod (walking beam) pumps, submersible pumps, and gas lift. The Soviets are also investigating the use of several methods of enhanced oil recovery (EOR) to raise recovery rates and to produce oil that artificial lift methods cannot extract. The Soviets consider EOR to be an attractive alternative because of its potential to recover additional oil in areas where large investments in oil industry infrastructure have already been made.

Fluid Lift

The Soviet practice of initial water injection as a pressure maintenance technique has paid benefits but not without exacting a high cost. By maintaining high reservoir pressures, water injection helps wells to remain off pump for longer periods, and tends to raise initial recovery rates by flushing oil from the reservoir more quickly. It also increases drilling requirements, however, as one injection well is generally drilled for every three to five producing wells, and creates ever larger amounts of fluid—a mixture of oil, gas, and water—that must later be lifted from the production wells and sent through a costly separation process (figure 17a). Furthermore, as the water cut—the share of water in the water and oil mixture recovered from wells—reaches 30 to 50 percent, the wells require some form of artificial lift to maintain oil output. In 1983, for example, [redacted] in Tyumen Oblast the Soviets plan to inject more than 1 billion tons of water and lift a possible 685 million tons of fluid in order to extract over 361 million tons of oil.

Table 6
Oil Production Goals and Oil Ministry Drilling Requirements

	1982	1985 Plan	1990 *
Oil production (*million b/d*)	12.25	12.6	12-13
Development drilling (*million meters*)	21.0	27.7	45
Exploration drilling (*million meters*)	2.3	2.8	5
Drilling brigades	1,400	1,600	2,100-2,200

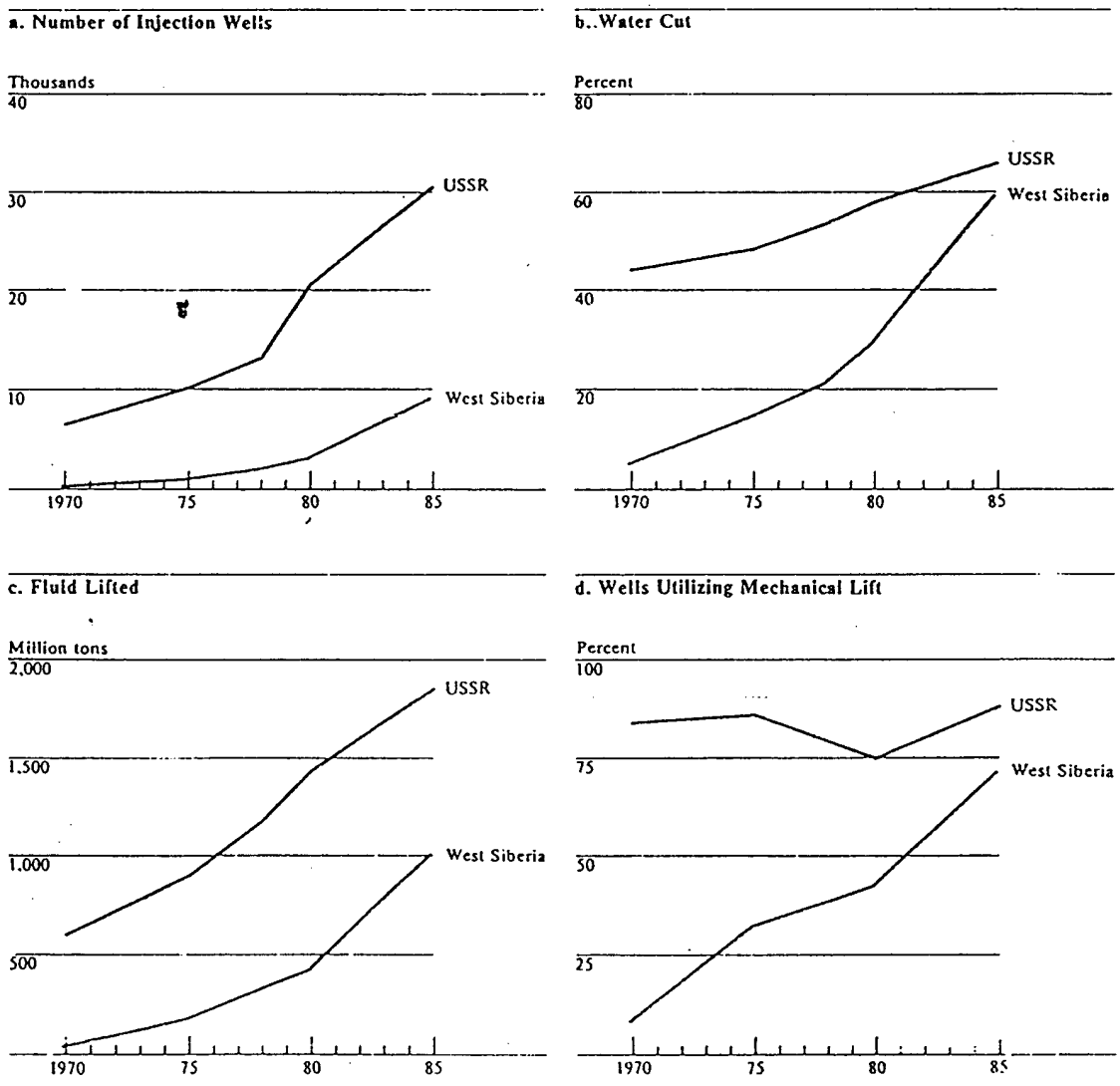
* Estimated.

