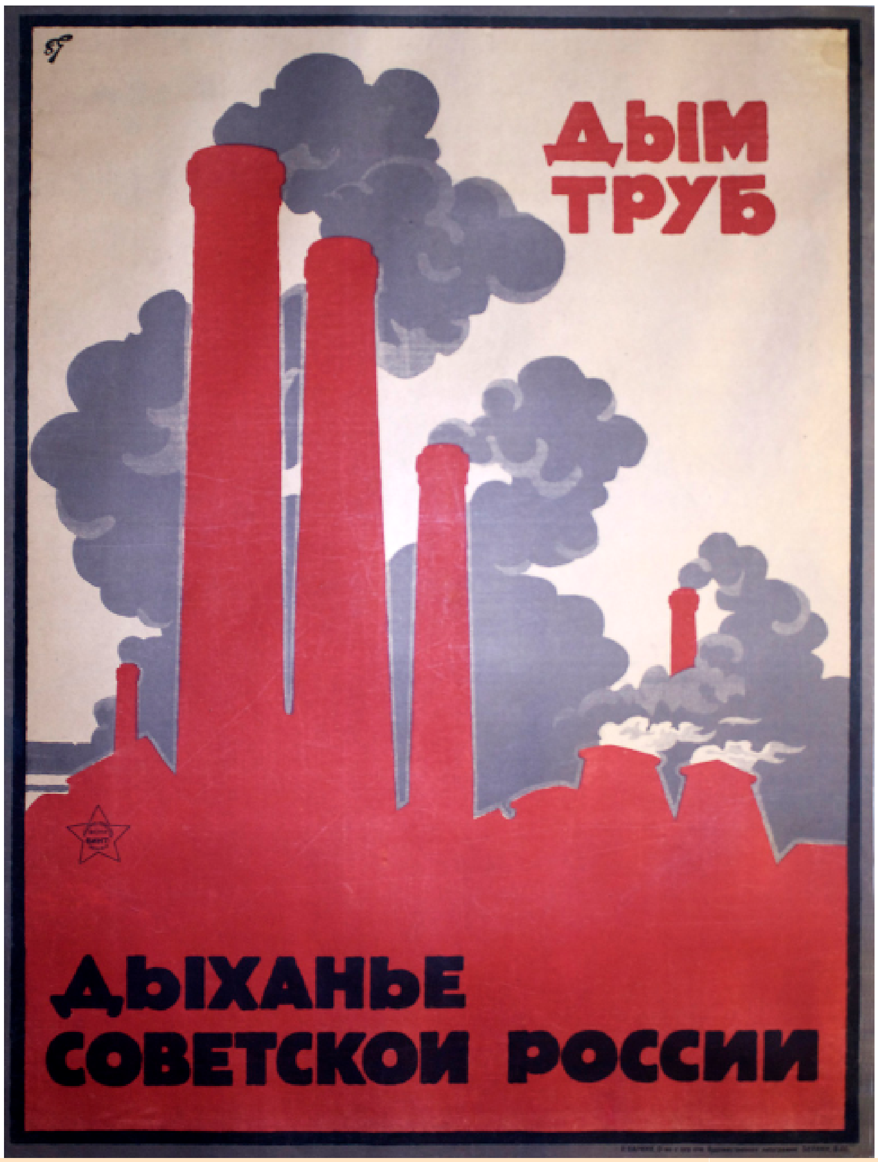
A CLASSIC EUROPA Guidebook

Powering the Red Army: Soviet Oil, Coal, and Peat in World War II

☭ Oil ☭ Coal ☭ Peat ☭ Natural Gas ☭ Oil Shale ☭ Wood Gas ☭
☭ Synthetic Oil ☭ Hydrogen ☭ Firewood ☭ Human and Animal Power ☭



Smoke Chimneys — Breath of Soviet Russia (Soviet Poster, 1927)

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1 About this Guidebook

This guidebook covers Soviet energy, fuel, and power up through the end of World War II. It briefly covers the origins of the energy industry in the Russian Empire and the brief Russian Republic of 1917, the predecessor states to the Soviet Union.

Several strands led me to research Soviet energy. I do frequent research for *Classic Europa* on topics related to the USSR in the World War II era. My work on Soviet trucks and tractors of the 1930s keep showing the Soviets had a growing shortage of vehicular gasoline in the second half of the 1930s. Further research revealed late 1930s shortages of aviation gasoline for the advanced military aircraft of this time period and of diesel fuel once the Soviets switched to diesel engines for the medium and heavy tanks in the late 1930s. Did these systemic shortages occur during the Great Patriotic War, the Soviet name for their war with Germany in 1941–1945?

The great majority of English-language accounts of the war rarely if ever mention the Soviet military having fuel shortages. What little I saw mostly implied that such shortages were situational and temporary, such as when Soviet offensive advanced faster than the fuel supply services could bring fuel forward. Instead, English-language accounts mainly talk about every-growing hordes of Soviet tanks, other vehicles, and aircraft grinding down the Germans in a long war of attrition, ending victoriously with an advance into Germany and the capture of Berlin.

Russian-language sources reveal a different picture. The Soviet military had fuel shortages almost from the start of the war in 1941. The situation improved in 1942, but the Soviet oil industry was never able to make enough aviation gasoline for its military aircraft. Instead, the substantial Allied aid from the United States and Britain provided about half the aviation gasoline used by the Soviet military in war. Aviation gasoline aid started in the summer of 1941 and did not end until after World War II ended.

Russian-language sources also revealed significant energy shortages in coal following the German capture of the Donets Coal Basin in October 1941. From here, I went on to research all aspects of Soviet energy, fuel, and power that I could find. My work on “power” not only includes Soviet electricity, a fascinating story in itself, but also on the Soviet use of human and animal power.

This guidebook accordingly covers a lot of topics. As always with research on the Soviets, especially for the period of Stalin’s tenure from 1928–1953, there are things that remain uncertain. I try hard to avoid stating as fact what is is inference or deduction from the known facts, and I use words like “may” or “might” to indicate things that seem likely but remain uncertain. I find it unavoidable to speculate on some issues that are unknown, but I again try hard to label anything on these line as my speculation or analysis.

My guidebooks are not scholarly works and as such usually have few citations (footnotes). However, I found so much about Soviet energy that is not readily in available in English and ended up footnoting items far more than usual, although still not at scholarly level. Perhaps to emphasize this, I use my own scheme for citations rather than following an academic model.

This guidebook concentrates on Soviet energy. It briefing covers other Soviet topics as necessary. If you want a greater understanding of the USSR in general, please see *The Soviet State, 1917–1941: An Overview*, the Classic Europa guidebook on the Soviet state and its Communist Party.

Finally, this work is in a draft state, and some parts need an edit to make them less wordy, particularly the human and animal power section.

— John M. Astell, 9 January 2022

2 Terms and Conventions in this Guidebook

This introduction briefly conventions used in this guidebook. You can skip it without missing anything important if you are not interested such matters.

2.A Russian

The Soviet Union, with well over 100 ethnic groups and languages, did not have an official language. However, Russians were by far the biggest ethnic group, and the Russian language was used as the first-among-equals *lingua franca* of the country. Since written Russian uses a different alphabet than English — Cyrillic (technically, the Russian alphabet of the Cyrillic script) — when necessary Russian words are transliterated into English (technically, using the English alphabet of the Latin script). Since this guidebook concentrates on the World War II Soviets, I use a transliteration scheme based on those commonly used in that historical period.

Where possible I translate common words, to avoid needless and possibly confusing transliteration. For examples, the Soviet Union was officially named *Союз Советских Социалистических Республик*, which transliterates to *Soyuz Sovetskikh Sotsialisticheskikh Respublik*. However, all four of these words have common English equivalents, the Union of Soviet Socialist Republics. When transliterating or translating, I change the word order from Russian when necessary and add articles and prepositions to make it more understandable in English. For example, "*Severnye Lagerya Osobogo Naznacheniya*" becomes "the Northern Special Purpose Camps" rather than "the Northern Camps of Special Purpose", which preserves word order but sound stilted in English.

You're not so lucky on place names, however. I (like in *Classic Europa*) use the actual names of cities as spelled by their owning power, transliterated if not in the Latin script. Thus, it's Moskva (*Москва*), not Moscow (common name in English), *Moscou* (French), *Moskau* (German), *Mosca* (Italian), or *Moskwa* (Polish), for some examples. Similarly, it's Kiev (from *Киев*, the Russian word), which is was the Soviets used, even though today the city, the capital of Ukraine, is more often rendered as Kyiv (from *Київ*, the Ukrainian word). Finally, some cities were renamed over time. I use the name actually in use for the time period being covered in the text. For example, it's Sankt-Peterburg (often badly rendered as "St. Petersburg" in many English works) up to 1914, then Petrograd in 1914–1917 ("Peter's City", as "Sankt-Peterburg" was too Germanic for the Russians once World War I started), then Leningrad in 1924–1991 ("Lenin's City", named for the Bolshevik leader V.I. Lenin after his death in 1924), and finally from 1991 Sankt-Peterburg again. Perhaps the city will someday be renamed again, although I hope not Putingrad (Vladimir Putin was born in Leningrad in 1952). Sankt-Peterburg is an extreme example, but there were many cities renamed in the Soviet period, of which some later reverted to their old names. (Nizhniy Novgorod, for example, was Gorkiy in 1932–1990, while Perm was Molotov in 1940–1957.) Where necessary to provide context, I mention the city current name in parentheses when using its earlier name.

You're back in luck with country names. I possibly might prefer the name of the country as used by the country itself, but I follow the *Classic Europa* scheme of using the common English names for countries. While *Italia* (Italy) is easy and *Deutschland* (Germany) shouldn't be too hard for most people, then there's things like *Shqipëri* (Albania). The full range of all of them from *España* (Spain) to *Suomi* (Finland) to *Nippon* (Japan) and so on is just too much overload for most English speakers accustomed to the common English names.

For names of persons, I usually transliterate the name. *Михаил Николаевич Тухачевский* is Mikhail Nikolaevich Tukhachevskiy, a Marshal of the Soviet Union who was arrested, tortured into giving a false confession of treason, and executed in 1937 during Stalin's purges. Tukhachevskiy sometimes in other works is transliterated as Tukhachevsky or Tukhachevski, but I transliterate all the letters[1]. I do not substitute common English personal names for personal ones, so it is *Mikhail* (not Michael); the last Tsar and Tsarina of Russia were *Nikolay* and *Aleksandra* (not Nicholas and Alexandra).

During the eras of the Russian Empire and Soviet Union, personal names were commonly abbreviated in print, so that Mikhail Nikolaevich Tukhachevskiy would often be rendered to as M.N. Tukhachevskiy, not Mikhail Tukhachevskiy or M. Tukhachevskiy. I follow this convention unless confusion might occur or if another convention was commonly used. For example, Lenin and Trotskiy, top Soviet leaders, were often called Vladimir Lenin and Lev Trotskiy (often turned into the inane "Leon Trotsky" in English) rather than V.I. Lenin and L.D. Trotskiy.

I used the translated names of Russian and Soviet entities but their transliterated (not translated) abbreviations. Thus the People's Commissariat of Internal Affairs (***N****arodnyy* ***K****omissariat* ***V****nutrennikh* ***D****el*) is abbreviated NKVD, not PCIA.

1 I do omit the soft sign and hard sign, which are not letters and make the transliterated words less readable for almost everyone not accustomed to Russian. I also transliterate the Russian "*е*"always to "e" although sometimes it is pronounced "ye" based on context.

2.B Dates

I use the Gregorian or "New Style" calendar for all dates, even for the Russian Empire with used the Julian or "Old Style" calendar. The Julian calendar did not track the year as accurately as the Gregorian and so by 1917 was 12–13 days ahead of the Gregorian, which was in widespread use in many parts of Europe and the Americas. The Bolsheviks adopted the Gregorian calendar in January 1918[2]. If a Julian date is important, I mention it in parentheses after the Gregorian date.

The difference in calendars is really only evident in the names of the 1917 revolutions. The first revolution that toppled the Tsar started in March 1917, but this was late February in the Julian calendar and thus was commonly called the February Revolution. The same thing happened again in November 1917, when the Bolsheviks took over. Their revolution started in late October in the Julian calendar and thus was commonly called the October Revolution (the "Great October Socialist Revolution" to the Bolsheviks). Since the Soviets liked to name things after the revolution, "October Revolution" will crop up here and there. Just keep in mind it's the November 1917 revolution.

2.C Numbers and Measures

I use both US customary units (miles-pounds-Fahrenheit, etc.) and metric units (km-kg-Celsius, etc.), such as "20 miles (40 km)". In a paragraph that repeatedly uses a unit, like thousands of kilometers, I only give the conversion the first time, as subsequent mentions can be easily approximated from the first mention.

I scale or approximate numbers as appropriate. For example, while 1,000 kilometers is about 621.37 miles, this is overly precise while "about 620 miles" conveys the right since. Sometimes, just "about 600 miles" is better, in instances where "1,000 km" is clearly meant to be approximate.

I usually often round off or approximate production numbers for things like tanks, artillery pieces, and aircraft. The exact production number of an item is sometimes not known or in dispute. Even when it is not, stating that 714 Model X tanks were produced can mislead more than illuminate. For example, the 714 figure might include prototypes that were not sent to the field forces, or production vehicles that were diverted for use as experimental vehicles, or so on. Also, of the tanks actually delivered to the Red Army, a number of them

2 The anti-religion Soviets called the calendar the "Western European" calendar, rather than the "Gregorian" calendar, since the Gregorian name refers to Roman Catholic Pope Gregorius ("Gregory") XIII.

were rejected as defective and then scrapped or broken up for parts or returned to the factories to be fixed. All told, “about 710 Model X tanks were produced” or even “about 700” conveys proper meaning without descending into the spiral of exactly, precisely how many.

For another example, it is widely quoted that the USSR made 119,769 tanks and (armored) self-propelled guns in World War II. However, the 119,769 figure includes production only through the end of June 1945. While the war in Europe did end in May 1945, the was in the Pacific was still continuing. The USSR entered that war against Japan in August and conducted military operations into September 1945. Thus, Soviet WW2 production figures really should include production through the end of August or September. On the other hand, the 119,769 figure includes all of 1939’s production, even though WW2 did not start until early September 1939. So, the 119,769 figure might be precise (119,769 made from 1 January 1939 through 30 June 1945, although even this precision is questionable) but it is in no way exactly the Soviets’f actual WW2 production. Thus I prefer “about 120,000 tanks and SPGs” as conveying the scale of Soviet WW2 production.

2.D Other

I use a mix of American, British, and other style conventions for this guidebook. You probably won’t notice most, except maybe the fact that I don’t tuck punctuation inside quotes unless the actual quotation contains that punctuation.

Notes on Terminology

Soviet

"All Power to Soviets"

A *sovet* or **soviet** was a council. However, radical soviets controlled by socialists arose in 1917 in opposition to the official Provisional Government. The Bolsheviks (see next entry) came to dominate many of these councils. Their slogan "all power to the Soviets" was meant to undermine the government in favor of the Bolshevik-dominated soviets. The Bolsheviks retained this association of soviets with themselves, even after their revolution to seize power and their victory in the ensuing Russian Civil War. They always kept "Soviet" in the names of their states (see the Russian SFSR and USSR entries below) and thus became known as the Soviets.

In general, Soviet governments were organized as a hierarchy of soviets (councils), roughly from local level to regional level to union-republic level (such as the Belorussian SSR) to all-union level (the entire USSR). Enfranchised citizens in theory elected representatives to the local soviets, and each level of soviets in turn elected representatives to the next higher level. While the system seemed democratic, the Soviets in reality quickly subverted this system so that it functioned only how they wanted it to, which was with them in complete control.

The Bolsheviks Bolshevik Party Communist Party The Party The Communists The Soviets Old Bolsheviks	 Lenin speaking in Petrograd, 1917 **The Bolsheviks** derived from a faction in the Russian Social Democratic Workers Party. This party was riven by factions, two of which were the Bolsheviks and Mensheviks, firm opponents of one another. The party split in 1912 into the Russian Social Democratic Workers Party (Menshevik) and the **Russian Social Democratic Workers Party (Bolshevik)**, informally called the Bolshevik Party. They seized power in Russia in November 1917 and renamed themselves the **All-Russian Communist Party (Bolshevik)** in March 1918. After the Soviet Union was formed, they later renamed themselves the **All-Union Communist Party (Bolshevik)**. This name would last until 1952, when they renamed themselves the **Communist Party of the Soviet Union**. When I use "the Party", I mean the Bolshevik's party, whatever its name might be at the time. I typically use "the Bolsheviks" when referring to the people running the Party before they came to power in 1917. In 1917–1922, I use "the Soviets" when referring to the people who ran the Soviet state. For Party matters rather than state, I use "the Bolsheviks" or "the Party" until their 1918 name change and thereafter "the Communists" or "the Party". **Old Bolsheviks** in the 1920s became a way to refer to people who were in the Bolshevik Party before the Bolshevik Revolution of November 1917. After the Bolsheviks seized power, many people joined the Party. While many joined for ideological reasons, there was always a suspicion that some joined to advance themselves and had no real interest in Marxism, Communism, or the Revolution. Thus, "Old

	Bolsheviks” in part meant party members who were almost certainly the committed ideological revolutionaries. In the 1930s, Stalin would have many top Old Bolsheviks to be demoted, imprisoned, or even executed, to remove any possible rivals to his rule.
Russia Tsardom of Russia Russian Empire Russian Republic Russian SFSR	 “RSFSR”, Flag of the Russian SFSR, 1918 The word “Russia” has several associations, such as the land of the Russians and the multi-ethnic country controlled by the Russians. The **Tsardom of Russia**, later the **Russian Empire**, was the multi-ethnic state ruled by the tsars and dominated mostly by ethnic Russians together mostly with other Slavic groups (such as Belarusians and Ukrainians). In March 1917, a revolution caused the Tsar to abdicate, and the state eventually declared itself the **Russian Republic**. In November 1917, another revolution put the Bolsheviks in charge. They did not immediately name their state, and it was sometimes confusingly called the Russian Republic and often informally called things like Bolshevik Russia, Soviet Russia, Red Russia, etc. In January 1918 the Bolsheviks adopted **Russian Soviet Republic** as the state name but in July renamed it the **Russian Socialist Federative Soviet Republic** (Russian SFSR). I use Russian SFSR or the “Soviet state” for simplicity without worrying about the evolution of its actual name. The “Federative” part of the name meant the state was supposed to be a federation of multiple ethnic groups and not just a Russian-dominated state. (This was partly a propaganda move to win non-Slavic ethnic support, since many in the enemy Whites of the civil war were ethnic Russian nationalists seeking to restore the empire and the primacy of the Russians.)

