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USSR: Investment Trade-Offs Between Energy Production and Conservation, 1986-95

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A Research Paper

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USSR: Investment Trade-Offs Between Energy Production and Conservation, 1986-95 [redacted]

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A Research Paper

This paper was prepared by [redacted] Office of Soviet Analysis, [redacted] 25X1
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USSR: Investment Trade-Offs Between Energy Production and Conservation, 1986-95

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Preface

This paper focuses on the investment trade-offs between energy production and conservation. On the production side, our information allows us to assess the investment outlook for each type of fuel—oil, gas, and coal. On the conservation side, we are limited in our knowledge of how much of *each type* of fuel is consumed in each sector and, thus, how much of each fuel could be conserved. The *quantitative* forecasts of energy use and conservation are, therefore, discussed in terms of total energy. In the discussion of potential investment savings, we have made some assumptions as to how much of this energy would be oil, gas, and coal, but a detailed analysis of sectoral fuel consumption by type lies beyond the scope of this study. 25X1

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USSR: Investment Trade-Offs Between Energy Production and Conservation, 1986-95 [redacted] 25X1

Summary

Information available as of 30 January 1987 was used in this report.

With investment resources taut and energy production costs rising, the Soviets are increasingly aware of the need to trim outlays for energy production and to spend more on energy conservation. The cost of oil production is rising steeply, and the nuclear power program will incur added costs as a consequence of the Chernobyl' nuclear power plant accident. As the economy grows, energy consumption will continue to rise. Energy exports will remain both a necessary support to Eastern Europe and other client states and the Soviets' main source of hard currency earnings. [redacted] 25X1

Gorbachev's industrial modernization program provides a framework for improved conservation through introduction of new, more efficient machinery and faster retirement rates for aging capital. Investment aimed at both upgrading capital equipment and saving labor and raw materials may contribute, in the long run, to energy efficiency. But, in the short run, these investments may well increase energy use. This seeming anomaly is because of the relatively high growth planned in energy-intensive sectors of the economy, particularly machine building, and the efforts to boost labor productivity through further mechanization in agriculture and materials handling. [redacted] 25X1

Reacting to the growing economic burden of energy production costs, Moscow will probably try harder than in the past to find a workable combination of increased energy production, improved energy conservation, and interfuel substitution (notably, natural gas for oil). Decisions will be based in part on comparisons of the investment requirements for the alternative courses of action. But they will also reflect compromises between long- and short-run objectives and between the needs of the energy sector and the needs of other sectors of the economy. The energy investment burden is already substantial: investment in oil, gas (including pipelines), coal, and electric power together claimed one-sixth of total Soviet investment in 1981-85. In the 1986-90 plan period, investment in energy production is slated to rise by 42 percent, half again as fast as the growth in total investment. [redacted] 25X1

We have estimated the marginal investment requirements for new energy production capacity and for a range of specific energy conservation measures in several major energy-using sectors of the economy. Observing

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the extent to which the Soviets are implementing these measures will provide indications of how seriously Moscow is pursuing energy conservation. 25X1

Our estimates of the marginal investment requirements for new energy production capacity covered oil, gas (including new pipeline construction), and coal. These account for about 95 percent of Soviet primary energy production. (New energy production capacity not only provides for output growth but also offsets declines in output from the stock of wells or mines existing at the end of the previous period.) Our estimates indicate that investment requirements for oil (previously the lowest per ton of standard fuel) now exceed those for gas. Coal will remain the most costly of the three fuels. 25X1

Projections of energy use for 1986-95 under two conservation-oriented scenarios were compared with energy use based on past trends, which emphasized energy production. The results indicate that, by 1995, under scenarios calling for roughly 1-4 billion rubles in annual investment in conservation, potential energy savings could reach 130-250 million tons of standard fuel annually. The investment saved by not producing that amount of energy would be on the order of 10-15 billion rubles in 1995—roughly half as much as is invested in the oil, gas (including pipelines), and coal industries together in 1985. 25X1

The value of conservation becomes clearer when we compare conservation costs (which should not change dramatically over time) with our projections of rapidly rising production costs. We expect 1991-95 investment requirements for new energy production capacity to average about 270 rubles per ton—more than double the 1985 level. Furthermore, because of the annual depletion of production capacity, producing an extra 130-250 million tons of standard fuel in 1995 would mean adding an additional 180-350 million tons of new production capacity over the 1986-95 period. 25X1

Despite the potential for saving investment resources, energy conservation in the USSR will continue to be hampered by the lack of incentives to conserve; a tradition of low retirement rates for obsolescent capital equipment; and the difficulty of achieving coordinated implementation of thousands of individual actions. Other factors also work against Soviet efforts to improve energy efficiency. The continuing degradation in the quality of raw-material supply (lower oil well flows and poorer grade ores) requires the use of more energy and other inputs in extraction activities. In areas such as oil refining and metal processing, the demand for improved quality of output necessitates an increase in energy-intensive processing. Energy consumption is increased further by the rising average distances that goods—fuels as well as other products—must be transported. These factors add to the risk involved in an all-out effort to shift the emphasis of energy investment strategy from production to conservation. [redacted] 25X1

Projecting investment requirements for energy conservation in the USSR is difficult and complex. Lacking adequate Soviet data, we used US experience to provide benchmarks for a detailed examination of the costs and potential benefits of energy conservation in oil refining, ferrous metals, and chemicals. [redacted] assessed the relevance and potential impact 25X1 of these investments for the USSR, given Soviet plans and the state of Soviet technology. [redacted] the cost of substantial 25X1 energy conservation ranges from virtually zero for "housekeeping" types of improvements to high for the installation of new processes. [redacted] 25X1

Only a small portion of potential energy savings is dependent on the very-high-cost measures. For the entire range of measures, investment costs in the three industrial activities studied in detail averaged about 120 rubles per ton of standard fuel conserved annually. Eliminating the six highest cost measures would, however, cut the conservation investment costs to just over 85 rubles per ton of standard fuel conserved, while reducing potential energy savings by only 3 percent. [redacted] 25X1

Our calculations show that imports of Western conservation equipment would be an efficient way to conserve energy. When weighing the estimated lifetime energy savings from the use of such equipment against initial investment and discounted operating costs, all but two of the measures surveyed would cost less in dollars than the energy saved would earn on the world market. [redacted] 25X1

The conservation potential of the other major energy-consuming activities in the Soviet economy (agriculture; construction; residential; transportation; and, in industry, cement, electric power, fuels, machine building, and nonferrous metallurgy) were examined in less detail. We found a wide spectrum of possibilities. In some sectors—particularly the residential,

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agricultural, and fuel-producing sectors—conservation is potentially substantial and relatively cheap, but depends on thousands of small actions. Elsewhere, notably in cement and electric power, major improvements in conservation are tied to extensive transition to expensive new technologies. [redacted] 25X1

The Long-Term Energy Program published in 1984 and the 1986-90 Five-Year Plan both assert the importance of energy conservation. Our analysis supports Soviet contentions that energy conservation is economical. The Soviets are not likely, however, to realize anything close to our estimated potential savings of energy and, hence, of investment. Efforts to achieve large-scale energy conservation during the next 10 years will continue to be inhibited by many factors, including: the limited supply of energy-conserving equipment; the high front-end costs of introducing new technology; the managerial and incentive deficiencies affecting implementation of low-cost measures; and the risk that midlevel managers will continue to concentrate resources on boosting output. [redacted] 25X1

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Energy Investment Alternatives: Production Versus Conservation

Moscow faces a combination of rising energy-production costs, rising domestic demand for energy, and continued need for energy exports. The Soviets can handle this situation by altering the mix of energy produced and consumed (gas-for-oil substitution, for example), by continuing to emphasize production increases despite the rising costs, by improving energy conservation through greater efficiency, or by some combination of these. What energy choices the Soviets make and how successful they are in implementing those choices will affect the strength of the Soviet economy as well as the availability of energy for export.

The Soviet energy sector is one of the most important elements in the Soviet economy. Energy exports are essential—providing in recent years over half of Soviet hard currency earnings and roughly 70 percent of Eastern Europe's oil and gas consumption. The USSR is quite limited in its ability to offer alternative exports for hard currency, and Eastern Europe would find it difficult to pay hard currency for substantial energy imports from other suppliers. Domestically, even with improved energy efficiency, some increase in domestic energy availability is necessary to support economic growth, modernization in industry, and further mechanization of agriculture.

The energy sector is also one of the most expensive components of the Soviet economy. In the early 1980s this sector absorbed about one-fourth of Soviet investment and about one-seventh of the labor force.[1] Soviet authors note that the energy sector consumes about 15 percent of machine-building output, 65 percent of steel pipe output, up to 20 percent of other ferrous-metal production, 15 to 20 percent of copper and aluminum production, and 13 to 16 percent of cement.[2] 25X1

The investment requirements for energy production depend in large measure on identifiable factors such as well-flow rates, drilling depths, pipeline requirements, and pumping requirements. In most cases, historical Soviet data permit approximation of the relationships involved. Taking uncertainty into account, energy-related investment requirements can be forecast, particularly for the USSR, where production is close to capacity and where output does not respond to market forces to the same degree as does energy production in the West. Using this approach, we estimated investment requirements per ton of coal, gas, and oil for the 1986-95 period. 25X1 25X1

Forecasting energy consumption and energy conservation is considerably more uncertain. The outlook for energy consumption depends not only on changes in the efficiency of energy use but also on the structural composition of the economy, the weather, the level of mechanization in the economy, and the population's attitude toward energy use. The increase in energy efficiency per unit of gross national product in the United States since the mid-1970s, for example, was in part because of a structural shift away from energy-intensive heavy industry and toward the less-energy-intensive service industries. In addition, an increase in the severity of a winter increases energy consumption relative to industrial output, although the general efficiency of energy use may have risen. The importance of these factors and their interactions make historical data less useful in forecasting energy 25X1

[1] The "energy sector" here is broadly defined to include all elements of the economy involved in the production, transformation, and distribution of energy; in the associated transportation and other infrastructure in support of energy; and in the production and operation of boilers and other major heat-producing equipment. *EKO* (No. 4, April 1983): p. 20. 25X1

[2] A. A. Beschinskiy *et al.*, *Energetika i topliva* (No. 4, 1982): p. 33. 25X1

consumption or conservation than in forecasting energy production. Moreover, the effect of higher energy prices, which stimulated much of the conservation in the West, is far less important in the planned Soviet economy. 25X1

We address conservation narrowly defined to mean using less energy to obtain the same product—whether through the introduction of new, more efficient equipment or through better operating techniques to ensure smoother, waste-free utilization of existing equipment and structures. The Soviet definition is much broader, including gains made by restructuring and substitution, and including organic fuels "saved" by the increased use of hydroelectric and nuclear power.[3] 25X1

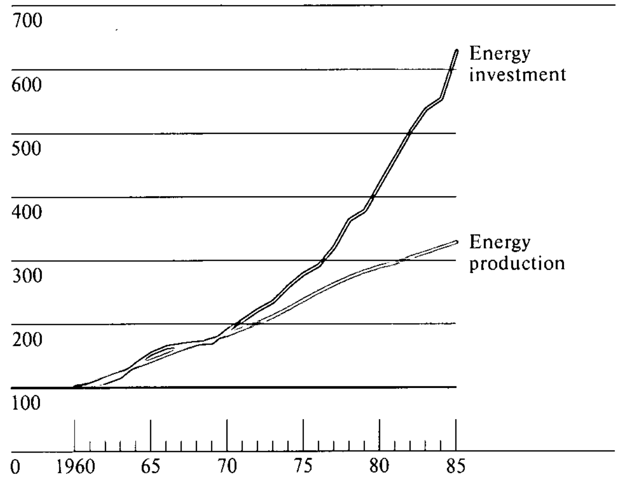
In addition to the complexity of forecasting energy conservation, there is a scarcity of relevant data. Although the Soviets have an extensive literature that discusses hundreds of energy-conservation measures, information on the investment required for individual measures or on the energy savings associated with them is minimal. Moreover, Soviet literature gives very little indication as to which measures are to be accorded priority and which will probably be funded. To the extent that actual conservation gains (as opposed to meeting plan targets) are treated, the discussion is usually either at a very generalized level or so specific to a single plant that generalized conclusions are difficult to draw. 25X1

Furthermore, many investments discussed for their energy-conservation merits (such as the plan to increase the share of continuous-casting output in the steel industry) are being made for reasons such as improvements in product quality or savings of labor and raw materials in the energy-using industry. Energy conservation is often only one of many reasons for making one investment and not another. 25X1

Projections of energy conservation levels were made in two steps. First, energy consumption was forecast over the 1986-95 period, based on past trends in the five basic energy-consuming sectors of the Soviet economy

Figure 1
USSR: Growth in Energy Production and Investment

Index: 1960=100



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(industry, construction, transportation, agriculture, and residential), as well as in the nonfuel category of energy use (principally, industrial feedstocks). We estimated gains in energy efficiency by 1995 from the contractor study and our own survey of energy-consuming sectors. These gains were then incorporated into the basic forecast to calculate projected energy savings. The future benefits of this energy conservation were then viewed in terms of both lower investment in energy production and greater availability of energy for export. 25X1

Investment in Energy Production 25X1

Although Soviet energy production has grown rapidly since 1960, it is increasingly more expensive (see figure 1). The Soviets possess large resources of coal, gas, and oil, but these are becoming more difficult to locate, produce, transport, and process. Investment in

[3] All of the latter type of savings fall under what in Western nomenclature would be referred to as a composition effect. 25X1

coal, gas, oil, and electric power industries absorbed over half of the increase in Soviet industrial investment in 1981-85, although these sectors accounted for only about one-fifth of the increase in the industrial component of GNP. Furthermore, the work force in these sectors increased by about 200,000 workers—growing at a faster rate than the national average.

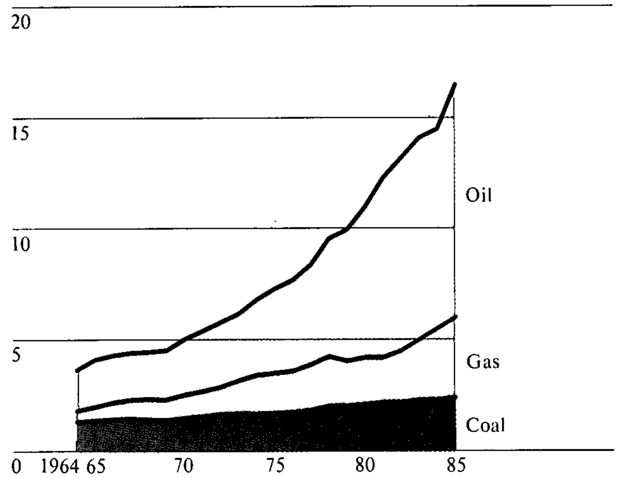
While Moscow recognizes that the cost of energy production is escalating, we believe it may be underestimating the rate of increase. For example, the Soviet Long-Term Energy Program, issued in 1984, projects that direct investment in the production, transformation, and distribution of energy will average 20 to 22 percent of total capital investment during the rest of the century—up from a share of about 18 percent in 1985.[4] Our assessment of energy-production targets and investment requirements suggests that direct investment in the production of oil, gas, and coal alone will rise from 13 percent of investment in 1985 to 21 percent in 1991-95.

Oil Investment. The rise in oil investment is the principal force behind the rise in overall energy investment (see figure 2). In brief, virtually all of the factors that affect oil production are worsening: new-well flow rates are falling, well depths are increasing, the share of free-flowing (easy maintenance) wells is falling, and the importance of expensive offshore and high-sulfur onshore oilfields is growing. As a result, we project that oil industry investment will have to at least double between 1985 and 1990 to keep production from falling sharply.

The principal factor that could change these trends, the discovery of a giant or supergiant oilfield, would have little effect on production over the next 10 years because of the long leadtimes required to bring new oilfields into full production—particularly if the discovery is in deep water offshore. 25X1

Figure 2
USSR: Investment in Primary Energy Production

Billion rubles, 1970 prices



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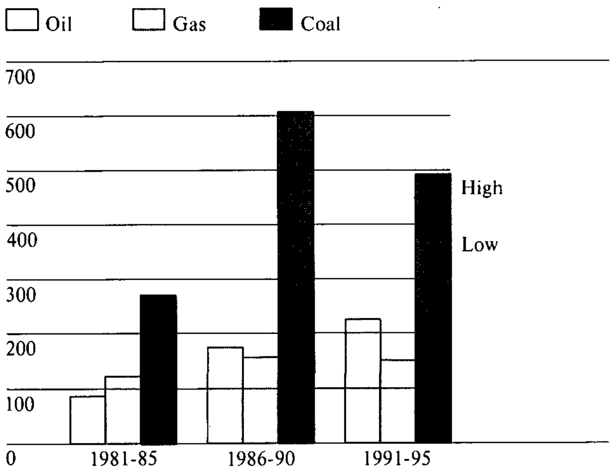
Indications from the 1986-90 plan, as well as from the 1986 plan, suggest that the Soviets are planning large investment increases in oil production. Both development and exploration drilling in the principal oil region (West Siberia) are to double in 1986-90, compared with drilling in the 1981-85 plan. Investment in infrastructure to support the production efforts is also slated to increase substantially. Indeed, the investment increment planned for the oil industry in 1986 was about as large as the increase in the entire 1981-85 period. 25X1

We estimate that oil investment requirements will continue to increase rapidly throughout the period. Our estimates are based on the investment requirements for producing 11.3-12.0 million barrels per day 25X1

[4] *Osnovnyye Polozheniye Energeticheskoy Programmy SSSR na Dlitel'nyyu Perspektivy (Moscow: Izdatel'stvo Politicheskoy Literatury, 1984), p. 29.*

[5] Our projections of oil and gas investment are based on our assessment of the efforts required to produce the amounts of oil and gas that we forecast, while the coal projection is based on analysis of two scenarios—one a high-cost option of developing Eastern coal basins and the other a continuation of previous trends. Details on the projection methodology are available upon request to the Chief, Economic Performance Division, National Issues Group, Office of Soviet Analysis.

Figure 3
USSR: Estimated Investment Requirements for New Oil, Gas, and Coal Capacity [a]
Rubles per ton of standard fuel in 1970 prices



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in 1990—investment in drilling, oilfield equipment, and production infrastructure in West Siberia, investment for exploration drilling, and investment to support production in regions outside West Siberia.[6] A similar analysis was used to project investment requirements in the 1991-95 period. We estimate that oil investment requirements per ton of new capacity will double in 1986-90 compared with investment requirements in 1981-85, and will increase again by about 30 percent in 1991-95 (see figure 3). The slower increase in 1991-95 is because of two factors—a projected tapering off of the decline in the flow rates of new oil wells in West Siberia and the availability of additional infrastructure established in 1986-90.[7]

[7] Soviet data show that new-well flow rates in West Siberia fell by 57 percent between 1980 and 1985. We estimate that they will fall by nearly 30 percent between 1985 and 1990, and by another 25 percent between 1990 and 1995.

