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USSR: Single-Cell Protein Industry (U)

A Research Paper

IA 84-10027
March 1984

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Summary

Information available as of 1 January 1984 has been used in this report. (U)

The Soviet single-cell protein (SCP) industry represents a major effort to support livestock production by producing a protein-rich feed supplement for animals. We estimate that the Soviets had the capacity to produce about 1.8 million metric tons of SCP in 1983 and that this will increase to about 2 million metric tons by 1985.

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Actual Soviet SCP production is probably considerably less than capacity because the Soviets have encountered delays in bringing newly constructed plants into full operation. As a result, we believe that the Soviets will probably not reach their goal of 2.3 million metric tons of SCP production in 1985, and probably will only reach 2 million metric tons in the late 1980s. Based on Soviet claims, 2 million metric tons of SCP would replace as much as 10 million metric tons of grain, about 5 percent of Soviet annual grain production. (S

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Currently, the Soviets produce SCP from both cellulose- and petroleum-based feedstocks. We believe, however, that any major expansion of the Soviet SCP industry will probably involve construction of plants using methanol, produced from natural gas, as the feedstock. Reports from European technical journals indicate that the Soviets plan to produce about 4 million metric tons of methanol-based SCP by 2000. (C)

Contents

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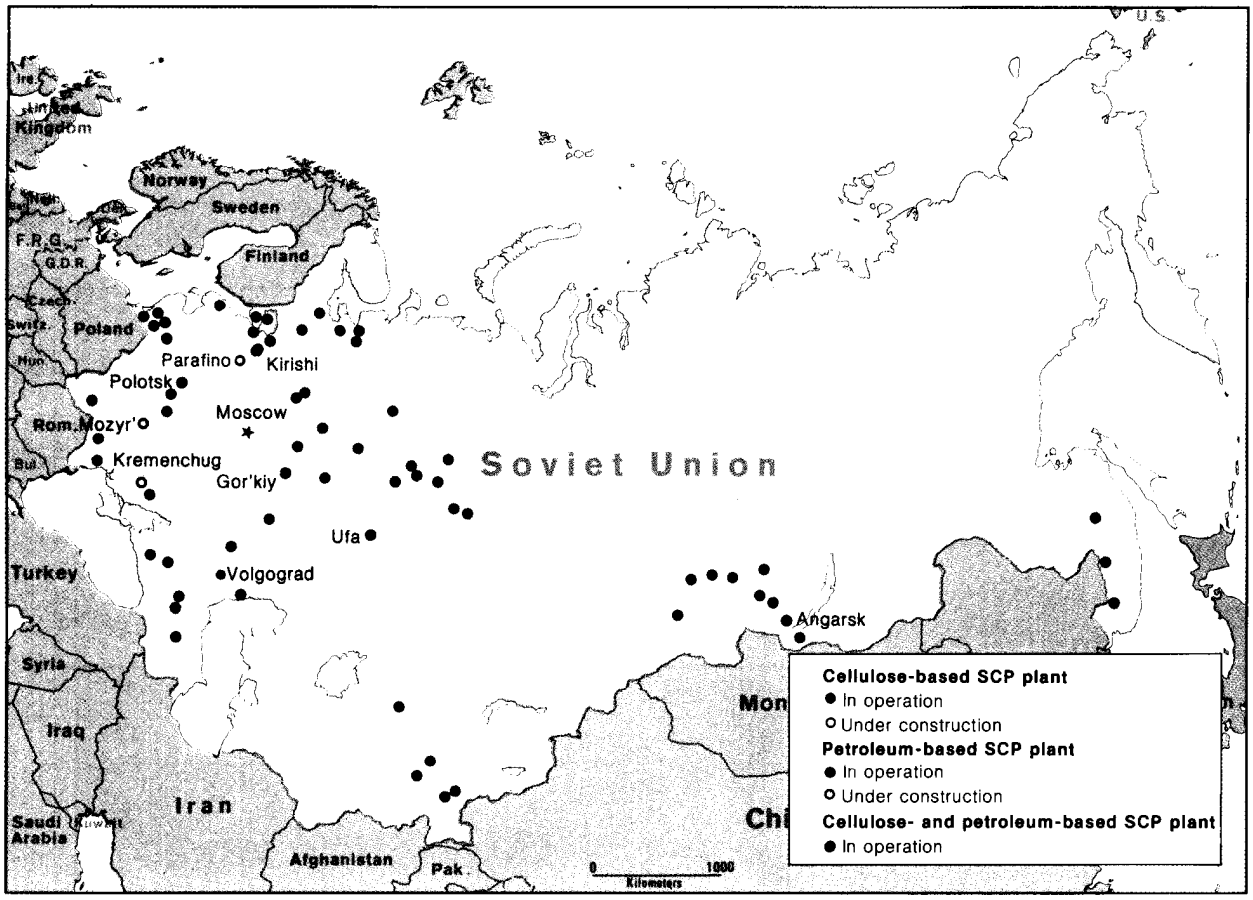
Figure 1