We calculate the average water cut to be 60 percent or more nationwide and close to 50 percent in West Siberia (figure 17b). [redacted]

Based on Soviet plans and our analysis of past trends, we expect the water cut to continue to increase through the 1980s, reaching 65 to 67 percent in 1985, and exceeding 70 percent by 1990. The water cut in West Siberia would still lag behind the national average, but by only several percentage points.

The result of the rising water cut is that increasing amounts of fluid must be extracted and separated for each barrel of oil produced. Figure 17c shows the fluid lifted since 1970 and our estimates of fluid-lift requirements through 1985 and 1990. The seriousness

Figure 17
Water Injection and Fluid Lift Requirements



of the increasing fluid-lift requirement can be illustrated by a comparison of estimated fluid growth versus planned oil growth during the current FYP. We estimate that fluid production must increase by about 40 to 50 percent between 1980 and 1985 just for the Soviets to achieve their planned oil production increase of approximately 4.5 percent for the same period. Fluid lift requirements in 1990 will depend upon Soviet production goals, water cut, and the Soviet's technical capability. In the event that the water cut reaches the 70 to 75 percent we believe to be possible by 1990, the Soviets would need to lift roughly 45 million barrels of fluid per day just to maintain the current Soviet oil production rate. This would imply a 60-percent increase in fluid output over the amount now being lifted [

Because of the increasing fluid-lift requirements, the Soviets have had to place a growing share of their wells on some type of artificial lift (figure 17d). The Soviets plan a 52-percent expansion in the number of wells on artificial lift between 1980 and 1985. By 1985, according to Soviet plans, only 10 to 12 percent of the wells will flow by themselves. The cost of this program has been and will continue to be high. The Soviets have not been successful in producing top quality submersible pumps or gas-lift equipment—the two more sophisticated and high-capacity methods of artificial lift—and have had to import both or make do with lower capacity and less reliable domestically produced equipment. We expect that they will continue to do so. We also expect that fluid lift requirements will probably exceed capacity later in this decade and become a constraint on Soviet oil production.

Enhanced Oil Recovery (EOR)

The Soviets have expressed high hopes for their budding EOR program—hopes that have yet to be realized. During the mid-1970s several high Soviet officials including the Chairman and Deputy Chairman of Gosplan and the Minister of the Petroleum Industry voiced their support for the EOR program and boasted of its potential to boost oil recovery rates by 10 to 15 percent. Instead, [ ] confirm that the enhanced recovery program has been besieged with management problems, scandal, technology assimilation problems, and an apparent lack of adequate funding. As a result, only about 60,000 b/d of current Soviet oil production can be attributed to enhanced recovery