Gas Investment. The exploitation of natural gas resources involves coping with technically challenging problems that require expensive solutions. Gas from the new fields of the pre-Caspian Depression is exceptionally high in corrosive hydrogen sulfide and other contaminants, requiring the use of state-of-the-art production and processing equipment from the West. Gas from the West Siberian fields has to be transported to the European USSR through 2,500 to 3,500 kilometers of large-diameter pipeline, most of which has been constructed with imported pipe. Roughly 10 percent of the gas transported such distances is used to fuel the pipeline compressors. 25X1

Nevertheless, gas production is in some respects a simpler matter than production of either oil or coal. Reserves are abundant. Gas Ministry drilling requirements are about one-tenth of those of the Oil Ministry (because of the high flow rates of gas wells, and lower depletion rates). Labor productivity is far higher for gas than for other fuels, and no new technology—such as the long-distance slurry pipelines or liquefaction facilities being considered for coal—is required for the production and transmission of most Soviet gas. 25X1

Our projections show that gas-industry investment requirements will rise slowly in 1986-90 (see figure 3). Although the Soviets will be moving increasingly offshore, into high-sulfur fields, and farther north in West Siberia in 1991-95, they can build on existing infrastructure in West Siberia and apply experience already gained in developing high-sulfur fields at Astrakhan' and Tengiz. Pipeline investment requirements will probably continue to account for about 60 percent of the gas investment total. 25X1

Coal Investment. The outlook for coal investment depends on whether the Soviets carry out their plans

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to develop extensively the low-quality Siberian and Kazakh coals.[8] We project two coal scenarios:[9]

- A low option in which coal investment grows at its historically low annual rate (3.5 percent since 1970) and coal production falls to roughly 700 million tons by the early 1990s.
- A high option in which the coal industry receives an increase in investment and accelerates development of its eastern coal basins. Under this scenario, coal production rises to as much as 800 million tons by 1995.

In the high coal option, we project that the investment costs per ton of new capacity will increase rapidly in the late 1980s, as the expensive front-end investment in eastern coal is made with little initial gain in output. By the 1990s, however, investment is projected to decline slightly, as investment costs per ton of new capacity decline. In the low-investment case, costs rise in 1987, but grow only slowly through 1995 (see figure 3). Although the high option is more expensive, the Soviets may see the potential gain—an additional 400 million tons of coal above the low coal option during the 1987-95 period—as worth the cost, particularly given the enormous resource base in coal (reserves widely estimated to be some 200 times as large as current annual production) and the increasing difficulty in maintaining the level of oil output at a relatively high level.

In both coal scenarios, we estimate that coal production remains well below Soviet targets. The 1986-90 Five-Year Plan calls for production of 780-800 million tons of coal in 1990. Press reports indicate that the Soviets are looking at a 1995 coal production target in the range of 850 to 900 million tons—6 to 13 percent higher than our high estimate. Our estimate reflects an assessment of the difficulties that the Soviets will have in overcoming the technical problems related to the transport, conversion, and use of coal from the eastern regions. 25X1

Despite rapidly rising costs and little or no growth in the production of oil, investment in the oil industry was for long the cheapest way for Moscow to increase new energy capacity (see inset). For example, as late as 1985 a ruble of oil investment bought about 10 percent more energy than a ruble of gas investment (including gas pipelines).[10] But nearly all of the steep rise in oil investment offsets depletion—without this rise, oil production would decrease markedly. 25X1

The conclusion that gas was the more expensive fuel, but that oil is surpassing it, agrees with published Soviet energy discussions.[11] This cost trend is only one of the factors that favor an emphasis on gas production. Other factors include: the relative ease of production, the abundant reserves, and the long-run benefits of pipeline investment (compared with investment in new oil wells or pumping equipment). 25X1

Investment in Energy Conservation 25X1

The growing awareness of energy's burden on the economy's investment resources has intensified interest in energy conservation. Soviet writers repeatedly stress the relative cheapness of energy conservation measures. They commonly assert that the investment required to boost net energy production by one unit is two to three times as great as the investment required to conserve an equivalent amount of energy. Figures cited for the investment cost of conservation measures are in the range of 35 to 80 rubles per ton of standard 25X1

[8] Coal production has stagnated until recently due in part to the necessity of working thinner and deeper coal seams in the older coal regions, especially in the Donets Basin, which still produces some 25 percent of Soviet coal. There are abundant, easily mined but largely low-grade coal deposits in Siberia and Kazakhstan. Large-scale production from these regions, however, awaits expensive technological solutions to problems of transportation and quality enhancement.

[10] In 1985, for example, 11.5 billion rubles (1984 rubles) were invested in the oil industry, and new production capacity of an estimated 100-110 million tons of standard fuel was created. Gas industry investment of 4.2 billion rubles for production and 5-6 billion rubles for pipelines added an estimated 80 million tons of new capacity. 25X1

[11] L. A. Melen'tev and A. A. Makarov, eds., *Energeticheskii Kompleks SSSR* (Moscow: Energoizdat, 1981), p. 53. 25X1

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Comparison of Investment Costs

The forecasts of investment-to-new-capacity ratios for individual fuels can be converted to a standard-fuel-equivalent basis and then compared (see figure 3). The following conclusions can be drawn:

- *Oil investment requirements per ton (standard fuel) of capacity were the lowest among the three major fuels through the 1981-85 period, although they are growing considerably faster than those for gas. Beginning with the 1986-90 period, however, investment requirements for oil will exceed those for gas.*

- *Investment requirements for a given amount of new energy capacity from gas (including pipelines) were greater than those for oil before the 1986-90 period. These requirements were high initially (in relation to investment in oil) because of the high capital outlays required for gas pipelines.*

- *Coal investment presents the greatest uncertainty. The trend in investment requirements depends heavily on the priority given to the sector and on the Soviets' ability to solve the technological and transportation problems relating to use of the cheaper eastern coal. The results of both scenarios examined, particularly when the falling average energy content of coal is taken into account, suggest that coal is the most expensive option. Even in the low case for coal, investment per ton of standard fuel is higher than that in the high scenario for oil in 1995. Given Gorbachev's concern about slowing the growth in investment in energy production, the chances for adoption of the intensive coal option appear less likely when the other investment alternatives are examined.*

fuel.[12] This range is lower than our estimates of 75 to 95 rubles of average investment required per ton of capacity to offset depletion and provide net growth in output (including gas pipeline investment). In addition, gains from conservation investment normally have a longer lifespan than those from production investments. 25X1

The Soviet Potential for Energy Conservation

Despite many obstacles to conservation (see inset), the Soviets still have considerable potential for implementing energy savings. Overall, they do not use energy efficiently. The general structure of Soviet energy production, transformation, and consumption as of 1980 is illustrated in figure 4. The Soviets at that time converted into usable energy only 37 percent of the original energy content of the energy produced—compared with 45 to 55 percent for most industrialized countries in the mid-1970s.[13] 25X1

Moreover, overall measures of efficiency hide some relative inefficiencies. The Soviets are highly efficient in supplying electricity and heat because of the high percentage of cogenerational power plants,[14] but are considerably less efficient than the West in areas such as oil refining and production of chemicals. 25X1

A striking fact emerging from examination of the end uses of Soviet energy is that the energy sector (including production of fuels, refining, electric power, and heat production) is itself the largest energy consumer, accounting for nearly one-third of overall energy consumption.[15] Hence, energy conservation by other sectors not only reduces energy consumption directly but also offers a potential for reducing the energy sector's internal use of energy. 25X1

Methodology for Assessing Soviet Energy Conservation Potential

We used a four-stage process to assess the outlook for energy conservation through 1995. As a first step, we 25X1

[12] *Ekonomicheskoye sotrudnichestvo stran-chlenov SEV*, June 1981, for example.

[13] Joy Dunkerly, *Trends in Energy Use in Industrial Societies, An Overview* (Washington, D.C.: Resources for the Future, 1980), p. 29. 25X1

[14] Cogeneration is the process of capturing and using heat generated in an industrial process, particularly in the production of electric power. This heat can be used for space heating or for industrial steam needs. 25X1

[15] A. S. Nekrasov, ed., *Optimizatsiya Razvitiya Toplivno-Energeticheskogo Kompleksa* (Moscow: Energoizdat, 1981): p. 20. 25X1

Factors Hindering Soviet Energy Conservation

Limited Investment. *Investment in energy conservation has been slighted. In 1983, according to the Soviet press, ministries were allocating only 0.5 percent of their investment allocations to energy conservation.*

Emphasis on Output. *Despite the assigning of energy conservation indicators, an enterprise's success still depends on output. Energy conservation measures that impede output, even if only in the short run, thus receive low priority. Changes in the prices of inputs generally have failed to alter managerial behavior or provide incentives for increased efficiency.*

The Nature of the Problem. *Large-scale energy conservation requires thousands of small-scale actions. Conservation measures are often plant-specific, relying heavily on individual initiative. The problem is not well suited to a centralized national approach.*

The Lack of a "Conservation Industry." *Although the installation of control devices, such as thermostats, is one of the simplest and cheapest ways to conserve energy, a 1983 press report indicated that the Ministry of Instrument Making was supplying industry with only 10 percent of that year's requirements for such conservation equipment.*

Poor Implementation. *Even when the equipment is available, it is often poorly used, not working, or never installed. One press report, for example, discussed heat-recovery boilers that were delivered to several plants but never installed. In one case, the boiler was left in an equipment yard for over 10 years.*

Poorly Developed Energy Norms. *A plant's "norms"—the amount of energy required to produce a unit of output—determine its energy allocation. Inflated norms, encouraged in part by the lack of measuring instruments, appear to be widespread. At the plant level, inflated norms can mean greater assurance of supply and easier attainment of conservation targets. At the national level, these false norms can lead to energy shortages and false indications of energy savings.*

Long Leadtimes. *Many conservation measures take a long time to implement. The replacement of old processes with new energy-efficient ones can take seven to nine years, according to one Soviet energy expert.*

The Aging Capital Stock. *Retention of obsolete capital also makes conservation gains difficult. Retirement rates have been especially low in some of the most energy-intensive sectors (electricity, ferrous metals, machine building, and chemicals). Gorbachev calls for turning the situation around, but it will be difficult.*

Decreasing Quality of Raw Materials. *A degradation in the quality of raw materials is compounding the structural and administrative problems already cited. Lower quality metallic ores, lower flow oil wells, deeper and more remote coal mines, all require increased efforts, including increased energy use, per unit of output.*

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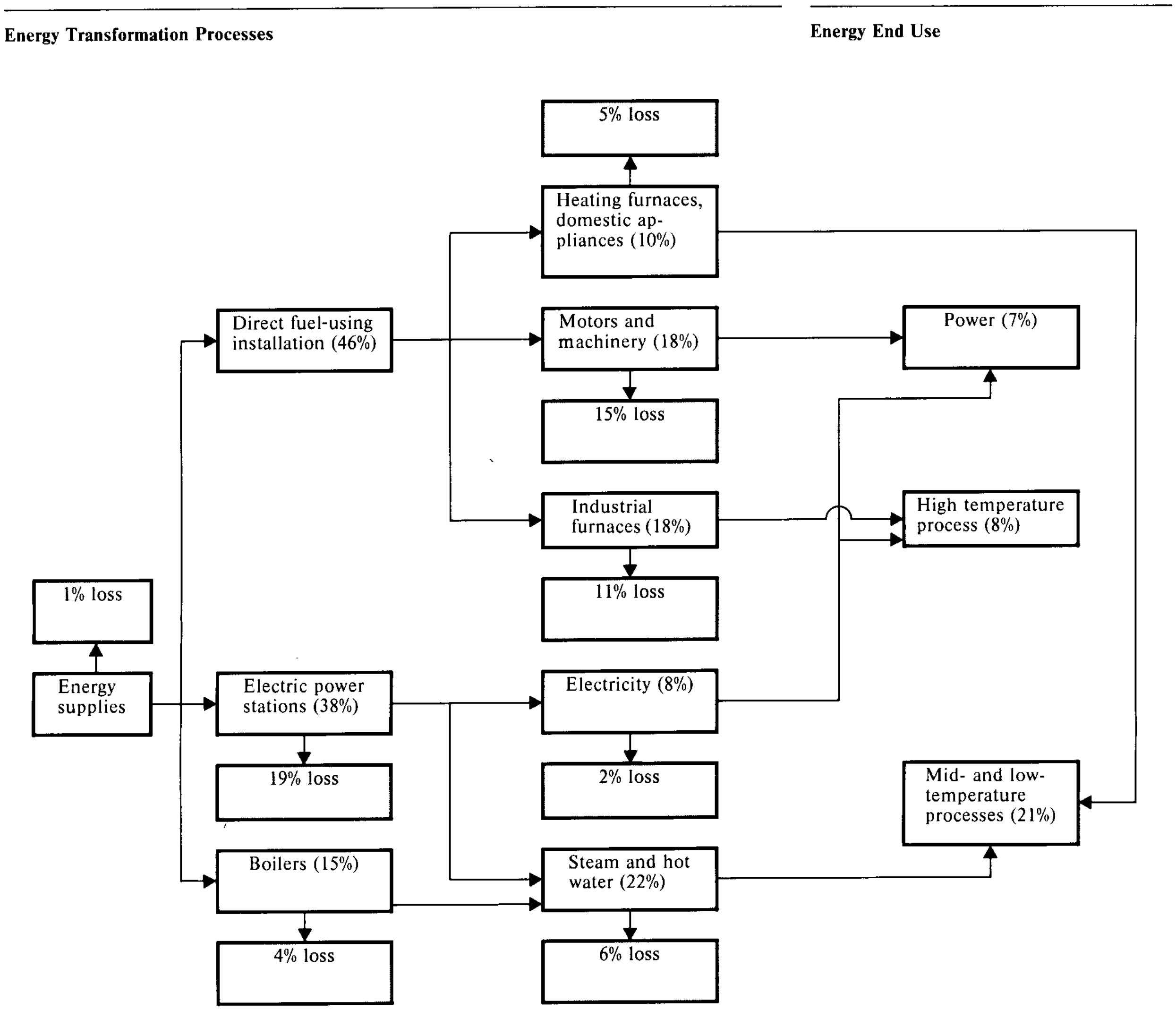
Figure 4
USSR: Energy Use Patterns, 1980



Note: The energy remaining following the energy transformation process is 37 percent, 1 percent higher than the energy in end use. This is because about 1 percent was used for the electric power sector's own needs.
Source: *Promyshlennaya energetika* (Number 9, September 1984): p. 6.

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assessed the potential for energy conservation not requiring added investment. Second, we assessed the potential for energy conservation entailing investment in new plant and equipment. Next we assessed how far the Soviets are likely to proceed with the different conservation approaches, given our perceptions of their priorities and the availability of investment resources. Finally we compared the potential gains from energy conservation measures against offsetting factors that would increase the energy used per unit of output.

Many potential energy conservation measures involve little or no investment. These involve only greater attention to an activity and more efficient management of energy use within the given technological environment. The resulting savings would reflect the "human factor" that Gorbachev has often stressed. Studies performed by the contractor found a range of low-cost, essentially "no-investment," energy-efficiency improvements that could yield savings equivalent to about 5 to 10 percent of energy use in 1980, based on assessments of Soviet technology and US experience in energy conservation with such technology.[16] We estimate that Soviet potential would be near the bottom of this range, on the basis of evidence from comparison of individual industries. Although the US experience may understate the potential savings in the more wasteful Soviet economy, the savings achieved in the United States were in part because of substantial financial incentives and the availability of sufficient metering instruments and other essential low-cost devices. Such equipment is in short supply in the USSR, and incentives appear to be insufficient at both the managerial level and the household level to have the kind of impact on energy use that was seen in the United States.

We also assessed potential gains in energy efficiency because of investment in new plant and equipment—in considerable detail for the three sectors evaluated by the contractor and in a more summary fashion for the other major energy-using sectors of the Soviet economy. The investment options examined ranged from inexpensive modifications of existing equipment to high-cost shifts to totally new technologies. These investment-based gains in energy efficiency were then added to the low-cost conservation potential to provide an estimated upper bound of energy conservation potential. 25X1

Next, we combined our estimate of conservation potential with our assessment of Soviet priorities and availability of investment to estimate a "more likely" range of conservation gains, a range that falls below the upper bound of potential conservation. This step involves a consideration of the side effects of conservation. If, for example, the conservation measure results in substantial savings of labor or raw material, or if it results in improved quality, then even expensive measures are more likely to be implemented than if there are no positive side effects. We also examined other factors, such as what else is happening in a given sector, that may influence conservation decisions. 25X1

25X1

Finally, we assessed offsetting elements—factors that could cause the energy intensity of the Soviet economy to rise. Energy use per unit of output can increase for several reasons:

- A degradation in the quality of raw material inputs or an increase in the difficulty of obtaining them may require more energy that in the past (iron ore and crude oil extraction are examples).
- Demands for higher quality output may require more energy in processing activities (oil refining and metal processing).
- Labor-saving innovations (such as increased mechanization in agriculture or in materials handling) substitute energy for labor and can increase the energy used per unit of output. 25X1

These increases may well more than offset conservation gains that are occurring at the same time.

25X1

Even net conservation gains do not mean that energy consumption will decrease, energy use may simply grow less rapidly. For example, according to Soviet

[16] In one case, ammonia production, the contractor's study estimated that no-cost efficiency gains could reach 20 percent. Of this estimated potential gain, however, 12 percentage points were because of the removal of bottlenecks that have impeded an increase in production capacity. In actuality this effort would probably involve some investment costs.

25X1

statistics, the electricity and heat consumed to produce 1 ton of ammonia dropped substantially, by over 20 percent, between 1981 and 1985. Output of ammonia, however, grew by about 27 percent, so the total amount of energy used in ammonia production actually increased. [redacted]

Results of Case Studies on Oil Refining, Ferrous Metals, and Chemicals

The sectors chosen for the contractor studies—oil refining, ferrous metals, and chemicals—were selected on the basis of their importance to the Soviet economy, their high energy-intensiveness, and their potential for conservation (evaluated in the light of Western experience). [redacted]

The methodology entailed examination of conservation measures taken in the corresponding sectors of US industry, focusing on technology comparable to current Soviet technology. The assumption was then made that the energy savings in the USSR from a given conservation measure would be the same as on comparable US equipment. Although Soviet problems in implementing these measures could lessen the impact, the *potential* of the conservation measures should be roughly comparable. The impact of each conservation measure (energy saved per unit of output) was multiplied by that portion of Soviet production capacity where the relevant measure was deemed applicable. Total investment requirements and annual energy savings were computed. We then converted the 1980 dollar costs provided by the contractor to 1970 rubles to make the investment requirements comparable to those for production investment.[17] We used 1970 rubles rather than 1984 rubles because of the limited availability of some essential details in 1984 prices (see inset). [redacted]

[redacted]

Choice of a Price Base

On 1 January 1982 the Soviets changed prices from those that existed in the 1970s to a new price base. Over the past four years changes have continually been made in this new price base, and we do not as yet know many of the prices.