Location of Soviet Single-Cell Protein Plants



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USSR: Single-Cell Protein Industry (U)

Introduction

Single-cell protein (SCP) is a term used to describe single-cell microorganisms, such as yeast, that can be cultivated in commercial quantities and used as food or feed additives. SCP has traditionally been cultivated on cellulose-based growth media, such as agricultural wastes and byproducts of the wood processing industry. More recently, petroleum-based feedstock that is more easily obtained has provided growth media for SCP production. (U)

Self-sufficiency in protein feed supplies is an avowed aim of the Soviet leadership. Because the USSR cannot produce adequate quantities of high-protein oilseed meals and other high-protein crops needed for balanced livestock feed rations, the Soviet Union has established the world's largest SCP industry. In addition, the Soviets have attempted to alleviate recurring feed deficits with large-scale grain imports. The use of high-protein supplements increases the efficiency of Soviet feed rations and serves to reduce these grain import requirements. (C)

The Soviets began experimental production of cellulose-based SCP from hydrolyzed straw in 1936. A Soviet text book reports that by 1943 they had begun industrial production of SCP at two plants; they have continued to expand this cellulose-based portion of the industry since that time. In 1963 the All-Union Scientific Research Institute for Protein Synthesis began research on production of SCP from liquid paraffin obtained from crude oil. Experimental petroleum-based SCP production began at the Krasnodar Biochemical and Vitamin Preparation Combine in the late 1960s, and construction of six commercial-scale plants began in the early 1970s. The first of these petroleum-based plants began partial operation in 1975. (S

This report discusses Soviet SCP production processes and facilities and presents estimates of the Soviet capacity to produce SCP from both cellulose-and petroleum-based raw materials. It also provides an overview of prospects for the Soviet SCP industry and discusses implications of the Soviet SCP program for augmenting Soviet livestock feed supplies. (S

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Soviet Single-Cell Protein Production

We have identified 68 Soviet plants that produce SCP. There are 59 operating cellulose-based SCP plants, and one cellulose-based plant is under construction. In addition there are six operating petroleum-based SCP plants, and one petroleum-based plant is under construction. One additional operating plant produces both cellulose-based and petroleum-based SCP (figure 1). (S

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Soviet SCP plants are usually located near their sources of feedstocks. Many of the cellulose-based plants are in agricultural areas or are part of large paper or lumber mills. All Soviet petroleum-based SCP plants are located near petroleum refineries. (S

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Processes and facilities at cellulose-based plants differ from those at petroleum-based SCP plants. The cellulose-based plants have a smaller capacity and also produce wood-based byproducts, such as furfural and lignin, in addition to cellulose-based SCP (sometimes referred to as fodder yeast by the Soviets). The more modern petroleum-based plants use a standardized process whose only product is SCP. SCP cultivated on petroleum feedstock is sometimes called protein-vitamin concentrate (BVK—byelokovo-vitaminyy kontsentrat) by the Soviets. (S

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Cellulose-Based SCP

Process Flow. The production process for cellulose-based SCP begins with hydrolysis of either a solid feedstock, such as wood waste or corn cobs, or a liquid feedstock, such as waste liquor from the pulp and paper industry (figure 2). The feedstock is combined with dilute sulfuric acid and heated in a hydrolysis tank. When waste liquors are the feedstock steam hydrolysis is used, probably to remove sulfur dioxide. The hydrolysis step produces simpler carbohydrates that are more readily digested by the SCP organisms. After neutralization and purification the carbohydrates, along with air and mineral salts, are sent to a fermentation vessel where they are innoculated with yeast. Following fermentation the SCP is purified, dried, and bagged for shipment. (U)