The Soviets have experimented with EOR programs in many fields, emphasizing chemical and thermal applications. In the declining Volga-Urals Basin, they have experimented with polymer flooding at Arlan and CO_2 injection at Romashkino. In the Kazakhstan, Azerbaijan, and Komi regions, they have used thermal methods such as steam or hot water injection and *in situ* combustion to aid in the recovery of heavy, viscous oils.[21]

The Soviets' difficulties with EOR have in part been caused by the limited production capabilities of Soviet industry. The Soviets have not been able to build the steam generators needed for thermal recovery nor to produce sufficient amounts of surfactants or polymers for chemical and polymer flood programs. We know [ ] that the Soviets have turned to the West for technology, equipment, and supplies, but have often experienced problems assimilating the sophisticated Western technology [ ] for example, that Western-built steam generators are just now in place and working at the Uzen oilfield after several years of Soviet installation and startup problems. In 1981 Soviet officials, possibly spurred by the problems they were facing, stated that any new steam injection projects would need to be turnkey, with the Western supplier providing both equipment and initial operating assistance.

In addition to the normal problems of duplicating laboratory results in any oilfield, management and financial problems also have plagued the Soviet EOR program. Most notably, the Deputy Minister of the Petroleum Industry in charge of enhanced recovery projects was fired in 1981 for falsifying data and "gross waste of enhanced recovery materials." Since the scandals surrounding the EOR program became public, the Soviets have postponed several EOR projects, citing both management difficulties and high costs.

[ ]

Enhanced recovery programs, normally risky ventures to start with, require large upfront expenditures of scarce hard currency for an often minimal amount of additional oil recovery several years in the future. Largely for this reason, we do not believe that EOR will play a significant role in the near future, although the Soviets will still actively experiment with its use. In 1980 the Soviets stated their hopes to eventually recover 2.5 million b/d of oil from EOR. More recently, however, they announced a target of 160,000 b/d for 1985. In normal industry use, EOR techniques are not intended to produce large volumes of oil but rather to produce oil that cannot be recovered at all by conventional methods. We believe the Soviets have no chance of reaching even the lower goals, and that they will only obtain about 100,000 b/d by 1985 and less than 200,000 b/d by 1990. Yet, enhanced recovery will probably remain an attractive idea because of its application at older fields that the Soviets are reluctant to abandon.

Offshore

The Soviet Union is looking to its offshore areas to provide a future boost in oil production. Soviet offshore areas have enormous oil and gas potential, but production from offshore deposits has had very little impact on national oil output to date. Technical requirements for offshore work are high, and Soviet capabilities in this sector lag much farther behind the state of the art than in any other part of the oil industry. Consequently, offshore production is now only some 200,000 b/d, most of it from older and near-shore deposits in the Caspian Sea.

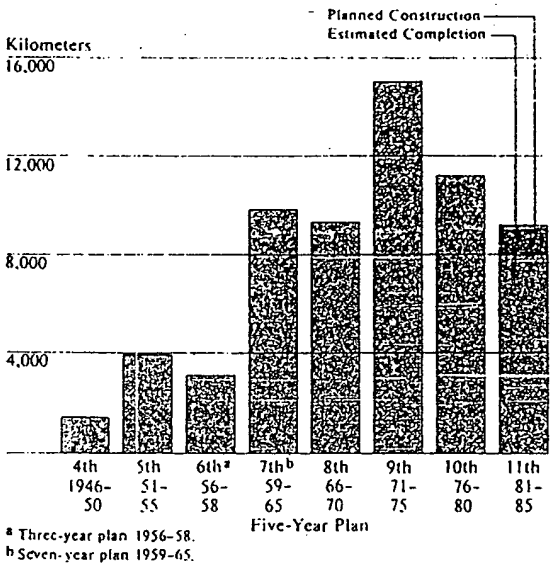
The Soviets are attempting to upgrade their offshore capabilities through direct purchases from the West, reproduction of Western designs, and strengthening domestic manufacturing capability. In the south the Soviets are importing some jack-up and semisubmersible platforms and parts to explore new and deeper Caspian Sea areas. Two construction yards in the region—one equipped by a French firm—have already turned out eight offshore platforms. Additionally, the Soviets have begun to develop an offshore capability in their untapped northern waters. The Soviets now operate a foreign-built offshore platform in the Baltic as part of a joint effort with the Poles and East Germans. To begin exploration of the Arctic offshore region, they have bought three Arctic-capable drillships from Finland. Two have been delivered, and both have begun to drill in the Barents Sea. [redacted] indicate that the Soviets are negotiating with the Norwegians, Swedes, and possibly the Portuguese for semisubmersible offshore drilling platforms. The Soviets are also developing an indigenous production capability in the northern part of the country. The Soviet press has announced the construction of a semisubmersible drilling platform at a yard in Vyborg for use on the Baltic coast. Along with drilling platforms, [redacted] Moscow has sought a variety of other types of sophisticated offshore equipment. They have bought or expressed a desire to buy underwater survey systems including low-light television, ship and rig station-keeping equipment, subsea wellheads, and underwater pipelaying equipment.