This paper uses 1970, rather than 1982 or later, prices for two principal reasons:

- *The calculations in this paper require the use of ruble-dollar ratios for numerous components of the complex machine-building sector. Prices at this level of detail are not yet available in 1982 or later prices.*

- *In this paper we focus on the marginal, comparative investment requirements for energy production and conservation. Both types of investment involve the purchase of machinery, either for producing or saving energy. The fact that in 1982 energy prices rose relative to machinery prices enhances the gains from both types of investment, but it is not clear that these increases favor one type of energy investment over another. Soviet internal prices for crude oil prices rose by 130 percent in 1982, but prices of refined oil products rose by only 12 to 51 percent. To the extent that energy price increases are not fully passed on to the energy consumer, the price increases would somewhat favor energy production over energy conservation.*

[redacted]

Both the nature of measures requisite for conservation and the resulting energy-savings potential differ widely from sector to sector. In oil refining, for example, the recapture of waste heat and the more careful monitoring of energy use can yield big energy savings. In another area—ammonia production—the major sources of conservation are in simply operating existing equipment more efficiently. In still other cases—

Table 1
Summary of Results of Conservation Case Studies

Sector	Energy Saved (*million tons standard fuel*)	Investment Required (*million rubles*)	Investment Cost (*rubles per ton standard fuel*)
All three industries	54.58	6,424.9	117.7 [a]
Ferrous metallurgy			
Coke	23.66	4,083.1	172.6
Other	10.36	1,781.2	171.9
Oil refining	9.7	400.0	41.2
Chemicals			
Methanol	0.4	36.0	90.0
Ammonia	9.12	71.6	7.9
Caustic soda	1.34	53.0	39.6

[a] Weighted average (based on per-ton investment cost weighted by energy saved for each sector shown).

[redacted] 25X1

steel and methanol—many gains are expensive and made by a transition to new, more energy-efficient processes and technologies. Furthermore, the type of energy saved varies. Conservation in oil refining saves principally oil, while efforts in ferrous metals will save principally coking coal. Conservation gains in many areas of the chemical industry will principally reduce the industry's consumption of natural gas. [redacted]

Energy conservation in ferrous metals is the most expensive among the industries surveyed, yielding only about 60 percent of the aggregate energy savings for over 90 percent of the investment. We believe this finding to be typical of sectors of the Soviet economy such as electric power, cement, and nonferrous metals, where older technology is generally used efficiently and improvements are linked to the expensive transition to new technology. The energy conserved as a percentage of the sector's 1980 consumption is highest for chemicals (25 percent) and lowest for ferrous metals (12 percent). [redacted]

Overall, implementing all of the measures surveyed by the contractors would *potentially* save about 55 million tons of standard fuel annually (about 2.5 percent of primary energy production) at an average investment cost of 120 rubles per ton (see table 1 and figure 5). Eliminating the six highest cost measures (representing 3 percent of the potential energy saved, but 30 percent of the investment required for the whole package of conservation measures), would reduce the investment required to 85 rubles per ton. Housekeeping and other measures requiring little or no investment account for nearly 30 percent of the potential energy saved. [redacted] 25X1

25X1

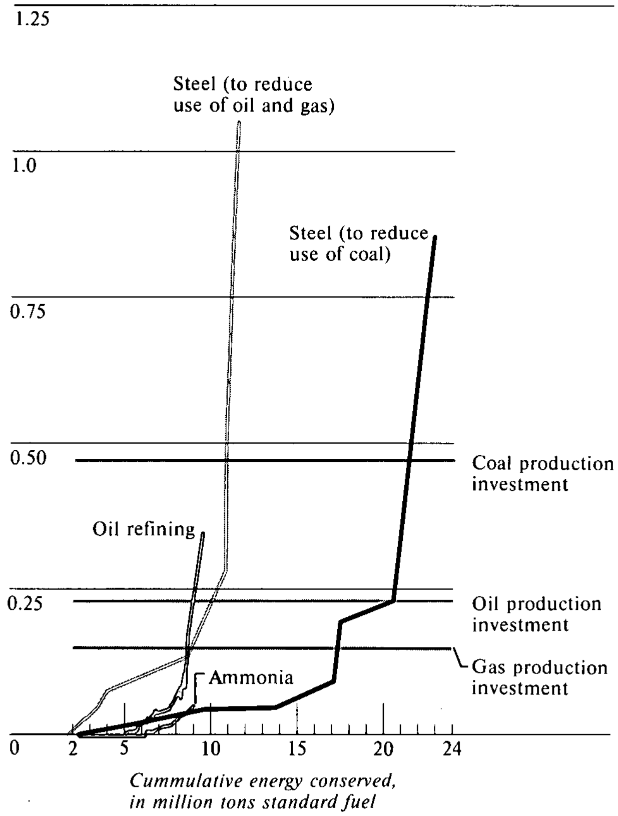
Some actions the Soviets are discussing, such as the move to continuous casting of steel, appear to be too expensive if only the energy-saving aspects are considered. However, the improvements in labor productivity and the savings in metal, as well as product-quality improvements, make the process appealing. [redacted]

The results noted above assume that new machinery and processes replace (rather than add to) old, less efficient machines and processes. The addition of an energy-efficient machine or process, if it is used for new capacity without retiring any less efficient machine or process, increases total energy use. Energy is "conserved" only in the sense that less energy is used than if additional capacity based on the older process

25X1

25X1

Figure 5
USSR: Investment Trade-Offs Between Incremental Energy Production and Energy Conservation in Selected Industries, 1991-95[a]
Investment in production or conservation[b]



Note: The curves for steel, oil refining, and ammonia show marginal investment cost for energy savings as progressively more expensive measures are employed.

In the steel industry, for example, investment in the less expensive conservation measures leading to reduced use of oil and gas is cheaper than investment in more oil and gas production—up to savings of about 9-10 million tons of standard fuel.

[a] For illustrative purposes, incremental energy investment is assumed constant for the period 1991-95.
[b] Rubles per kilogram/standard fuel.

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were built instead of the new one. Such "savings" are indeed included in the Soviet definition of conservation. Such improvements on the margin will probably continue—new refinery units will probably be built closer together so that less heat is lost, new ammonia and methanol plants are being imported or copied from the West, and new steel plants will use electric-arc and basic-oxygen furnaces rather than open hearth. Such marginal improvements, however, change the average efficiency of a large industry only slowly. 25X1

Analysis of Conservation Potential in Other Activities
We also conducted a more general survey of the energy conservation potential and investment outlook in the other major energy-consuming sectors—agriculture, construction, electric power, urban-residential, transportation, and four industrial sectors (construction materials, fuels, machine building, and nonferrous metals). These activities, together with the three evaluated in detail, account for 90 to 95 percent of total Soviet energy consumption. The results of this broader survey, discussed more fully in appendix B and summarized in table 2, confirm that, while substantial conservation potential is present, the costs tend to be high after initial gains. 25X1 25X1 25X1 25X1 25X1

In some activities—notably elements of the residential, agricultural, and fuel-producing sectors—conservation potential is substantial and relatively cheap, but relies on thousands of small actions, each of which has little impact by itself. These actions include the installation of meters and other control devices, insulation, and improved piping and storage equipment. In sectors such as cement, aluminum, and electric power, big improvements are tied to the transition to new technologies—a very expensive and long-term proposition. In some cases, such as the energy-inefficient housing built after the mid-1970s when insulation standards were *lowered* (standards have since been raised), change will occur slowly over several decades. 25X1

25X1

Table 2
Summary Evaluation of USSR Potential for Energy Conservation [a]

Activity	Principal Energy Source(s) [b]	Efficiency Relative to US Activity	Conservation Potential of Fuel Use	Conservation Cost
Agriculture	Oil	Medium	Medium	Low
Construction	Oil	Low	Medium	Medium
Electric power	Oil, gas, coal	High	Medium	High
Residential	Gas, heat, electricity	Low	High	Low
Transportation	Oil, electricity	High	Medium	Medium
Industry				
Building materials	Oil, gas, heat	Low	Medium	High
Chemicals	Oil, gas, heat, electricity	Low	High	Low
Ferrous metals	Coal, oil, gas	Low	High	High
Machine building	Heat, electricity	Medium	Medium	High
Nonferrous metals	Electricity, heat	Medium	Low	High
Oil refining	Oil, gas, heat	Low	High	Low

[a] The information on ferrous metals, chemicals, and refining was provided by the contractor. The terms low, medium, and high are used to give a qualitative characterization of the situation in each sector. In terms of relative efficiency, the Soviet sectors are rated as being less efficient (low), about the same (medium), and more efficient (high), compared with their US counterparts. In terms of conservation potential low implies potential energy savings of less than 5 percent; medium implies savings of 5 to 10 percent; and high implies savings of over 10 percent. With regard to conservation cost, low implies average costs of less than 50 rubles per ton of standard fuel; medium implies average costs on the order of 50 to 100 rubles per ton; and high implies costs of over 100 rubles per ton.
[b] Heat refers primarily to steam generated in boilers.

25X1

Energy Trade-Offs: 1986-95

Moscow will find no easy solution in the trade-off between energy production and conservation: Soviet energy use will rise whether the leadership emphasizes production or conservation. Investment costs, moreover, are rising sharply for production of fuels:

- For oil, because of sharply diminishing returns to drilling and increasing difficulties at existing wells.
- For gas, because new wells are deeper, offshore, or are in gasfields where corrosive gases are also present (also because of the continued burden of pipeline investment required for expansion of West Siberian gas production).
- For coal, because of worsening mining conditions in the western USSR and the expensive technological solutions required for the development of low-quality eastern coal.

25X1

Given the rising trends in marginal investment requirements for production of oil, gas, and coal, the Soviet emphasis on meeting incremental energy needs with gas appears to be the best production choice over most of the 1986-95 period. Oil is rapidly becoming more expensive; large reserves of gas are readily available and gas is easier to produce than oil in the USSR; and a large expansion of coal production calls not only for high investment but also new technology.

25X1

We estimate that achieving the energy conservation potential in the Soviet economy would reduce energy consumption by 5 to 10 percent from trend level by 1995, freeing investment resources for other uses. The advantages of this course of action could appeal to

Moscow because it grapples with the need for greater investment in industrial modernization. So far, however, Moscow has shown little inclination to move in this direction.

The Energy Conservation Option

Energy conservation presents risks and penalties as well as rewards. Soviet policymakers averse to near-term risks may try to avoid these risks and penalties by continuing their traditional emphasis on production. The heavy emphasis on energy production in the 1986-90 plan, along with continued discussion of the importance of energy conservation, may represent a less risky choice than an all-out drive for energy conservation. Low energy-production targets, coupled with high conservation expectations, could lead to energy shortages and economic disruption if conservation efforts are not markedly more successful than in the past. The Long-Term Energy Program's goal of a transition to an "energy-efficient growth path" could require a rather painful transition period, just as adjustments elsewhere in the world after the 1973 oil-price shock were disruptive.

Moscow may also be concerned about the indirect costs of measures that, while entailing little or no direct expenditure, call for additional investment in supporting industries, transportation or other infrastructure, or training. Perhaps more significant in the long run—and the most difficult to bear—would be the political and social costs of providing effective incentives to alter the behavior of managers and workers in ways that promote energy conservation.

Conservation efforts could follow two tracks. First, the Soviets will probably continue their efforts to improve energy efficiency by means not requiring additional investments. Such efforts include turning off equipment when not in use, better monitoring and control of energy use, and better operational procedures such as maximizing use of production capacity and avoiding frequent stopping and starting of units. Although some efforts may be cost-free or very cheap, large-scale implementation continues to be hampered by the lack of necessary monitoring equipment, the continuation of raw-material bottlenecks that prevent efficient utilization of machinery, a shortage of skilled workers, and insufficient incentives to those who must implement the measures. Second, Soviet planners have numerous energy-conserving options that require substantial investment. Many of these involve the introduction of new technology and, as discussed above, often depend on ancillary advantages to justify a large share of their cost.

25X1

25X1

Since investment resources are scarce, Moscow will presumably rank in order of priority the allocation of resources for conservation. We do not know what these priorities will be or exactly how they will be determined. But we can make two basic assumptions: (a) oil is the scarcest fuel, followed by coking coal, and (b) energy is not the only scarce resource—capital, labor, and other materials (metal, for example) will be in relatively shorter supply in the coming years than they were in the past. We believe that Soviet economic planners faced with these conditions would probably give priority to some of the following measures:

- Continuous casting of steel (expensive, but steel quality would be improved and labor productivity would be higher during a period of increasing demand for steel).

25X1

- Further installation of heat-recovery boilers and heat exchangers, especially in the refining, ferrous metals, and chemicals industries (widespread implementation of a relatively cheap and simple technology can yield big energy savings).

- Increased dieselization of trucks (light oil products are saved).

25X1

- Low-cost coke-saving measures in the ferrous metal industry.

- Surfacing of dirt roads. (More asphalt is used, but trucks will be more fuel efficient. The potential reductions in agricultural losses are probably more important than the energy savings).[18]

25X1

- Improved oil-storage equipment—floating roof tanks, for example. (Oil savings from this measure could be substantial, particularly in the agriculture and fuel sectors.)

- Attempts to replace small, inefficient boilers in the heating sector with centralized heat supply wherever possible (big potential savings). [redacted]

In addition to implementing a number of these measures, the Soviets could make more widespread use of energy-efficient processes and structures in new construction and in industrial expansion. Benefits from this option may be slow to materialize, however. Gorbachev's plans for modernization focus heavily on retooling and renovation rather than on new construction. As in the West, incorporation of efficient designs and processes is usually cheaper in an initial installation than in retrofitting older units. [redacted]

A Role for Western Technology? The Soviets have expressed interest in importing conservation technology from the West. Given the considerable problems Moscow has had implementing conservation measures and the relatively primitive status of the Soviet "conservation industry," imports would be an efficient alternative where equipment compatibility problems are not prohibitive. Computing estimated lifetime energy savings, investment, and discounted operating costs and using an estimated 1990 oil price of $20 per barrel as a benchmark (deflated to $13.54 in 1980 dollars), all but two measures (measures representing about 5 percent of the total annual energy savings) would cost less than the saved energy could earn on the world market. If energy cost savings were the only consideration, we would thus expect the Soviets to seek Western conservation technology actively. Other hard currency import requirements, for industrial machinery and grain imports for example, will limit the Soviets' ability to import energy efficient equipment. [redacted]

Potential Energy Savings

Despite uncertainties about data and Soviet intentions, we can obtain a rough estimate of potential energy savings for 1995 by comparing the energy requirements projected for 1995 (based on an estimated range of energy conservation measures) with those based on no improvement in energy conservation. Using projected data on population, GNP, and capital stock from our macroeconomic model of the Soviet economy, we projected trends in energy use after 1980 in the six basic economic sectors, assuming no increase in energy efficiency. The projection for 1981-85 was, on average, within 1 percent of reported total energy consumption, suggesting that little conservation had occurred in 1981-85. This finding is further supported by published Soviet data on 1981-85 energy efficiency in the production of 28 goods and services, which showed little or no improvement in nearly all cases.[19] [redacted] we have estimated gains in energy efficiency by 1995 (see table 3). The simulations show that, for the same level of economic output in 1995, Soviet energy consumption could be lowered by roughly 5 to 10 percent if our estimated range of energy conservation measures are taken, compared with no improvement in efficiency relative to 1980. The prospective energy consumption and savings are summarized in the following tabulation:

	1990	1995
Million tons of standard fuel		
No improvement over trend	2,260	2,590
Conservation in effect	2,160-2,210	2,340-2,460
Savings	50-100	130-250

The indicated savings are lower than those implied for 1995 by the Soviet conservation goal of 540-580 million tons for the year 2000 included in the Long-Term Energy Program. The higher Soviet estimate of energy savings probably results from the Soviets' use of assumptions concerning economic growth, the impact of economic reform, and plant-level commitment to conservation that are more optimistic than ours (see inset). [redacted]

[19] *Vestnik statistiki* (No. 12, Dec. 1986): pp. 73-75. [redacted]

Table 3
USSR: Conservation Potential by Economic Sector

Percentage

	Potential Conservation (*percent relative to 1980 consumption*)	Estimated Attainable Conservation [a]	Estimated Share of Industrial Energy Consumption in 1980	Weighted Average [b]
Industry				**4.5-8.9**
Chemicals	25	10-20	11	1.1-2.2
Construction materials	10-15	5-10	13	0.7-1.3
Ferrous metal	12	5-10	21	1.1-2.1
Fuels	10	2.5-5	9	0.2-0.5
Machine building	5-10	5-10	14	0.7-1.4
Nonferrous metal	5-10	2.5-5	6	0.2-0.3
Oil refining	13	0	5	0.0-0.0
Other	5-10	2.5-5	21	0.5-1.1
Other sectors				
Agriculture	NA	2-5		
Construction	NA	3-5		
Nonenergy uses	NA	2.5-7.5		
Residential	NA	2.5-7.5		
Transportation	NA	5-7		

[a] Includes estimated impact of energy-intensifying factors.
[b] Weighted by share of industrial energy consumption in 1980.

25X1

The Bottom Line: Conservation, Investment, and Hard Currency

The aggregate potential for energy saving from conservation in the USSR can be roughly quantified in a simple example: if the economy grows at roughly 2 to 3 percent per year through 1995, a stable energy-GNP ratio would require 200 to 250 million tons more standard fuel in 1995 than if the ratio declined by only 10 percent (half of the 1970-81 decline experienced in the United States). This added amount of energy is equivalent to 10 to 13 percent of total Soviet energy consumption in 1985.