A Soviet text on production of SCP states that feedstock equivalent to a metric ton of dry coniferous wood will yield about 230 kilograms of SCP. At some plants the carbohydrates are fermented to produce ethyl alcohol and the remaining mash is then used to grow the SCP. According to the Soviet text, this reduces the yield to 32 kilograms per metric ton of wood equivalent. (U)

Capacity Estimate. The methodology used to estimate Soviet cellulose-based SCP production capacity was developed by the Analytical Support Group, Directorate of Intelligence, CIA.[1] This methodology is based on imagery and data from Soviet open-source literature and human sources. (S [redacted]

We identified a distinctive piece of processing equipment, a large open-topped tank, at all but one of the 60 plants that produce cellulose-based SCP (figure 3). Although we could not determine the function of these tanks, the number of tanks at each plant appears to be proportional to the overall size of the plant. (S [redacted]

For 15 of the plants, production capacity data are available from either open-source literature or human-source reporting. These data and the number of open-topped tanks at each plant provide a basis for a regression analysis to estimate total production capacity for the cellulose-based plants (figure 4). (See Appendix A for the number of tanks and reported capacity at each plant.) (S [redacted] 25X1
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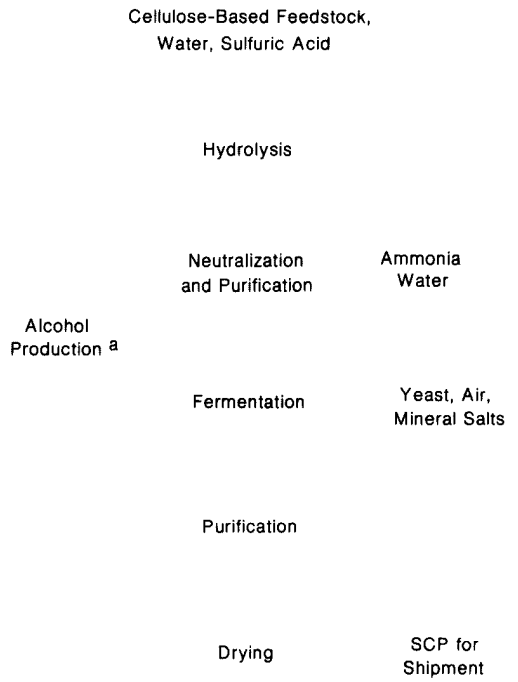
The data used in the regression estimate were first screened for reliability and then weighted based on the year of the report, the reliability of the source, and a comparison of the reported capacity to the size of production facilities [redacted] In 25X1

Figure 2

Process Flow for Cellulose-Based SCP Production



[a]An optional step found at some cellulose-based SCP plants.

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addition, the plants were classified into two groups based on the availability of feedstock. The first group consists of plants with year-round access to feed materials and the second group consists of plants with seasonal access to feed materials. Our judgement of the availability of feedstock is based on the geographic location of each plant, its proximity to sources of feed materials, and the size of feed-material stockpiles. (S

Based on the regression analysis, we estimate the annual production capacity of the 59 SCP plants with open-topped tanks was about 915,000 metric tons in 1983.[2] The one additional operating Soviet plant, at Kirishi, has no open-topped tanks, but based on the size of its facilities compared to other cellulose-based SCP plants, we estimate that it has a capacity of about 25,000 metric tons per year.[3] Therefore, we estimate total Soviet cellulose-based SCP production capacity in 1983 was about 940,000 metric tons. (S