Because of the high technology requirements and the great expense of developing offshore areas, the Soviets have even concluded joint venture agreements with foreign countries. In addition to participating with the East Germans and Poles in the jointly owned firm Petro-Baltic, the Soviets have joined with the Japanese in a joint venture to explore and produce oil and gas from the area around the Sakhalin Island. Furthermore, [redacted] the Soviets are negotiating with the Norwegians for either the lease of equipment or the creation of a joint venture in the Barents Sea. Joint ventures in the offshore areas are particularly attractive to the Soviets, who gain access to advanced technology while the foreign partner usually bears the brunt of the investment expenditure in return for a share of future oil production

We expect improvements in Soviet offshore technology to have little effect on national oil output in the 1980s. The use of the semisubmersible platforms in the Caspian may result in new production from deeper waters, but there is no indication that it will do anything more than compensate for declines from older offshore deposits in the area. We expect minimal oil production from offshore Sakhalin in this

decade, and probably no more than 80,000 to 90,000 b/d by the mid-1990s. Recent indications [redacted] suggest that the Sakhalin program may be scaled back substantially. Drilling in the Baltic has met with limited success, and only gas has been discovered in the Black Sea and the Sea of Azov. Prospects are bright for the 1990s, however, if the Soviets are able to continue to acquire Western technology. The Soviets are only beginning to explore their most promising offshore area—the Arctic. Producing oil from this hostile region will be enormously expensive and will require equipment and technology more sophisticated than that currently available, even in the West. These difficulties, combined with long leadtimes, should delay significant offshore production until the 1990s

Figure 18
Soviet Union: Crude Oil Pipeline Construction



[a] Three-year plan 1956–58.
[b] Seven-year plan 1959–65.