The impact of conservation on investment can be calculated by allocating the savings among oil, gas, and coal, and examining the investment that could be saved by *not* producing the saved energy. We currently estimate that the Soviets will invest over 30 billion rubles in 1990 and 40-45 billion rubles in 1995 in the oil, gas, and coal industries. Assuming for illustrative purposes that half of the savings in our forecast are in oil and the rest is split evenly between gas and coal, investment in energy production could be about 5-10 billion rubles less in 1990 and 10-20 billion rubles less in 1995 with the conservation assumptions. 25X1

This calculation does not take account of the investment required to achieve the conservation. Taking as typical the 85 to 120 ruble-per-ton range of energy-saving costs in the case studies, and assuming the Soviets increase conservation by 15-30 million tons of standard fuel annually, we estimate conservation investment at 1-4 billion rubles each year—cheaper 25X1

Considerations Affecting the Estimates

—Ten-year forecasts of GNP and capital stock are used to estimate future sectoral energy consumption. These rough forecasts are based on a specific set of Soviet resource allocation policies. Changes in these policies would change the forecasts.

—Major structural shifts in the Soviet economy reflecting differential rates of growth for the various sectors could have a large impact on overall energy consumption.

—Investment allocations—amounts and whether for energy conservation or production—will affect energy consumption.

—Soviet capabilities and resolve to maintain high levels of oil output even at a high cost could lessen the emphasis on conservation.

—Improved East-West relations leading to increased trade could increase the import of Western technology either to speed conservation or to improve energy production. Alternatively, a trend toward greater autarky could slow energy conservation.

—Economic reforms that emphasize enterprise initiative and that move away from the predominant production orientation of planning would probably encourage conservation.

—A serious effort by the machine-building sectors to manufacture sufficient energy-efficient equipment and energy monitoring devices is essential for much of the easy "low-cost" conservation. Our forecasts assume that, over the next 10 years, efforts will be made to improve the situation. A failure to do so could severely hamper conservation efforts.

25X1

than production, but still expensive. The net reduction in energy investment would, nevertheless, mean that billions of rubles of investment could be reallocated to other sectors of the economy. 25X1

Alternatively, if higher energy production levels were maintained, but the energy saved in the Soviet economy were to be exported for hard currency, additional earnings would be $85 million in 1990 and $105 million in 1995 per million tons of standard fuel annually.[20] Actual earnings would be less because of the sensitivity of energy prices to large increases in supply. The benefits of energy conservation—either reduced investment in energy production or increased earnings from energy exports—therefore appear to be substantial enough to justify considerable investment in energy conservation. 25X1

With respect to energy savings available from the industries discussed earlier, our projections indicate that—even under the harsh assumption that investment must be paid back in one year—nearly all of the conservation measures evaluated become efficient choices relative to our estimated 1995 investment requirements for energy-production capacity (figure 5). Some of the more expensive measures, such as the continuous casting process, could be attractive to the Soviets if nonenergy-saving benefits are substantial. More generally, however, the Soviets may be expected to choose conservation measures that offer the greatest savings at the least cost. Relatively low-cost opportunities abound. In refining, for example, conservation measures requiring investment of less than 50 rubles per ton account for 80 percent of our estimated energy savings relative to 1980, but only 14 percent of the estimated total investment required to implement all measures surveyed for that sector. In steel, measures requiring less than 50 rubles per ton accounted for about half of the estimated potential savings, but only 7 percent of total investment required to implement all measures surveyed. In the ammonia industry, the virtually cost-free measures accounted for 69 percent of the estimated energy savings. Our survey of other activities suggests that such conclusions are typical. While the financially cheaper measures account for the bulk of the potential energy savings, they may be among the most difficult to implement (see inset on factors hindering Soviet energy conservation, page 15). 25X1

[20] These estimates of earnings assume a change in gas and coal prices proportional to the forecasted change in oil prices—$20 per barrel in 1990, and $24.25 in 1995. 25X1

Appendix A

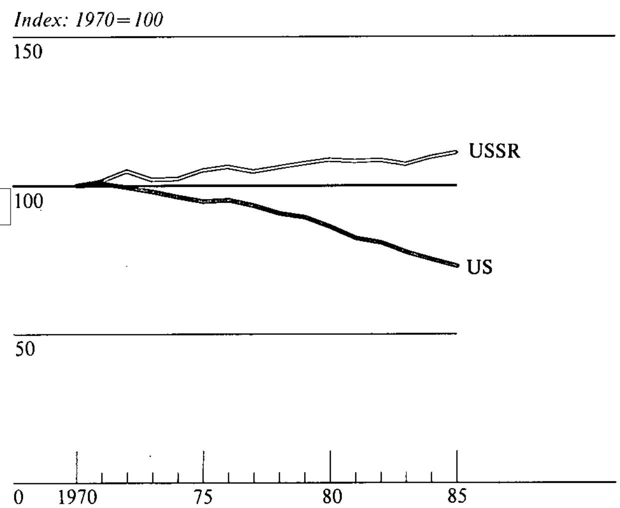
Soviet Energy Conservation: Plans Versus Performance

The USSR is a large and inefficient consumer of energy: with a GNP only about half as large as that of the United States, it consumes about 70 percent as much energy. Soviet energy consumption is higher relative to output than US energy consumption for three basic reasons:

- On average, the climate of the USSR is colder.
- In the USSR the energy-intensive sectors of industry account for a larger share of GNP.
- The Soviets are, in many cases, less efficient in their use of energy than are their US counterparts. 25X1

Energy consumption can be reduced by reducing the level of economic activity (either closing factories or rationing energy); by restructuring the economy in favor of low-energy users (such as trade and services and food processing); by substituting oil or gas for coal, which burns less efficiently; and by implementing energy conservation. 25X1

Figure 6
USSR and US: Energy-GNP Ratios



[a] The index of energy efficiency for each country is calculated by dividing on index of energy consumption by an index of GNP.

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The Soviets look increasingly toward energy conservation as the best solution to competing claims on expensive energy. But Moscow's record to date is wanting, largely because the economic structure continues to be dominated by energy-intensive sectors of heavy industry. Indeed, the energy-intensive sectors' share of GNP rose from 41.5 percent in 1970 to 48.6 percent in 1981. This share, like the energy-GNP ratio, then remained relatively stable until 1984, when both rose.[21] As a result the energy-to-GNP ratio (see figure 6) rose during the 1970s and early 1980s. 25X1

The Soviet experience contrasts markedly with that of the United States, where over the 1970-83 period the share of the energy-intensive sectors of mining, manufacturing, and transportation fell from 31 percent to 28 percent, and the share of low energy users, such as trade and services, rose from 42 percent to 47 percent.[22] These structural shifts supplemented the effects of conservation measures to produce the downward trend of the US energy-GNP ratio over the same period. 25X1

With GNP measured in 1983 dollars, the Soviet energy-GNP ratio is about 20 percent higher than the

[21] The energy-intensive sectors are energy, electric power, ferrous and nonferrous metallurgy, construction materials, and transportation. 25X1

[22] U.S. Bureau of the Census, *Statistical Abstract of the United States: 1986* (Washington, D. C., 1985). 25X1

US ratio.[23] This is explained in part by the higher share of energy-intensive sectors in the USSR, as well as the greater share of energy used to provide heat in the colder climate. In 1980 the residential sector in the USSR used over 300 million tons of standard fuel (about 18 percent of total energy consumption).[24] In the United States, despite the greater predominance of single-family dwellings, air-conditioning, and other household appliances, residential energy use is less than 13 percent of total energy consumption.[25] Even with the conservation gains that can be made in space heating (see the discussion of the residential sector in appendix B), residential energy use will remain a larger share of total energy use in the USSR than in the United States. 25X1

The Soviets have made substantial progress in conserving energy in electric-power production and railroad transportation (see figure 7). According to a 1983 Soviet monograph, improvements in the railroad and electric power sectors, along with the shift from coal to oil and gas, accounted for 75 percent of the energy conservation achieved in the 1960s and 1970s, but further gains from these sources will be small.[26] In heat production, which accounts for about 40 percent of energy consumption, the Soviets appear to have reached the efficiency limits of their current approach. In addition, other factors, such as the increasing mechanization of agriculture, the rising average distance of freight hauls, the need to substitute capital for labor in industry, and the rising amount of energy required for qualitative improvements in activities such as steel-rolling-mill operation and oil refining, will tend to further increase energy requirements per unit of output. 25X1

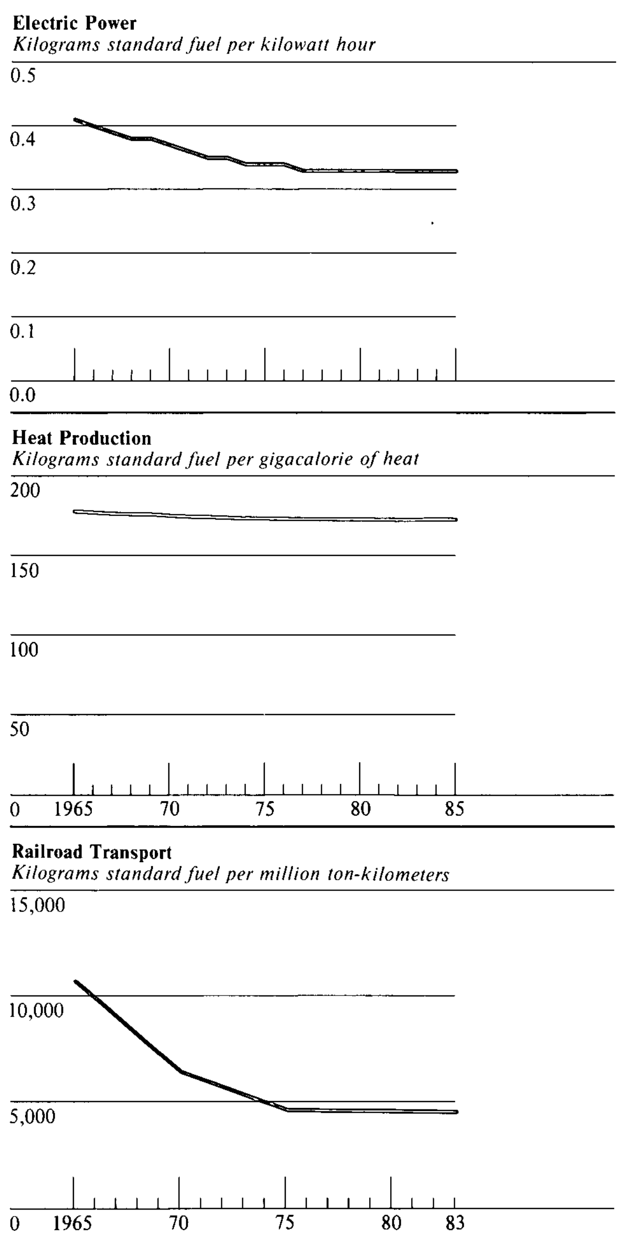
Energy Conservation Plans and Policies

Energy conservation is not a new concept in Soviet economic planning. Indeed, it is an element in Moscow's drive to move away from extensive growth (where growth in output is sought by means of a growth in inputs) to intensive growth based on more efficient use of inputs—a dominant theme of Soviet economic literature over the past 20 years. 25X1

[24] Makarov and Melent'yev, op. cit., p. 43. 25X1
[25] Statistical Abstract of the United States, 1985, op. cit. 25X1
[26] Makarov and Mel'entev, op. cit., p. 121. 25X1

Figure 7
USSR: Energy Efficiency in Selected Sectors

Note scale change



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Energy conservation goals have been specifically included in Soviet five-year plans since at least 1971-75, but little overall progress has been made. Nevertheless, statements by Gorbachev and others in early 1985 suggested that conservation would be the major focus of the 1986-90 energy policy. The 12th Five-Year Plan, however, shows a continuation of the production-oriented energy policy the Soviets have followed in the past. The plan, combined with our estimates of minor energy sources not mentioned in the plan, indicates that the increase in energy production from 1985 to 1990 is slated to about 400 million tons of standard fuel, compared with the actual increase of about 250 million tons from 1980 to 1985.

Energy conservation in the 1986-90 plan calls for savings in 1990 of 125-140 million tons of standard fuel (after deducting energy counted by Moscow as "saved" by increases in hydroelectric and nuclear power output). These savings are less than the corresponding savings envisioned in the 1981-85 plan (146 million tons after deducting hydroelectric and nuclear gains). See inset for planned measures that directly or indirectly affect conservation.

On the whole, the 1986-90 conservation goals appear to be relatively modest, compared with the energy production goals. The Soviets may be attempting to be more realistic in their conservation expectations, reflecting the disappointing results of the 1970s and early 1980s. For example, the Soviets achieved about 70 percent of the energy conservation planned for the 1981-85 plan period, according to official Soviet statistics. Furthermore, the emphasis on machine building and other energy-intensive industries in the 1986-90 plan will have a tendency to boost energy use relative to output, at least in the short run.

The more modest approach to conservation reflected in the 1986-90 plan appears to be in line with the conservation goals set forth in the Long-Term Energy Program. These goals called for energy use to support natural income to be 540-580 million tons of standard fuel less than if 1980 levels of efficiency were to persist. This conservation is to be accomplished through higher efficiency levels (excluding "conservation" gains due to increased nuclear and hydroelectric

Conservation Measures in the 12th Five-Year Plan (1986-90)

—Ferrous metallurgy is to be restructured and modernized, including a 30- to 40-percent increase in production from the more efficient basic-oxygen and electric-arc furnaces but little increase in pig iron production, implying a substantial increase in the share of output from the more efficient processes. The share of production from continuous casting process is to double.

—The output of diesel trucks is planned to increase to 40 to 45 percent of the total truck output (compared with 18 percent of the total truck output in 1980). 25X1

—The nonferrous metals industry is to conserve 3 billion kWh of electricity and 1 million tons (standard fuel equivalent) of fossil fuels.

—The electric power industry is to dismantle 25 million kW of inefficient capacity and modernize another 25 million kW. Total capacity in 1984 was 304 million kW. 25X1

—Railroad electrification is to increase by 8,000 kilometers (a 17-percent increase over the total length of electrified rail in 1984).

—Aircraft fuel consumption per kilometer is to decline by 3 to 5 percent.

—Fuel efficiency in agricultural equipment is to improve by 3 to 5 percent.

—Capital retirement rates are to double compared with 1981-85. Over one-third of existing active capital stock is to be renewed. 25X1

—The output of instruments for monitoring and regulating energy is to increase.

25X1

production). An additional 400-500 million tons of standard fuel are to be "conserved" by increasing the use of hydroelectric and nuclear power and nontraditional energy sources—considerably more than our estimate. 25X1

Although some gains—from nuclear power in particular—may be in question, the principal sources of conservation laid out in the Long-Term Energy Program are still being touted as the current game plan:

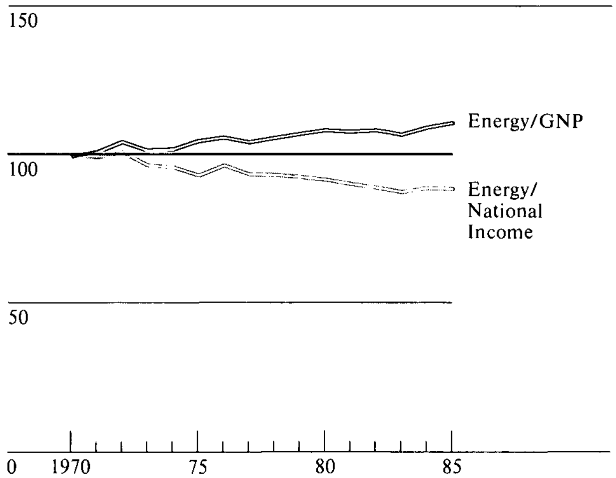
- A transition to energy-conserving technologies.
- A decrease in the material-intensiveness of production (lowering the metal content of machines, for example).
- Better organization of production processes.
- Improvement of energy equipment.
- Retirement and reconstruction of outmoded equipment.
- Improvement in the use of secondary energy (capturing the heat now lost from chemical processes, for example).
- Reduction in energy losses of all types.
- More rational location of energy consumers in relation to energy producers. 25X1

To implement the measures aimed at raising efficiency of energy use, the machine-building industries are tasked with large-scale production of energy-efficient equipment and regulating devices. No energy sector of the economy is excluded from the program. But despite the attention to conservation in plans and in the media, the actual priority of energy conservation thus far is not clear. Furthermore, information on the investment requirements or the energy savings associated with these measures is minimal. To the extent that actual conservation gains are discussed in the literature, the discussion is usually either at a very generalized level with few details, or at a very specific, technical level (one plant's experience, for example).

In the Long-Term Energy Program, as in other discussions of long-term energy conservation, conservation is generally seen as proceeding in two phases. The first will emphasize organizational measures, closer monitoring of energy use, and other measures that require relatively little capital investment. The second will be characterized by the introduction of more energy-efficient processes and equipment requiring significant capital outlays. 25X1

Figure 8
USSR: Energy-GNP and Energy-National Income Ratios[a]

Index: 1970=100



[a] These rates are calculated by dividing an index of energy consumption by indexes of GNP and National Income.

25X1

314359 10-87 25X1

The Record to Date: Little Success

Despite Soviet claims of success in conservation and the energy savings achievements now published in official statistics, the effort has in fact met with relatively little success. The implied success is due largely to Soviet use of national income, rather than GNP, to measure the amount of economic activity per unit of energy used (see figure 8 and inset). The majority of ministries and departments missed their conservation targets during 1981-82, according to the Soviet press.[27] Reports since then indicate similar failure for the nation as a whole.[28] Because conservation goals are included in each year's energy balance 25X1

25X1

[28] *Sovetskaya rossiya* (25 May 1984): p. 1. 25X1

Soviet "Success" in Energy Conservation—A Statistical Artifact?

Soviet perceptions of success in energy conservation, as reported in official statistics, are likely to be more optimistic than an energy-efficiency index based on GNP suggests. Because the basic Soviet measure of economic activity, national income, grew faster than our estimated GNP for the USSR, trends in the GNP-based energy efficiency index differ markedly from trends in the index based on national income. National income grows faster than GNP, partly because the product of the slowly growing services sector of the economy is not included as part of national income.