Union of Soviet Socialist Republics USSR Soviet Union	 USSR Flag, 1936–1955 The Soviet state lost its western provinces in the Treaty of Brest-Litovsk in March 1918, and several ethnic groups separately managed to gain various degrees of independence. These regions were technically not part of the Russian SFSR. However, the Bolsheviks continued to operate in many of these regions, setting up puppet socialist soviet republics there. The pretense was that local socialists were in control of these republics, but in actuality, the Bolsheviks of the Russian SFSR controlled all important issues in these republics themselves, with their Red Army being the dominating military power. When the civil war ended, there were four nominally independent republics: the Belorussian Social Soviet Republic, the Russian SFSR, the Transcaucasian SFSR (of three federated SSRs), and the Ukrainian SSR. In December 1922, the Bolsheviks officially merged these four as “union republics” of the **Union of Soviet Socialist Republics (the USSR**, aka the **Soviet Union**). (In the 1930s, the union republics swapped the order of “Socialist” and “Soviet” in their names to match the sequence used in the USSR name. Thus, “Socialist Federative Soviet Republic” became “Soviet Federative Socialist Republic” and “Socialist Soviet Republic” became “Soviet Socialist Republic”.)
All-union country-wide all-Russian country/*strana* homeland/*rodina* Mother Russia/ *Matushka Rossiya* motherland/*rodina-mat*	The Soviets used “**all-union**” to refer to institutions and organizations that applied across the entire USSR. For example, the All-Union Communist Party (Bolshevik) was the country-wide party of the USSR. I accordingly use “all-union” or “country-wide” to keep the same sense. Some works in English instead use “national”, but this is poor usage for the USSR, as covered below. Before the USSR was formed, the Soviet state was the Russian SFSR, and “all-Russian” was used in the same way that “all-union” would be later. *Strana* means country, and I use it accordingly. Again, some works in

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English use “national” for *strana*, but this is poor usage. So, *PVO Strany* is PVO of the Country or Anti-Air Defense of the Country but not ~~National Air Defense~~.

Rodina means homeland. It is sometimes translated as motherland, because of the commonly used *Rodina-mat*, which means “Motherland” (literally, “Mother Homeland”; “Mother Motherland” is another common translation). *Rodina-mat* was frequently used by the Soviets, especially during the Great Patriotic War. “Mother Russia” (*Matushka Rossiya*) was also used.

For Motherland!

So, why is “national” poor usage when referring to the overall Soviet Union? The USSR was a multi-ethnic state, not a nation state in the sense of a country with a large majoritarian ethnic group like France or Italy. The Soviets had a word for “national” (*natsionalnyy*), but they did not use it to refer to the country as a whole like they did with “all-union”. Instead, it was used in connection with Soviet ethnic groups or “nationalities” (*natsionalnosti*). So, a “national district” (*natsionalnyy okrug*) was an autonomous district for a small ethnic group, one not large enough to get its own autonomous region or autonomous soviet

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	socialist republic.
Party Organizations and State Bodies	The Communist Party entwined itself throughout the Soviet state, ensuring Party control of the government. However, it kept Party organizations and state bodies separate. For example, the Soviet secret police, from the original Cheka, to the NKVD's GUGB, and to the final KGB, were always government bodies. Similarly, the Red Army and the NKVD's internal forces were government armed forces. This is in contrast to other extremist left-wing and right-wing states, which often had their own secret police or military forces. For example, the People's Liberation Army of China is officially under the Chinese Communist Party. The Waffen-SS of Nazi Germany and the Blackshirts of Fascist Italy were party-controlled armed forces separate from (but often enmeshed with) the state military forces. Nazi Germany had both state and Nazi Party security forces, which ended up working together closely under the command of Heinrich Himmler the head of the SS and the German police.
World War II Great Patriotic War	 Great Patriotic War poster Behind the Red Army troops are the "heroic shadows", representing Aleksandr Nevskiy, who defeated the Teutonic Knights, M.I. Kutuzov, who defeated Napoleon in 1812, and an anonymous machinegunner from the Russian Revolution. World War II started in September 1939 when Germany invaded Poland, prompting Britain and France to declare war on Germany.

	Over roughly the next two years, to the end of 1941, the war expanded, eventually involving countries on all six inhabited contents, with active military operations going on in Europe, Asia, Africa, the Atlantic Ocean, the Pacific Ocean, and the Indian Ocean. Officially, the USSR was not part of this war. Germany and its Axis allies invaded the USSR in June 1941, opening what was to most of the world the Eastern Front of WW2, by far the largest land campaign of the war. To the USSR, this was the **Great Patriotic War**. The Soviet Union deliberately adopted that term in hopes of stroking Russian patriotism. They believed this was a better way to encourage the Slavic populations of the USSR to fight the invaders, rather than appeals to defend socialism or communism. The war's name evoked the Patriotic War of 1812, the Russian name for the conflict in which Russia defeated the French Empire and Napoleon[3].
Officer, Commander, Political Officer, Commissar	For simplicity, I just use "officer" and "commander" interchangeably when referring to Soviet military leaders. At times the Soviet military officially only had commanders but not officers, which had a class-enemy connotation for the early Soviets. The military did, however, have a separate organization of political leaders watching over them. These people were in change of Communist Party political indoctrination and watched the soldiers, sailors, and especially the commanders for signs of disloyalty. For simplicity, I just use "political officer" to refer to them. At times, some of these officers were called "commissars". The Soviets had several militarized or paramilitary organizations, particularly the NKVD's various armed forces and the NKVD/NKGB secret police. These organizations also used a form of the military's ranks. See Wartime Soviet Ranks for an overview of the larger story.
Class Enemies	Marxism–Leninism held that various classes of people were by their very nature enemies of the proletariat and of any socialist or communist state. These included royalty, aristocracy, the bourgeoisie, the clergy, and others. The Soviets began railing against enemies of the people in 1917, soon after they seized power, and for decades would persecute them, deny them the right to vote, and imprison them.

3 The Russian Empire in World War I also sometimes called their portion of the war against the Central Power the "Second Patriotic War" for similar reasons.

	The Soviets used several terms along these lines: enemy of the people (*vrag naroda*), enemy of the proletariat (*vrag proletariata*), enemy of the workers (*vrag trudyashchikhsya*), and class enemy (*klassovyi vrag*). I use "class enemies" in this work as the overall term.
Allied aid "Lend-Lease"	I use "**Allied aid**" to the USSR to cover the aid Allied countries sent to the USSR in 1941–1945 to help them fight the Axis. Some works instead use "**Lend-Lease**" to mean the same things, but this is technically inaccurate. Only the USA sent Lend-Lease aid (at the US president's discretion via the Lend-Lease Act). Also, before Lend-Lease to the USSR began in October 1941, the USSR purchased some American military equipment under the US "cash and carry" policy. This equipment sometime is included in the Lend-Lease figures. However, cash-and-carry purchases were somewhat small, as the US government discouraged private American companies from selling the Soviets some military equipment and some technologies after the USSR attacked Finland in November 1939. This opposition to such sales remained in force until Germany invaded the USSR in June 1941. American companies could ignore the US government on this. Very few did, however, partly out of the belief that the US would not purchase equipment from them if they ignored the government's wishes about sales to the Soviets.
World War II era	I use this for the period of the rise and fall of German Nazism, Italian Fascism, and Japanese militarism. It spans from 1931 (the Japanese invasion of Manchuria) through 1945 (the defeat of Germany and Japan).

3 Introduction to Soviet Energy, Fuel, and Power

The Soviet Union during the World War II era derived energy from many sources to run its economy, heat its buildings, and power its military: coal and other solid fuels, gasoline and other liquid fuels, natural gas and other gases, hydropower, wood, and human and animal power. They even used hydrogen as fuel in internal combustion engines to a limited extent during World War II. The Soviet military particularly depended upon liquid fuels made from oil, especially for its air, naval, and mechanized ground forces.

Selected Pre-war Soviet Energy Supplies (million tons coal equivalent)

Year	Total	% Coal	% Oil	% Natural Gas	% Primary Electricity
1925 MTCE	25.3	16.4	8.7	0.2	< 0.1
1925 %	100%	64.9%	34.2%	0.7%	0.1%
1929 MTCE	53.0	37.6	14.9	0.4	0.1
1929 %	100%	70.9%	28.1%	0.8%	0.1%
1933 MTCE	98.6	71.9	25.1	1.5	0.1
1933 %	100%	72.9%	25.5%	1.5%	0.1%
1938 MTCE	176.3	128.9	43.9	3.0	0.7
1938 %	100%	73.1%	24.9%	1.7%	0.4%

Source: Energy in the World Economy; Joël Darmstadter; 1971. MTCE is million tons of coal equivalent. “Primary Electricity” is electricity that is not generated from fuels. For this period, this was hydroelectricity from dams (the 1930s Soviets had no wind, solar, tidal, or geothermal electricity generation).

1925 shows the energy state of the USSR in its early years of economic recovery, after the vast devastation caused by World War I and the Russian Civil War. 1929 was just after the start of the USSR’s first 5-year plan, in which major efforts began to increase industrialization and resource extraction. 1933 was the first year after the first 5-year plan. 1938 was the first year after the second 5-year plan. As can be seen from the table, coal and oil were by far the main energy sources for the 1930s Soviet economy, with coal’s share rising from about two-thirds to almost three-quarters of the total.

The above table does not cover peat, oil shale, and firewood. Peat was an important fuel, especially for Soviet electricity generation. Oil shale was a locally-important fuel in some regions. Firewood was extensively used as a fuel for heating and cooking. Fortunately, information is available for all these fuels for 1940 and for the Great Patriotic War of 1941–1945.

Soviet Fuel Production (million tons fuel equivalent)

Year	**1940**	**1941**	**1942**	**1943**	**1944**	**1945**
Total	237.7	222.0	119.2	136.0	158.5	185.0
Coal MTFE	140.5	128.3	56.5	69.7	90.9	115.0
Coal %	59.1%	57.8%	47.4%	51.3%	57.4%	62.2%
Oil MTFE (includes gas condensate)	44.5	47.2	31.4	25.7	26.1	27.8
Oil %	18.7%	21.3%	26.3%	18.9%	16.5%	15.0%
Firewood MTFE	34.1	30.0	22.5	29.3	28.8	28.4
Firewood %	14.3%	13.5%	18.9%	21.5%	18.2%	15.4%
Peat MTFE	13.6	11.2	6.0	8.7	9.4	9.2
Peat %	5.7%	5.0%	5.0%	6.4%	5.9%	5.0%
Natural Gas MTFE	4.4	4.6	2.7	2.4	3.1	4.2
Natural Gas %	1.9%	2.1%	2.3%	1.8%	2.0%	2.3%
Oil Shale MTFE	0.6	0.7	0.14	0.15	0.17	0.4
Oil Shale %	0.3%	0.3%	0.1%	0.1%	0.1%	0.2%

Source: Narodnoe Khozyaystvo SSSR v Velikoy Otechestvennoy Voyne 1941–1945 gg. (*People's Economy of the USSR in the Great Patriotic War 1941–1945*); a 1959 formerly-secret statistical compilation by the Soviet government. MTFE is Million Tons Fuel Equivalent, a measure based on a 7,000 kilocalorie unit and is different than the MTCE of the previous table. Percentages does not always add up to 100.0% due to rounding.

Of the six fuels in the above table, natural gas and oil shale together supplied less than 2.5% of Soviet fuel use by MTFE, an almost insignificant share. Peat hovered at just 5%-6% of fuel use, but it was still a vitally important fuel, as many Soviet electricity-generating plants burned peat.

Well over 90% of Soviet fuel use came from coal, liquid fuels (fuel oil, gasoline, diesel fuel, kerosene, naphtha) refined from oil, and firewood. Coal was the most-important fuel and was used extensively throughout the economy including by many Soviet steam locomotives (railroads being the key component of the Soviet transport system), many factories, and many cities for heating. The German invasion overran key coal fields in 1941, as coal's MTFE figures show, declining from a high 140.5 in 1940 to just 56.5 in 1942, the low point.

Of the liquid fuels from oil, gasoline and diesel fuel were absolutely crucial in fighting the war, as they fueled the aircraft, tanks, self-propelled guns, armored cars, and trucks the Red Army used to fight the enemy and to keep itself in supply. The German summer offensive of 1942 disrupted oil production, with its MTFE figures going from a high of 47.2 in 1941 to a low of 25.7 in 1943.

Allied aid supplied gasoline to the USSR, especially critically-needed high-octane aviation gasoline. About half of the wartime Soviets' supply of aviation gasoline was due to Allied aid. Allied aid also supplied equipment and technology to help keep the Soviet oil and coal industries operating. However, Allied aid did not and could not supply all the fuel needs of the USSR, and the Soviets had another resource that helped them fight the war: firewood. Firewood was extensively used even in peacetime (34.1 MTFE in 1940, 14.3% of fuel use). During the war, firewood replaced scarce coal for heating many cities and for powering many steam locomotives.

Even firewood production fell in the war, to a low of 22.5 in 1942. This was not because the Germans were able to deny the Soviets use of forests. The central-northern regions of the USSR were forested from the Baltic Sea in the west to the Pacific Ocean in the east. Instead, the fall was due to the mobilization of millions of men into the Red Army to fight the enemy, with Soviet firewood production now depending on the labor of the elderly, schoolchildren, and, especially, women. In 1943, with coal production slowly recovering and oil production at its nadir, firewood even briefly surpassed oil to become the USSR's second most-used fuel by MTFE, making up 21.5% of Soviet fuel production.

4 Liquid Fuels

4.A Petroleum Liquid Fuels

> "Modern war is a war of engines. But the motors themselves are lifeless steel. In order for them to work, to be useful, to smite the enemy, you need gasoline. Gasoline is the blood of aircraft, tanks, cars, and industry. Our oilmen revive the cold steel of the motors, power them. They will give the front as much fuel as it needs." — *Pravda*, 8 February 1942

> "First, therefore, all available forces will be concentrated on the main operations in the southern sector, with the aim of destroying the enemy before the Don River, in order to secure the Caucasian oil fields and the passes through the Caucasus mountains themselves." — *Führer* Directive 41, 5 April 1942

> "A further force composed of all remaining mountain and light infantry divisions will force a passage of the Kuban, and occupy the high ground around Maykop and Armavir…. At the same time a force composed chiefly of fast-moving formations will give flank cover in the east and capture the Groznyy area. Detachments will block the military road between Ossetia and Groznyy, if possible at the top of the passes…. Thereafter the Baku area will be occupied by a thrust along the Caspian coast." — *Führer* Directive 45, 23 July 1942

4.A.1 In the Beginning: Kerosene and the Russian Oil Boom

The oil industry of the Russian Empire as of 1914

The vast majority of oil extraction and refining capacity was located in the Transcaucasus (Baku) and the North Caucasus (particularly Groznyy).

As the Russian Empire expanded south into the Caucasus Mountains region and beyond, the Russians fought a series of wars with "Persia" (*Persiya* in Russian), the Qajar Dynasty of Iran. In 1813, the Russians annexed the region around Baku on the western shores of the Caspian Sea. The Qajaris then lost their 1826–1828 attempt to reconquer the region. Baku was now firmly under Russian control.

Baku was on the Absheron Peninsula, which was a source of oil used by the local peoples likely back to prehistoric times. Petroleum seeps brought crude oil to the surface, and there were also natural gas seeps, some of which were burning, likely due to lightning strikes. Bitumen was gathered and used as a waterproofing substance and as construction adhesive. At least one temple with an “eternal flame” was built at a gas seep. Arab writings of the 9th Century seem to be the first historical mention Baku’s oil. By this time, people had discovered how to make a light, easily-burning “white oil” from the crude oil. At some point, the local people began to manually dig pits that would fill with crude oil. Bitumen and crude oil would be stored in containers and transported by animal power for trade. The local people had no way to store or transport natural gas, but they found local uses for it for heating, cooking, and lighting. At some point, they began using the gas to make lime: locally-quarried, crushed limestone would be placed in pits near gas seeps and the gas would then be lit, reducing the limestone to lime.

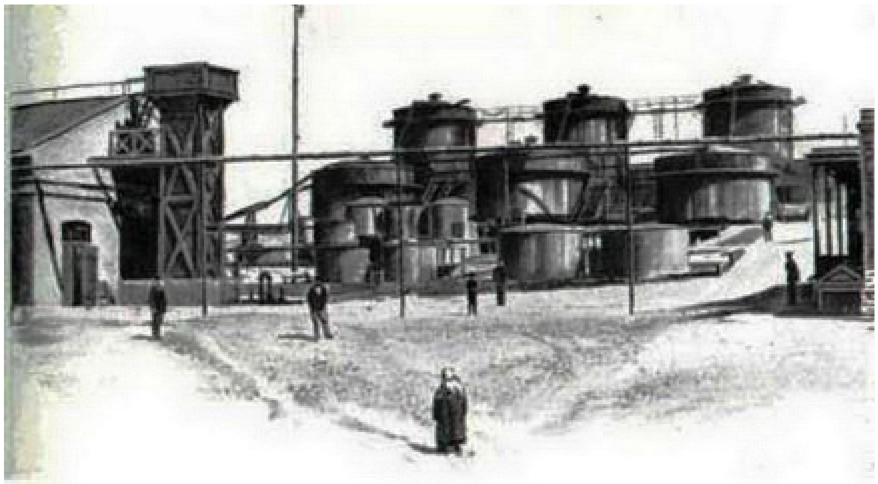
The early 19th Century Russians were aware that Baku had oil. In the early 1700s, Tsar Pyotr I (“Peter the Great”) imported some white oil from Baku. However, the oilfields were of little strategic interest to the Russian Empire until later in the 19th Century. Baku’s oil was mostly used locally and regionally, with commercialization increasing when an oil well was drilled there in 1846. This was Russia’s first oil well, and it might have been the first in the world. However, this did not lead to a Russian oil boom.

Indeed, Baku wasn’t even Russia’s first source of oil. For centuries, oil from seeps along the Ukhta River and its tributaries in the Pechora region of northern Russia had been collected and used by the local inhabitants, and by 1597 some of this oil was being sent to Moskva. By the mid-1700s, a small industry existed to scoop up oil from the surface and shores of the rivers, but production was tiny, typically less than one ton per year. Some oil wells were drilled there in 1868–1873, but again production was quite small compared to what Baku was by then producing. The Ukhta region was remote, roadless, and with a sub-arctic climate, so it was accessible only by rivers, which were frozen for more than half the year. This area accordingly would languish until the 20th Century.

In the 1840s-1850s, several methods to distill kerosene were invented in North America and Europe, first from coal tar and oil shale, then from oil. The invention of safe kerosene lamps soon followed. These lamps burned much brighter than candles and vegetable- or animal-oil lamps[4]. Kerosene became relatively cheap as its production scaled up in the 1850s-1860s.

4 Hemp and flax were grown in various parts of Russia and their oils used for lamps. Sometimes turpentine was mixed in, as turpentine was quite flammable and made from conifer trees, of which Russia had plenty. Hemp oil and turpentine-hemp oil were often used for outdoors street lamps. Turpentine-alcohol fuel (*svetilnyy spirt*, lighting spirit [alcohol] or luminous spirit)

Kerosene fuel and lamps quickly became popular in many parts of the world, including in Russia where it was called *kerosin*, *fotogen* (photogen[5], "light producer"), and other names. Kerosene went on to be used as a cooking fuel, a heating fuel, a solvent, and a dangerous medical treatment (for head lice). It was far more prized than gasoline, which at the time had little use other than as a solvent or a dangerous medical treatment (again for head lice). Gasoline often was only used a fuel locally where it was made or even just burned off in pits to get rid of it.



A kerosene refinery owned by the Nobel brothers at Baku, 1890

Russia's first kerosene production facilities were built in or near Baku in 1857–1863. However, this still did not lead to a Russian oil boom. The land containing the oilfields was owned by the local rulers, who rented or "farmed" out the land for oil production, usually on short terms like five years. This discouraged long-term investment. In contrast, American oil wells and kerosene production proliferated in the 1860s, and Russia ended up importing large quantities of American kerosene. This got the attention of the Russian government, which saw little reason to import kerosene when Russia had Baku. In the 1870s, Russian legal reforms ended oil farming and favored the development of the oil industry, making land at oil fields easy to acquire, encouraging foreign capital to invest, and welcoming foreign technicians and other experts. The Russian government generated revenues for itself from the reforms, through oil and gas production leases, through customs duties on American kerosene, and through excise tax on domestic kerosene production[6]. Although both foreign and domestic kerosene was taxed, the taxation favored domestic production. The domestic excise tax did not generate much revenue, but Russian kerosene producers

also were used. Animal fats and oils were also used for oil lamps, and whale oil was a prized but increasingly expensive oil that kerosene mostly replaced.