Pipelines

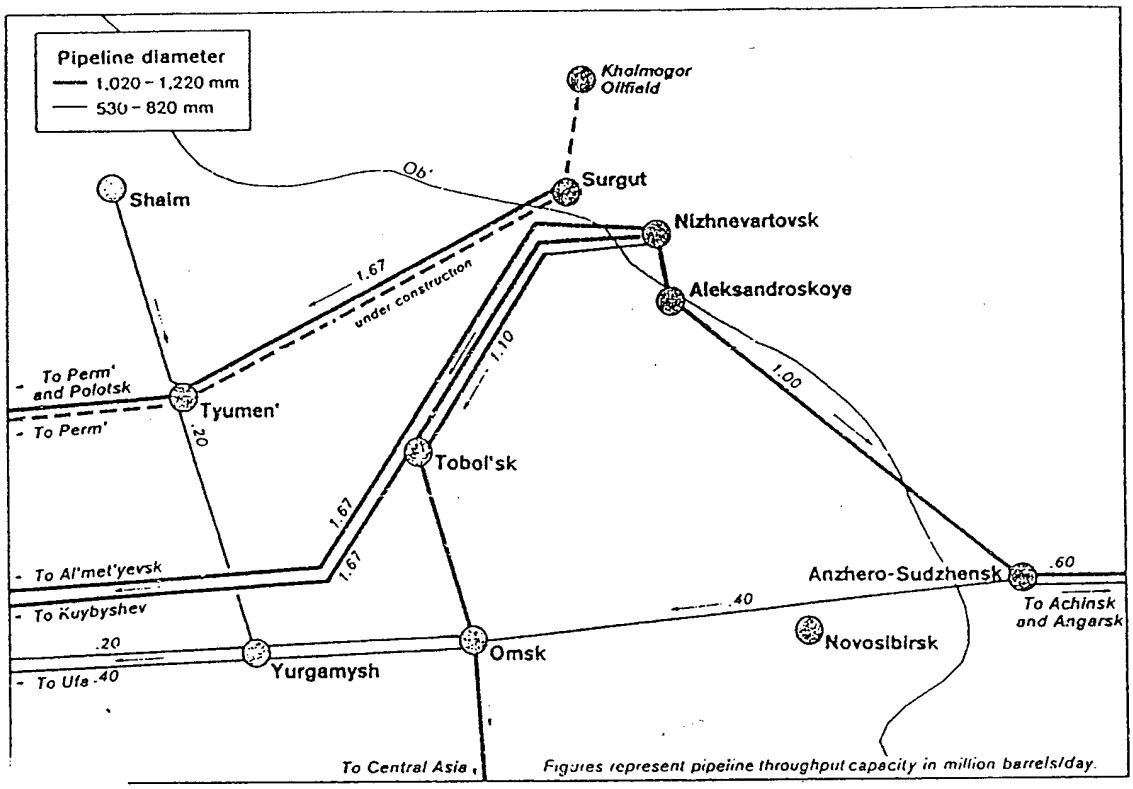
The USSR relies on pipelines, the most cost-effective method, for transporting more than 90 percent of its crude oil production. Most of the Soviet oil pipeline network is relatively new, having expanded from 4,000 kilometers (km) in 1946 to more than 60,000 km in 1981. Nearly 80 percent of the larger diameter—1,020 and 1,220 millimeter (mm)—oil pipeline network was laid between 1970 and 1981

The Soviet oil pipeline industry is also largely self-sufficient; there is no single piece of required equipment the Soviets cannot supply from domestic sources. The Soviets do import, on a selective basis, pipelayers, bulldozers, surge control valves, and insulating materials to speed construction and to improve the operational capacity and service life of their pipelines. The average quality of domestically produced Soviet pipelines, however, is well below Western standards as a result of deficiencies in construction techniques and pipe manufacturing technology. Soviet welding and insulating procedures are inferior to those of the West, and quality work is often sacrificed for the sake of speed. Shoddy construction practices, when combined with the poor quality of domestically produced pipe, facilitate pipe deterioration; and [redacted] the Soviets are already replacing sections of some relatively new pipelines. Nevertheless, 80 percent of the pipeline network is less than 20 years old, and we believe a major replacement program large enough to affect the movement of crude oil will not be needed until the 1990s.

The construction target for crude oil pipelines in the 1981-85 plan, 9,200 km, is small compared to earlier plans—22,000 km for the 1971-75 period and 15,000 km for 1976-80. To some extent this may reflect an anticipated leveling off of oil production. Because of competition from the gas pipeline program and a Soviet history of overly ambitious pipeline construction targets, we believe that oil pipeline construction in the 1981-85 period may amount to only 8,000 km, some 1,200 km (13 percent) short of the current plan goal (figure 18).

Whether or not this pipeline construction shortfall will affect oil production in the 1980s will depend largely on the Soviets' ability to complete a major trunkline, construction of which may have already

Figure 19
West Siberian Crude Oil Pipelines



begun, from the new fields in the Kholmogor area of West Siberia into the Volga-Urals region (figure 19).[24] We estimate that the present West Siberian trunk pipeline network has about 7.2 million b/d of usable throughput capacity—slightly more than the current rate of production for the region. The Soviets will consequently need to add another 700,000 b/d of transportation capacity—either in new pipelines, enhancements to existing systems, or a combination of the two—to accommodate planned production through 1985. In the past the Soviets have never failed to have the required trunk pipeline capacity available in West Siberia to transport increased crude oil output. In this five year plan, however, the Soviets are extending their gas pipeline network at an unprecedented rate; and it is by no means certain that they possess adequate labor and material resources to complete the new oil pipeline on schedule.