More important, however, is the existence of hidden inflation in Soviet national income data, primarily because of the overpricing of new products. [a] *To indicate the extent of this hidden inflation, we can compare growth rates of GNP in current and constant prices for the only two years available—1970 and 1982. Using current prices, GNP grew at 5.4 percent, considerably faster than the 2.8 percent growth rate when measured in constant prices. Soviet conservation plans to meet 75 to 80 percent of the increase in 1990 demand for energy through conservation (relative to the 1985 energy-national income relationship) are thus less ambitious than projections based on GNP would suggest.* [b]

[redacted] 25X1

[b] Sovetskaya rossiya *(9 March 1986): p. 2.* [redacted] 25X1

[redacted] 25X1

and factored into the planning of energy supplies, failed conservation goals result in overconsumption of energy and can lead to energy shortages. A 1984 *Izvestiya* editorial, for example, blamed energy shortages on failed conservation measures.[29] [redacted] 25X1

Several obstacles are apparent in the failure to achieve planned conservation of energy. These include policy issues such as investment allocations and problems in implementation (for example, the difficulty of obtaining the large numbers of meters and equipment needed), as well as the difficulty of properly installing and using conservation equipment once delivered (see inset on page 7). Although some can be modified with time, many of these problems will continue throughout the 1986-95 period. [redacted] 25X1

[29] *Izvestiya* (10 July 1984): p. 1. [redacted] 25X1

Appendix B

Analysis of Energy Conservation Potential in Selected Activities

[redacted] 25X1

[redacted] 25X1

Conservation in the Oil-Refining Industry
The Soviet oil-refining industry is energy intensive (consuming about 2.5 percent of Soviet energy) and presents considerable opportunity for introduction of conservation measures.[30] Although the basic refining processes used are generally similar to those in Western refineries, the Soviet product mix is substantially different. For example, in the United States about 45 percent of total output is gasoline, with less than 10 percent residual fuel oil. In the USSR residual fuel oil accounts for 35 to 40 percent of total output, and gasoline's share is less than 20 percent. This difference in product mix reflects the markedly different historical patterns of use for oil products in the two economies. The dominant theme in Soviet plans relating to refining is the need to shift the refinery mix away from fuel oil and to produce more light products, principally diesel fuel and gasoline. The demand for these lighter fuels is expected to grow considerably over the next decade, and the demand for fuel oil is to decline because of fuel substitution. [redacted] 25X1

At any refinery, oil flows initially through primary distillation columns, which segregate the basic components of the oil. The rest of a refinery essentially purifies and alters these components in various secondary operations, most of which are more energy-intensive than primary distillation [redacted] Thus, the higher the level of secondary processing, the greater the energy-intensiveness of the overall process. [redacted]

When individual processess are compared, the Soviets use considerably more energy per ton of refined oil than do the US refiners. Overall, however, the Soviets refining industry uses less energy per barrel of crude. In the United States, the capacity of secondary operations of all types is about 20 percent *larger* than primary distillation capacity, because of the large and fluctuating demand for a wide variety of light products. In the USSR in 1983, secondary capacity was only about 30 percent as large as primary distillation capacity, reflecting the larger share of heavy products and a simpler product mix.[31] This sharp difference means US refineries consume on average more energy per barrel of oil refined than do Soviet refineries, because the energy requirements for secondary refining are so much greater than those for primary

25X1
25X1
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[redacted]

[30] *Vestnik statistiki* (No. 12, December 1986), pp. 74 and 75, combined with an estimate of the amount of oil refined. [redacted] 25X1

refining. For example, in 1981 energy used by US refineries represented about 11 percent of the energy contained in the oil received by the refineries. In contrast, the comparable share for Soviet refineries in 1980 was about 6 percent, according to a Soviet journal.[32] Implementation of Soviet plans to expand secondary processing will tend to increase the energy use per ton of oil refined.[33] [redacted] 25X1

The greatest opportunities for energy conservation in oil refining are in the recovery of waste heat. Among the techniques used are improvements in the heat-exchange system, recovery of heat from stack gases, process-heat integration, and added insulation on product lines, furnaces, tanks, and other units. Additional energy can be recovered by improving boiler and heater efficiencies and optimizing steam balances. Computer-optimizing control and other instrumentation and monitors can also contribute to energy efficiency. Another source of saving is recovery of flue gas that can be used as fuel. These and other measures taken in the United States and considered relevant to the USSR are listed in table 5. These measures involve only the retrofitting of older refineries. Although the Soviets have retired some of their oldest refining units, the replacement of older units with new ones remains a small share of total construction of Soviet refineries. [redacted] 25X1

Each of the conservation measures was assessed against the amount of Soviet refining capacity we believed to be relevant for application of that measure. For example, air preheaters were considered relevant only for the larger crude-oil units. [redacted] 25X1

Clearly the largest impact is possible from the measure with the greatest uncertainty—better housekeeping. This concept requires a greater watchfulness, awareness, and guarding against energy waste by all parties, as well as the introduction of relatively inexpensive meters and valves. Such measures allowed

Table 5
Estimated Conservation Measures: Soviet Refining Industry

Conservation Measure [a]	Energy Saved (*million tons of standard fuel*)
Total annual saving of energy if all measures are taken	9.69
Housekeeping	5.05
Sour gas recovery (delayed coking)	0.09
Revamp heat exchanger (catalytic cracking)	0.03
Flow control on heat exchanger (catalytic reformers)	0.28
Conductivity analyzer (crude unit)	0.17
Direct charge of naphtha (catalytic reformer)	0.12
Retray fractionator (crude unit)	0.01
Convection section (crude unit)	0.64
Preheat exchanger (catalytic cracking)	0.02
Heat exchanger (catalytic reformer)	0.08
Soot blowers on CO boilers (catalytic cracking)	0.04
Preheat exchangers (crude unit)	0.89
O_2 analyzers on heat exchangers (catalytic reformer)	0.02
Microprocessors (crude units)	0.11
Heat exchanger (alkylation unit)	0.004
Replace feed heater (catalytic cracking)	0.05
Air preheater (catalytic reformer)	0.34
Process monitor (alkylation)	0.003
Heater improvements (crude unit)	0.72
Flue-gas analyzers (crude unit)	0.19
Computer control (crude unit)	0.06
LP steam system	0.03
Air preheater on CO boiler	0.004
Flare-gas recovery	0.74

[a] Measures are listed approximately in order of increasing cost per unit of energy saved. (For simplicity, applications of the same measure on the same type of unit were combined, although costs differ, depending on the capacity of the unit involved.)

[redacted] 25X1

[32] The number on energy use by US refineries was [redacted] compared with the volume of oil sent to refineries in *Statistical Abstract of the United States, 1985*, p. 562. The Soviet number is from *Vestnik statistiki* (No. 12, December 1986): pp. 74-75. [redacted] 25X1 25X1

[33] A. M. Nekrasov and A. A. Troitskiy, eds., *Energetika SSSR v 1981-1985 Godakh* (Moscow: Energoizdat, 1981): pp. 56, 94. [redacted] 25X1

the US refineries to reduce their energy use by 7 to 10 percent in the 1970s. We estimate that, despite the larger potential for savings in Soviet refining, the realized savings will be close to the bottom of this range, because of implementation problems and the difficulties in obtaining even simple monitoring equipment. If the Soviet refineries implemented all of the measures evaluated, they could save 9.7 million tons of standard fuel, or 13 percent of their 1980 energy use; the total cost of implementation would be 428 million rubles.

Conservation measures discussed by the Soviets (see inset) focus on many of the points cited above—heat exchangers, direct feed, waste-heat boilers. They also emphasize other directions, such as increased emphasis on centralized combination units (which colocate the distillation and cracking processes to maximize energy efficiency) and improved catalysts. There is, therefore, probably some conservation potential in Soviet oil refining that our estimate does not capture.

In view of the savings achieved in US refining, the less-efficient operation of Soviet refineries and the implementation problems (such as the cited failure of several refineries to install heat-recovery boilers that had been delivered) that have hampered conservation measures thus far, we believe that the conservation supply curve in figure 5 represents an achievable level of conservation for the Soviets:

- We believe that the Soviets will attempt to implement conservation measures in refining. This industry is a good candidate for conservation, and a relatively large percentage of energy can be saved through inexpensive measures such as metering and better organization. Organizational measures fit well with the low investment "first stage" of energy conservation discussed in the Long-Term Energy Program and the "human factor" emphasized by Gorbachev. Moreover, most of the energy saved will be oil—the Soviets' prime conservation target.

- The Soviets could, however, fail to make the most efficient conservation choice. The refining industry has been slow to modernize, despite plans to do so since the early 1970s. Its failure probably reflects a combination of relatively low investment priority, the difficulties of maintaining the existing level of operations, and other factors. These influences may well continue to impair conservation efforts. Furthermore, the industry's main task—boosting the yield of light products—may absorb nearly all of the investment resources and designers' time over the decade. Even so, given the importance of saving oil,

Conservation Measures Planned for Oil Refining in the USSR [a]

—*Reconstruct active units.*
—*Introduce system of industrial heating.*
—*Replace steam-driven technical units with electric-drive units.*
—*Transfer power system to direct electric feed instead of intermediate transformers.*
—*Use new, more efficient catalysts.* 25X1
—*Cut losses through floating-roof storage tanks, automated product transfer.*
—*Increase use of waste heat, particularly in combined refining units.*
—*Eliminate intermediate heating of raw materials through better unit location.*
—*Install 150 waste-heat boilers.*
—*Install 450 air preheaters.*
—*Reconstruct 12 installations of thermal blocks.*
—*Provide better heat exchange in distillation columns.* 25X1
—*Improve tray placement in distillation columns.*
—*Improve reformer furnaces—achieve better sealing, install controls and regulators for furnace exhaust, improve injector nozzle, reequip air cleaners.*

[a] *Soviet planned conservation measures are taken from four principal sources: D. G. Zhimerin, ed.,* Sovremennyye Problemy Energetiki. *(Moscow: Energoatomizdat, 1984); D. B. Vol'fberg, ed.,* Effektivnoye Ispol'zovaniye Toplivno-Energeticheskikh Resursov. *(Moscow: Energoatomizdat, 1983); L. A. Melent'yev and A. A. Makarov, eds.,* Energeticheskii Kompleks SSSR *(Moscow: Ekonomika, 1983); and A. M. Nekrasov and A. A. Troitskiy,* Energetika SSSR v 1981-85 Godakh *(Moscow: Energoizdat, 1981).*

25X1

we believe that savings could be large—on the order of 10 to 15 percent of refinery energy consumption relative to 1980.

Overall, however, these potential energy savings probably would be offset by the continuing shift in refining toward lighter and higher quality products. This shift was behind a 4-percent rise in energy intensity between 1981 and 1985, after a decline in intensity during the 1970s. We estimate that this structural shift could increase the energy intensity by another 5 to 10 percent between 1985 and 1995, essentially offsetting the gains from conservation.

Conservation in the Ferrous Metals Industry [34]

The ferrous metals industry is one of the most energy-intensive in the USSR, consuming about 11 percent of the domestic energy supply in 1980,[35] and the Soviets have focused considerable attention on the sector as a conservation target.

Steelmaking includes four basic stages of production: cokemaking; pig-iron production; steelmaking; and casting, forming, and finishing. Each process has its own relevant conservation measures:

Cokemaking. The coking process transforms metallurgical-grade bituminous coal into a carbonaceous residue called coke. Besides providing chemical reagents for reducing iron ore, coke is the principal fuel used to produce heat required for smelting in the blast furnace. Data presented in Soviet technical journals and reports indicate that the technology for cokemaking in the USSR does not deviate significantly from typical world practice.

Pig-iron production. Pig-iron production is the most energy-intensive process in the industry. The focus of attention in pig-iron production in the USSR and elsewhere has been on reducing the coking rate through the increased use of hydrocarbon fuels, principally natural gas.

Steelmaking. There are three basic types of steelmaking furnaces—open-hearth (OH), basic-oxygen (BOF), and electric-arc (EAF). The Soviets rely far more heavily on the OH process, the oldest and least efficient process, than do other major steel-producing countries.

Casting, forming, and final finishing. This stage includes several operations, of which the remelting of ingots is the most energy intensive. The continuous casting process saves reheating of ingots, and thus saves substantial energy. Although the Soviets installed the world's first commercial continuous caster, the proportion of steel cast by this process in the USSR is low relative to that in other steel-producing countries.

The conservation measures deemed relevant to the Soviets' situation are presented in table 6. The Soviet technical literature on conservation discusses many of these measures, emphasizing "big-ticket" items, such as new BOFs, EAFs, and continuous casters, as well as less expensive measures such as better insulation and increasing the flow of oxygen to the furnace (see inset).

The 12th Five-Year Plan includes ambitious plans for modernizing the steel industry. Some 30 million tons of open-hearth furnace capacity is to be replaced, while the share of output from continuous casting is slated to double by 1990. The pattern of steel industry investment in this plan contrasts sharply with that in earlier plans. According to the Soviet press, 50 percent of investment is to be used to renovate existing plants, 30 percent of improving product quality, and only 20 percent for expanding production capacity. Past five-year plans allocated up to 75 percent of investment for growth in output. We expect that plans will be hampered by the inability of Soviet machinery producers to supply the necessary equipment and on the Soviet's limited ability to import equipment from the West

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[35] D. G. Zhimerin, ed., *Sovremennyye Problemy Energetiki* (Moscow: Energoatomizdat, 1984): p. 79.

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Table 6
Estimated Conservation Measures: Soviet Ferrous Metals Industry

Conservation Measure [a]	Energy Saved (*million tons of standard fuel*)
Total annual energy conserved for all fuels if all measures are taken	34.01
Coking coal savings	
Energy conserved if all measures are taken	23.65
High-scrap option (retrofit)	2.40
Scrap preheaters/offgas hoods (retrofit)	3.38
External desulfurization (retrofit)	4.14
Coal injection (retrofit)	4.46
Scrap preheaters/offgas hoods (new)	3.38
Installation of top (retrofit)	0.37
Direct reduction—gas recovery (new)	3.07
Formcoke (new)	1.48
Natural gas injection (new)	0.57
Installation of top (new)	0.32
Preheat coal and wet coke	0.08
Other fuel savings	
Energy conserved if all measures are taken	10.36
Increase oxygen injection (retrofit)	1.73
Auto-ignite coke oven flare (retrofit)	0.16
Auto-combustion control (retrofit)	0.34
Preheat scrap, add hoods (retrofit)	1.17
Add offgas hood (retrofit)	0.60
Dry quenching of coke (retrofit)	4.75
Conversion to q-BOP (retrofit)	0.11
Monobeam furnace with heat recuperator (new)	0.03
Continuous casting process (new)	0.95
Dry quenching of coke (new)	0.52

[a] Measures are listed in order of increasing cost per unit of energy saved.

[redacted]

Conservation Measures Planned for the Ferrous Metals Industry [a]

- *Replace open-hearth furnaces with basic oxygen converters or electric-arc furnaces (30 million tons of furnace capacity in 1986-90 plan).*
- *Increase use of continuous-casting process.*
- *Use dry-coking process.*
- *Increase temperature of blast-furnace gas.*
- *Increase pressure of gas at top of blast furnace.*
- *Improve insulation of blast furnace and associated pipes.*
- *Improve heat exchangers.*
- *Increase iron content of the charge.*
- *Blow oxygen into the blast furnace.*
- *Make fuller use of waste heat from all processes.*
- *Increase capacity of coke batteries through building new units and reconstruction of old ones.*
- *Increase share of iron pellet production relative to share of agglomerate.*
- *Lower the moisture content of the charge.*
- *Use dry flux from the charge.*
- *Remove outmoded, small-capacity furnaces.*
- *Use compressorless turbines to generate electricity from waste gases.*

[a] *Soviet planned conservation measures are taken from four principal sources: D. G. Zhimerin, ed.,* Sovremennyye Problemy Energetiki. *(Moscow Energoatomizdat, 1984); D. B. Vol'fberg, ed.,* Effektivnoye Ispol'zovaniye Toplivno-Energeticheskikh Resursov. *(Moscow: Energoatomizdat, 1983); L. A. Melet'yev and A. A. Makarov, eds.,* Energeticheskii Kompleks SSSR *(Moscow: Ekonomika, 1983); and A. M. Nekrasov and A. A. Troitskiy,* Energetika SSSR v 1981-85 Godakh *(Moscow: Energoizdat, 1981).*

[redacted] 25X1

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Given the tight investment outlook and the anticipated growth in major ferrous-metal-consuming activities (such as machine building and energy production), the Soviets may be hard pressed to retire as much open-hearth furnace capacity as planned. Furthermore, the dramatic loss in oil revenues over the past year may curb imports of equipment for ferrous-metal production. Conservation in this sector will be expensive. [redacted] 25X1 34 million 25X1 tons of standard fuel (12 percent of 1980 energy consumption in this sector) could be saved, at a cost of nearly 200 rubles per ton (figure 5). A Soviet study of measures to conserve energy in the ferrous metals industry found that it can be quite expensive. Focusing on new construction, the report found that energy could be saved (how much was not specified) at a cost of 1,623 rubles per ton of standard fuel. [redacted]

We forecast two conservation paths for the steel industry. In the low case, investment is tight, steel demand remains high, and few of the older plants are closed. In this case, we estimate that the Soviets can achieve energy savings of about only 5 percent, rather than the 12 percent total [redacted] In the high case, the Soviets proceed with their modernization efforts, although they fall short of plans, and by 1995 we project energy conservation of about 10 percent. In both cases we assume that general upgrading at equipment and structural shifts toward more efficient processes will roughly offset increased energy use because of poorer-grade iron ore or higher standards for output. (This was roughly true between 1981 and 1985.) [redacted]

Conservation in the Chemical Industry

The chemical industry accounted for about 6 percent of total Soviet energy consumption and 14 percent of electric power and heat use in 1980. It used a total of 99.5 million tons of standard fuel in that year, of which 55 percent was used as raw material, and the rest was used for heat and power.[37] [redacted]

The Soviet chemical industry has considerable potential for conservation. In the United States, for example, the chemical industry has had great success in energy conservation, increasing overall energy efficiency by over 34 percent from 1972 to 1984, according to a survey by the Chemical Manufacturing Association.[38] Conservation measures planned for the Soviet chemical industry focus on the introduction of more efficient processes and the capture of waste heat. Of the energy savings planned for 1981-85, over half were to come from the use of improved technical processes, one-fourth from various "organizational-technical" measures (better monitoring and control of processes, for example), and about one-fifth from improved capture of waste heat and energy.[39] By 1980 the industry was already using 75 percent of the secondary energy that was considered economically usable, according to one Soviet text, thus limiting somewhat the potential for improvement.[40] [redacted] 25X1 25X1

The chemical industry is probably the most complex in the industrial sector of the economy. Thousands of chemicals are manufactured in a vast array of processes. Each process has its own energy-conservation potential. We chose for analysis three major industrial chemicals—caustic soda, ammonia, and methanol. The first, caustic soda, is a basic industrial product. Its output is growing slowly. The last two are, in addition, rapidly developing export products, increasingly based on imported technology. Unlike the case for oil refining, there is no apparent increase or decrease in the relative share of the more energy-intensive components of the chemical industry to offset or reinforce estimated conservation gains. [redacted] 25X1 25X1

Caustic Soda. Caustic soda and chlorine are produced by the electrolysis of a sodium chloride (common salt) solution. The chlorine gas is removed, and an aqueous solution of caustic soda remains. The purity and concentration of the caustic soda depend primarily on the type of electrolytic cell used—mercury, diaphragm, or permionic membrane. In the United States, the mercury cell has been almost entirely phased out because of the environmental hazard associated with the use of mercury. Over 75 percent of US capacity uses the diaphragm cell, with the newer membrane cells accounting for the rest. In contrast, in the USSR about two-thirds of production is based on diaphragm cells, with virtually all of the rest based on mercury cells. Annual production of caustic soda is about 3 million tons in the USSR, compared with about 10 million tons in the United States. The relatively small tonnage limits the overall impact of conservation measures in this area. [redacted] 25X1 25X1

[37] O. I. Balabaychenko, *et al.*, *Povysheniye Effektivnosti Ispol'zovaniya Energii v Tekhnologicheskikh Ustanovkakh Khimicheskoy Promyshlennosti* (Moscow: Khimiya, 1983): p. 4. [redacted]
[38] *Hydrocarbon Processing*, (September 85): p. 13 [redacted] 25X1

[39] D. I. Zhimirin, ed., *Sovremennyye Problemy Energetiki* (Moscow: Energoatomizdat, 1984): p. 81. [redacted] 25X1
[40] Ibid. [redacted] 25X1

Table 7
Caustic Soda Production:
Estimated Energy Conservation Options

Conservation Measure	Energy Saved (*million tons of standard fuel*)
Total annual energy saved if all measures are taken	1.34
Housekeeping	0.22
Diaphragm cell: install metal anodes	0.15
Hydrogen recovery	0.14
Diaphragm cell: install membrane cell	0.56
Mercury cell: install metal anodes	0.11
Diaphragm cell: go to four-effect evaporation system	0.10
Cogeneration in a diaphragm cell plant	0.06

Energy Conservation Measures in the Caustic Soda Industry Discussed by the Soviets [a]

—Introduce membrane method (30-percent savings).
—Introduce diaphragm method.
—Replace graphite anodes with metal anodes (10- to 20-percent savings).
—Improve the quality of the purifying solution.
—Improve operating procedures for using electrolyzers.
—Capture secondary heat more fully, especially hydrogen in the electrolysis process and heat from the chlorine and hydrogen gases.