5 In many countries, photogen was often made from lignite rather than petroleum.

6 Vagit Alekperov; *Oil of Russia: Past, Present & Future*; 2011.

incurred the tax each day they produced kerosene, regardless of how much they produced. This incentivized producers make as much kerosene as possible per day, to minimize tax payments. It also discouraged producers both from producing other petroleum products in quantity and from investing in new petroleum technologies. To fix this, the government removed the kerosene excise tax in 1877. Within about a decade, Russian oil production had increased 10 times that of 1877, with a range of oil products being made. Kerosene production also benefited, and the domestic price of kerosene fell by 80%, making it affordable to all but the very poorest or the most remote people. Russian kerosene was easily shipped up the Caspian Sea and Volga River to the Russian heartland, and it soon replaced imported American kerosene in the country. Russian kerosene also competed with American kerosene internationally, being exported to many countries.

In the 1880s, a Swedish-Russian partnership was formed to exploit Baku's oil. Partners were Ludvig, Robert, and Alfred Nobel[7], Swedish brothers from a family with long-standing commercial interests in Russia, and P.A. Bilderling, a Russian industrialist, general, and veteran of the Crimean War. They developed a hugely-successful oil company at Baku, soon joined by other oil companies there owned by the French Rothschilds and various local businessmen. The Nobels created a petroleum research institution at Baku, built the first Russian oil tanker, and built an 885-km (550-mile) pipeline to transport kerosene from Baku to Batum (renamed Batumi in 1936) on the Black Sea, from where it was exported to other countries as well as sent to Russian ports along the sea. Before the pipeline was built, the Transcaucasus Railroad was the only practical way to transport oil and oil products from Baku to the Black Sea. However, railroad fees consumed about three-fourths the profits the exports generated. The railroad also had to transit a mountain pass, which limited transport capacity, and was occasionally damaged by river floods. One flood in 1895 closed down the railroad to oil traffic for two months, as rails and bridges had to be repaired and rebuilt. A kerosene pipeline was obviously needed.

While in the late 19th Century it was routine to pipe crude oil, a kerosene pipeline was a technological challenge. Kerosene was much lighter and more fluid than crude oil and thus prone to leakage and evaporation. It was also much more flammable, so a pumping accident could cause a major fire or explosion. Russian technicians studied American pipeline technology and adapted it for kerosene transport. American pumps were imported for the line's pumping stations. The Soviets in the 1920s-1930s and again in World War II would similarly depended upon American oil technology to build the Soviet oil industry.

7 This is same Alfred Nobel famed for his work with explosives and creation of the Nobel Prizes. About 12% of his funding for the prize came from his profits from Baku oil.

The pipeline was built in stages, starting in 1896, with sections complete in 1900 and 1904. The full length of the pipeline became operational in the summer of 1906[8] and within five years not only paid back its large investment cost but was also yielding significant profits.

Russia's oil boom was finally on. Up to 1910, Baku's population grew faster than (although not larger than) the populations of booming western cities like London and New York. Russian kerosene was used throughout Russia for lighting, cooking, and heating. It became so important that a portion of some factory workers' wages was paid with kerosene rather than rubles. Beside kerosene (*kerosin*), the bulk of production, Baku refineries made petroleum ether (*petroleynyy ethir*, also called benzine in English[9]), which was used as a solvent, gasoline (*benzin*), lubricants, and some other products. Even some of the heavy, tarry oil residue left over from refining found a market: it was sold as ship fuel for steamers in the Caspian Sea and soon mostly displaced coal there as a ship fuel. Later, this evolved into the various grades of fuel oil (also known as marine fuel oil, bunker oil, boiler oil, and many other similar names) that was used by merchant ships, warships, and industrial boilers.

The success of Baku also created an oil boom throughout the Russian Empire. Any time commercially-exploitable oilfields were found, domestic and foreign companies scrambled to exploit them. "Commercially exploitable" not only meant meant the oilfield had significant amounts of oil that could be extracted within reasonable expense, but there also were affordable means to transport crude oil or refined oil products to the consuming markets. Using animal power, such as horse-drawn wagons carrying wooden barrels of oil, was too expensive and low-capacity for all but local uses. Instead, in the second half of the 19th Century, only three methods were affordable enough: water transport, railroads, and pipelines. Baku had the advantage of being on the Caspian Sea, so that barges and tankers could carry oil north up the sea and Volga River to domestic markets in Russia. The Transcaucasus Railroad allowed oil to be brought to Batum on the Black Sea, for export to other countries or for shipping to Russian Black Sea ports like Odessa. Later, the Baku-Batum pipeline made exporting kerosene even more affordable.

Most but not all of the Russian Empire's refineries were located near the major oilfields. In 1879, an oil refinery was built at the village of Konstantinovskiy in the Yaroslavl region, northeast of Moskva. Dmitri Mendeleev, Russia's preeminent chemist and designer of what became the modern periodic table of the elements, became involved with the plant in the 1880s. In turn, the plant was named after him, the Yaroslavl Oil-Refining Plant named for

8 Alekperov claims the pipeline went into operation on 21 June 1907. Other sources claims 1906, and the Russian company Transneft says it went into operation in the summer of 1906; https://en.transneft.ru/about/story/.

9 Benzine, not benzene, which is something else. Be aware that the Russian *benzin* typically means gasoline, not benzine!

D.I. Mendeleev (*Yaroslavskiy Neftepererabatyvayushchiy Zavod imeni D.I. Mendeleev*). Some Soviet-based sources claim the plant only received the Mendeleev name in 1934, but various sources (including these Soviet-base sources) refer to the plant as the "Mendeleev Refinery" long before 1934. Other names for the plant were YaNPZ (from ***Ya****roslavskiy* ***N****efte****p****ererabatyvayushchiy* ***Z****avod*), the Mendeleev Refinery, the Konstantinovskiy Refinery, and the Yaroslavl Refinery. This latter name is most misleading, as Konstantinovskiy was about 25 km (16 miles) from the city center of Yaroslavl, and "Yaroslavl Refinery" was later used for the refinery the Soviets built in the city itself in the 1960s. While the Yaroslavl region had no nearby oilfields, its location on the Volga River allowed Baku oil to be easily shipped there and then it refined products easily shipped to regional markets such as Moskva. Most likely its major products were kerosene and fuel oil. The Mendeleev Refinery has the distinction of being the oldest Russian refinery still in operation as of 2021.

In the 1880s, oil wells were drilled in the Fergana Valley in Central Asia, the Turkestan region of the Russian Empire. (The parts of the valley with the oil centers later became part of the Uzbek and Turkmen SSRs under the Soviets and are now parts of Uzbekistan and Turkmenistan.) A refinery was built there and processed oil mostly into kerosene and fuel oil for local consumption. The fuel oil was used in part to power steam locomotives in the valley. Oil output was modest.

The region near Kazan in the central Volga River valley was known to have oil since 1762. In the 1860s-1870s, very small-scale oil extraction and kerosene refining occurred there, with all output being used locally. It became clear by the 1870s-1880s that the region had large reserves of oil, but they were too deep to be reached by the oil drilling technology of the late 19th Century. Interest in the area's oil then lapsed until the early 20th Century, but renewed attempts to extract this oil again failed. Only small-scale operations for local consumption were practical.

It was well know in the 19th Century that the Groznyy area of the North Caucasus had oil deposits. However, Groznyy was not significantly developed until well after Baku, because there was no affordable way to transport oil from the area. Oilfields and refineries near Groznyy finally saw major development starting in 1893, soon after the Vladikavkaz Railroad was built in the region. Groznyy became the Russian Empire's second largest oil center, after Baku, and Groznyy crude oil and oil products, mainly fuel oil (up to 75% of the refineries' production) and kerosene, were used in Russia and exported. Naphtha, used a boiler fuel, and some gasoline were also made. Railroad tanker cars for transporting gasoline were developed, but apparently from fear of explosive accidents Russia only allowed them to operate on the Caucasus rail lines, no further than the ports of Rostov-na-Donu near the Sea of Azov in the north and Novorossiysk on the Black Sea in the south. Gasoline production, for export, became more important from 1902 as gasoline-engine automobiles became popular in many countries. Gasoline then overtook naphtha as the third-most-produced product, after fuel oil and kerosene.

Once Groznyy was a major oil center, the Vladikavkaz railroad, which served the North Caucasus region, converted its locomotives to use fuel oil instead of coal or firewood. The railroad ended up with its own refinery at Groznyy to produce its own fuel oil, and it went one to sell fuel oil and other petroleum products, mainly to export markets. The railroad already had a line to Novorossiysk on the Black Sea for exporting Russian wheat, and it built oil storage facilities there for export. The railroad also built a short line to Petrovsk-Port (later renamed Makhachkala) on the Caspian Sea plus oil storage facilities there, to send oil up the Caspian Sea and Volga River to the domestic Russian market. Other Groznyy oil companies also built a pipeline from Groznyy to Petrovsk-Port. However, the cost of transporting Groznyy oil and oil products to Petrovsk-Port made them more expensive than oil and oil products from Baku. Groznyy oil thus only had a small part of the domestic market, and Petrovsk-Port remained a minor port.

Like the Vladikavkaz Railroad, the Transcaucasus Railroad, which operated in the Russian Empire south of the Caucasus Mountains, converted at least some of its locomotives from using firewood to fuel oil. This conversion happened much later than for the Vladikavkaz Railroad, starting only in 1910. (The Soviets would in the 1930s convert the Transcaucasus Railroad to use electric locomotives.)

In the 1880s, oil was discovered in the northern and eastern parts of Sakhalin Island in the Pacific Ocean. However, for years attempts to find commercially-exploitable oilfields failed. Although Sakhalin was remote and had a forbidding, cold climate, its location made it attractive as a potential oil source to make kerosene for the growing Asian market. It was only in 1903 that large-scale exploitable deposits were found, with companies and syndicates being formed to extract this oil in 1904. However, that year also saw the outbreak of the Russo-Japanese War, with a string of Japanese victories over the Russian army and navy culminating in the occupation of all of Sakhalin in July 1905. The peace treaty unexpectedly gave only the southern half of Sakhalin to Japan, and both Russian and foreign companies resumed oil exploration in North Sakhalin. A productive well began operation in 1911, increasing interest in developing North Sakhalin. The outbreak of World War I in 1914 ended foreign interest there while also diverted Russian companies from investing there.

More than a decade would elapse before significant development of North Sakhalin's oil would begin, under Japan and then the Soviet Union.

In the first decade of the 20th Century, three commercially-exploitable oilfields were found in the Fergana Valley of Central Asia, and a refinery was built there in 1908. Its main products were likely fuel oil and kerosene, likely for local and region use, although I do not have much information on this. The Fergana Valley did not see any further significant oil development until the Soviet era.

In 1909, oil was discovered at Maykop in the North Caucasus. This sparked the 1909–1910 Maykop Oil Fever, with many companies being formed to extract this oil. Maykop was on a tributary of the Kuban River, so this marked the start of what is sometimes called the Kuban oil center. Refineries were built at Maykop and at Ekaterinodar (later renamed Krasnodar), with a pipeline built from Maykop to Ekaterinodar. Another pipeline was built from Maykop to the port of Tuapse on the Black Sea, for export purposes. Maykop fever also led to oil exploration in the greater Kuban River region, where Maykop was located, and on the nearby Taman Peninsula along the eastern shores of the Black Sea[10].

Oil was also discovered near the northeastern shores of the Caspian Sea, in the Russian Empire's Ural Oblast (later part of the Kazakh SSR of the USSR and now part of Kazakhstan). In 1911, an oilfield at Dossor was developed, followed in 1915 with initial development of what would be called the Emba Oil Basin, in the Emba River region near the Caspian Sea.

In the early years of the 20th Century, the Russian oil boom brought renewed attention to the Ukhta River region. New wells were drilled there starting in 1907, and a refinery for the production of kerosene went into operation there in 1914. Output was still small compare to other Russian oil centers, but Ukhta oil products were used in northwestern Russia. Although my sources do not mention this, the refinery likely made fuel oil as well as kerosene. If so, this would have been used as ship fuel on rivers in northwestern Russia and on the White Sea and other nearby Russian Arctic waters. During World War I, the Ukhta region was explored for new oilfields, but no major developments were undertaken there during the war.

Russian kerosene and crude oil were exported around the world, and by the start of the 20th Century Russia was producing over 40% of the world's oil. Russian production briefly

10 Early in the second half of the 19th Century a productive oil well had been established in the Kuban region and a refinery built on the Taman Peninsula for export of oil products. However, the venture went bankrupt, and the region was not seriously developed until the 1909 discover of oil at Maykop.

surpassed American production and once reached about 50% of the world's oil output. However, increasing Russian kerosene exports to Europe and Asia alarmed Standard Oil, at them time an American oil monopoly. Standard Oil attempted through legal and illegal means to maintain its international dominance in kerosene. Its most effective tactic was to great reduce its kerosene prices in some countries to make Russian kerosene unprofitable there, although this tactic also lowered Standard Oil's profits.

Over the next two decades, American oil production would vastly increase while Russia's declined due to domestic unrest. In 1905–1906, an abortive revolution convulsed the Russian Empire, amplified at Baku due to ethnic tensions between Christian Armenians and Muslim Azerbaijanis there. In August 1905 a general strike at Baku degenerated into religious-ethnic violence, resulting in thousands of casualties; arson damaged oil facilities and burned oil wells. The industry did not fully recover until about 1913. In 1914, World War I broke out.

World War I (1914–1918) profoundly affected the Russian oil industry. The hostile Ottoman Empire soon closed the Turkish Straits to Russian exports and then went to war with Russia. This deprived Baku and the North Caucasus of most of their export markets. As a result, for the domestic market, less kerosene and more fuel oil was made. Growing Russian steel shortages in 1915 meant fewer new wells were being drilled to replace older wells as they became depleted, and production began to contract in 1916.

Russian Oil Production, 1913–1917 (millions of tons)

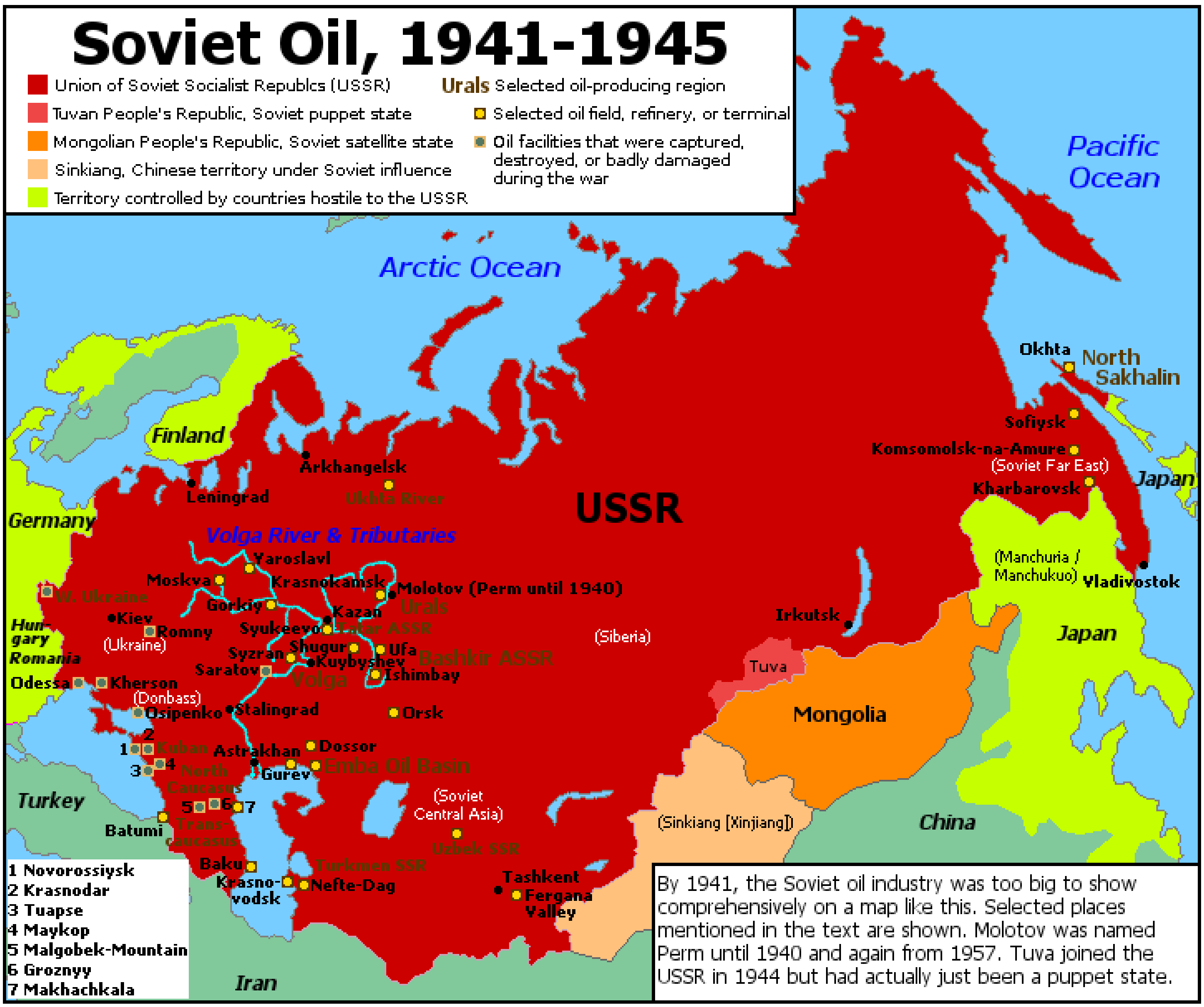
Year	Russian Oil Production
1913	10.179
1914	10.260
1915	10.326
1916	10.076
1917	9.656

Source: Vagit Alekperov; *Oil of Russia: Past, Present & Future*; 2011.

The Russian government increasingly intervened in the industry, trying to ensure supplies of fuel for the military and the civilian economy. The Russian military needed fuel oil for the navy and gasoline for the army, which by late-war had up to 2,000 aircraft and several thousand trucks. Construction of new oil processing plants was authorized, for production of toluene, an ingredient of explosives, although it is unclear when or if these plants began production. To increase oil production, the government in 1916 began the development of state-owned oilfields with a planned output of 6 million tons.

However, in 1917 the oil industry and most of Russia were plunged in disarray by economic collapse, social unrest, and revolution. The oil industry was badly affected by steel shortages and worker unrest. The Bolsheviks seized power and created their Soviet state. The country fell into civil war, with the Soviet Red Army fighting the anti-Soviet White Army, with the anarchist Black Army seeking stateless communism, and the various Green movements seeking local autonomy and self defense. The Soviets won the Russian Civil War (1918–1920) but the country was devastated, and the oil industry was mostly in ruins.