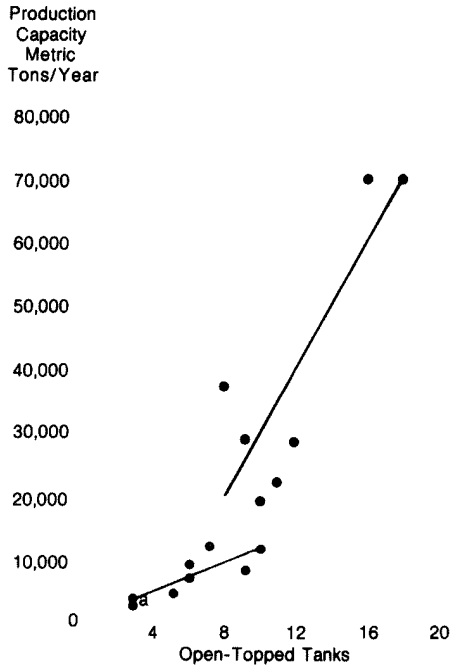
We were unable to differentiate between those cellulose-based plants that produce SCP as a primary product and those which produce alcohol as a primary product and SCP as a byproduct. Nevertheless, we believe the plants for which we have capacity figures are sufficiently representative of the entire group that our estimate of overall capacity is valid. Although the inclusion of information about alcohol production in the regression analysis might have reduced the confidence interval width, there is no statistical indication that this would have substantially changed our estimate of production capacity. We believe the availability of the feedstock is the only significant variable, aside from the number of tanks, in the regression equation. (S NF

[2]The 90-percent confidence interval for cellulose-based SCP production is 754,000 to 1,076,000 metric tons. This excludes the capacity of the Kirishi plant. (S

[3]We do not know why Kirishi does not have visible open-topped tanks. The tanks may be inside buildings or concealed by other equipment at the facility. (S

Figure 4

Correlation of the Number of Open-Topped Tanks to Production Capacity at Soviet Cellulose-Based SCP Plants



- Reported capacity for plant with seasonal access to feedstocks.
- Reported capacity for plant with year-round access to feedstocks.

[a] We have assumed that the production reported for the Leningrad plant, 18,000 tons a year, was garbled and that it was actually 1,800 tons a year.

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Petroleum-Based SCP

Process Flow. The petroleum-based SCP process at Soviet plants uses normal paraffins (n-paraffins), obtained from crude oil during the petroleum refining process, as the growth media. Nutrient salts are mixed with n-paraffins to form a substrate. The substrate is then innoculated with yeast of the Candida genus and fermented. The yeast produced is

killed, purified, concentrated, and dried before being packaged for shipment (figure 5). Most of the process steps are concealed from view inside buildings, but the fermentation tanks and dryers are large, readily identifiable pieces of equipment that are constructed as separate structures. (S

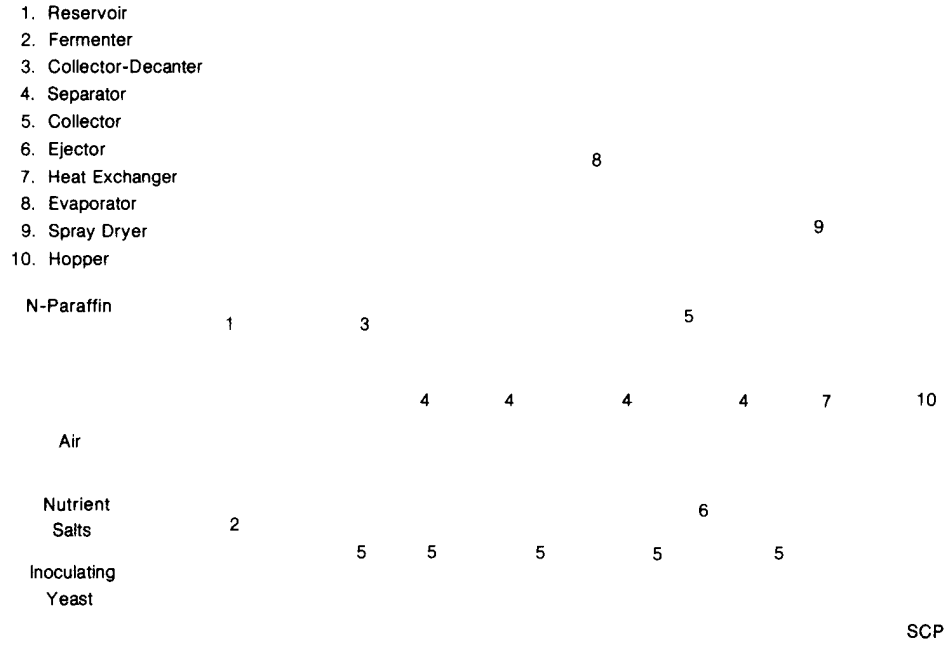
Purification is a critical step in processing SCP because paraffins contain some benzopyrene, a carcinogenic hydrocarbon. Any benzopyrene in a feed additive is dangerous because it may be passed on to humans through the meat of the animals. (C