[24] In August 1982 the Soviet press reported that construction had begun, and [redacted]

[redacted] Since then, Soviet open sources have announced that construction is proceeding slowly. The evidence that the Soviets will complete this line in time to meet the goals of this FYP remains [redacted]

Refining

The refining industry, the last major stage in the Soviet oil supply chain, must not only be able to process the required quantity of crude, but also produce a mix of end products that satisfies the particular demands of the Soviet economy (table 7). Our analysis indicates that the Soviet refinery system is of adequate size to process enough crude oil to provide for current consumption of about 9.0 million b/d. We estimate current capacity for crude oil distillation—the initial process in which crude oil is separated into gases, gasoline, kerosene, diesel fuel, and heavy products—to be in the range of 8.5 to 9.3 million b/d, with an additional 520,000 b/d due to be completed by mid-1983 and subsequent smaller additions to capacity scheduled throughout the decade.[25]

Table 7
Estimated Fuel Mix From Soviet Oil Refineries

Percent

	1960	1965	1970	1975	1980
Gasoline	18.3	17.2	17.0	15.7	14.7
Kerosene	10.9	7.6	7.2	6.4	6.0
Diesel fuel	22.3	24.8	23.1	21.4	21.5
Other light products	2.1	1.9	1.9	2.6	3.0
Share of light products (including gas condensate)	53.6	51.5	49.2	46.1	45.2
Lube oils	4.3	3.8	3.1	2.6	2.5
Fuel oil	30.8	33.8	36.3	38.7	39.9
Other residuals [a]	3.4	3.0	3.5	4.8	4.7
Share of heavy products	38.5	40.6	42.9	46.1	47.1
Gas and loss	7.9	7.9	7.9	7.8	7.7

[a] Includes asphalt, petroleum coke, wax, and similar products.

[redacted] however, that the Soviets are facing difficulties with their refinery mix and are suffering from shortages of several of the lighter products. Inadequate secondary processing and cracking capacity, processes that convert the output from the crude oil distillation process into light products, is the source of the Soviet problem. In the past the Soviets have been able to increase their production of gasoline and other light products by simply producing more crude and constructing more distillation units to handle the increased crude production. Stagnant or declining oil output is foreclosing this option. The Soviets have repeatedly emphasized the need to convert their heavier oil products into lighter ones but have not installed adequate amounts of catalytic cracking and hydrocracking capacity to accomplish this task. We estimate that Soviet secondary processing capacity is now only 30 to 40 percent of primary capacity—compared to 120 percent in the United States—and that the share of heavy products coming from Soviet refineries is increasing rather than decreasing. This lack of secondary capacity has resulted in poor quality refined products, increased production of heavy fuel oil at the expense of more desired products such as high octane gasoline, low-sulfur diesel fuel, lubricating oil, and less flexibility in adjusting the product mix to meet seasonal changes in demand.

The shortage of secondary processing capacity is not an actual constraint on future Soviet oil production as such. It does, however, present a serious roadblock to Soviet plans to bridge any potential oil gap through substitution of natural gas and coal in the domestic economy. Although substitution possibilities for light products are very limited, natural gas and coal can replace some of the huge quantities of heavy fuel oil burned in power plants and industrial boilers. The success of such substitution hinges, however, on the modernization of the Soviet refinery industry. Unless the refinery industry increases its ability to convert fuel oil into lighter products, the Soviets will have to continue to burn fuel oil in power plants, boilers, and other applications for which natural gas is suitable, keeping crude oil demand high

[25] This range reflects the uncertainty involved in estimating a subject the S[redacted] as a state secret [redacted] the SOVA forthcoming report, *The Soviet Oil Refining Industry: Trends and Prospects.*) The higher end of the range is based on reported Soviet production combined with estimates of losses, pipeline and storage additions, and direct use of crude oil, to determine the amount of crude oil handled by refineries. Numerous variables could explain the 9 percent difference in the two estimates. Preliminary analyses of these variables indicate that actual refining capacity is probably near the center of the range.

Since the late 1960s the Soviets have been increasing their secondary processing capabilities, but not in the catalytic cracking process that increases yields of lighter products. Unless scarce hard currency is made available soon for increased purchases of appropriate Western equipment, we believe the inadequacies of the Soviet refinery industry could, at the minimum, exacerbate the effects of an oil supply shortfall later in the decade.