4.A.2 The Soviet Oil Industry



The revolutionary Bolsheviks or Soviets were violent, radical, dictatorial Marxists with little regard for human life. Their plans were to replace capitalism and private ownership of important property like land, farms, buildings, factories, machinery, etc., with state-owned socialism, with the goal of eventually achieving the stateless communism of Marxist ideology. The oil industry was a prime target once the Soviets seized power in November 1917, although they were busy at first in consolidating power, preventing a democratically-elected assembly from forming a government not to their liking, building their Red Army, and fighting increasing resistance that developed into the White Army and a civil war. The Soviets thus took over the oil industry in stages. In November 1917, the Soviets issued a Decree on Workers' Control, putting the workers in charge of all industrial, commercial, and agricultural enterprises. In March 1918, the Soviets appointed a chief commissar for the oil industry with broad powers including the ability to set prices. In May, the oil commissar gave way to a Main Oil Committee which had authority over all aspects of the oil industry, including extraction, refining, distribution, and pricing. Finally, in June the Soviets confiscated the major oil industry enterprises without compensating the owners; everything except some small-scale enterprises were placed under state ownership. In addition, the Main Oil Committee took over control of the enterprises from the workers' committees. Oil workers, technicians, and administrators were all required to remain in their jobs.

Worker control had proved inept at running enterprises, contributing to economic decline. However, centralized Soviet control also proved inept and ideologically inflexible at running the economy, so economic decline continued. The oil industry was now in bad shape. Chechen rebels had also set fire to the Groznyy oilfields in late 1917, devastating much of the local industry.

The Soviets had quickly taken over most of the Yaroslavl region during 1917, including the Mendeleev Refinery at the village of Konstantinovskiy. During the civil war, this plant at times in 1918–1919 seems to have been the only major refinery under Soviet control and many have been the only major oil facility not damaged in the civil war. However, its output, likely mainly kerosene and fuel oil, depended upon the plant receiving oil from elsewhere. This was a problem at the time, since as covered below the Soviets often either didn't control the major oilfields or were unable to transport oil from these fields to other places.

Transcaucasus region and nearby areas, 1918

Baku and Groznyy were major oil centers with both oilfields and refineries. Batum (later renamed Batumi) was an oil terminal on the Black Sea formerly used to export oil and oil products to foreign countries as well as to ship them to Russian Black Sea ports. However, the Ottoman Empire in 1914 blocked Russian exports from the Black Sea. From 1918, Batum then changed hands several times, falling to the Ottoman Empire in February, with control of the city passing to the British and Georgians in 1919. The Soviets only gained control of the area in 1921. Petrovsk-Port (later renamed Makhachkala) was a port on the Caspian Sea for sending Groznyy oil and oil products north to Russian markets on the Volga River system.

In the first half of 1918, Baku was Soviet controlled and still producing, but transportation problems made it increasingly difficult to move oil and oil products by rail or water. The Transcaucasus region was in great turmoil with Armenia, Azerbaijan, Georgia, and other places there declaring independence, although the Soviets retained control of some enclaves. Ethnic conflict in Baku between Armenians and Azeris broke out again, like it did during the abortive revolution of 1905. Baku's oil was a strategic prize, and Azeri forces, an Ottoman army, a German military expedition, and a British military expedition all sought to gain control of Baku. In July 1918, a coup at Baku placed the city under control of the Armenians and anti-Soviet Russian socialists. A small British force arriving to assist them, while the Ottomans continued to advance on the city. The Soviet loss of Baku drove the Soviets and Germans to cooperate in August: the Germans would try to persuade the Ottomans, their Central Powers ally, to forgo taking Baku. In return for neutralizing the Ottoman threat, once Soviet forces regained control of the area Germany was to thereafter receive one-quarter of Baku's oil production[11]. However, the Ottoman commander in the Transcaucasus refused to halt operations, and the Ottoman army captured Baku on 14 September.

11 To be sent up the Caspian Sea and Volga River for delivery to German forces occupying Ukraine.

With the Ottomans in Baku, control of its oilfields and refineries passed to the Central Powers. Had they had time enough to exploit this resource, it might have relieved the alliance's massive fuel shortages and just possibly help revive their fortunes. However, it was too late. The entire alliance by this time was in a state of military collapse due to Allied offensives. Bulgaria surrendered in late September 1918, followed by the Ottoman Empire and then Austria-Hungary in October. Germany surrendered in November 1918, ending World War I. German forces in Georgia were the closest Germany would ever get to Baku's oil riches in either world war. Baku and its oil now passed to control of the Azeris and the British.

Besides the loss of Baku, September 1918 also saw the White Army capture Maykop from the Soviets. Grozny was still badly damaged and at times was captured or besieged by the Whites. The Soviets had also lost control of the northeastern Caspian oilfields, so they controlled no major oil extraction centers and no major refinery except for the Mendeleev Refinery in the Yaroslavl region. The small-scale Volga region oil enterprises remained under Soviet control but were totally insufficient to supply Soviet fuel needs. Nevertheless, since they were about all the Soviets had, they were confiscated from their owners and placed under state ownership by 1 July 1919[12].

The need for oil was so great that the Soviets in 1919 began exploring for new oilfields in the Volga-Urals region, most of which they controlled. The Volga region was known to have oil deposits, and the geology of the nearby Urals region indicated it likely had oil[13]. Despite the need for oil, exploration proceeded slowed because of lack of equipment and oil experts. No large deposits capable of being extracted were found during the Russian Civil War, and exploration was ended in 1924.

The Soviets had no ability to import oil or fuel, as the World War I Allied countries had informally but quite effectively blockaded the Soviet state. The Soviets thus were reliant on existing fuel stockpiles under their control, with no means to replenish them. Faced with this emergency, in 1919 the Soviets required any fuel usage to be authorized by the Main Oil Committee. When the Whites threatened to capture fuel stocks in parts of the Volga River region that year, the Soviets went to extraordinary measures to move these stocks to safety. Anyone caught using fuel without authorization or failing to save the fuel stocks was to be

12 https://www.tatneft.ru/about-tatneft/history-of-tatneft-group?lang=en

13 "The basis for the high expectations held for the region was the presence of numerous oil shows such as asphalt, tar, and bitumen in the Permian rocks", page 12 from James A. Peterson and James W. Clarke; "Geology of the Volga-Ural Petroleum Province and detailed description of the Romashkino and Arlan oil fields" (capitalization per the paper itself); Open-File Report 83–711; 1983; Geological Survey, United States Department of the Interior.

prosecuted under martial law by military revolutionary tribunals, which could impose capital punishment.

Soviet Fuel Use in the Russian Civil War, 1918–1920 (percent of total fuel use)

Year	Wood	Coal	Petroleum	Peat and Oil Shale
1918	71.0%	14.0%	12.0%	3.0%
1919	88.0%	3.5%	5.0%	3.5%
1920	50.0%	36.0%	10.5%	3.5%

Source: Vagit Alekperov; *Oil of Russia: Past, Present & Future*; 2011.

The Soviets had lost control of major coal and oil centers in 1918–1919, such as the Donbass coal mines and the Baku oilfields. They extensively substituted firewood in place of other fuels for heating, cooking, and railroad transportation, with many steam locomotives using wood instead of coal or fuel oil.

While the fuel situation was dire, it seems to have affected the civilian economy much more than the military. The Red Army had just a limited number of trucks, few armored cars, few aircraft, and a tiny number of tanks, so its military fuel needs were modest. Instead, the army relied extensively on foot infantry, horse cavalry, and horse-drawn artillery, with most military and logistical transport using horse-drawn wagons and the railroads. Nevertheless, oil stockpiles dwindled until the Soviets only had 204,000 barrels of oil (on the order of 27,700 tons) on 1 November 1919. However, by this time the Red Army had inflicted significant defeats on many of its opponents and was now seizing considerable territory from the Whites, although not yet any major oil centers. In 1919, they did take control of the Ukhta River region, but the oil industry there was quite small. The Soviet oil situation changed in early 1920, with the northeast Caspian and the North Caucasus regions falling to the Soviets. In April 1920, the Red Army took Baku. Within days of the conquest, over 156,000 barrels of oil were being sent up the Caspian Sea and the Volga River to the Soviet heartland, soon followed by millions more. The Mendeleev Refinery resumed quantity output. By 1922 the plant's production had surpassed its prewar level (107% compared to 1913).

The Soviets now controlled all major oil centers. They even temporarily controlled the Okha oilfields on North Sakhalin Island, taking them from the Whites, although the Japanese would soon occupy all of North Sakhalin and hold it until 1925.

"Only close union of workers and peasants will save Russia from destruction and hunger."
(Soviet propaganda poster from the Russian Civil War)

Major fighting in the civil war ended in 1920 in decisive Soviet victory, although the Soviets would continue to suppress insurgencies and revolts for several years. An attempt to spark proletarian revolution in Germany and elsewhere in central Europe failed when the 1920 Soviet invasion of Poland was crushed in August. The Soviets then quickly made peace and focused their attention on economic recovery. To rebuild their oil industry, the Soviets planned to grant oil concessions to foreign oil companies at Groznyy and Baku. The plan was to grant a company a concession to extract oil for 25 years, although the Soviets would have the option to buy out the concession after 15 years. The Groznyy concession would also require the company to build a new kerosene refinery and an oil pipeline from Groznyy to Moskva. However, the Soviets found little foreign interest in the concessions, because of the Soviet state takeover of the oil industry without compensating existing owners. Further, various oil companies including the Standard Oil Company of New York[14] ("Socony") had bought the property rights to many of these oil assets from their displaced owners and so

14 The original Standard Oil had been broken up into many separate companies in 1911, as a result of US anti-monopoly laws. Several of the companies retained "Standard Oil" as part of their names, including Standard Oil of New York (Socony), Standard Oil of New Jersey, and Standard Oil of Ohio (Sohio). (The state names reflected where the companies were incorporated; they operated in many states and internationally.) Soviet-based sources often just refer to "Standard Oil" and are often unclear about or perhaps sometimes even unaware of the multiple Standard Oils in the 1920s and 1930s. It is certain that the Soviets at least dealt with Standard Oil of New York but may have dealt with others, too, like Standard Oil of New Jersey. When accounts are not clear, I attribute mentions of "Standard Oil" to Standard Oil of New York, which the Soviets extensively dealt with.

wanted compensation themselves. In 1922 the Soviets offered to consider compensation in some cases, but their failure to agree to mass restitution ended foreign interest.

Diplomatically, the Soviet refusal to honor the debts incurred by the Russian Empire isolated the Soviets from the victorious countries of World War I. The Soviets claimed that Allied intervention and blockade in 1917–1920 damaged their economy far in excess of the Tsarist debts, and thus Allied countries needed to grant the Soviets credits for rebuilding before they would consider any restitution, which would only proceed on a case-by-case basis. Negotiations with Allied countries ended without agreement.

The Soviets needed to import equipment to rebuild, since Soviet industry was in ruins. However, paying for imports was a problem because of their refusal to honor Russian Empire debts and their confiscation of private enterprises without compensation. Foreign banks would not issue loans to the Soviets, nor would foreign countries extend credits to the USSR. The victorious countries of World War I also prohibited countries from accepting Soviet gold as payment, regarding it as stolen from the Russian Empire (and thus rightfully should be used to pay the empire's debts). Finally, foreigners would not accept Soviet rubles, so the Soviets had to use foreign currencies to pay for imports[15]. The Soviets had no reserves of foreign currencies but had to raise them by exporting grain, particularly wheat, and resources, particularly lumber[16], crude oil, and oil products. The need for foreign currencies and ruthless nature of the Soviet regime meant that the Soviets would export grain even during times of famine in the USSR.

In 1921 the Soviets began exporting Baku kerosene via the pipeline to Batum. This was difficult at first. Although the informal Allied blockade was crumbling, foreign oil companies wanting compensation from the Soviets organized a voluntary boycott of Soviet oil. This then failed in 1922–1923. The Soviets became skilled not only at finding trading partners but also at playing oil companies off against one another. For example, Socony wanted compensation, but Royal Dutch Shell, Socony's big international rival, was willing to deal with the Soviets. In 1922, Shell secretly bought Soviet kerosene and resold in Asia. In 1923, a British company began openly buying Soviet kerosene, which broke the boycott. By late 1923 the USSR was exporting significant amounts of crude oil and refined products

15 The Soviets managed to sell gold at a discount through intermediaries, particularly Sweden, so the gold blockade was not absolute. Also, Germany, one of the losers of WW1, would secretly take Soviet gold. Nonetheless, the Soviets still needed great amounts of foreign currency to pay for imports.

16 In various English speaking countries, "timber" and "lumber" have different meanings. In some places, timber is processed wood products liked milled boards while lumber is unprocessed wood. In other places, the meanings are reversed or sometimes partly conflated. For simplicity, I just use "lumber" to mean both timber and lumber.

including kerosene, gasoline, and fuel oil, through the ports of Batum and Novorossiysk on the Black Sea and, for a time, Petrograd (soon to become Leningrad) on the Baltic Sea[17].

Not only was the oil industry in a poor state, so was the rest of the economy including the transportation sector. Insufficient transport for oil and oil products was thus a bottleneck for the Soviet economy. The Soviets lacked shipping for oil transport on both the Caspian and Black Sea and took steps to remedy the situation there. Rail transport was also a problem, and the Soviets ordered 1,500 rail tanker cars from foreign companies.

The Soviets had fought the civil war using War Communism, in which the state not only confiscated factories and other enterprises without compensation but also in essence took anything it needed, particularly food, with at best nominal compensation. The state also forbade workplace strikes and made growing use of conscripted labor of citizens and forced labor of prisoners. The goal was to feed the cities and towns, the Soviets' power base, and to provision and arm the Red Army. War Communism worked in the short term but caused economic collapse. For example, war communism appropriated "surplus" food, whether or not it was really surplus, at nominal compensations rates, which impoverished peasants and led to rural unrest and smaller harvests.

In March 1921, with the war won but the economy collapsing, the Soviets temporarily relaxed their policies, starting the New Economic Policy (NEP). Limited amounts of private enterprise for profit were allowed, and peasants could sell their surplus food for profit in markets[18]. The Soviet economy started to revive under the NEP, which would continue until Stalin consolidated power and began to industrialize the country and collectivize agriculture in 1928.

Large industrial and other enterprises remained state owned. Direct state management of these enterprises, however, was ended. Instead, enterprises were organized into "trusts". A trust managed itself, with the requirement to use part of its profits to build up a reserve of money capital both for investment into increasing production and for covering any losses that might occur, as the Soviet government would not assume debts of trusts. Trust managers received bonuses based on profits. The state received a share of the profits and, for some trusts, a portion of the trust's production without compensation. Several trusts could be in the same field, such as textiles or oil, but trusts were also allowed to form monopolistic

17 My sources do not cover why Petrograd became an oil exporting center, but mostly likely it was exporting oil products refined at the Mendeleev Refinery in the nearby Yaroslavl region. It would have made no sense to export products from Baku or the North Caucasus through Petrograd, given the availability of the much-closer Black Sea ports.

18 The NEP charged the peasants a tax, payable in agricultural output, at about half of what used to be confiscated. This gave peasants incentives to grow food again.

syndicates. This system resulted in economic recovery via the profit motive, although the nature of syndicates often resulted in needlessly higher prices so that managers could earn large bonuses. This caused the Soviets to institute a system of price controls in 1924, which still allowed the trusts to realize profits, albeit reduced ones.

For the oil industry, three major trusts were created in the early 1920s:

- Azneft Trust ("Azerbaijan-Oil"), *Trest "Azneft"*,(*Az* for *Azerbaidzhan* [Azerbaijan, the territory in which Baku was located] and *neft* [oil]).
- Grozneft Trust ("Groznyy-Oil"), (*Trest "Grozneft", Groz* for Groznyy), formed in 1922.
- Embaneft Trust ("Emba-Oil"), (*Trest "Embaneft", Emba* for the Emba oil region).

At some point, the Uzbekneft Trust ("Uzbek-Oil", *Trest Uzbekneft*), Sakhalinneft Trust ("Sakhalin-Oil", *Trest "Sakhalinneft"*[19]), and Maykopneft[20] ("Maykop-Oil") were also formed, although I have not yet found a definitive date for these. Similarly, as the oil industry developed over the years, other "nefts" were formed for other oil-producing regions. By World War II there were many nefts, including Ishimbayneft, Kazakhstanneftekombinat, Permneftekombinat, Syzranneft, Turkmenneft, Tuymazaneft, and many more. I make no attempt to track all the nefts, especially the "Bolshevik nefts". At some point, there were at least five nefts names for Bolshevik leaders: Leninneft, Stalinneft, Molotovneft, Ordzhonikidzeneft, and Kaganovichneft. Molotovneft in some sources is called the Emba Molotovneft (*Embenskiy Molotovneft*), so I suspect the Bolshevik nefts were just existing nefts that got Bolshevik names tacked on.

The Soviets also had governmental structures over the nefts, but these changed and were redesignated frequently as Soviet government underwent numerous reorganizations. For example, at times the oil industry was under the heavy industry commissariat or the fuel commissariat, and at other times it was its own commissariat. Similarly, there were unified export organizations for the nefts and at one point a Soyuzneft ("Union-Oil") with some function over the individual nefts. For simplicity, I just use "Soviet oil industry" rather than try to track all of this.

As oil exports grew, the Soviets built a new oil pipeline from Baku to Batum alongside the Tsarist-era one. This pipeline carried crude oil and, although I have not confirmed it yet, it

19 This alternatively was known as the Sakhneft Trust (for example, see Walter A. Radius; "The Play of Petroleum Forces in the Far East"; *Far Eastern Survey* Vol. 7, No. 18 (Sep. 7, 1938).

20 Maykopneft does not seem to have been called a trust, so it may have been formed later. A few sources call it Mayneft rather than Maykopneft, but I suspect this is either informal usage or a mistake for a locality called Mayneft in the North Caucasus area.

probably could carry some refined products, likely fuel oil at least. The original Tsarist-era kerosene pipeline was also converted to be able to carry crude oil, and it likely could still carry kerosene and other oil products.

The Soviets had sought to develop the North Sakhalin oilfields by granting a concession to Sinclair, an American oil company. Negotiations started in 1921[21] and were finalized in 1923. However, the concession could not begin operations, as Japan had occupied North Sakhalin during the Russian Civil War, and the Japanese were extracting North Sakhalin oil for their own use. Soviet-Japanese negotiations in 1924–1925 ended with North Sakhalin being returned to Soviet control, but only in return for the Japanese being granted concessions to extract some of North Sakhalin's oil and coal[22]. The oil concession was for 45 years and involved the Japanese paying royalties on oil production there as well as a land tax[23]. Japanese oil production on North Sakhalin ramped up quickly; the Japanese had extracted about 13,000 tons of oil in 1924 but by 1929 were extracting 165,000 tons, supplying about 13% of Japan's oil that year. Much of this oil went to provide fuel for the Imperial Japanese Navy. Japanese oil production on North Sakhalin reached 200,000 tons in 1931 but soon went into decline. This was likely because the oil fields in the concession were becoming depleted and the Japanese were not allowed to exploit other areas of North Sakhalin. According to Soviet sources, 1938 production was 118,000 tons and then steeply declined to 44,000 tons in 1940 and 17,000 tons in 1942. At the Tehran Conference in 1943 with the US and Britain, the USSR agreed to buy out the concession from Japan. In 1944, the Soviets agreed to pay Japan one million US dollars and send Japan 50,000 tons of oil per year for five years for the concession, and Japanese production on North Sakhalin ceased that year. The Soviets managed to avoid paying the Japanese or delivering any oil[24].