Capacity Estimate. The methodology used to estimate the capacity of the eight Soviet petroleum-based SCP plants is based on imagery analysis and reports of plant capacities in Soviet open-source literature. From imagery we can identify the plants and count the number of fermentation tanks at each (figure 6). (S 25X1

Comparison of the number of these tanks at each plant with the plant's reported capacity indicates that each tank has a production capacity of 10,000 metric tons of SCP per year. At Gor'kiy the number of tanks multiplied by 10,000 tons per year equals the reported capacity. The layouts of the Angarsk and Kremenchug plants strongly suggest that, when complete, the number of tanks multiplied by 10,000 tons will equate to their reported capacity. The capacities indicated by the numbers of tanks observed at Polotsk, Ufa and Volgograd differ slightly from the reported capacities for these plants, probably because the Soviets are expanding these three plants beyond their reported original design capacity. No precise capacity figure for Kirishi has been reported 25X1 25X1 25X1

Figure 5

Process Flow for Petroleum-Based SCP Production



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by the Soviets. Construction at Mozyr has not progressed sufficiently to determine the number of tanks planned. (See Appendix B for the number of tanks and reported capacity of each plant.) (S

The seven Soviet petroleum-based SCP plants we believe to be in operation had a total of 82 complete fermentation tanks in 1983. Based on this number we estimate Soviet petroleum-based SCP capacity at the end of 1983 was 820,000 metric tons per year. (S

Prospects for the Soviet SCP Industry

We estimate that the Soviets had a total SCP production capacity of about 1,760,000 metric tons in 1983. Between 1983 and 1985, we believe that all production capacity increases in the industry will result from completion of fermentation tanks now under construction at petroleum-based SCP plants. (S

From imagery, there is no evidence that Soviet cellulose-based SCP production capacity will be expanded by 1985. The single cellulose-based plant known to be under construction, at Parafino, is reported by a Soviet engineer to have a annual capacity of 70,000 metric tons. In August 1983 this plant was still in the midstage of construction; it will most likely not be completed by 1985. Therefore, we estimate Soviet cellulose-based SCP production capacity in 1985 will be about 940,000 metric tons, the same as in 1983. (S

Soviet petroleum-based SCP capacity will continue to increase in 1984 and 1985. The eight Soviet petroleum-based SCP plants had 21 fermentation tanks under construction in 1983. Analysis of previous tank construction rates indicates that all the unfinished tanks could be complete by the end of 1985. If this occurs, Soviet petroleum-based SCP production capacity will be about 1,030,000 metric tons in 1985. (S

Soviet plans call for production of 2.3 million tons of SCP in 1985, but it is unlikely that the Soviets will reach this goal. We believe Soviet production capacity for both cellulose-based and petroleum-based SCP will be only about 1,970,000 metric tons by the end of 1985, and we doubt they will be able to operate their SCP plants at design capacity because of delays in bringing plants into full operation. Based on open-source reports, the petroleum-based plants have taken a minimum of seven years to reach full-scale production following construction, and at least one, Ufa, had not done so after 11 years of construction. The Gorkiy plant, which began production in 1975 and had all its production equipment in operation in 1976, was first reported to have reached design capacity in 1982. Some of this delay may have resulted from technical problems with the original air supply system for the fermentation tanks. The Soviets were apparently unable to resolve the problems in the original system and, by 1976, began replacing it with an entirely new system. (S

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Implications of the Soviet SCP Program

Although the Soviets are unlikely to reach their goal of producing 2.3 million tons of SCP in 1985, the industry's contribution to the Soviet livestock feed program continues to grow and annual Soviet SCP production could reach 2 million tons by the late 1980s. Such a quantity of SCP would replace up to 10 million tons of grain, based on the Soviet claim that each ton of SCP replaces 5 tons of grain. This would equal about 5 percent of Soviet average annual grain production. (S

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The Soviets are likely to continue their modest expansion of cellulose-based SCP facilities and complete the petroleum-based facilities now under construction. Additional supplies of cellulose raw material are not sufficiently concentrated to encourage widespread expansion of cellulose-based plants.