[a] *Soviet planned conservation measures are taken from four principal sources: D. G. Zhimerin, ed.,* Sovremennyye Problemy Energetiki. *(Moscow Energoatomizdat, 1984); D. B. Vol'fberg, ed.,* Effektivnoye Ispol'zovaniye Toplivno-Energeticheskikh Resursov. *(Moscow: Energoatomizdat, 1983); L. A. Melet'yev and A. A. Makarov, eds.,* Energeticheskii Kompleks SSSR *(Moscow: Ekonomika, 1983); and A. M. Nekrasov and A. A. Troitskiy,* Energetika SSSR v 1981-85 Godakh *(Moscow: Energoizdat, 1981).* 25X1

25X1

Conservation measures involve transition to the more efficient cells, use of improved anodes, better use of waste heat, and the recovery of hydrogen (see table 7 and figure 5). Housekeeping measures—simply better operating and maintenance procedures—could provide estimated savings of about 5 percent. The conservation measures discussed by the Soviets (see inset) closely correspond to the conservation measures that appear to be most appropriate to their technology. The specific measures applicable to caustic soda production are relatively few—changing cells, changing anodes, hydrogen recovery, and cogeneration.

The major source of conservation is the electricity saved by replacing the mercury and diaphragm cells with membrane cells. A direct changeover from mercury to membrane cells is both technically and economically feasible and is being done in Japan, for example. Instead, the Soviets plan to expand the diaphragm process, developing the membrane process as a long-term objective. A 1985 press article, for example, complained that, after years of effort, the successful development of the membrane cell is still "somewhere on the distant horizon."[41] This is a case where a decision to import could allow the Soviets to leapfrog directly to a newer technology. 25X1

Shortfalls in production of caustic soda suggest that this part of the chemical industry may not have the investment priority required to permit changeover from the electrolytic cells. Production last year missed the original 1985 production target of 3.5 million tons by 13 percent.[42] Although potential conservation gains are relatively large—equivalent to saving nearly one-fourth of the energy used in 1980, the total gains from all of the measures would be only about 1 million tons of standard fuel, made at a relatively high investment cost (figure 5). Moreover, hard currency constraints may preclude the use of imported technology. We estimate that the Soviets may adopt the virtually cost- 25X1

[41] *Izvestiya* (14 June 1985): p. 2. 25X1
[42] *Narodnoye khozyaystvo SSSR v 1985*, p. 146; *Referativnyy Sbornik, 20, Ekonomika Promyshlennosti* (1985): p. 12. 25X1

free measures and perhaps three-fourths of the moderate cost measures—yielding savings on the order of 5 to 15 percent compared with 1980 efficiency levels.

Ammonia. Soviet production of ammonia has grown rapidly—from 7.6 million tons in 1970 to about 23.6 million tons in 1986. The USSR is the world's leading exporter of ammonia, with annual sales of 3.5 million tons anticipated over the next several years. Nearly all of the remaining ammonia output is further processed into fertilizer. Although other fuels can be used as a feedstock, natural gas is used for over 90 percent of Soviet ammonia production. The natural gas is also used as fuel in the process.

Essentially, the natural gas is converted to hydrogen in gas reformers (using high temperatures and pressures in the presence of catalysts) and is then combined with nitrogen, purified, compressed, and liquified. Large unified, single-train plants built since the mid-1960s have improved the energy efficiency of ammonia production considerably. In contrast to the caustic soda industry, the Soviet ammonia industry is relatively modern, since about 75 percent of current capacity was built after 1970.

Despite their relative newness, Soviet large-scale ammonia plants consume on average about 25 percent more total energy (feedstock and fuel) per ton of ammonia than comparable US plants. Fuel usage itself appears to be excessive—about twice as high per ton of ammonia as in US plants. This condition is attributable to poor operating practices in Soviet plants. Since 1980, capacity use rates averaged only 72.5 percent—an inefficient level of operation. The idle time appears due principally to unscheduled downtime resulting from an inadequate supply of properly trained labor and material-supply problems traceable to the transportation network. The severity of the industry's problems is illustrated in a Soviet progress report on the large-scale plants. The report recommended that, because of operators' unfamiliarity with the equipment, 30 extra days be scheduled for preventative maintenance in addition to the world-standard 34-day shutdown for scheduled maintenance. Such a change by itself would reduce maximum operating capacity by nearly 10 percent.

Table 8
Estimated Conservation Measures: The Soviet Ammonia Industry

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Conservation Measure [a]	Energy Saved Per Year (*million tons of standard fuel*)
Total annual energy saved if all measures are taken	9.12
Increase online operation time	2.53
Increase capacity by 10 percent by removing bottlenecks	3.80
Preheat process air	0.12
Use absorbent in final purification	0.30
Superheat and/or reheat steam	0.57
Preheat combustion air	0.40
Add gas-turbine drives	0.14
Use low-pressure drop converter	0.49
Recover purge gases	0.34
Use molecular sieve	0.43

[a] Measures are listed in order of increasing cost per unit of energy saved.

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Energy savings in the production of ammonia can be substantial and cheap. Simply improving operations and maintenance, together with removing unnecessary bottlenecks, can increase capacity, improve the flow of the process, and save some 6.3 million tons of standard fuel annually, primarily natural gas. This technologically simple step will not be easy, since it requires an increase in the skill and the motivation of the operational and maintenance personnel. Clearly it will take time, even if little or no investment is required. Measures entailing investment include the recapture of waste heat, adding gas turbines, and using molecular sieves to aid in the final purification process (see table 8). These additional measures bring the total potential energy savings to 9.1 million tons, or about 30 percent of total energy consumption in the ammonia industry (figure 5). Soviet measures discussed for this sector generally parallel those cited above (see inset).

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Energy Conservation Measures in the Ammonia Industry Discussed by the Soviets [a]

- —*Retire outmoded plants.*
- —*Increase the capacity of large plants through organizational measures and increasing the between-repair time of the units.*
- —*Introduce unified 450,000 ton/year units that more fully capture and use heat from the chemical reactions.*
- —*Use improved catalysts that increase the completeness of the conversion and methanization processes, the degree of utilization of natural gas, and improve the natural gas combustion.*
- —*Ensure better use of byproduct combustible gases.*
- —*Develop catalysts for new production process that is faster and operates with higher pressures, thereby cutting natural gas use by 20 to 30 percent.*

[a] *Soviet planned conservation measures are taken from four principal sources: D. G. Zhimerin, ed.,* Sovremennyye Problemy Energetiki. *(Moscow Energoatomizdat, 1984); D. B. Vol'fberg, ed.,* Effektivnoye Ispol'zovaniye Toplivno-Energeticheskikh Resursov. *(Moscow: Energoatomizdat, 1983); L. A. Melet'yev and A. A. Makarov, eds.,* Energeticheskii Kompleks SSSR *(Moscow: Ekonomika, 1983); and A. M. Nekrasov and A. A. Troitskiy,* Energetika SSSR v 1981-85 *Godakh (Moscow: Energoizdat, 1981).*

Because the measures undertaken to conserve energy in the manufacture of ammonia also result in more efficient use of capacity and an increase in output, we believe that the Soviets will proceed to implement conservation in this branch of the chemical industry, because of the value of ammonia as a hard currency export and its use in fertilizer production. Furthermore, as the newer plants are "broken in" and as the labor force becomes better educated, some of the indicated improvements should gradually occur. We project that the by 1995, the Soviets can gain 70 to 80 percent of the capacity improvements and 50 to 75 percent of the remaining energy-saving measures, yielding conservation gains on the order of 17 to 23 percent.

Methanol. Methanol (methyl alcohol) provides a base for the production of a variety of other products. The USSR produced 2.9 million metric tons of methanol in 1985, making it one of the largest producers in the world. Production should increase to about 3.5 million tons annually as two new large plants, imported from the United Kingdom, are brought to full capacity.

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Before the 1970s methanol was principally manufactured by a high-temperature, high-pressure catalytic process in which synthesis gas made up of carbon dioxide, carbon monoxide, and hydrogen was compressed to a pressure of 300 atmospheres (atm) at temperatures of 330 to 370 degrees C. Although coal was the original source of synthesis gas, most of this gas now comes from the reforming of natural gas.

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In the Western methanol industry, improved catalysts have resulted in process changes that have lowered both the temperature and pressure required in the methanol conversion step. In 1966 a new low-temperature, low-pressure methanol process was developed based on a new, highly active, long-life copper catalyst. Operating at a pressure of only 50 atm and temperatures less than 300 degrees C, this process offered several advantages over the older process, including large energy savings:

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- Steam-driven centrifugal compressors can be used. These compressors are cheaper and more energy-efficient than the electrically driven reciprocating compressors required by the high-pressure process. Electricity requirements per ton of methanol are reduced by 60 percent in this step. Operation and maintenance costs are also lower for the centrifugal compressors. Moreover, centrifugal compressors can be driven by steam from the reformer, and steam from the compressors can then either be returned to the reformer or used in the methanol-purification section of the plant.
- In the low-pressure process, the hydrogen-rich synthesis gas stream contains sufficient carbon dioxide for the methanol synthesis, so that additional carbon dioxide is not required.

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- The low-pressure synthesis also has the advantage that fewer byproducts are formed, thus producing more methanol per unit of feedstock and also simplifying the purification step.

Potential energy savings are substantial, because the low-pressure process in a 50,000-ton-per-year plant (a size typical of many of the Soviets' older plants) uses only 4 percent as much electricity as the high-pressure process. Most new plants built in the United States and Western Europe use this more efficient process.

With the exception of two imported 750,000-ton-per-year plants, nearly all Soviet methanol plants are based on the older, high-pressure synthesis technology. This technology is comparable to US technology of the late 1960s. Energy use in the Soviet methanol industry was reported to be 2.2 tons of standard fuel per ton of methanol (including natural gas used as both feedstock and fuel) in 1980—high by Western standards. Total energy consumption by the methanol industry was 4.9 million tons of standard fuel, about 5 percent of the chemical industry's total energy use in 1980. Over 95 percent of the industry's methanol energy supply is now natural gas.

The conversion from high-pressure to low-pressure methanol synthesis is the single most important conservation measure that the Soviets can undertake. This conversion would offer all of the advantages noted above. The typical low-pressure synthesis retrofit could include other energy-saving modifications—raising the operating pressure of the synthesis loop, and preheating the purge gas. These add-ons would logically accompany any retrofits. The basic retrofit would account for about half of the investment and 70 percent of the energy savings. Other measures can also be taken at the high-pressure plants short of a complete conversion to the low-pressure process: better refractories, flue-gas heat recovery, preheating the combustion air and natural gas, and insulating the reactor. These other measures vary greatly in both cost and energy savings from plant to plant, and are therefore not considered in this analysis.

The complete low-pressure retrofit would only be undertaken at a moderate-size plant—one with a capacity of about 300,000 metric tons per year. Only four Soviet-built plants fall into this category. Plants with a smaller capacity, but at least 100,000 tons per year, would probably only be retrofitted in connection with a capacity expansion. The potential savings at these older plants are thus relatively small—a total of only 0.4 million tons of standard fuel per year, or about 8 percent of 1980 energy consumption in the methanol industry (figure 5).

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Soviet discussions of conservation measures in the methanol industry focus almost exclusively on the benefits from adding the larger capacity units and the retirement of some older, inefficient units. They also referred to some recapture of waste heat. Overall, Soviet plans called for a 15-percent reduction in the energy use per ton of methanol between 1980 and 1985. The plan to roughly double methanol output between 1980 and 1985 would mean that 1985 energy consumption in the methanol industry would have been substantially higher than in 1980, despite the planned reduction in energy use per ton. Most of the conservation in Soviet plans will, therefore, come from this structural shift—from the growing share of production from newer plants, rather than any major conservation at existing plants. This approach appears to be rational since conservation in existing plants will be expensive, some 100 to 105 rubles per ton of standard fuel conserved. By 1995, then, we could see a 15- to 20-percent reduction in energy use per ton of methanol.

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Analysis of Other Sectors

Agriculture

Agriculture consumed about 120 million tons of standard fuel in 1980, about 7 percent of total Soviet energy use.[43] Oil, particularly light products, accounts for more than half of agricultural energy use. Energy use in the sector is expected to rise for the foreseeable future because of planned increases in mechanization, local transportation capabilities, and increased pumping requirements for irrigation. Despite rapid growth

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[43] Melent'yev and Makarov, op. cit.: p. 43.

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in tractor support, for example, the USSR lags well below the mechanization level reached in the United States.

Press reports of poor storage of oil products, poor accounting practices, and a general deficiency in energy measuring and control devices suggest that agriculture has conservation opportunities. About 3 to 5 percent of fuel supplies are lost in storage and distribution, according to a 1984 Soviet report.[44] Furthermore, many of the conservation measures discussed in the Soviet technical literature (see inset) are inexpensive, particularly those relying primarily on administrative measures or the installation of metering devices.

The success of conservation in this area will depend not only on investment but also on the ability to implement thousands of decentralized actions at the local level. We do not believe that the incentives and the necessary equipment will be available for this sector to reduce its 1995 energy consumption by more than 2 to 5 percent (relative to past trends). The overall trend for an increase in fuel use because of greater mechanization, irrigation, and transportation will continue throughout the period.

The Construction Sector

Though a principal consumer of some of the economy's most energy-intensive products, the construction sector itself consumes relatively little energy. In 1980 this sector accounted for only about 2 percent of total Soviet energy use.[45] Nearly 40 percent of the energy used is oil, principally used to operate machinery and to supply heat and electricity to construction sites. The work of this sector has, however, major consequences for energy use. The incorporation of conservation principles in new construction, including the

Conservation Measures in Soviet Agriculture [a]

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- *Increase fuel efficiency of tractors, other machinery (improve engine design and transmission).*
- *Improve roads (1- to 3-percent improvement in fuel economy).*
- *Improve storage and transport of oil products (save 2 to 3 percent of the fuel).*
- *Reduce use of tractors for hauling freight, from 10 to 7 or 8 percent of the total.*
- *Increase deisel truck share of truck hauling.*
- *Use shallower plowing techniques (saves 9 kg standard fuel per hectare).*
- *Use of multipurpose machines to combine tractor operations, completing different activities in same pass (2 to 17 kg standard fuel per hectare).* 25X1
- *Improve grain drying and feed production—better recovery of waste heat and reduce the moisture content of grain before drying (planned savings by 1985 was 1.45 million tons standard fuel).*
- *Introduce electricity metering equipment (planned 1985 savings, 0.8 billion kWh).*
- *Replace incandescent lamps with flourescent lamps (planned 1985 savings 0.45 billion kWh).*
- *Introduce electric heat thermostats (planned 1985 savings, 1.34 billion kWh).* 25X1
- *Measures to improve organization (use of right capacity machines for the job, turning off lights when not in use, and other similar no-cost measures).*
- *Better construction of greenhouses, increased use of secondary heat in greenhouses.*

[a] *Soviet planned conservation measures are taken from four principal sources: D. G. Zhimerin, ed.,* Sovremennyye Problemy Energetiki. *(Moscow:* Energoatomizdat, *1984); D. B. Vol'fberg ed.,* Effektivnoye Ispol'zovaniye Toplivno-Energeticheskikh Resursov. *(Moscow: Energoatomizdat, 1983); L. A. Melent'yev and A. A. Makarov, eds.,* Energeticheskii Kompleks SSSR *(Moscow: Ekonomika, 1983), and A. M. Nekrasov and A. A. Troitskiy eds.,* Energetika SSSR v 1981-85 Godakh *(Moscow: Energoizdat, 1981).*

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[44] 13 May 1984 *Vremya* TV broadcast, reported in FBIS V3, number 96, 16 May. These losses may include some fuel that was stolen and used elsewhere in the economy. In terms of energy use, this theft would not be a true "loss" to the economy.