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21 Technically, the Far Eastern Republic, a Soviet puppet state set up as a buffer between the Russian SFSR and Japan, started the negotiations. The Far Eastern Republic was folded back into the Russian SFSR as soon as better relations with Japan allowed.

22 Prior to the agreement, the Japanese were extracting North Sakhalin oil under a concession granted in 1919 by the Whites, but the Soviets contended the Japanese were illegally taking the oil. With the Whites out of the picture by 1924, part of the Soviet-Japanese settlement over Sakhalin involved the Japanese paying the Soviets for the oil they extracted before they received the Soviet concession.

23 The Japanese also received right to explore for new oilfields on North Sakhalin for 11 years and to develop some of these fields; in 1936 this right was extended for another five years (Walter A. Radius; "The Play of Petroleum Forces in the Far East." *Far Eastern Survey* Vol. 7 No. 18 (Sep. 7, 1938). I do not know if this right was extended again in 1941, although given signing of the Soviet-Japanese non-aggression pact that year, it is certainly possible.

24 Some other sources claim or imply that Japanese kept the North Sakhalin concession until August 1945 when the USSR declared war on Japan. They claim the Soviets then unilaterally rescinded the concession and seized the Japanese oil facilities there. I have not done the research to resolve this apparent contradiction. Perhaps what happened in 1945 was that the Soviets renounced their obligation to compensate the Japanese for the purchase of the concession. Another possibility is that the two sides had agreed to the terms in 1944, but one side or the other dragged out negotiations over minor details to avoid finalizing and implementing the agreement. A third possibility is that the buy-out only covered the oil part of the concession, and the

The Japanese concession did not include all the oilfields on North Sakhalin. The Soviets organized their own oil-extraction operations under Sakhalinneft. By now, the Soviets were no longer interested in granting a concession, so Sinclair never got to extract oil on Sakhalin[25]. Since the Soviets had no refineries in the Soviet Far East until 1935, most of the Soviet oil production from North Sakhalin was sold to Japan. In addition, the Soviets were exporting gasoline to the Japanese in the 1920s and 1930s, including aviation gasoline, even after the Japanese occupied Manchuria and thus gained a long border with the USSR. At times, half of the exported gasoline went to the Japanese Army in Manchuria, which the Soviets even knew about through their sales negotiations with the Japanese[26].

In the 1920s and 1930s, industrial development of the Soviet Far East usually lagged other regions of the USSR, as the Soviets tended to concentrate their scarce resources to industrialize less-remote, less-expensive, more-populated regions. However, the far east was strategically important, as it had important natural resources and gave the USSR a major port and naval base (Vladivostok) on the Pacific Ocean, connected to the rest of the country by the Trans-Siberian Railroad. The Soviet Far East thus had a growing contingent of military forces stationed there. All these Red Army and Navy trucks, tanks, aircraft, and ships needed fuel, almost all of which had to be shipped there over thousands of kilometers (thousands of miles) on the Trans-Siberian Railway.

In 1924, Socony abandoned its boycott of the USSR and began selling equipment to Azneft. Technology from Socony and other American oil companies improved Soviet oil operations, making them faster, more efficient, and less expensive. In 1924–1928, the Soviets spent about 750 million rubles in capital investments in the oil industry. Without American technology, they would have had to invest another 200 million rubles to achieve the same level of production. The American companies' eagerness to make money from the Soviets helped them partially overcome banks' unwillingness to issue loans to the USSR. Major companies would themselves borrow from banks and then loan the Soviets the money to purchase the companies' equipment and services, with the loan typically being paid off in five years or less. Azneft seems to have been the first Soviet organization to get such as loan, from Socony,

Japanese retained the coal part of the concession until August 1945.

25 Some sources note that the Soviets involved Sinclair, an American company, with the hopes of sowing discord between the USA and Japan. US state department documents show that Sinclair petitioned the US government several times to press their case over Sakhalin, but the State Department refused to do so.

26 "Soobshchene A. Rozengol'tsa — I.V. Stalinu Ob Usloviyakh Dogovora Soyuznefteeksporta s Mukdenskim Aktsionernym Obshchestvom Vozdushnykh Soobshcheniy" ("Message from A. Rosengolts to I.V. Stalin on the Terms of the Contract of Soyuznefteexport with the Mukden Joint Stock Society of Air Communications "); March 1933; https://coollib.net/b/502403-tatyana-semenovna-bushueva-halhin-gol-issledovaniya-dokumentyi-kommentarii/read

but this practice soon was used with other Soviet industries. American oil companies also assisted in delivering Soviet oil exports, which helped make oil one of the Soviets' largest export industries.

Even by the late 1920s and with American assistance, the overall Soviet oil industry was not particularly modern. Many refineries could only make gasoline using inefficient traditional techniques, which turned 1 metric ton of oil into only 130 kilograms of low-octane gasoline. For the domestic market, the industry primarily produced easy-to-make fuel oil (which was used for ship fuel, heating, and power generation) and kerosene (which was used for cooking, heating, lighting, and as a fuel). Most gasoline was for export.

The international market for exported oil products was changing significantly in the 1920s. Economically-developed countries had both decreasing demand for kerosene, as people switched to electric lighting, and increasing demand for gasoline, as people and companies bought millions of cars and trucks. Soviet kerosene exports increasingly went to less-developed countries. There was also increasing demand for fuel oil, which the Soviets with their less-advanced refining technology found easier to make. The result was that gasoline and fuel oil made up the bulk of Soviet oil exports. For example, kerosene and crude oil made up about 77% of the Russian Empire's oil exports in 1913 but only about 24% of the Soviet Union's oil exports by the mid-1920s.

ROP advertising for the British market

The growth of these Soviet exports was matched by a growing Soviet commercial presence in many countries. There, the Soviets set up locally-registered, Soviet-owned companies to market Soviet oil products. These companies sometimes built up sizable assets. In the United

Kingdom, for example, the Soviets incorporated "Russian Oil Products, Ltd." (ROP) on the London Stock Exchange and advertised ROP-branded gasoline, kerosene, and aviation gasoline in Britain. ROP often sold gasoline at a lower price than other British companies, thereby gaining a good market share, up to 10% of the British gasoline market at one point. ROP had its own rail tanker cars, tanker trucks, storage facilities, and at least two oil terminals for deliveries from the USSR. Soviet-owned companies were also set up in Germany, France, Italy, and several smaller European countries. The Soviets made no effort to build an international brand but instead ran each company for its own market: *Deutsch-Russische Naphta-Gesellschaft* (German-Russian Oil-Society) in Germany, Petrolea in Italy, etc. Sometimes the Soviets partnered with a local concern. In Spain, they set up a joint company with Argus Bank of Barcelona and soon captured 30% of Spain's gasoline imports.

Socony and Royal Dutch Shell had been happily making money distributing Soviet oil products. However, the increasing international importance of the Soviet oil industry temporarily changed this. By 1925, the Soviets had 8% of the European oil products market, causing both Socony and Shell to view the Soviets as a potentially serious competitor. They purchased lesser amounts of Soviet oil products, particularly gasoline, and launched secret measures to inhibit sales of Soviet oil products. In Britain, for example, Shell ran an advertising campaign through a third party, attacking Soviet oil as being stolen from its rightful owners. This temporarily depressed Soviet oil exports.

However, the international oil market was growing strongly, and major oil companies resumed making as much money as they could by dealing with the Soviets. For example, Socony in 1926–1927 built a new refinery at Batum in the USSR and distributed its kerosene to Asian markets. By 1927, the Soviets had 4.5% of the global total for petroleum product exports and 11.5% of Europe's gasoline imports. The USSR itself did not yet have a large fleet of gasoline-engine vehicles, so its domestic gasoline requirements were modest. The vast majority of Soviet-made gasoline was exported (87.8% in 1927).

A new oilfield was found in the Fergana Valley in 1927, leading to further development of the oil industry in this region. In 1932–1935, more oilfields were found there. At some point, at least one more refinery was built in the region. Fergana Valley oil products were mostly used only in Soviet Central Asia.

1920s Soviet Oil Production (million tons)

Year	Total Oil Production	Azneft Share	Azneft %
1920	3.85	2.50	65%

1921	3.78	2.45	65%
1922	4.66	3.12	67%
1923	5.28	3.64	69%
1924	6.06	4.06	67%
1925	7.06	4.73	67%
1926	8.32	5.57	67%
1927	10.29	6.79	66%
1928	11.63	7.67	66%
1929	13.68	8.62	63%
1930	18.45	10.52	57%

Source: Rebecca Lindsay Hastings; "Oil Capital: Industry and Society In Baku, Azerbaijan, 1870- Present", dissertation; 2020.

Azneft controlled the Baku oilfields, and Baku's importance to Soviet oil production is shown by the fact that for many years two-thirds of Soviet oil came from Azneft. By 1930, Soviet economic recovery and investment had increased Azneft's production by over 400%. Soviet development of other oilfields, mostly in the North Caucasus, temporarily dropped Azneft's share of production to 57% by 1930, but continued investment in Baku would raise Azneft's share to 73.6% by 1940.

The late 1920s saw Stalin achieve dictatorial control over the USSR. Stalin abandoned the New Economic Policy and resumed direct state management of all major enterprises. Syndicates were disbanded. The neft trusts became state industrial associations rather than actual trusts, although at least some of them retained "Trust" in their designations for some time. (Some World War II Soviet sources, for example, called them trusts.)

Stalin's program included central planning of the economy, collectivization of agriculture, and rapid industrialization. Industrialization required foreign expertise and imports of machinery, and technology. To pay for this the USSR needed even more foreign currency, which in turn meant increasing Soviet exports, particularly oil products. 1928 plans for the oil industry included increasing oil extraction, improving refining technology to increase gasoline production, and improving oil transportation capacity to the Black Sea export ports. American companies were contracted to assist in these efforts.

Tuapse on the Black Sea coast was developed with oil storage facilities as a new oil export center for North Caucasus oil, joining Batum (for Baku oil) and Novorossiysk (also for the North Caucasus oil). The Soviets built an oil pipeline from Groznyy to Tuapse in 1928. With

American assistance, they also built a refinery there, which went into operation in 1929 to make products for export. Soviet oil exports increased in the early 1930s, but they brought in less foreign currency than the Soviets expected, as the Great Depression was now affecting many capitalist countries. World-wide demand for oil dropped, requiring both capitalist oil companies and the Soviets to lower their prices in order to sell their oil.

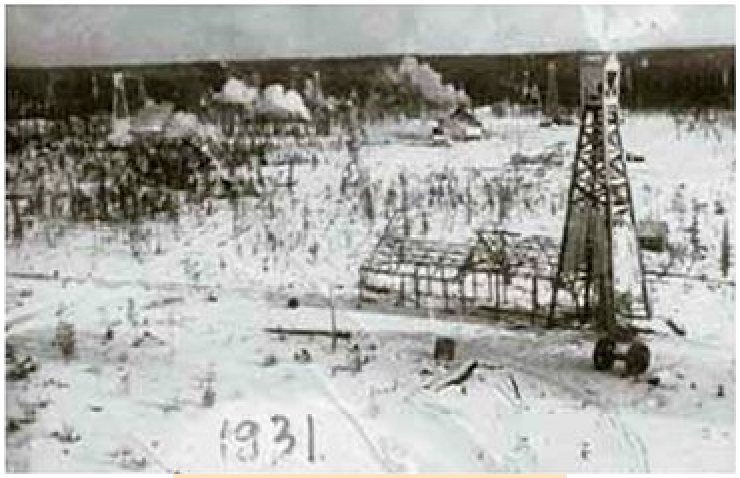
Soviet Oil and the Great Depression, 1929–1933

Year	Oil Production (million tons)	Exports (million tons)	Export Revenues (million rubles)	Rate (rubles per ton)
1929	15.08	4.25	138	32.47
1930	20.34	5.19	157	30.25
1931	24.68	5.70	116	20.35
1932	23.60	6.70	107	15.97
1933	n/a	5.39	76	14.10

Source: Vagit Alekperov; *Oil of Russia: Past, Present & Future*; 2011. Oil production is crude oil production. Exports include both crude oil and refined oil products.

Alekperov does not give oil production for 1933. Other, older, sources give slightly lower production figures, perhaps based on inaccurate Soviet figures. They also indicate production declined by 100,000 tons in 1933 from 1932.

By May 1932, the world oil situation was of such concern that the Soviets met with leading western oil companies to discuss what to do. All parties in essence wanted to rig the market to prop up prices, but the western companies wanted the Soviets to reduce exports and to accept a fixed price for 10 years. This was unacceptable, and Soviet counter proposals were equally unacceptable to the western companies. The conference ended without agreement. The Soviets expected the western companies to drive down the price of oil in hopes of discouraging Soviet exports. However, a price war was acceptable to the Soviets. Soviet automotive industrialization was already increasing domestic demand for fuel and would only keep increasing, so the Soviet oil industry needed to keep increasing production regardless of international conditions. In the short term, any excess oil products could be dumped on the international market to earn whatever it could.



An Ukhtaneft oil rig in 1931

Like the earlier Russian oil boom, the 1930s Soviet oil boom brought renewed interest in the Ukhta River region. Ukhtaneft, the small-scale oil operation there, no longer had refining ability, as its kerosene refinery ceased operation in 1924[27]. Preliminary exploratory work in the region began in 1929, with new wells being drilled in 1930 and new oilfields being developed. To get the increasing amounts of Ukhtaneft oil production to the greater USSR, transportation had to be improved. The region was in roadless taiga, part of the great boreal forests of the USSR. The only communications route there was the Ukhta River, which because of the sub-Arctic climate was frozen for over half the year. Also, there were few people in the Ukhta River region, most of whom were engaged in traditional economic activities, so Ukhtaneft also needed workers. This being Stalin's USSR, the Soviets decided to mostly rely on the forced labor of prisoners. They established GULag camps there to exploit oil, lumber, and other natural resources and to build communications lines, a power station, a refinery, and other infrastructure. In the 1930s, the prisoners built a graveled road to the region, followed by a broad-gauge rail line (part of the Kotlas-Vortuka rail line to gain year-round access to Vorkuta coal). With the railroad, the USSR obtained ready year-round access to Ukhtaneft's oil production. By perhaps no coincidence, around this time a number of oil industry experts ended up being purged as industrial "wreckers" and sent to the GULag, where they ended up working in the Ukhta region for Ukhtaneft. (While it is not certain that these oil workers were imprisoned simply to provide skilled workers for the GULag, the 1930s Soviets did do this for other projects, to provide engineers for the White Sea-Baltic Canal and for aircraft technicians for prison aircraft design bureaus for two examples.)

27 No reason is given for this. I speculate that perhaps, because of the regions low oil production, the Soviets decided it was not worthwhile to maintain a refinery here and perhaps salvaged its equipment to send to a more-productive region.

By the early 1930s, the USSR was rapidly industrializing and mechanizing. It would soon be building hundreds of thousands each of tractors and trucks, and tens of thousands each of tanks, aircraft, passenger cars, and specialty vehicles likes buses and ambulances. All these machines required liquid fuel, mostly gasoline, and lubricants, almost all of which were refined from petroleum. Since the USSR vied with Venezuela for being the second biggest oil producer in the world, you might think it could supply all the fuel it needed. By the mid-1930s, it could not.

The USA was the top oil producer by far. According to the League of Nations report on crude oil production[28], output in millions of metric tons for 1940 for the top 15 producers is shown in the following table.

World 1940 Oil Production, Top Producers (million tons)

Country /Colony (c)	Production	Notes
USA	182.657	Domestic use and exported
USSR	29.700	Domestic use; some exported to Germany and Italy
Venezuela	27.443	Exported
Iran	10.426	Exported
Dutch East Indies (c)	7.939	Exported
Mexico	6.721	Exported
Romania	5.764	Exported, some to Germany
Columbia	3.636	Exported
Iraq	3.438	Exported
Argentina	2.871	Exported
Trinidad (c)	2.844	Exported
Peru	1.776	Exported
Burma (c)	1.088	Exported
Canada	1.082	Domestic use[29]
Egypt	0.929	Exported

Before the outbreak of World War II in September 1939, Germany got two-thirds its oil from the USA and Latin America, but German overseas imports were then blocked by the Allies.

28 http://digital.library.northwestern.edu/league/le0280ah.pdf

29 Canadian oil production did not remotely meet domestic consumption during the World War II era. "However, until the giant Leduc discovery near Edmonton in 1947, Canada depended on imports for up to 90 per cent of crude oil supplies." — Robert D. Bott; *Evolution of Canada's Oil and Gas Industry*; 2004.

The figure of 29.700 million tons for the USSR is almost certainly an estimate. It is unlikely the USSR supplied the League or anyone else with production information, especially since the League expelled the USSR from its ranks in December 1939 over the Soviets invasion of Finland. Soviet-based sources claim the USSR produced 31.121 million metric tons of oil in 1940.

The reason for the Soviet gasoline shortage was that the refinery industry could not modernize and expand fast enough to keep up with the rapidly expanding fleet of Soviet gasoline-fueled vehicles.

The 1930s Soviets were well aware that they needed needed advanced petroleum technologies. However, these technologies, such as modern cracking ability and all sorts of gasoline additives, were technologically challenging and dominated by American, Anglo-Dutch, and German companies that were developing them[30]. To master them, the Soviets needed many more highly-skilled engineers, many more highly-advanced chemists, and high-quality precision manufacturing to make efficient advanced cracking plants. All these were bottlenecks. Soviet intelligence helped by acquiring some technical knowledge through espionage.

The Soviets, as they often did in the 1920s and 1930s, overcame these obstacles by importing foreign technology. Beginning in 1928 with the first five-year-plan, the latest foreign, often American, refining equipment was imported, with Soviet engineers studying it so that Soviet industry could build its own versions. A number of foreign advanced cracking units were installed at five refineries. According to some sources supposedly all went to refineries in the North Caucasus and Transcaucasus (Baku, Groznyy, and Batum). However, the history of the Mendeleev Refinery in the Yaroslavl region indicates it received a cracking unit in the early 1930s[31].

By the mid-1930s, Soviet versions of these cracking units were being produced. Some were installed at existing refineries, almost all of which were in oil extracting regions. It seems that most unit, however, went to new refineries being built near where gasoline was being consumed. The Soviets often just called these new refineries “cracking plants” rather than refineries, even though many older refineries used older cracking technology.

30 Cracked gasoline was actually first developed in 1913. While it was more effective against knock than standard gasoline, it was also less stable and tended to gum up engines. Cracked gasoline was accordingly disliked, especially for aircraft, until the 1930s, when additives were developed to fix the gumming problem.

31 https://ru.m.wikipedia.org/wiki/Ярославский_нефтеперерабатывающий_завод_имени_Д._И._Менделеева. The early 1930s was too soon for Soviet-made cracking units, so it had to have been an import.

Moskva Cracking Plant (later Plant № 413)

In the spring of 1935, the Soviets decided to build their first advanced cracking plant using Soviet-designed cracking technology, for production of gasoline. The plant had an initial planned production capacity of 155,000 tons of gasoline per year. They decided to build it near where gasoline was consumed. Moskva itself by then had about 30,000 gasoline-fueled vehicles[32], so a site near the city was selected for the plant. The location was by the Moskva River, which allowed barges to bring fuel oil from Baku, via the Caspian Sea and Soviet rivers and canals. (The plant used fuel oil as a feedstock rather than crude oil.) Construction of the plant began in February 1936 and gasoline production began in April 1938. During construction, increasing Soviet experience with advanced cracking technology led them to begin construction of a second cracking unit for the plant, with a planned capacity of 540,000 tons per year. This unit achieved production in May 1939. Further experience led to modifications at the plant in 1939 that decreased the cost of producing gasoline by 35%. At some point, possibly in 1939, the plant was renamed Plant № 413.