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In addition, the problems associated with the petroleum-based process may discourage construction of additional petroleum-based plants. We believe it is likely that any major expansion of Soviet SCP production will involve construction of plants using a new process, based on methanol produced from natural gas. Existing petroleum-based plants could also be converted to produce methanol-based SCP. (S

Expanding Soviet production of natural gas makes methanol-based SCP an attractive alternative for the Soviet Union. A European technical journal reported the Soviets plan to use 600,000 metric tons of methanol per year as an SCP feedstock by 1990 and 6 million metric tons by 2000. Based on feedstock-to-output ratios for a Western methanol-based SCP plant, this would equate to a methanol-based SCP production of about 400,000 metric tons in 1990 and about 4 million metric tons in 2000. Although we doubt the Soviets will be able to meet the goals, the large increases in SCP capacity planned indicate continuing Soviet belief in the utility of SCP to supplement grain production (figure 7). (S

Soviet licensing of methanol-based processing technology or purchase of turnkey plants would be a key indicator of their intentions to develop methanol-based SCP production. The Soviets could also choose to use domestic technology and equipment. In this case imagery would likely provide the initial indications of a Soviet program to develop methanol-based SCP. (S

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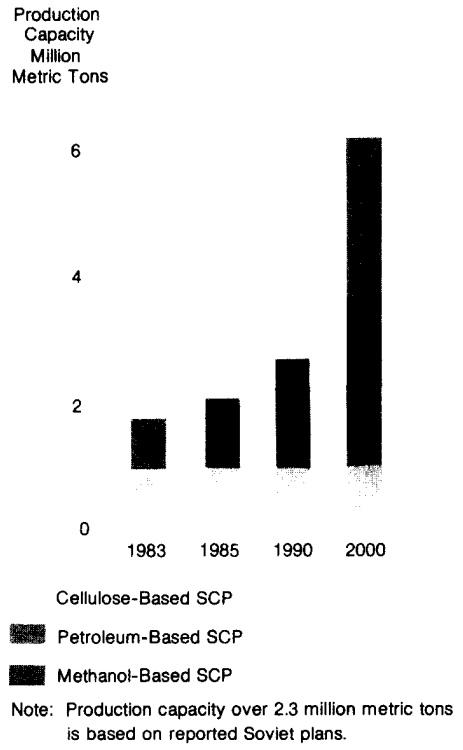
Figure 7

Soviet SCP Production Capacity



Note: Production capacity over 2.3 million metric tons is based on reported Soviet plans.

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Appendix A

Soviet Cellulose-Based SCP Plants

Name (Alternate Names) Geographic Coordinates	Growth Media	Availability	Open-Topped Tanks	Reported Capacity[a]
Akhmeta Cellulose SCP Plant 420315N 0451208E	Unknown	Seasonal	3	2,000
Amursk Cellulose and Cardboard Combine 501407N 1365112E	Probably sulfite liquor	Year-round	10	20,000
Andizhan Cellulose SCP Plant 404602N 0722059E	Probably cotton plant waste	Seasonal	5	
Arkhangel'slk Cellulose SCP Plant Povrakul'skiy 643850N 0403300E	Wood waste	Year-round	6	
Archangelsk Cellulose and Paper Plant 642530N 0404900E	Wood waste	Year-round	6	
Astrakhan Cellulose SCP Plant 462527N 0475832E	Probably sulfite liquor	Year-round	7	
Balakhna Cellulose and Paper Combine Pravdinsk (Balakinsk) 563154N 0433355E	Sulfite liquor	Year-round	3	
Baykalsk Paper and Cellulose Plant 513110N 1041210E	Probably sulfite liquor	Year-round	8	

Soviet Cellulose-Based SCP Plants (continued)

Name (Alternate Names) Geographic Coordinates	Growth Media	Availability	Open-Topped Tanks	Reported Capacity[a]
Beltsy Cellulose SCP Plant 474512N 0275335E	Corncobs and sunflower seed hulls	Seasonal	6	10,000
Bendery Cellulose SCP Plant 464756N 0292926E	Unidentified waste vegetation	Seasonal	9	
Biryusinsk Cellulose SCP Plant 555800N 0974912E	Wood waste	Year-round	9	
Bobruysk Alcohol and Wood Plant 530940N 0291320E	Wood waste and peat	Year-round	8	
Bratsk Lumber, Cellulose, and Paper Complex 560716N 1013605E	Sulfite liquor	Year-round	16	
Chernogorsk Cellulose SCP Plant (Khakasskiy) 534835N 0912405E	Wood waste	Year-round	9	
Chimkent Hydrolysis Plant 421721N 0693650E	Unknown	Seasonal	6	
Fergana Chemical Plant 402212N 0714821E	Probably cotton plant waste	Seasonal	6	7,000
Georgiyevsk Cellulose SCP Plant 440930N 0432835E	Unknown	Seasonal	5	