[45] V. A. Gol'strem and Yu. L. Kuznetsov *Spravochnik Po Ekonomii Toplivno-Energeticheskikh Resursov* (Kiev: Tekhnika, 1985): p. 7.

installation of insulation and proper sealing of buildings, has implications for energy use long after construction is completed. [redacted]

Aside from improved equipment operations and elimination of unnecessary motor idling, there are few direct energy conservation measures that can be taken in this sector. Soviet discussions have focused on more efficient use of construction materials and the incorporation of conservation measures in building designs. The impact of better insulation and improved building designs is discussed below in the residential sector. [redacted]

The issue of conserving energy-intensive materials (such as curbing waste of materials, cutting down on steel content of machinery, and substituting less energy-intensive materials whenever possible) is a very important source of energy savings, although beyond the scope of this study. The importance of such conservation is evident from the large amount of materials used in construction. In 1984 the construction program was scheduled to consume 110 million tons of cement, 37 million tons of fabricated metal, 12 million tons of steel pipe, 245 million square meters of glass, 100 million cubic meters of lumber products, and 58 billion bricks. The energy used to produce the cement and metal alone was greater than the total direct energy consumption by this sector. Direct energy conservation in the sector will probably be relatively low—less than 5 percent—given the relatively low level of savings opportunities. [redacted]

Construction Materials

The production of construction materials—principally cement, bricks, and glass—is highly energy-intensive, accounting for about 7 percent of Soviet energy use. Cement is the largest energy consumer of these products, using about 45 million tons of standard fuel in 1980, and has been targeted by the Soviets for energy conservation.[46] [redacted]

The Soviets are, by world standards, inefficient in energy use in cement production. Although energy efficiency improved during the 1960s and 1970s with the switch from coal to the more efficient oil and gas, energy efficiency stagnated in the 1980s as substitution opportunities have diminished. The Soviets' inefficiency is due primarily to the structure of cement-making capacity. While most of the world's cement industries converted to the more efficient "dry" process (which consumes only 55 percent as much energy as the older "wet" process), some 90 percent of Soviet cement is still produced by the wet process.[47] The efforts to switch to the dry process are hampered by problems in the raw material base. The requirements for raw material quality (low moisture and homogeneous composition) for the dry process are stringent; as of the mid-1970s, however, only 4 percent of explored limestone deposits in the USSR met these requirements.[48] According to a 1984 press report, only seven of the 30 new cement production lines installed during the previous 10 years used the dry process—no doubt in part because of the raw material quality problem.[49] Moreover, a Soviet economic journal stated in mid-1985 that the share of production from the wet process had risen to about 90 percent, up from 85 percent in 1981.[50] [redacted]

Major energy savings in cement production depend on the continued transition to the dry process, which not only would be expensive but also may not be feasible on a large scale. Small savings can be made at the margin, but they will be subject to the same constraints in supply of heat exchangers and other such equipment as are encountered in other sectors using this kind of equipment (see inset). [redacted]

Conservation measures in the construction materials sector are, on the whole, expensive. One Soviet study cited costs of 968 rubles per ton of standard fuel saved as the average for several conservation measures in the construction materials sector as a whole.[51] A new

[46] D. G. Zhimerin, op. cit.: p. 83. [redacted]

[redacted]

[49] *Pravda* (24 May 1984): p. 3. [redacted]

[50] *Voprosy ekonomiki* (No. 6, June 1985): p. 53. [redacted]

[51] *Voprosy ekonomiki* (No. 6, June 1984): p. 43. [redacted]

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dry process cement plant could be built at a cost of 500 to 600 rubles per ton of energy saved, according to a 1984 *Pravda* article.[52] Other approaches are cheaper—the use of additives and waste byproducts, such as slag and ashes to reduce the clinker content (95 percent of the energy used to produce cement is used in the production of clinker), improved heat exchangers and heat-retaining screens, and improved burner design.

Investment in the cement industry was low in the 1981-85 plan.[53] Future plans will have to increase investment and/or lower planned production increases if major energy savings are to be achieved. Given the existence of some low-cost, energy-saving measures and the raw material constrained on the dry process, we estimate that energy conservation in this sector will be small—on the order of 5 percent.

Electric Power

The electric power industry is the largest consumer of energy in the Soviet Union. In 1985 thermal plants burned nearly 350 million tons of standard fuel—nearly 20 percent of the country's total energy consumption. Hydroelectric and nuclear power plants represented the equivalent of another 110 million tons of standard fuel. Overall, the electric power sector accounted for nearly 25 percent of 1985 Soviet energy consumption. This sector is efficient by world standards. Efficiency gains have slowed in recent years (figure 8), and the Soviets may have pushed existing technology about as far as possible.

The Soviets continue to emphasize conservation in electric power production, which annually uses about 125 million tons of oil—over one-fourth of Soviet oil consumption. Gas substitution is being emphasized as the primary way to reduce oil usage, but conservation is a second means. In addition, because this sector consumes so much energy, even small percentage gains can add up to big savings in the amount of energy used. Furthermore, the share of total energy

Conservation Measures in the Cement Industry [a]

- *—Convert to dry process.*
- *—Use of plasticizers to lower clinker content of cement.*
- *—Use of slag, ash, other waste material to lower clinker content (use of 30-percent slag lowers energy requirements by 22 percent).* 25X1
- *—Increase furnace operating rates.*
- *—Use of additives to reduce moisture of slurry (1-percent reduction in moisture yields 1-percent reduction in energy use).*
- *—Begin production with low-temperature saline process.*
- *—Improve heat recovery by using heat exchangers and heat screens.*
- *—Increase output of new, less energy-intensive portland cement (a 2.4-percent reduction in the average grade of cement was planned for 1981-85).* 25X1
- *—Modernize burners.*
- *—Add surfactants to intensify grinding process.*
- *—Use electrostatic precipitators to lower material losses (indirect energy savings).*
- *—Use large filters to advance the drying process.*
- *—Improve operation of grinding units to cut electric power use.*
- *—Reconstruct rotating furnaces (wet process) to increase capacity.*
- *—Use pneumatic batchers to directly feed ground clinkers into kiln heat exchanger.*

[a] *Soviet planned conservation measures are taken from four principal sources: D. G. Zhimerin, ed.,* Sovremennyye Problemy Energetiki. *(Moscow: Energoatomizdat, 1984); D. B. Vol'fberg ed.,* Effektivnoye Ispol'zovaniye Toplivno-Energeticheskikh Resursov. *(Moscow: Energoatomizdat, 1983); L. A. Melent'yev and A. A. Makarov, eds., Energeticheskii Kompleks SSSR (Moscow: Ekonomika, 1983); and A. M. Nekrasov and A. A. Troitskiy, Energetika SSSR v 1981-85 Godakh (Moscow: Energoizdat, 1981).* 25X1

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[52] *Pravda* (24 May 1984): p. 3.

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Conservation Measures in the Electric Power Sector [a]

—*Modernize existing turbines.*
—*Reconstruct existing condensation blocs, in European USSR plants with 150- to 300-megawatt capacity, to further develop cogeneration.*
—*Introduce 500- and 800-megawatt units based on coal (2- to 3-percent improvement over 300-megawatt units).*
—*Retire one-third of small outmoded boilers (1985 goal: save 8 million tons standard fuel).*
—*Rely more heavily on centralized heating system.*
—*Reduce transmission losses from 9 to 8.5 percent (savings of 2 million tons standard fuel).*
—*Improve operating procedures on existing units to minimize downtime and restarts.*
—*Improve transport, handling, and processing of fuels, especially low-grade coal, to ensure smoother operations.*
—*Improve current distribution in sequentially regulated transformers.*
—*Use sectioning to eliminate unfavorable current distribution in networks of different voltage.*
—*Increase the degree of compensation of reactive loads with additional compensators/equalizers/condensers.*
—*Add boiler units to cogeneration plants to improve variability of output (20 to 25 grams standard fuel/kWh improvement).*
—*Raise steam pressure from 540° Celsius to 565° Celsius.*
—*Improve flexibility of 300- to 800-megawatt blocks.*
—*Increase air intake in fuel oil burning bloc (1,000 tons standard fuel per 300 megawatts).*
—*Install air preheaters.*
—*Keep boiler heating surfaces clean.*
—*Renovate regenerative heaters; for example, upgrade seals.*
—*Improve sealing of boiler furnaces and flues.*
—*Increase operation time of individual units (500-megawatt units operate only 74 to 75 percent of the time).*
—*Introduce mechanical heating and cooling system for electric power buildings (1,000 to 1,200 tons standard fuel per 500- and 800-megawatt unit).*

[a] *Soviet planned conservation measures are taken from four principal sources: D. G. Zhimerin, ed.,* Sovremennyye Problemy Energetiki. *(Moscow: Energoatomizdat, 1984); D. B. Vol'fberg ed.,* Effektivnoye Ispol'zovaniye Toplivno-Energeticheskikh Resursov. *(Moscow: Energoatomizdat, 1983); L. A. Melent'yev and A. A. Makarov, eds., Energeticheskii Kompleks SSSR (Moscow: Ekonomika, 1983); and A. M. Nekrasov and A. A. Troitskiy, Energetika SSSR v 1981-85 Godakh (Moscow: Energoizdat, 1981).*

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going to this sector is expected to rise over the next decade as Soviet use of electric power intensifies.

Realizing the continued potential for conservation in electric power production will be expensive. Low retirement rates have resulted in an aging capital stock. A 1983 press report warned that the share of operating capacity representing thermal power plants working beyond their rated service life could soon reach one-third of total installed capacity.[54] Problems since the Chernobyl' nuclear power plant accident have heightened this problem of relying on older equipment. Modernizing and replacing some of this capacity would in itself be expensive. 25X1

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[54] *Sotsialisticheskaya industriya* (2 July 1983): p. 2. 25X1

Basic methods of conservation in the electric power industry include measures that lead to steady operation of equipment, eliminating the incidence of unnecessary downtime and restart operations, which require additional fuel (see inset). Many Soviet power plants, however, lack flexibility and are capable of producing electricity at only one output level; that is, they cannot adjust to the daily fluctuations in electricity demand. Flexible units make up only 0.4 percent of total generating capacity, compared with a minimum target of 8 to 10 percent, according to the journal of the State Planning Committee.[55] As a result, much equipment has to be shut down at night, necessitating energy-intensive daily startups. In Moscow, for example, the load is one-third less at night than during the day. [redacted] 25X1

Another potential source of energy saving in this sector is increasing the share of 800-megawatt turbines relative to that of the 150- to 200-megawatt turbines. The larger units are some 10 percent more efficient.[56] The replacement process is slow, however. By the mid-1980s, the Soviets had installed only 15 of the 800-megawatt turbines—less than 5 percent of total electricity generation capacity [redacted] 25X1

Efficiency also depends on the fuel used. Natural gas is about 4 percent more efficient than fuel oil in power plants. Gas-for-oil substitution would, therefore, provide some efficiency gains, just as any long-run increase in the share of coal (a less efficient fuel) in power plant fuel use would have a negative impact on efficiency. For the next decade, however, substitution—which would increase the share of gas in total power-plant fuel use—will probably have an overall positive impact on efficiency. [redacted] 25X1

In summary, conservation will be expensive in this industry. Because of the efficiency gains the Soviets have already made in electricity power, there are few easy steps to take. Replacing equipment is costly, and the Soviets may be hard pressed to make the requisite investment, given the rising demands for electricity, the need to improve the reliability and flexibility of the power supply, and the setback caused by the Chernobyl' disaster. Efficiency should improve on the margin with increased reliability and flexibility, and meters and other conservation equipment may be installed when other equipment is upgraded (see inset). On the basis of our estimate of the future structure of the Soviet electric power industry and the level of new construction, we estimate that energy used to generate electric power and heat will decline by only about 2 percent between 1985 and 1995. [redacted] 25X1

Fuels Production

Energy conservation in the production and transportation operations of the oil, gas, and coal industries adds another dimension to the discussion of efficiency measures. In addition to promoting the more efficient use of energy in other economic activities, conservation efforts focus on controlling the direct losses of energy at the production sites—for example, capturing gas that is now flared and preventing spillage in the oilfields (see table 9). [redacted] 25X1

Oil producers use energy to provide heat for oilfield processing facilities and electricity for operating the equipment that drills the wells and pumps the oil. The oil industry uses less than 2 percent of national electricity output and less than 0.5 percent of heat production.[57] Conservation measures focus on cutting down on oil spillage (now about 2 percent of production), use of more efficient burners and better capture of process heat in oilfield operations, installation of gas turbines to use gas now often flared, and greater use of automation and metering. Measures such as metering and reducing energy use in pumping by keeping the pipelines clean are not expensive; but, because these measures require equipment and manpower that is in short supply, gains may be difficult. Reducing oil spillage by replacing pipes and valves will be expensive and labor intensive. Press reports

[55] *Planovoye khozyaystvo* (No. 12, December 1983): p. 106. [redacted] 25X1
[56] *Economicheskoye sotrudnichestvo stran-chlenov SEV* (No. 5, May 1984): pp. 2-5. [redacted] 25X1

[57] Nekrasov and Troitskiy, op. cit.: pp. 55, 94. [redacted] 25X1

Table 9
Conservation Measures in the Fuels Sector

	Conservation Measures
Oil	Recapture boiler heat
	Better insulate heat lines
	Use wellhead pressure more fully
	Use vacuum stabilizers in oil collection systems
	Use more economical heating units
	Use meters and automated control more widely
	Keep pipelines clean of paraffin deposits
	Equip mobile power plants with heat-recovery equipment
	Use gas-turbine power units in fields where gas is now flared; use heat from the turbines
Gas	Replace gas turbines with electric motors in compressor stations
	Use automatic regulation in gas processing plants
	Install heat recovery equipment
	Use energy of gas pressure to pump liquids in gas separation plants
	Improve compressor cleaning operations
	Increase use of inhibitors to keep pipelines clean
	Keep heat exchanger surfaces clean
	Increase metering
	Use computers to optimize field operations
Coal	Capture and use methane gas
	Use more efficient boilers and ventilation equipment
	Raise level of automation of energy systems
	Improve energy efficiency of mining equipment

[a] Soviet planned conservation measures are taken from four principal sources: D. G. Zhimerin, ed., Sovremennyye Problemy Energetiki. (Moscow: Energoatomizdat, 1984); D. B. Vol'fberg ed. Effektivnoye Ispol'zovaniye Toplivno-Energeticheskikh Resursov. (Moscow: Energoatomizdat, 1983); L. A. Melent'yev and A. A. Makarov, eds., Energeticheskii Kompleks SSSR (Moscow: Ekonomika, 1983); and A. M. Nekrasov and A. A. Troitskiy, Energetika SSSR v 1981-85 Godakh (Moscow: Energoizdat, 1981).

indicate that the spillage problem is getting worse in West Siberia because of advanced corrosion in pipes. Conservation in this area may, however, be accorded low priority because of the small share of total energy consumption it represents and the difficulty of performing the thousands of operations that are required.

25X1

Gas production itself uses relatively little energy, because of the high well-head pressures of many Soviet fields and the absence of major separation problems, with the notable exception of gas from high-sulfur fields, including Astrakhan'. Several measures can be taken, however, to improve the energy efficiency of processing efforts—the use of larger, more efficient units, the use of heat exchangers, improved cleaning operations, and the use of computers and improved metering. Gas pipelines are, however, major consumers of energy. Major gas lines coming out of West Siberia, for example, use about 12 to 13 percent of the transported gas to power the pipelines.[58] Soviet studies show that replacing the gas-turbine drives for the compressors with electric motors can *save* substantial energy at a relatively low cost—*if* excess electric power is available in the area.[59] 25X1

Conservation in gas production and transport will probably be slow. As with oil, but to a much lesser extent, numerous operations at hundreds of fields will be difficult to implement. Many operations will be hampered by the same lack of metering and other control devices plaguing other industries. Finally, the largest single measure identified—the use of electricity rather than gas to power the pipelines in areas with excess generating capacity—may have a low priority because of the abundance of gas and the relative tautness of the electricity supply. 25X1

Coal producers' energy requirements depend substantially on the type of mining operation—open pit mines require only about 12 percent of the energy per ton of coal needed for deep mining, although coal from underground mines generally has a higher energy content.[60] The rising share of open pit mining, along with other measures, in the 1981-85 plan was expected to cause a 3-percent decline in heat used and a 0.5-percent decline in the electricity used per ton of coal 25X1

[58] *Gazovaya promyshlennost'* (No. 4, April 1984): p. 27. 25X1
[59] *Izvestiya AN SSSR Economic Series*, (No. 4, 1982), in JPRS 82861 (15 February 1983): pp. 15-16). 25X1
[60] *Promyshlennaya energetika* (No. 9, September 1984): p. 9. 25X1

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mined.[61] The deterioration in coal quality is, however, raising the energy requirements for coal processing. Between 1972 and 1982, for example, the electricity requirements for coal enrichment rose by 37.5 percent; for briquetting, 27.4 percent.[62] These trends are expected to continue. [redacted]

Coal production is a rather small energy user, but there is some potential for conservation. Conservation measures include the use of methane gas from the mines as a fuel source, improved boiler efficiency, increased use of automation, and the use of more efficient mining and ventilation equipment. Given the coal industry's production problems and low investment priority since the mid-1970s, conservation in this area will require a substantial turnaround in investment policy and a change that forces the investment into channels that enhance energy efficiency. [redacted]

For the fuels sector as a whole, conservation depends principally on the ability to control losses, particularly of oil and coal, in storage and transportation. The greater capture of associated gas in oilfields and the increased use of methane gas in coalfields is more a matter of increasing production than of energy conservation, in the sense that the latter concept has been used in this paper. Therefore, we estimate that the realistic conservation potential for this sector is relatively low—limited to tightening up the effort, better metering, greater care, and so on. These changes could yield savings up to 5 percent, savings that could well be cut in half by the negative factors of lower flow oil wells, longer gas transport, and lower grade coal. Thus, overall, we expect energy savings of 2 to 3 percent by 1995. [redacted]

Machine Building

Machine building, a diverse combination of civilian and defense industries producing machinery and equipment, consumes about 7 to 8 percent of Soviet energy. Its consumption of electric power and heat (16.5 percent of total Soviet consumption) is especially

[61] Nekrasov and Troitskiy, op. cit.: pp. 55, 94). [redacted]
[62] *Promyshlennaya energetika*, op. cit: p. 9. [redacted]

Conservation Measures in the Machine-Building Sector [a]

- *—Increase oxygen to steel-smelting furnaces (open-hearth type).*
- *—Preheat scrap for electric furnaces (10-percent savings in electricity).*
- *—Use liquid self-hardening mixture in casting.*
- *—Use automatic forging complex instead of steam hammers (cuts energy use by three-quarters).*
- *—Preheat charge to forge (650 to 800° Celsius).*
- *—Replace electric furnaces with gas-fueled furnaces (15- to 20-percent boost in energy efficiency).*
- *—Equip large furnaces with heat recovery unit (10- to 15-percent energy savings).*
- *—Use recovered heat to preheat air.*
- *—Equip furnaces with automatic regulators and gas jets (8- to 10-percent improvement).*
- *—Reconstruct large drying furnaces, recirculating the heat.*
- *—Replace noncontinuous furnaces with continuous action furnaces.*
- *—Use "hot threading" of pieces, rather than milling.*
- *—Use cold stamping instead of hot stamping.*
- *—Use automated production lines when relevant.*
- *—Expand use of numerically controlled equipment.*
- *—Replace metal with plastic.*
- *—Replace electric current with pneumatic drive in several operations.*
- *—Improve operations of plant electric power stations.*
- *—Improve operation of compressors.*