The Germans invaded the USSR in June 1941 and by July 1941 the Luftwaffe was bombing Moskva with a mix of high explosive and incendiary bombs. After some incendiary bombs fell near the plant, the Soviets extensively camouflaged the plant and built a dummy plywood replica at another location three kilometers (two miles) away. In case the dummy was bombed, the Soviets planned to burn barrels of oil and oily rags to produce flames and smoke, so that German aerial reconnaissance would report the site was damaged. Some Soviet-based sources claim the Germans were fooled by the dummy and repeatedly bombed the site until it completely burnt down. This story of the Germans making repeated attacks against the dummy plant seems embellished with propaganda. The Luftwaffe only launched two moderately large, night-time raids on Moskva in

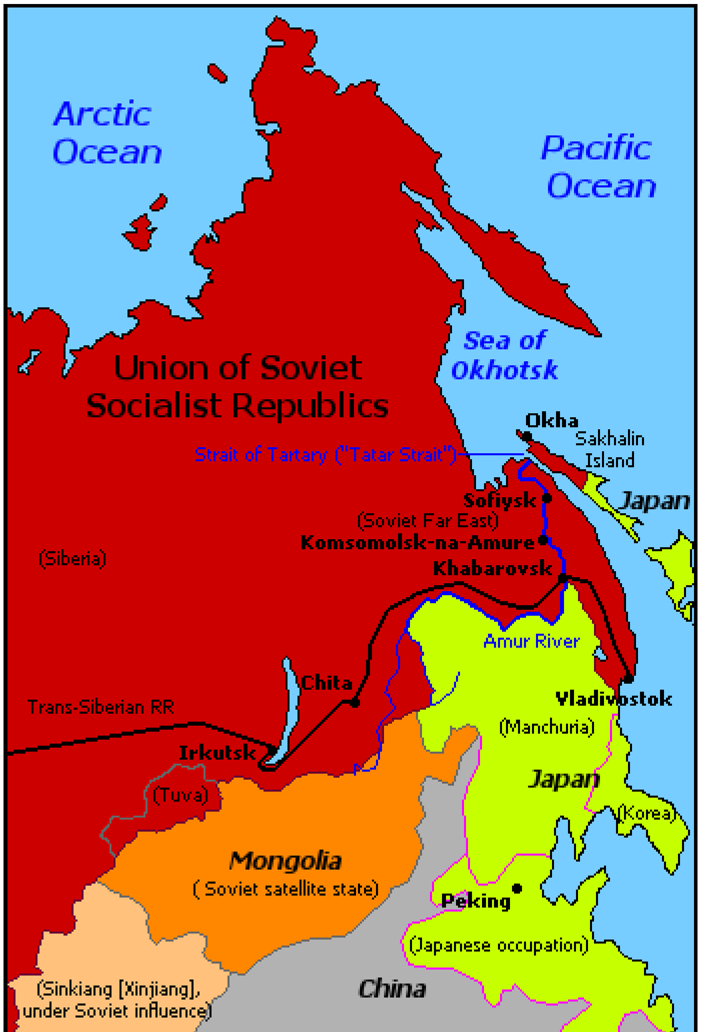
32 Although sources do not say it, Moskva likely had the highest concentration of gasoline-fueled vehicles of any location in the Soviet Union, since it was both the USSR's largest city and the country's capital.

July, followed by a many small night raids typically with no more than a squadron of bombers at a time. This hardly seems like an intense effort to destroy the plant.

In October, the German Operation Typhoon offensive was threatening Moskva. The Soviets faced a dilemma: the plant should be evacuated east to prevent its capture, but the Red Army needed every drop of gasoline it could make. They decided to evacuate parts of the plant that would not affect production and planned to try evacuate the cracking equipment if the Germans broke through. Demolitions were also set to destroy the plant in case there wasn't time to evacuate it. During the Battle of Moskva, the front lines at times were so near the plant that Red Army units would just refill their vehicles directly at the plant. The Germans did not break through, and the plant remained in place for the rest of the war, processing 2.8 million tons of oil into fuel.

Soviet oil pipelines, 1930s

In 1935, the Soviets built a second oil pipeline from Groznyy to Makhachkala on the Caspian Sea, by the original Tsarist-era one, which had been used to send oil and oil products from Groznyy to places in Russia. Now, however, both pipelines brought crude oil from Baku via Makhachkala to Groznyy, for refining there, as Baku's oil production exceeded its refining capacity. A pipeline was also built from Groznyy to the Donbass industrial region in eastern Ukraine, to bring oil products there. Sources disagree on when it was built, with one claiming 1928–1930 and another claiming work only began in 1931. A 709-km (441-mile) pipeline was built from Gurev (now Atyrau in Kazakhstan) to Orsk, a refining center, in the Volga-Urals oil region, starting in 1932. This pipeline went through the Dossor oil field and linked up with the pipeline than ran from the Emba Oil Basin to Dossor[33]. Gurev did not have an oilfield or refinery (one was built only in 1945), but it was a Caspian Sea port that allowed oil and oil products to be shipped to the Volga River.



Soviet Far East and Japan, 1941
Tuva ("Tuvan People's Republic") was a Soviet puppet state. Sinkiang was part of China but was controlled by a warlord under Soviet influence. Manchuria ("Manchukuo") was a Japanese puppet state. Korea had been annexed into Japan.

The Soviet Far East

Sakhalin Island was divided between the USSR (as the Sakhalin Oblast in the Soviet Far East, aka "North Sakhalin") and Japan (as the Karafuto Prefecture, aka "South Sakhalin"). **Khabarovsk** was the largest city in the Soviet Far East, with a refinery opening there in 1935. **Vladivostok** was a key

33 Sources are a bit contradictory on this pipeline network, with some stating Emba-Dossor-Orsk was the main line and Gurev-Dossor a secondary addition. I believe the Emba-Dossor pipeline was built first and then the Gurav-Dossor-Orsk line.

port and naval base. It had played an important role in importing supplies for the Russian Empire during World War I and would do so again for the USSR in World War II. **Komsomolsk-na-Amure** ("Komsomolsk on the Amur") was an industrial city built on the site of a small village starting in 1932; an oil refinery opened there in 1942. "Komsomolsk" honors the volunteers from the Komsomol, the Communist Youth League, who began building the city in 1932 (although soon civilians, military personnel, and forced-laborers from the GULag all participated). **Okha** was an important oil extraction center. **Sofiysk** was a small village and became important in 1942 when the Soviets opened an oil pipeline there from Okha, crossing the Strait of Tartary (the "Tatar Strait" to the Soviets). Oil arriving at Sofiysk was shipped up the Amur River for refining.

The lack of a refinery in the Soviet Far East meant that almost all oil products for the region had to be shipped there over great distances on the Trans-Siberian Railroad. Japan, hostile to the USSR from the birth of the Soviet state, became in the 1930s, increasingly aggressive in Asia. Japanese forces seized Manchuria from China in 1931–1932 and were now stationed along the long border between Manchuria and the Soviet Far East. To protect against possible Japanese aggression, the Soviets began reinforcing their forces in the Far East. However, the vital Trans-Siberian Railroad ran just north of the border with Manchuria and so was vulnerable to be blocked by a Japanese incursion, cutting the flow of supplies. It seems very likely this situation influenced the Soviet decision to build refineries in far east. These would refine oil from North Sakhalin, making the Soviet Far East somewhat less dependent upon oil products sent via rail. Also, even ton of fuel refined locally freed limited rail capacity for other uses.

The Soviets decided to built their first far-eastern refinery in Khabarovsk, the biggest city in the Soviet Far East. In theory, it might have been more efficient to build it at Vladivostok instead, since shipping oil from North Sakhalin to this port city would have been easier. However, Vladivostok was quite vulnerable to being occupied by Japanese forces, as had occurred during the Russian Civil War, as well as being blockaded by the superior Imperial Japanese Navy. Perhaps these considerations played a factor in the decision on where to build the refinery.

In 1935, the Khabarovsk refinery began operations, processing North Sakhalin oil, which was shipped by barge across the narrow Tatar Strait (aka the Strait of Tartary) separating North Sakhalin from the mainland and then up the Amur River to the refinery. However, both the strait and the river frozen over for many months each winter, so crude oil was only delivered seasonally. Once the Khabarovsk refinery was opened, Soviet sales of North Sakhalin oil to Japan essentially ceased.

In 1938, the Soviets decided to build a refinery at Komsomolsk-na-Amure, further downstream on the Amur. Construction of the plant started in 1939, but the outbreak of war with Germany in 1941 slowed completion. The refinery finally went into operation in December 1942, as State Union Plant № 87, and only had a refining capacity of 0.5 million tons per year, less than originally planned.

The Volga-Urals region had disappointed oil hopes from the 1880s to 1924. Only small-scale deposits near the surface could be tapped, as the larger discovered deposits so far were too deep for the then-current drilling technologies. Finally, at first by accident, large oil deposits that could be extracted were found. In the 1920s near the city of Perm in the Urals, the Soviets were drilling wells looking for potassium salts, an ingredient needed to make potash for agricultural fertilizer. Potassium salt deposits were indeed found, but in 1928, the twentieth well instead struck oil and gas. Given the decades-long hope of finding oil in the Volga-Urals region, the idea of the region becoming a "second Baku" quickly took hold. This was mostly speculation at first, since it was based on the output of just that one well. In 1929, the Soviets organized Uralneft ("Urals-Oil") for oil exploration and exploitation in the Urals region. By the middle of 1930, Uralneft had 36 oil wells under development. Uralneft's rapid development was possible due to equipment and experts brought in from Grozneft and Azneft. In 1930, Uralneft became part of a new organization, Vostokneft ("Eastern-Oil") charged with oil exploration and development in the Urals and Siberia. However, by 1931 some of the excitement over Second Baku was wearing off. Uralneft now had about 50 wells, of which only five had economically-exploitable amounts of oil. Three of these wells were quite productive, encouraging oil exploration to continue in the region. The next few years saw no major finds, until 1934 when a new oilfield was found. Perhaps ironically, this field like the first was found by accident, this time when a water well being drilled for a paper mill struck oil. By 1935, it was clear the field had worthwhile amounts of oil. The oilfield was in the vicinity of Krasnokamsk[34], just 34 km (21 miles) west of Perm. Both the oilfield and a refinery were developed, with both going into production in 1936.

34 Krasnokamsk was on the Kama Rive, and its name means "Red Kama [town/city]". Unlike many Soviet locations with names starting with "Krasno…" ("Red"), this location was a new settlement circa 1930 and did not have a prior name in the Russian Empire. The discovery of oil and building of a refinery there caused rapid population growth, with Krasnokamsk being classified as a city in 1938. During the war, the Leningrad Mint was evacuated to Krasnokamsk, perhaps for paper from the paper mill for the printing of Soviet paper currency. It went into operation in October 1941 as the Krasnokamsk Mint. Besides currency, the mint made medals and state awards for the government. However, the war created a huge demand for medals, which the Krasnokamsk Mint could not meet, leading the Soviets to open a second mint in Moskva, the Moskva Mint established in 1942.

Oil was also found in the Bashkir Autonomous Soviet Socialist Republic (now the Republic of Bashkortostan in the Russian Federation) in the Urals area south of Perm. Bashneft (Bashkir-Oil) was formed, and the area began to be developed in 1932, with Ufa, the republic's capital, becoming an oil refining center. To transport crude oil to Ufa, both a railroad and a pipeline, each about 170 km (105 miles) were built to the city from the oilfields.

Oil and gas were discovered in the Sumy and Poltava regions of eastern Ukraine. In the mid-1930s, a well being drilled for water near Romny in the Sumy region encountered material suggestive of the existence of salt domes, which in turn can indicate the presence oil and gas deposits. Oil and gas exploration began in the region in 1935, with oil being found near Romny in November 1936. However, it took time to find large-enough deposits worth extracting, and small-scale industrial production only began at Romny in 1940. Oil was also found at a site further east in March 1941 but oil exploration there was halted when the war broke out.

In the Poltava region, the Lubny area, about 100 km (60 miles) south-southwest of Romny, was known from historical times to have surface oil seeps, the only place in central Ukraine where such seeps occurred. The discovery at Romny naturally caused interest in Lubny, and oil exploration started there in 1940–1941. The start of the war, however, halted this effort, as well as few other oil and gas exploration efforts in central Ukraine.

Even by the mid-1930s, there were many regions in the USSR that had not been surveyed for oil. The Soviets initiated oil exploration efforts in some of these areas, such as western Siberia. By 1940–1941, oil exploration had discovered 14 fields awaiting development, and the USSR's known oil reserves may have been the largest in the world at 5,200 million tons, with many places of the country still to be explored. (The Soviets used a different system to classify oil reserves than the "proven reserves" scheme used by capitalist countries, making it contentious to compare the two.)

Soviet Central Asia already had oilfields at Dossor, the Emba River region, and the Fergana Valley. Other parts of the region now saw oil development, with an oilfield at Nefte-Dag[35] in the Turkmen SSR being developed in 1933. In 1936, two oilfields in the Uzbek SSR began production, and more oilfields were under development in the Turkmen SSR. The port city

35 Nefte-Dag, also rendered as Neftedag, means "Oil Mountain" using the Russian word for oil and the Turkmen word for mountain. In 1946, it was renamed Nebit-Dag (also rendered as Nebitdag), using the Turkmen words for oil and mountain. After the collapse of the USSR, the Turkmen SSR became Turkmenistan and in 1999 renamed the city Balkanabat, Balkan being the name of the region the city is located in, and abat meaning either "peaceful" or "city".

of Krasnovodsk, at the end of the Trans-Caspian Railroad on the eastern shores of the Caspian Sea became an oil terminal for shipping Central Asia oil to other parts of the USSR. Other oil and gas fields were also found in Central Asia, particularly in Uzbekistan. Central Asian oil production remained relatively modest compared to the main Soviet oil centers throughout the 1930s and World War II.

Other oilfields, some relatively minor, were also developed from the mid-1930s, including in the Crimea[36], in Dagestan west of Groznyy, in the Azerbaijan SSR other than at Baku, and in the Kuban region (part of Maykopneft). One important field was found and developed in the Caucasus Mountains, Malgobek-Mountain, with the local village turned into the "working settlement" of Malgobek for the oil workers. In 1940, two oil pipelines, one 100 km (62 miles) and the other 56 km (35 miles) were built at different points in the field to send its oil to Groznyy.

In addition to developing new oilfields, refineries were also built or expanded, including two in the Bashkir ASSR (Ishimbayevo and the Ufa cracking plant). Despite all these accomplishments, the oil industry fell short of their 1936 goals, including well drilling, oil production, and refining capacity. In comparison, many other industries had already achieved their 1937 goals in 1936. Worse, 1936 marked the start of Stalin's Great Purge, so this was a worse time than usual to fall short of plan. In 1936–1938, many oil workers and experts were purged, with some being executed and most being sent to the GULag. The loss of these people affected the oil industry, which actually saw oil production decline slightly from 31.4 million tons in 1937 to 31.3. million tons in 1938, despite Soviet demands for greater production.

The oil industry was given even more ambitious goals for the third five-year plan (1938–1942). Also, in March 1939, the Soviets officially set a goal of making the Volga-Urals region the "Second Baku"[37]. The oil industry struggled to meet these targets and goals. Production did increase, reaching 34.3 million tons in 1940, but it was 5.6 million tons less than what the Soviets wanted. One problem was that the Soviets were not drilling enough "prospecting" oil wells to make up for declining production at existing wells as they became depleted. (Sources I've seen do not explain the reason for this, but perhaps the expansion of the Soviet

36 I have so far been unable to discover much about this oilfield. Crimea currently has two oilfields, the Serebryanskoye in the northwestern part of the peninsula and the Oktyabrskoye, an off-shore field. Both, however, were developed after World War II.

37 Officially, the March 1939 decision to create "Second Baku" was made by the XVIII Congress of the Communist Party of the USSR, which the government then implemented. In reality, the decision was made early by Stalin, with the Party rubber-stamping it.

defense industries in the late 1930s might have consumed so much steel that not enough was left for other steel-intensive industries.) The Soviets drilled 153 prospecting wells (with a total depth of about 133,000 meters [437,000 feet]) in 1936, but the number of prospecting wells drilled declined until only 21 were drilled (with a total depth of about 41,000 meters [134,000 feet]) in 1939. The decline in prospecting wells might also explain why the much-touted "Second Baku" of the Volga-Urals region was actually developing rather slowly, producing just 2.2 million tons of oil in early 1941, only about 6% of total Soviet production. The Baku and Groznyy regions still produced the great majority of Soviet oil, as they had in the 1920s and 1930s as well in Imperial Russian times.

Many Soviet oil wells, especially at Baku, also produced natural gas. While the Soviets did not utilize natural gas much until after World War II, they did separate some liquid fuels out of the gas:

- Natural-gas condensate (also known as "natural gasoline"). Natural-gas condensate had an octane rating ranging from 30 to 50 and could only be used in low-compression engines.
- Naphtha ("camp oil", "lighter fluid", "white gasoline"; also known as "heavy gasoline" in Russian), which was also made from petroleum. (In Russian both *nafta* and *ligroin* mean naphtha; in English ligroin is a different petroleum product, corresponding to "heavy ligroin" in Russian.) Naphtha was a cooking fuel and would also become a fuel for some models of Soviet agricultural tractors. The Soviets sometimes called it heavy gasoline because it was heavier than gasoline, being distilled at 100° C (212° F), in between gasoline (*benzin*) at 50° C (112° F) and kerosene (*kerosin*) at 200° C (392° F).
- Heavy ligroin, which in most countries was mostly used a solvent but in the USSR was also used as a boiler fuel.

The Soviet oil industry was not as technologically advanced as the American, British-Dutch (Royal Dutch Shell), or German oil industries on the creation of octane-boosting gasoline additives. The Soviets also greatly lagged behind the Germans on the production of artificial gasoline, another Soviet goal. The industry's backwardness was understandable. The Soviets spent most of the 1920s rebuilding their ruined oil industry and only started to seriously build a modern oil industry in the late 1920s, while countries with advanced oil industries benefited from decades of investment and experience. However, the nature of the Soviet economic system, with its central planning and lack of competitive markets, likely hindered the Soviet oil industry in the 1930s. In a competitive capitalist economy, shortages typically caused profit-seeking companies to invest more to expand production[38]. In the Soviet system, with the oil industry had neither a profit motive nor control over how much to invest. Instead, the central government made the investment decisions.

By about 1937–1938, there wasn't enough gasoline for either the civilian economy or the Red Army. The army, in addition to its peacetime fuel requirements, wanted to build up a strategic fuel reserve in case of a prolonged war. Only two organizations seem to have had enough fuel: the relatively small Soviet Navy had full stockpiles of easier-to-make marine fuel oil, and the NKVD with its many state security functions had gasoline to meet all its needs.

High-octane aviation gasoline, which was used for modern aircraft and many light tanks, was in very short supply. The Soviets made four grades of aviation gasoline with different octane ratings, but many of these grades were only usable by older aircraft. The most modern Soviet aircraft had high-performance engines designed for B-78, the Soviet 78-octane grade of aviation gasoline. This was quite difficult for the Soviets to make and only comprised 4% of their aviation gasoline production. Even with B-78, the late-1930s Soviets had technologically fallen behind the western and German oil industries, which were making 87-octane gasoline for their air forces and commercial aviation. In the early years of World War II, advanced American and British aircraft would switch to 100-octane gasoline.