(Continued)

Name (Alternate Names) Geographic Coordinates	Growth Media	Availability	Open-Topped Tanks	Reported Capacity[a]
Gubakha Cellulose SCP Plant 585058N 0574658E	Wood waste	Year-round	3	
Ivano Frankovsk Food Processing Plant 3 485612N 0244239E	Unknown	Seasonal	5	
Kaliningrad Cellulose and Paper Combine 2 544209N 0202632E	Probably sulfite liquor	Year-round	3	
Kansk Hydrolysis Plant 561137N 0954402E	Probably wood waste	Seasonal	5	
Kedainiai Chemical Plant 551618N 0240059E	Wood waste	Seasonal	7	12,000
Khor Hydrolysis Plant (Khorsk) 475228N 1345658E	Wood waste	Year-round	8	38,000
Kirishi SCP Plant[b] 592935N 0320100E	Wood waste	Year-round	0	
Kirov SCP Plant (Kirovsk) 583650N 0493550E	Wood waste	Year-round	18	70,000
Klaipeda Cellulose and Paper Combine 554143N 0210815E	Sulfite liquor	Seasonal	3	

Soviet Cellulose-Based SCP Plants (continued)

Name (Alternate Names) Geographic Coordinates	Growth Media	Availability	Open-Topped Tanks	Reported Capacity[a]
Kondopoga Cellulose and Paper Combine (Kondopozhsk) 621115N 0341635E	Probably sulfite liquor	Seasonal	3	
Krasnodar Biochemical and Vitamin Combine 450135N 0390055E	Reportedly rice hulls	Seasonal	5	
Krasnokamsk Cellulose and Paper Plant 580419N 0554620E	Probably sulfite liquor	Year-round	4	
Krasnoyarsk Hydrolysis Plant 560200N 0930220E	Bisulfite liquor	Year-round	5	
Kropotkin Chemical Plant 452546N 0403536E	Reportedly corn cobs, rice husks, and sunflower stalks	Seasonal	8	
Kzyl-Orda Cellulose SCP Plant 445201N 0652658E	Possibly sulfite liquor	Year-round	3	
Leningrad SCP Plant 595345N 0301455E	Wood waste	Seasonal	3	27,000[c]
Lesozavodsk Cellulose SCP Plant 452820N 1332300E	Wood waste	Year-round	9	28,000
Lobva Cellulose SCP Plant 591058N 0603225E	Wood waste	Seasonal	6	
Manturovo Cellulose SCP Plant 581802N 0444545E	Wood waste	Year-round	16	70,000

(Continued)

Name (Alternate Names) Geographic Coordinates	Growth Media	Availability	Open-Topped Tanks	Reported Capacity[a]
Nartkala Cellulose SCP and Chemical Plant 433323N 0435048E	Unknown	Seasonal	4	
Neman Cellulose SCP Plant 550235N 0220155E	Probably sulfite liquor	Year-round	3	
Onega Cellulose SCP Plant (Onezhsk) 635538N 0380435E	Wood waste	Year-round	5	
Parfino SCP Plant Under Construction 575900N 0313925E	Unknown			70,000
Pershino Cellulose SCP Plant (Ivdel) 603941N 0603117E	Wood waste	Seasonal	5	4,821
Priozersk Cellulose SCP Plant 610258N 0300940E	Probably wood waste	Seasonal	4	
Rechitsa Cellulose SCP Plant 522110N 0302655E	Wood waste	Seasonal	8	
Saratov Chemical Combine 513010N 0455835E	Wood waste	Year-round	5	
Segezha Cellulose and Wood Combine 634410N 0341940E	Wood waste or sulfite liquor	Seasonal	5	

Soviet Cellulose-Based SCP Plants (continued)