[a] *Soviet planned conservation measures are taken from four principal sources: D. G. Zhimerin, ed.,* Sovremennyye Problemy Energetiki *(Moscow: Energoatomizdat, 1984); D. B. Vol'fberg ed.,* Effektivnoye Ispol'zovaniye Toplivno-Energeticheskikh Resursov. *(Moscow: Energoatomizdat, 1983); L. A. Melent'yev and A. A. Makarov, eds.,* Energeticheskii Kompleks SSSR *(Moscow: Ekonomika, 1983); and A. M. Nekrasov and A. A. Troitskiy,* Energetika SSSR v 1981-85 Godakh *(Moscow: Energoizdat, 1981).*

[redacted]

important. Machine building made substantial conservation progress in the 1970s—the electric power and heat used per ruble of output declined by one-fifth and one-third, respectively. Although Soviet plans call for direct energy conservation gains in machine building, the principal opportunity for energy conservation is in the production of machinery that is more energy efficient and contains less metal. [redacted]

Conservation measures discussed by the Soviets (see inset) focus principally on capturing secondary heat given off in production processes, notably forging and casting. The 1981-85 plan called for the utilization rate of secondary energy, principally in the form of low-temperature heat and steam, to rise from 14 percent to over 30 percent of the potential.[63] Such a gain will be difficult. Much of the currently uncaptured heat appears to be from small units, for which there is neither suitable recovery equipment nor steady use for the low-grade heat or steam that would be captured.[64] [redacted]

Some plants in this sector are so large that they include their own furnaces and power plants. For these plants, some of the conservation measures discussed under metallurgy and electric power should be relevant. [redacted]

The 1986-90 plan calls for a rapid expansion of machinery output—40 to 45 percent, including energy-conserving equipment. The scramble to meet high output targets may push conservation measures aside. Finally, energy costs represent only a small part (about 3 to 4 percent) of total expenditures in machine building.[65] The emphasis on growth of output suggests that energy conservation measures that have no labor-saving or quality-improving side benefits will probably have a very low priority in this sector. [redacted]

Despite the emphasis on expanding machine-building output, the progress already made in the 1970s (limiting the potential for conservation), and the emphasis on improved quality (often accompanied by increases in energy requirements wherever metal is concerned), we believe that the availability of energy conservation opportunities, some of them identical to those in ferrous metals production, can lead to conservation gains on the order of 5 to 10 percent, depending on the impetus to conserve. Success in conserving metal in this sector (another element of the Soviets' overall efficiency campaign) will have a reinforcing effect on energy conservation prospects. [redacted] 25X1 25X1

Nonferrous Metals

The production of nonferrous metals consumed about 3 percent of Soviet energy consumption in 1980.[66] We selected aluminum for review because it is the most electricity-intensive of these metals, some of the conservation measures for aluminum are relevant to other metals, and the information is somewhat more available (because of the importance of nonferrous metals in defense applications, the Soviets publish little data on production or reserves of most of them). [redacted] 25X1 25X1

The aluminum industry in the USSR has made efficiency gains, but it remains less efficient than that in the West. Aluminum is one of the most electricity-intensive of all industrial products—consuming about 17,000 kWh per ton (down from 18,146 kWh per ton in 1965).[67] The industry's efficiency in use of electricity is roughly comparable to that in the United States in the early 1970s. The high energy consumption is because of the high temperatures required to separate aluminum from alumina (aluminum oxide). [redacted] 25X1 25X1

A special problem that can affect aluminum production is damage caused by electric power outages. Power outages have occurred in the past, causing one plant to shut down its smelting pots. Shutting down 25X1

[63] V. A. Gol'strem and Yu. L. Kuznetsov *Spravochnik Po Ekonomikii Toplivno-Energeticheskiky Resursov* (Kiev, Tekhnika, 1985): p. 7. [redacted]
[64] S. P. Sushon, et al., *Vtorichnyye Energeticheskiye Rusursy Promyshlennost' SSSR* (Moscow: Energiya, 1978): p. 106. [redacted]
[65] *Narodnoye khozyaystvo SSSR*, 1985: p. 126. [redacted]
[66] *Promyshlennaya energetika* (No. 11, 1977): pp. 2-7 and *Promyshlennaya energetika* (No. 11, 1984) p. 12. [redacted]
[redacted]

25X1
25X1
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25X1

the pots is expensive—the pots can be damaged, and restarting them is time consuming. Therefore, assuring a reliable supply of electricity probably has a higher priority than conservation of electricity in this sector. [redacted] 25X1

Some relatively inexpensive conservation measures can be taken. For example, a 1981 Soviet press article discussed heat recovery units that were installed at a cost of only 8 rubles per ton of standard fuel saved.[68] A measure used heavily in the West is the recycling of aluminum. Recycling aluminum requires less than 5 percent of the energy needed to produce aluminum from bauxite.[69] It is not clear, however, that major sources of aluminum for recycling exist in the USSR. Other conservation measures discussed (see inset) include general efficiency measures that apply in almost any industrial process—reduce machinery idling time, tighten the insulation and fittings on furnaces, and increase the use of automation. [redacted] 25X1

Soviet plans call for about 7 million tons of standard fuel in energy savings in the 1980s for all of the nonferrous metal industries.[70] This total represents about 15 percent of total Soviet nonferrous energy consumption in 1980. The completion of the new Sayansk aluminum plant and a variety of measures to recoup secondary heat should result in achieving energy savings for the entire nonferrous sector of 2.5 to 5 percent by 1995. [redacted] 25X1

The Residential Sector

This sector, one of the largest consumers of energy in the USSR, in 1980 used 336 million tons of standard fuel (nearly 20 percent of total national consumption). Of this amount 250 million tons were used for space heating, air-conditioning, and hot water heating. Nearly 57 million tons were used for electricity and 29 million tons for food preparation.[71] This sector's energy demand will continue to rise, because housing

Conservation Measures in the Aluminum Industry [a]

- —*Recycle aluminum (recycled metal has 5 percent of the energy requirement of bauxite).*
- —*Improve use of secondary heat from furnaces.*
- —*Improve preparation and use of fluxes.*
- —*Reduce idle running of equipment.*
- —*Modernize furnaces during overhauls (9- to 30.6-percent reduction in fuel use).*
- —*Improve direct directional heat (3- to 15-percent reduction in fuel use).*
- —*Improve gas furnaces by improving fittings, installing insulation, and improving durability of construction.*
- —*Use exhaust gases to preheat air to furnaces.*
- —*Install heat recovery units.*
- —*Improve electric furnaces by using heat from drying aluminum chips increase capacity of transformers.*
- —*Transfer aluminum as liquid whenever possible (savings of 500 kWh/ton).*
- —*Introduce automation.*
- —*Expand gas use in roasting furnaces.*
- —*Use prebaked anodes (reduce kWh/ton 5 to 8 percent).*
- —*Add copper salts to electrolysis solution.*
- —*Use heat exchangers more widely in making aluminum oxide.*
- —*Use high-temperature leaching for aluminum oxide (allows lower bauxite concentration, less heat).* 25X1

[a] *Soviet planned conservation measures are taken from four principal sources: D. G. Zhimerin, ed.,* Sovremennyye Problemy Energetiki. *(Moscow: Energoatomizdat, 1984); D. B. Vol'fberg ed.,* Effektivnoye Ispol'zovaniye Toplivno-Energeticheskikh Resursov. *(Moscow: Energoatomizdat, 1983); L. A. Melent'yev and A. A. Makarov, eds.,* Energeticheskii Kompleks SSSR *(Moscow: Ekonomika, 1983); and A. M. Nekrasov and A. A. Troitskiy,* Energetika SSSR v 1981-85 Godakh *(Moscow: Energoizdat, 1981).*

[redacted] 25X1

[68] *Izvestiya* (24 September 1981): p. 1. [redacted] 25X1
[69] *EKO* (No. 7, July 1985): p. 144. [redacted] 25X1
[70] *Planovoye khozyaystvo* (No. 1, January 1981): p. 39. [redacted] 25X1
[71] Vol'fberg, op. cit.: p. 70. [redacted] 25X1

is projected to grow throughout the period. Waste is substantial in this sector, and the potential for conservation is great, although implementation may be difficult:

- Stories abound of overheated apartments cooled by open windows in the winter because of the lack of valves and thermostats.
- Per capita hot water consumption in the USSR was 50 to 67 percent higher than in other countries, according to a 1981 press report.[72]
- Insulation standards were lowered in the 1970s by 10-20 percent, so that residences constructed during the 1970s required more energy to be heated than buildings built 25 years earlier, according to a 1980 Soviet economic journal.[73] Standards had apparently been raised by 1982, according to a later report in another journal.[74]
- Heat-supply lines reportedly lose 13 percent of their heat in transit, because of poor insulation. (The Soviet standard is 5 to 6 percent loss, according to a 1983 Soviet monograph.) [redacted] 25X1

Conservation Measures in the Urban-Rural Residential Area [a]

—Insulate walls, doors, windows, and heat pipes.
—Modernize existing buildings (18- to 20-percent reduction in heat losses).
—Use new construction techniques such as new designs, better insulation, better materials (15- to 20-percent reduction in heat losses, compared with current conditions).
—Recapture vented heat (1985 goal was to recapture 30 million tons of potential 65 million tons).
—Install individual thermostats (save up to 15 percent of heat loss).
—Reduce temperatures in unused rooms and after working hours (11 million tons per year).
—Use high-efficiency furnaces.
—Use hot water flow regulators.
—Reduce use of small inefficient boilers; increase reliance on centralized heat.
—Build larger buildings, when possible, to reduce relative outside exposure.

[a] *Soviet planned conservation measures are taken from four principal sources: D. G. Zhimerin, ed.,* Sovremennyye Problemy Energetiki. *(Moscow: Energoatomizdat, 1984); D. B. Vol'fberg ed.,* Effektivnoye Ispol'zovaniye Toplivno-Energeticheskikh Resursov. *(Moscow: Energoatomizdat, 1983); L. A. Melent'yev and A. A. Makarov, eds.,* Energeticheskii Kompleks SSSR *(Moscow: Ekonomika, 1983); and A. M. Nekrasov and A. A. Troitskiy,* Energetika SSSR v 1981-85 Godakh *(Moscow: Energoizdat, 1981).*

[redacted] 25X1

Soviet plans for conservation in this area (see inset) for the most part parallel measures taken in the West over the past 10 years—better insulation, the use of building materials with better heat-retaining properties, better building designs, adding thermostats, and the recapture of vented heat. Much of the conservation gain realized in the West was based on individual actions in response to rising prices. In the USSR the availability of nonmetered or nominally priced energy, together with the lack of private ownership of residences, sharply reduces individual incentive to conserve. [redacted] 25X1

There are nearly 5 billion square meters of housing (urban and rural) in the USSR, with over 100 million square meters being built annually.[75] Although new construction methods and materials can reportedly cut heat loss by 15 to 20 percent, new construction will affect the total energy efficiency only slowly.[76] Modernization of existing buildings can also cut heat losses by up to 20 percent, but, as in the West, such retrofitting tends to be expensive.[77] Making a substantial improvement in the older housing stock will be a slow and expensive process. The implementation of new designs will take even longer. As noted earlier in

[72] *Izvestiya* (24 July 1981): p. 2. [redacted] 25X1
[73] *EKO* (No. 9, September 1980): p. 119. [redacted] 25X1
[74] *Stroitel'naya gazeta* (8 September 1982): p. 3. [redacted] 25X1
[75] *Narodnoye khozyaystvo SSSR v 1985* (Moscow: Statistika, 1986): p. 424. [redacted] 25X1

[76] Vol'fberg, op. cit.: p. 73. [redacted] 25X1
[77] Ibid. [redacted] 25X1

our discussion of poor Soviet implementation of conservation, a recent Soviet survey of new building designs showed that the designs did not take conservation measures into account. [redacted]

In view of the recent low priority given to housing investment, the lack of nonenergy side benefits, the disparate nature of the problem, and the long lifetime of the housing stock, we believe that conservation progress in the sector will be considerably slower than in the West, perhaps improving energy efficiency on the order of 2.5 to 7.5 percent, depending on the impetus given to the effort. [redacted]

The Transportation Sector

The transportation sector has an importance well beyond that suggested by its relatively small (about 7-percent) share of total Soviet energy consumption.[78] Transportation accounts for about one-third of total oil consumption and nearly half of the scarcest energy commodity—light oil products.[79] Fuel requirements are expected to grow as transport distances continue to increase and the level of freight and passenger traffic continues to grow. Overall, the Soviet transportation sector is quite efficient by Western standards, largely because of the high degree of railroad electrification and the high share of total freight that is hauled by rail (see table 10). In the USSR, the more efficient modes of transportation (pipeline, rail, and inland waterway) account for over 90 percent of freight handled, compared with only 75 percent in the United States. The structure of transportation use largely explains the basic energy-use pattern in this sector. Many of the opportunities for efficiency gain available in the past—the rapid increase in rail electrification and the replacement of the steam locomotives—have largely been exhausted. Furthermore, a major source of energy savings in the United States—voluntary reductions in driving and improved energy efficiency in private cars—is a relatively minor factor in the USSR. [redacted]

[78] Makarov and Melent'yev, op. cit.: p. 43. [redacted]
[79] *Izvestiya* (15 April 1982): p. 2. [redacted]

Table 10
Relative Fuel Expenditure, by Type of Transportation

25X1

	Index of Fuel Use Per Ton-Kilometer Transported (*US Experience*)	Percentage of Total Inland Freight Handled in 1983	
		USSR	US
Total		100	100
Oil pipelines	100	24	25
Railroads	149	63	36
Inland waterway	151	5	15
Truck	844	8	24
Airplane	9,333	NEGL	NEGL

25X1

Sources: *Narodnoye Khozyaystvo SSSR 1983* (excluding maritime shipping and gas pipelines to make the data comparable with US data); *Statistical Abstract of the U.S.* 1985; Hammond, *et al.*, *Energy and the Future*, (Washington, D. C., AAAS, 1973): p. 137.

[redacted] 25X1

Despite Soviet achievements in transportation, further energy conservation potential still exists, although rather expensive. Most conservation measures discussed by the Soviets (see inset) involve either conversion to new equipment (the dieselization of trucks, improved engines and better design for aircraft) or measures that require very widespread implementation (surfacing dirt roads and improving railroad track conditions, for example). Two examples illustrate the extent of need for such measures:

- The Soviets cite dieselization of the truck park as a major source of conservation. The greater cost and higher maintenance requirements of diesel engines are offset by better fuel efficiency. Soviets claim that diesel engines can be 30 to 35 percent more fuel efficient than internal combustion engines.[80] The 1986-90 plan calls for the share of freight handled by diesel trucks to reach 60 percent, with fuel

[80] Vol'fberg, op. cit., p. 68. [redacted]

25X1
25X1
25X1
25X1

Conservation Measures in Transportation [a]

Railroads:
- *Improve organization to maximaze use of locomotive and car capacities.*
- *Improve construction of engines and railroad cars.*
- *Install new, improved bearings on cars.*
- *Further electrify railroad lines (savings of over 2 million tons annually per 10,000 km of track).*
- *Further electrify urban transport.*
- *Improve recovery of electricity from rails (potential savings of 1.1-1.5 billion kWh per year).*
- *Improve transmission of electricity to rails.*
- *Use larger capacity trains.*

Trucks and automobiles:
- *Expand dieselization (savings of 25 million tons 1980 to 1990).*
- *Improve roads (paving dirt roads).*
- *Improve internal combustion engine.*
- *Increase role of larger trucks.*
- *Improve organization to maximize capacity.*

River and maritime:
- *Improve organization of shipping operations.*
- *Use more efficient diesel engines.*
- *Increase maritime ship capacity (35-percent increase over 10 years).*
- *Improve mechanization of freight handling.*
- *Increase use of barges for river freight.*

Air:
- *Use better organization—operational procedures, aircraft tasking.*
- *Improve engines.*
- *Use better aircraft construction (smooth surfacing, for example).*
- *Increase aircraft capacity (replace smaller planes on longer runs with larger planes).*

[a] *Soviet planned conservation measures are taken from four principal sources: D. G. Zhimerin, ed.,* Sovremennyye Problemy Energetiki. *(Moscow: Energoatomizdat, 1984); D. B. Vol'fberg ed.,* Effektivnoye Ispol'zovaniye Toplivno-Energeticheskikh Resursov. *(Moscow: Energoatomizdat, 1983); L. A. Melent'yev and A. A. Makarov, eds.,* Energeticheskii Kompleks SSSR *(Moscow: Ekonomika, 1983); and A. M. Nekrasov and A. A. Troitskiy,* Energetika SSSR v 1981-85 Godakh *(Moscow: Energoizdat, 1981).*

[redacted] 25X1

savings of 18 to 20 percent by 1990 (compared with 1985). The relative share of diesel trucks is rising rapidly.[81] There is room for improvement, since in 1984 less than 20 percent of Soviet trucks were diesel.[82]

- Surfacing dirt roads improves fuel mileage by 25 to 30 percent.[83] Between 1980 and 1985 hard-surfaced roads' share of total roads rose from 68 to 73 percent. Still, in 1985 there were about 415,000 kilometers of non-hard-surfaced roads in the USSR, virtually unchanged since 1980. Despite some progress, surfacing a large percentage of these roads will be slow. [redacted] 25X1

Conservation progress in transportation will continue to maintain a high profile because, in nearly every case, the conserved fuel is a light oil product. Conservation will probably be impeded somewhat for the

[81] W. Kelly and H. Shaffer, *Trends in Fuel Consumption Rates Among Trucks in the 1980s* (Battelle Columbus Laboratories: November 1983). [redacted] 25X1
[82] *Kommunist'* (No. 14, October 1984): p. 128. [redacted] 25X1
[83] Vol'fberg, op. cit., p. 68. [redacted] 25X1

reasons noted. Progress will probably result principally from the slow but steady increase in rail electrification and from the more rapid gains in truck dieselization. Perhaps some improvement in operations at all levels to maximize capacity use and minimize fuel losses will also contribute to conservation progress in the transport sector. 25X1

Trucks handle only about 6 percent of freight measured in ton-kilometers (tons times the distance hauled). Therefore, gains in dieselization, perhaps of 10 to 15 percent, will be largely offset by the limited potential in other areas where tightening of operations may yield improvements of some 5 percent. We project improvements of about 5 to 7 percent by 1995 for the transport sector as a whole. 25X1

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