The Soviets were well aware of their B-78 shortage. In their 1941 economic plans, they ordered a 600,000-ton increase in cracking plant capacity, which would allow greater quantities of all grades of gasoline to be made, including B-78. The plan included finishing already-in-progress expansions of existing cracking plants, new expansions of existing cracking plants, and the construction of new refineries. In addition, eight artificial gasoline plants with a total capacity of 200,000 tons of product per year were ordered to be built. The outbreak of war would soon interfere with many of these plans. Soviet manpower, industrial resources, and finances were all devoted to fighting the war, as the Soviet state was in an existential struggle for survival. Various construction projects were canceled, but, given the Soviets' need for petroleum products, construction of some new refineries continued.

38 Not that capitalism was without problems. The early decades of the automobile age often saw a boom-and-bust cycle for gasoline. Car ownership would outstrip the gasoline supply, with high demand leading to high gasoline prices. The high prices encouraged oil companies to invest to increase gasoline production. This often then resulted in gasoline supply outstripping demand, leading to falling gasoline prices. Lower prices dissuaded oil companies from increasing gasoline production, leading in turn to a new gasoline shortage.

Increasing Soviet domestic fuel needs were so great that Soviet oil industry exports went into deep decline. For example, the Soviets in 1932 exported 6.7 million tons of crude oil and refined products. By 1937, this was 2.1 million tons, then 1.5 million tons in 1938, and just 0.8 million tons in 1939 and again in 1940. Soviet foreign policy also changed the nature of the Soviet oil export effort. In August 1939 the USSR and Germany negotiated a non-aggression pact that split eastern Europe between them. They also negotiated a commercial agreement in which the Soviets would exchange oil, raw materials, and food for advanced German equipment and technology. After this agreement, Soviet oil exports to world markets ceased. The Soviets only exported to German and Italy, which had a separate, earlier commercial agreement with the USSR. The Soviets exported oil to Germany right up until the Germans invaded in June 1941, but only a total of 0.745 million tons was sent[39]. There some irony in the fact that the Communist USSR supplied oil or oil products to all three signatories of the Anti-Comintern Pact: Germany, Italy, and Japan.

The partition of eastern Europe between Germany and the USSR gave the Soviets new oilfields. Germany and the USSR divided Poland between them in September-October 1939. The Soviets annexed the eastern half of Poland, which included oil and gas fields and refineries in what became a western region of the Ukrainian SSR. These oilfields had first been developed in the 19th Century when the region was part of Austria-Hungary and had passed to Poland soon after its formation following World War I. While the oilfields were not major producers like Baku or Groznyy, they were still a welcome addition to the oil-hungry Soviet economy. Although, the actual amount of oil the Soviets gained was minor. The partition of Poland had given Germany about a third of the Polish oilfields and the Soviets the rest. However, Germany also wanted the oil from these Soviet fields. The German-Soviet commercial agreement allocated some Soviet oil to go to Germany; various sources indicate that the amount to be sent was equivalent to the 1939 production of the Polish oilfields under Soviet control. The oilfields thus were still a welcome addition, as they (temporarily) sated the German thirst for Soviet oil, while any increase in production there could go to the Soviet economy.

Fuel shortages continued in early 1941 across the Soviet civilian economy and military. By now, only the NKVD apparently had enough fuel. Even the Soviet Navy was not fully fueled, although this seems due to the Navy trying to build up a strategic reserve of marine fuel oil in case of prolonged war.

39 I do not have figures for how much the Soviets exported to Italy during this time period. I suspect the Soviet exports to Germany were mostly or completely crude oil, which the Germans would refine to their own standards. Exports to Italy likely were mostly crude oil for Italian refineries or fuel oil for the Italian Navy.

In the second half of the 1930s, Soviet-Japanese tensions escalated from border incidents into full battles between Japanese forces in Manchuria and Soviet-controlled forces in the Soviet Far East and Mongolia[40]. With the possibility of war breaking out with Japan, the USSR wanted the Soviet Far East to utilize oil from North Sakhalin as much as possible, to reduce the amount of oil products than had to be sent there from elsewhere in the USSR. North Sakhalin's production kept expanding, but getting the oil to the mainland for refining was a bottleneck. To increase oil transport, a 368-km (240-mile) oil pipeline was built from the Okha oilfields in North Sakhalin across to Sofiysk on the Amur River. The project began in the autumn of 1941 and was finished on 11 June 1942[41]. 10,000 workers, including many from the GULag were sent to work on the pipeline, including in the middle of the brutal Siberian winter. Oil was then shipped by barge from Sofiysk up the river for refining at Komsomolsk-na-Amure. Since barges could not travel the Amur River when it was frozen during the many winter months, the refinery only ran seasonally. (In the 1950s, the Soviets extended the pipeline all the way to Komsomolsk-na-Amure, allowing year-round refining.)

The Komsomolsk-na-Amure refinery played an important support role in the delivery of Lend-Lease aircraft from the US. Thousands of American Lend-Lease aircraft were flown from the continental US to Fairbanks, Alaska and then east to Krasnoyarsk, Siberia. A major product of the refinery was aviation gasoline, used to refuel these aircraft.

Systemic vs Situational Fuel Shortages

During World War II, the Red Army at times faced two different type of fuel shortages: systemic and situational. A systemic fuel shortage meant that the needed fuel (vehicular gasoline, aviation gasoline, diesel fuel) did not exist in sufficient quantity. This could curtail military operations or adversely affect the course of operations. (Other countries also at times had systemic fuel shortages, particularly Germany with both vehicular and aviation gasoline.)

A situational fuel shortage meant that the needed fuel was available in sufficient quantity but could not be supplied to Red Army forces fast enough. This sometimes occurred after a Soviet offensive broke through the enemy front: mechanized forces would surge forward faster than the supply services could bring up fuel. Similarly, on average for the war, 40% of Soviet rail capacity was tied up just transporting fuel to for military, factories, cities, and other activities, which, with the inevitable delays and losses during transportation made it difficult at times to supply the military[42]. (Other countries, particularly Britain, Germany, and the USA, also at times had situational fuel shortages when exploiting breakthroughs.)

40 "Soviet-controlled" forces includes Mongolian forces in Mongolia as well as Soviet forces in the USSR and Mongolia.

41 https://magazine.neftegaz.ru/articles/nefteservis/543122-neftegazovye-vekhi-velikoy-pobedy-maloizvestnye-istorii-velikoy-otechestvennoy-voyny/

42 A.K. Sokolov; "Neft i Voyna 1941–1945 gg." ["Oil and War 1941–1945"]; 2018; https://statehistory.ru/5779/Neft-i-voyna-1941–1945-gg/

When I cover Soviet wartime fuel shortages in the text below, I always mean systemic fuel shortages: the Soviets simply did not have enough fuel.

Germany invaded the USSR on 22 June 1941, smashing the Red Army in the border regions and driving deep into the USSR in a matter of weeks. The USSR was fighting for its existence, and the Soviet oil industry immediately faced severe challenges.

The Red Army experienced fuel shortages throughout the summer and autumn. In June 1941 the Red Army's fuel service had 247 depots for fuel[43] (a mixture of "stationary" storage depots and "fuel bases" which may have had some degree of mobility), plus 2,000 rail tanker cars. It had 653,000 tons of fuel[44], which included vehicular gasoline, aviation gasoline, and diesel fuel. The People's Commissariat of Defense also had a fuel reserve of 1,340,000 tons of petroleum products. About 90% of the fuel service's depots were located in the western border regions of the USSR, and 73 stationary depots with at least 170,000 tons of fuel were lost in the first month of operations. Over the next three months, the Red Army lost another 460,000 tons of fuel, including 300,000 tons of its strategic fuel reserves[45], with only about 60,000 tons being evacuated from regions falling to the enemy. In the first six months of the war, 506,000 tons were lost (176,000 tons from the fuel service and 330,000 tons from the reserves) with only 66,000 tons being evacuated. The Germans captured some of the fuel that was not evacuated, but Soviet scorched earth tactics likely burnt much of it.

The Soviet 1941 state defense plan was likely a major reason so much fuel was stored in the border regions. The plan called for Red Army forces in the border regions to absorb the blow of an invasion and halt it, using reinforcements from the reserves if necessary. Then, the reserves were to counterattack, surround, and destroy the enemy, followed by an advance into the enemy's territory. For this plan to work, the fuel must have been stockpiled where the Soviets thought they would need it. Unfortunately, the plan failed to work, and the rapid, deep enemy advance led to loss of fuel stockpiles in the border regions.

Even after the surprise and shock of the initial invasion wore off, the Soviets continue to lose much fuel in the war zone in 1941. During most subsequent enemy advances, it seems like the Soviet high command tried to implement the state defense plan again, just deeper in the

43 This and similar information is from https://burneft.ru/archive/issues/2020–05/4a, supplemented by Vagit Alekperov (*Oil of Russia: Past, Present & Future*; 2011).

44 The site actually states the depots had a total capacity of 653,000 cubic meters, but elsewhere it uses metric tons and apparently assumes a volume of one cubic meter is a mass of one ton.

45 Alekperov states that losses were the first six months, the People's Commissariat for Defense lost 176,000 tons of day-to-day fuel supplies and 330,000 tons of mobilization reserves. Only around 66,000 tons were evacuated.

USSR: forces at the front were to halt the enemy, reserves were to counterattack and destroy the enemy. This led to continued loss of much fuel.

Lack of transport was likely another major factor contributing to loss of fuel in 1941. Soon after the invasion began, the Soviets began evacuating important industrial enterprises and over 10,000,000 civilians to the east, away from the invaders. This consumed much of the capacity of the railroads and the internal waterway transportation system. (Road transport only played a minor role, as the Soviet intercity road network was quite primitive. Marine transport also only played a minor role, mostly being restricted to evacuating Soviet ports along the Black Sea.) The remaining transportation capacity was insufficient for all Soviet needs and quickly affected the oil industry at Baku: 573,000 tons of crude oil and 1,613,000 tons of refined oil products supposed to be shipped from at Baku accumulated there waiting for transport in 1941[46]. Oil and oil products that were able to be sent from Baku could take up to 45 days to reach their destinations[47]. With this in mind, it seems likely that lack of transport also affected the ability of the Soviets to evacuate fuel from the war zone, especially since transport would have had to be secure at short notice following an enemy breakthrough.

Other reasons could also have contributed to the Soviets evacuating so little fuel from the war zone:

- Luftwaffe interdiction of the battle zone may have made it difficult to evacuate fuel once the Red Army began to retreat from an area.
- There may have been insufficient storage facilities in the rear areas to handle evacuated fuel. The Soviet leadership did not anticipate that the enemy would advance so deep

46 *Source:* https://magazine.neftegaz.ru/articles/nefteservis/543122-neftegazovye-vekhi-velikoy-pobedy-maloizvestnye-istorii-velikoy-otechestvennoy-voyny/
Later, the extremely cold winter of 1941–1942 also adversely affected the water transport of oil and oil products. Extensive ice on the northern Caspian Sea and southern Volga River idled much of the Caspian tanker fleet. Caspian Sea icebreakers were unable to cope with the winter (perhaps in part because one or more of them had been converted into gun boats in the autumn of 1941). The worse month seems to have been February 1942, when only 25,000 tons of oil products reached Astrakhan, out of the 266,000 tons it was supposed to have received, a 90.6% reduction in deliveries. (See https://statehistory-ru.translate.goog/5779/Neft-i-voyna-1941–1945-gg/?_x_tr_sl=ru&_x_tr_tl=en&_x_tr_hl=en-US&_x_tr_pto=ajax,elem).

47 Although the source does not go into details on this, it is logical to assume that fuel for the Soviet military received priority for transportation. I suspect a lot of the oil products accumulating at Baku were various grades of fuel oil for industrial furnaces and boilers, perhaps since factories being evacuated were not using fuel. I also wonder if part of the crude oil accumulating at Baku might have been intended for Ukrainian refineries at Odessa and Kherson that went out of production and were evacuated east in July 1941.

into the USSR and likely concentrated limited Soviet resources into building most storage facilities near the border areas rather than in the rear areas[48].

The German invasion itself and the subsequent Soviet mobilization of manpower both disrupted many parts of the Soviet economy in 1941, but oil production that year slightly increased over that of 1940. Much if not all of the gain likely occurred in the first part of 1941, before the war began. Soon after war broke out, many oil workers went into the military and were replaced by teenagers and, especially, women. Workers' shifts were lengthened; officially to 11 hours, per a Soviet edict on 26 June 1941 that allowed management to impose a mandatory 3 hours of overtime per day, but in practice at least for the oil industry daily shifts of 12–14 hours became common. Weekend work became mandatory and all vacations were canceled. While some oilfields and refineries in Ukraine were lost in 1941, the Soviets' high-output oilfields and refineries were far from the front lines and kept up production. At the Baku oilfields, women made up about half of the work force, and Baku managed to produce 23.5 million tons of oil, 75% of the USSR's total production and 1.2 million tons more than 1940.

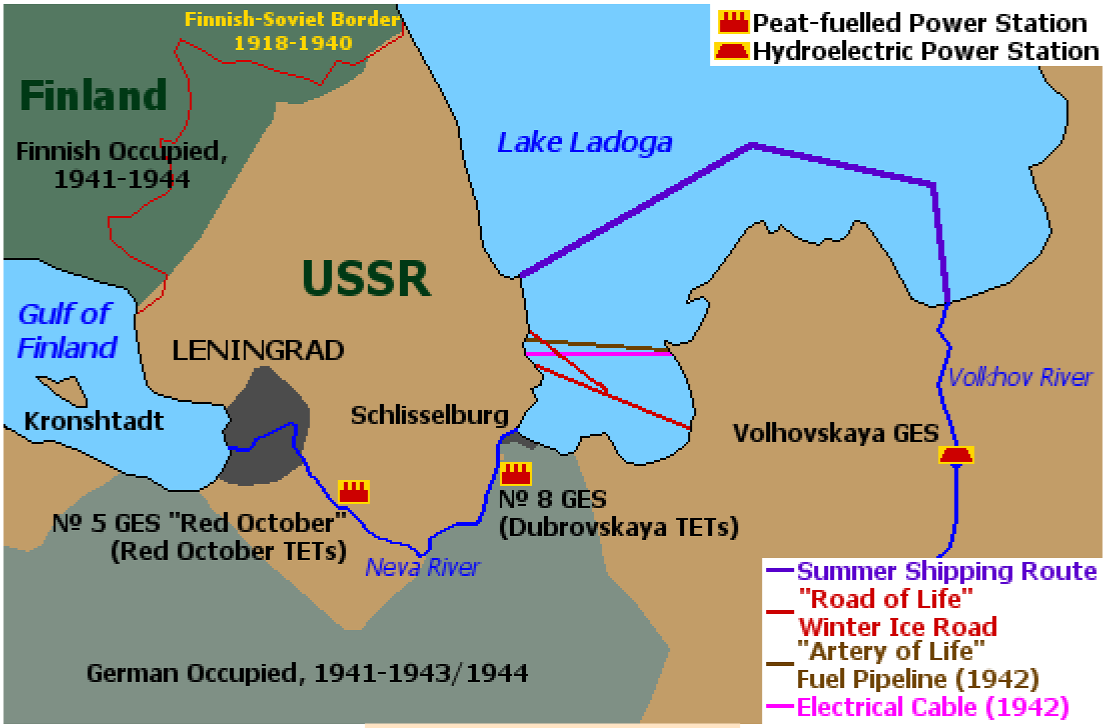
High-intensity combat operations created a huge demand for fuel. This was met as much as possible by the Soviets allocating top priority for fuel deliveries to the military and the defense industries. For example, the military's and the defense industry's share of gasoline production went from about 22% in 1940 to 68–74% in 1942–1944, while their share of diesel fuel production went from about 10% in 1940 to 62–71% in 1942–1944. The civilian economy had to get by with whatever was left.

Although no sources I've seen go into this, the huge equipment losses the Soviets suffered in 1941 like made their fuel situation a bit less bleak. In the first few weeks of fighting, the USSR lost tens of thousands of fuel-consuming trucks, tanks, tractors, and aircraft. The vehicle losses were certainly a disaster, especially for trucks, modern aircraft, and modern tanks, but it did end fuel consumption of the many thousands of obsolete aircraft and tanks that had little actual combat value.

The start of the ended the Soviets' diplomatic isolation from the countries opposing Germany. Britain and the USA both soon began sending military and material aid to the USSR, including high-octane aviation gasoline. The first British convoy to arrive at

48 In support of this last point, the Soviets had dismantled significant parts of the "Molotov Line" of fortifications along the old 1939 Polish-Soviet border to build a new line along the more western German-Soviet border. This indicated the high command did not anticipate needing to mount a major defense along the old line. Similarly, the Soviets made no effort to create hidden stockpiles of weapons and supplies to fight a partisan war in the rear of any invaders. Instead, they had actually dismantled existing caches that had been created in the 1920s for this purpose.

Arkhangelsk on 31 August 1941 included lubricants and aviation gasoline. The US sent significant amounts of petroleum products in its first shipments, consisting of about 132,000 tons[49] through 30 September 1941 (78.4% of the total tonnage sent). Most of the petroleum products sent were aviation gasoline, its equivalent[50], and octane-boosting additives.



Leningrad area, 1941–1944

In September 1941, the German advance cut all overland communications to Leningrad, beginning an epic siege of the city that lasted for years. The city was not completely isolated, as Soviet ships could reach the enclave across Lake Ladoga. The Soviets shipped in supplies and sent out industrial equipment and some civilians. The Soviets did not have enough shipping to meet all the supply needs of the enclave. Worse, the onset of winter soon froze the lake, creating a supply crisis. While the city's tragic food shortage in the winter of 1941/1942 is well known, what is less known is that the city faced severe shortages of all liquid fuels: vehicle gasoline for trucks and some light tanks, aviation gasoline for aircraft and some light tanks, and diesel fuel for medium and heavy tanks. The Soviets built an ice road, the "Road of Life", across the lake and used trucks to haul supplies (see picture above), but it was impossible to bring fuel in any significant quantity this way.

49 All tons are metric tons (1,000 kg). Many sources on Allied aid to the USSR use short or "US" tons (about 0.91 metric tons per short ton) for US deliveries and long or "Imperial" tons (about 1.02 metric tons per long ton) for British deliveries, often without specifying which ton they are actually using. I have tried to catch this and correct to metric tons. Thus, the 132,000 tons mentioned above is about 146,000 short tons.

50 This will be covered in more detail later on "light gasoline fractions".

When the lake thawed in the spring of 1942, Leningrad's stockpiles of liquid fuels were approaching exhaustion, with just 100 days supply remaining. As an expedient, rail tank cars of fuel were railed to the eastern lake shore, detached from their rail carriages, and floated across in the lake to the Leningrad enclave. This, too, was inefficient and insufficient, but it bought the Soviets time to lay a fuel pipeline on the bed of the lake[51]. On 25 April 1942 the Soviets ordered the pipeline to be laid and operational within 50 days. Preparations were complete by 26 May, which saw the first attempt to lay part of the pipeline. This failed because of a storm. Work began again on 31 May, and the entire line was in place on 16 June, with operation beginning a few days later. This "Artery of Life" could send 400–600 tons of fuel per day to the enclave. It remained open until March 1943, pumping a total of about 50,000 tons of fuel to Leningrad.