Name (Alternate Names) Geographic Coordinates	Growth Media	Availability	Open-Topped Tanks	Reported Capacity[a]
Sokol Cellulose Combine Kuybyshev 592712N 0400936E	Wood waste or sulfite liquor	Seasonal	3	
Sokol Cellulose and Paper Combine Sverdlov[d] 592832N 0400334E	Sulfite liquor	Seasonal	2	
Solikamsk Cellulose and Paper Combine 591446N 0564002E	Sulfite liquor	Year-round	8	
Sovetsk Cellulose SCP Plant 550530N 0215340E	Wood waste or sulfite liquor	Year-round	3	
Syas'stroy Cellulose Combine 600745N 0323345E	Probably sulfite liquor	Year-round	3	
Syktyvkar Cellulose SCP Plant Sloboda 614935N 0504350E	Wood waste	Year-round	12	28,000
Tallinn Cellulose Paper Combine Kingisepp 592533N 0244705E	Reportedly sulfite liquor	Year-round	4	
Tavda Wood Chemistry Plant 580425N 0651442E	Wood waste	Seasonal	9	
Tulun Alcohol Plant 543227N 1003542E	Wood waste	Seasonal	8	

(Continued)

Name (Alternate Names) Geographic Coordinates	Growth Media	Availability	Open-Topped Tanks	Reported Capacity[a]
Turinsk Cellulose Plant 580147N 0634315E	Wood waste or sulfite liquor	Seasonal	3	
Volgograd Hydrolysis Plant 484015N 0442752E	Unidentified waste vegetation	Seasonal	13	
Volzhsk Paper Plant 555057N 0482256E	Wood waste	Year-round	11	21,000
Vyborg Cellulose and Paper Plant Sovetskiy 603243N 0284045E	Probably sulfite liquor	Year-round	1	
Yangiyul' Biochemical Plant 410615N 0690310E	Ambari-hemp tow, cotton-plant waste, rice hulls, wood waste	Seasonal	9	7,000
Zaporozhye Cellulose SCP Plant 474925N 0351302E	Wood waste	Seasonal	10	11,000
Zima Cellulose SCP Plant 535540N 1020439E	Wood waste	Year-round	8	

[a] Capacities are given in metric tons per year.
[b] This plant also produces SCP from petroleum.
[c] This figure is probably incorrect. The more likely capacity of this plant is about 1,800 to 3,000 metric tons.
[d] One of the Sokol plants is also known as Sukhona.

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Appendix B

Soviet Petroleum-Based SCP Plants

Name (Alternate Names) Geographic Coordinates	Fermentation Tanks		Capacity[a]		Remarks
	Complete	Under Construction	1983	1985	
Total	**82**	**21**	**820,000**	**1,030,000**	
Angarsk SCP Plant 522910N 1035830E	11	1	110,000	120,000	Design capacity of 120,000 tons reported in 1970.
Gor'kiy SCP Plant (Kstovo, Novogorskiy) 560635N 0440700E	7	0	70,000	70,000	Design capacity of 70,000 tons reported in 1974.
Kirishi SCP Plant 592935N 0320100E	9	0	90,000	90,000	This plant also produces SCP from wood waste.
Kremenchug SCP Plant 491055N 0332855E	8	2	80,000	100,000	Design capacity of 120,000 tons reported in 1980.
Mozyr SCP Plant 515434N 0291731E	0	5	0	50,000	Design capacity of 300,000 tons reported in 1978.
Polotsk SCP Plant (Novopolotsk) 553300N 0283400E	12	1	120,000	130,000	Design capacity of 120,000 tons reported in 1981.

Soviet Petroleum-Based SCP Plants (continued)

Name (Alternate Names) Geographic Coordinates	Fermentation Tanks		Capacity[a]		Remarks
	Complete	Under Construction	1983	1985	
Ufa SCP Plant (Baskhir, Novoufimskiy) 550210N 0560120E	15	6	150,000	210,000	Design capacity of 180,000 tons reported in 1975.
Volograd SCP Plant (Svetloyarsk) 432810N 0444435E	20	6	200,000	260,000	Design capacity of 240,000 reported in 1975.

[a]All capacities are given in metric tons per year. Figures given are for the capacity of equipment installed. All this equipment may not be in operation. Detailed information on the construction chronologies for these plants is available on request.

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