The pipeline was closed down in March, as in January 1943 the Soviets had driven the Germans back from the south shore of Lake Ladoga, opening a narrow, overland corridor into the Leningrad enclave. The corridor ran across extensive swamplands and was without a road or rail line to the enclave. Attempts to expand the corridor failed against a stiffening German defense. The only option to get supplies to Leningrad was to build a single-track 33-km (20.5-mile) railroad across this corridor. 5,000 civilian workers, mostly women from Leningrad, built the line, including three bridges, in 17 days. German artillery shelled the workers, earning the route the name the "Corridor of Death". (Officially for propaganda purposes it was called the "Road of Victory".) The entire line was mass of expediencies: no proper rail bed, logs instead of sleepers, very tight turns, and steep grades. The rail line needed constant maintenance and repair to keep it in operation. Trains could only operate on the line at very slow speeds. The line was not only in range of German artillery and mortars, but in places it was in view of German artillery spotters. Trains could only run at night when spotting was difficult. To maximum traffic, trains were run one after another at very close intervals, guided by hand signals by people stationed along the tracks. Trains only ran one way each night; one night into Leningrad and the next night out. The first train made the run on 7 February 1943. By late March, 20–25 trains per night were making the dangerous run. German fire damaged dozens of locomotives and damaged or destroyed about 500 rail cars. Very incomplete data suggests that human casualties were in the hundreds. Nonetheless, the Corridor of Death kept Leningrad supplied. In late January 1944,

51 The Soviets claim the idea for the pipeline came from Nina Sokolova, the USSR's first female diver. By 1941, she was chief engineer in the 27th Detachment of EPRON (for ***E****kspeditsiyu* ***P****odvodnykh* ***R****abot* ***O****sobogo* ***N****aznacheniya*, Expedition for Underwater Operations for Special Purposes) at Leningrad, where her diving recovered supplies from sunken barges and helped lay an underwater telephone line to the city. For the fuel pipeline, Sokolova spent 644 hours diving underwater in the cold springtime waters of Lake Ladoga.

the Soviet finally drove the Germans back from the Leningrad area and soon restored regular communications to the city. In March, the Road of Victory ceased operations and was soon dismantled.

The Kherson cracking plant

Kherson was a Ukrainian SSR city and port on the Dnepr River near the Black Sea. In 1935, the Soviets began building a cracking plant there, which became operational in 1938. Its main product was gasoline, made from oil shipped over the Black Sea from Baku or perhaps the North Caucasus. In July 1941, the plant, its workers, and their families were evacuated to Syzran on the central Volga River, along with the Odessa cracking plant, which had also went into operation in 1938, making gasoline from Baku oil. The combined plants went back into production at Syzran in late 1941 or 1942. The Soviets liberated Kherson in March 1944. In 1946, the Soviets began construction of a new refinery on the site of the old one, which went into production in 1951. Odessa was liberated in April 1944, with a new refinery being built there in 1949–1950.

Note: The above picture allegedly is the 1938 Kherson cracking plant, but the quality of the photography strongly suggests it is actually the rebuilt plant and was taken in the 1950s or later.

In the opening weeks of the war, the Soviets lost the oilfields in western Ukraine plus two refineries there (Drogobych and Nadvoryanskiy). Determined to prevent their modern Ukrainian cracking plants from being captured or destroyed, the Soviets evacuated both the Odessa and Kherson plants to Syzran in July, before Axis forces were close to either city. At some point in the summer, the Ukrainian cracking plant at Osipenko[52] was also evacuated, to

52 he city of Berdyansk on the Sea of Azov was renamed Osipenko in 1939, in honor of Polina Osipenko, a word-record-setting female aviator who died along with Anatoliy Serov in a training flight when their UTI-4 (an I-16 trainer) crashed during an

Krasnokamsk, a small city in the Urals region just west of Perm. The refinery went into operation in 1943 there, as the second refinery at Krasnokamsk.

In early September 1941, during the Battle of Kiev in which the Germans smashed the Soviet forces defending Ukraine, the Romny oilfield fell to the Germans. Some sources indicate the German high command saw the capture of Romny as an important success, indicating that Romny oil would soon be supplying the Germans and that the North Caucasus oilfields would soon be conquered. However, the Soviets extensively demolished the Romny oilfield, such as by plugging the wells with concrete. Romny in any case was actually a minor oilfield and was so damaged that the German oil team sent there essentially had to rebuild it from scratch. They only managed to extract a total of about 4,000 tons of oil[53] by September 1943 when the Soviets recaptured the area for good.

For Soviet oil and fuel production overall, these Ukrainian losses were relatively minor. The German general advance in Ukraine after its September victory did inflict a major energy loss on the Soviets, but it wasn't in oil. They captured the Donbass coal and industrial region in October, depriving the USSR of about half its coal production and immediately creating an energy emergency (see the section on Coal). With the threat of further German advances east from Ukraine into the major Soviet oil-producing areas of southern Russia and the Transcaucasus, the Soviets started to dismantle parts of the North Caucasus and Baku oil industries, beginning to evacuate them to the central Volga River area and points east. As with the drive on Moskva, the drive toward the Caucasus east sputtered out in the autumn mud and early winter cold and snow, leaving the North Caucasus out of reach for 1941.

The Soviets launched their winter counteroffensive in early December 1941 and drove the Germans back from the gates of Moskva. With the Soviet high command expecting to achieve a major victory in the offensive, the Soviets halted oil industry evacuations on 12 December 1941[54]. Some, perhaps all, of the dismantled equipment was reinstalled at its original sites.

During the winter, offensives were launched across almost the entire front lines from Lake Ladoga near Leningrad to the Black Sea. During this period, the Soviet oil industry was finally able to meet all the Red Army's fuel needs[55]. However, it should be noted that Soviet military fuel needs were perhaps at their lowest for the entire war. The Soviet mechanized

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aerial acrobatic maneuver. The city of Osipenko was renamed Berdyansk in 1958 and now in Berdiansk, Ukraine.

53 *The Caucasus 1942–43: Kleist's Race for Oil*; Robert Forczyk; 2015.

54 Evacuation of the Groznyy refineries stopped on 12 December. (*Source:* M.M. Abuevna; dissertation, *Stanovlenie Protsessa Pervichnoy Pererabotki Nefti na Groznenskikh NPZ* [*Establishment of Primary Oil Refining Processes at Groznyy Oil Refining Plants*]; 2018.) By implication, this decision was for the entire North Caucasus and Baku oil industry.

and air forces were greatly under-strength. Many thousands of tanks and aircraft had been lost in 1941, but the evacuation of industry disrupted production, temporarily greatly decreasing the number of tanks and aircraft being sent to the Red Army. Also, the cloudy winter weather reduced flying time, and winter blizzards could limit ground operations.

The Soviet winter offensive failed to defeat the Germans and itself petered out in the spring thaw. An attempt to renew the offensive and liberate Kharkov in May failed disastrously. With German reinforcements arriving in the theater, the Germans now prepared to launch their summer offensive, planning to capture the Soviets' major oilfields and refineries. The Soviets had other plans.

German troops advancing on Soviet oil storage facilities at Maykop, set on fire by retreating Soviet troops, 1942

At the start of 1942, Baku and the North Caucasus region were producing 85% of the USSR's oil. Germany, which was now caught in a protracted war against Britain and its allies, the USSR, and the USA, wanted to gain control of greater oil supplies in order to enhance its ability to fight the war. The Germans were also well aware that the Baku-North Caucasus region was producing the bulk of Soviet oil[56]. They expected capture of the region would

55 This and some other points in this section are from Alexander Matveychuk; "Oil Front: Soviet Oil Industry during the Great Patriotic War"; 2020; https://www.gazprom-neft.ru/press-center/sibneft-online/archive/2020-may/4620374/

56 In early 1942, the Germans surmised the region was supplying 90% of Soviet oil, with Hitler claiming 92% at one point. See Joel S. A. Hayward; "Hitler's Quest for Oil: The Impact of Economic Considerations on Military Strategy, 1941–42"; *Journal of Strategic Studies* Vol. 18 No. 4; December 1995; https://www.researchgate.net/publication/248951446_Hitler

collapse the Soviet economy and war effort. They also knew that large amounts of the regions' oil was shipped north on the Volga River, together with Allied air arriving from Iran. They believed that interdicting the Volga in the Stalingrad region would hurt the Soviet war effort even before the oil resources of Baku-North Caucasus were captured. The German summer offensive accordingly targeted the Stalingrad region and the Soviet oilfields and refineries in the North Caucasus and Baku regions. The considerations were mostly correct, and had the Germans taken the oilfields, the Soviets would have greatly reduced fuel supplies for its tanks, other military vehicles, and aircraft. At a minimum, this would have reducing the Red Army's ability to strike back against the Germans.

Some western historians have criticized the German plan as unachievable even if the Germans had captured the oilfields, due to lack of transport capacity to bring the oil back to refineries in Germany or Romania. The Germans were aware of this problem: the rail network would only be able to handle a small volumes of oil shipments. Similarly, shipping oil from the Black Sea up the Danube could not be done, because capacity of the Danube barges was already taken up carrying Romanian oil to Germany. The Germans would have to clear the Black Sea of the Soviet Navy and the central/eastern Mediterranean Sea of the Royal Navy to ship oil to Axis Mediterranean ports. This was a longer turn goal, but would be achieved if the Axis 1942 summer offensives in the USSR and North Africa succeeded. Further, most of the oil would actually stay in the east.

The plan of the Reich Ministry of Economics was that the Germans would capture and quickly repair the Baku-North Caucasus oil fields and refineries, resulting in a production of at least 600,000 tons of oil and oil products per month[57]. 300,000 tons would be for use by the Axis forces, and I believe some if not most this likely would remain in the east for the Axis military forces there. The other 300,000 tons would be used in the German-occupied areas of the USSR, for agriculture and industry there. Ukraine was the prime area for agriculture and industry in the German occupied zone, and there was an oil pipeline running from Baku-North Caucasus directly into Ukraine. The Germans knew this and planned to capture it. The real flaw in the plan, other than the huge mountain range between the Germans and Baku, was the assumption that the Germans could quickly capture and repair damage to

%27s_Quest_for_Oil_The_Impact_of_Economic_Considerations_on_Military_Strategy_1941-42.

57 Information from E.M. Malysheva ("*Rossiyskaya Neft i Neftyaniki v Gody Velikoy Otechestvennoy Voyny*" ["Russian Oil and Oil-Workers in the Years of the Great Patriotic War"); 2008; http://economicarggu.ru/2008_4/10.shtml (in Russian).

Soviet oil infrastructure[58]. As we will see, the Soviets realized the intent of the German 1942 offensive and were determined to wreck their infrastructure to deny it to the Germans.

The Oil Campaign, the German 1942 Summer Offensive

"Comrade Baybakov, Hitler is rushing to the Caucasus. He has announced that if he fails to capture Caucasian oil, he will lose this war. Do whatever you need to make sure no single drop of oil falls into German hands. Keep in mind that if you leave even one ton of oil to Germans, we will shoot you."

—1942 remarks by Stalin to N.K. Baybakov, Deputy People's Commissar of the People's Commissariat of the Oil Industry.

After a short pause, Stalin then added:

"If you destroy the oilfields, but Hitler fails to reach them and we are left without fuel, we will shoot you again."

58 The Germans did plan for damage. They had almost 100 oil drilling rigs available from the 1939–1941 period of German-Soviet economic cooperation before the German invasion. The Soviets had ordered these from Germany, but the Germans managed to delay sending them to the USSR. Together with new production, the Germans planned to send 220 drilling rigs from Germany to the captured Soviet oilfields in 1942. On 19 July 1942, with the summer offensive so far going very well, the Germans anticipated success of the oil plan and ordered another 70 rigs for 1943 and 220 for 1944. See Robert Goralski and Russell W. Freeburg; *Oil and War*; 2021; https://www.usmcu.edu/Portals/218/Oil&War_WebUPDATE.pdf.

Baybakov survived this assignment and rose to become the People's Commissar of the People's Commissariat of the Oil Industry in November 1944. (Other versions of Stalin's remarks exist with different wording, but all have the same threats to Baybakov's life.)

Operation Edelweiss (*Edelweiss* is a mountain flower) was one part of the 1942 German offensive, with the objective of capturing the North Caucasus and Baku oilfields and refineries. The other part, Operation Fischreiher (*Fischreiher* is a grey heron, literally "fish heron" in German), was the drive on Stalingrad, initially intended only to secure the left flank of the German forces in the North Caucasus. The symbolism of capturing "Stalin's City" would increasingly dominated Hitler's attention and the German offensive effort.

As Edelweiss forces advanced into the North Caucasus and Fischreiher forces reached the Volga River north of Stalingrad, Soviet shipment of oil and oil products from the North Caucasus and Baku to the rest of the USSR was severely disrupted. The Soviets had shipped these products north by rail and barge. The main rail route ran through Rostov-na-Donu, which the Germans soon captured. A lower-capacity route remained open from Tikhorets to Stalingrad, but this too was soon lost. Aware of the vulnerability of their rail communications in the area, the Soviets earlier had decided to build a new rail line up the west coast of the Caspian Sea, sometimes laying the rails directly on the steppe without building a rail bed. The line became operational on 4 August 1942, the day before the Tihkorets connection was lost. The new line carried oil north and supplies south. It was by far the shortest route between Baku and Stalingrad, only about 1,200 km (750 miles), but it had rather low capacity[59].

The main barge route ran up the Volga River from Astrakhan, which received large quantities of oil and oil products being shipped north up the Caspian Sea from Baku as well as lesser quantities being shipped west across the Caspian from Gurev[60]. The Luftwaffe from July 1942 bombed and strafed river traffic on the Volga and dropped mines in the river. This sunk or damaged many river craft including oil barges, with the loss of 115,000 tons of oil and oil products up to 23 August. On that date, German ground forces reached the Volga north of Stalingrad and interdicted river traffic. The barge route was now cut. This did negatively impact the Soviets, but not to the extent that the Germans had thought it would. As an emergency expedient, the Soviets began shipping oil from Baku north to Gurev (for

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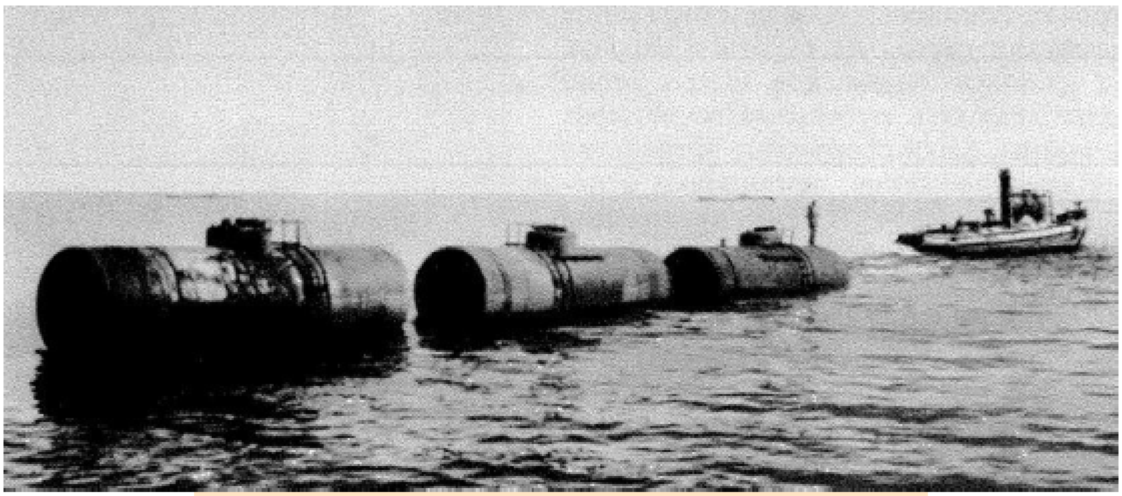
59 The Soviets decided to built this Kizlyar-Astrakhan line in August 1941, but serious work appears not to have begun until October, after multiple German breakthroughs in Ukraine raised concern that they might break into the North Caucasus.

60 It is unclear how much Gurev was being used to ship oil and oil products to the Volga via Astrakhan by this time. A major refinery had been built in Orsk, with a rail line and pipeline network running from the Dossor and Emba oilfields to Orsk. My impression is that some oil was still being shipped from Gurev to the Volga, but I do not have a source on this.

subsequent rail or pipeline transport north) and east across the Caspian to Krasnovodsk[61] (for subsequent rail transport on the Trans-Caspian Railway). Although the Sovietw made heroic efforts to ship oil and oil products on these routes, both had much less capacity than the Volga route. Using the Trans-Caspian Railway in particular meant a long, slow haul across the vast distances of Soviet Central Asia, from Krasnovodsk to east to Tashkent and then northwest to the European part of the USSR. For example, shipping fuel from Baku to Stalingrad via Central Asia involved a journey of about 5,000 km (3,100 miles), compared to the shortest, 1,200-km rail route between the two cities[62].



Floating oil tankers being towed on the Caspian Sea

With most of the rail lines leading north cut, the Soviets were left with more oil tanker rail cars in the Transcaucasus than they could use on the one remaining rail line, while the regular oil shipping on the Caspian Sea was insufficient to carry all the oil and oil products being produced at Baku. As an expedient, the Soviets used the rail tankers as barges: the tank portion was separated from its rail carriage and only filled about 50–67% with oil or oil products, which allowed the tank to float. Several tanks would be strung together and towed as a “sea train” (*morskoy poezd*) or “caravan”(*karavan*) by a tug boat or motor ship across the Caspian Sea. According to one source, all these sea trains went to Gurev, not Krasnovodsk[63],

61 The Soviets had renamed numerous places *Krasno-xxx*, meaning “Red-xxx”, like Ekaterinodar (“Ekaterina’s Gift [Ekaterina being “Catherine the Great”]) becoming Krasnodar (“the Reds’ Gift”). Krasnovodsk was not one of these! In the 19th Century during the Russian Empire’s conquest of Central Aria, the Russians built at fort, later a settlement, on the Caspian Sea bay of Kyzyl-Su (“Red Water”, as the bay of the area had plentiful red plankton) and named it with the Russian equivalent, Krasnovodsk. It is now the city of Türkmenbaşy in Turkmenistan.

62 The distance from Baku to Stalingrad was important since fuel refined in Baku was at least in part sent to Stalingrad during the battle there between the Germans and Soviets. Crude oil from Baku was not shipped to Stalingrad but to Saratov for refining there, a somewhat longer journey.

63 https://varandej.livejournal.com/877447.html

although another source claims they went to both ports[64]. Soviet motor ships also began towing oil barges to Gurev at this time[65].

In July 1942, the German advance threatened Krasnodar. The Soviets evacuated as much of the refinery there as they could, sending it to Ufa, and then destroyed the rest of the facility before it fell to the enemy in August. Baybakov, the official in charge of denying oil to the Germans, had organized special demolition units staffed with experienced oil workers[66], as they would know what to destroy and how best to destroy it as quickly as possible.

The Germans also captured the Maykop oilfields in August, but only after the Soviets evacuated and then destroyed as much of the oil industry infrastructure there as they could, including the oil pipeline[67]. Maykop refinery equipment was sent to Blagoveshchensk on the Amur in the Soviet Far East[68]. The Soviets were determined to prevent the Germans from capturing intact oilfields or refineries. The State Defense Committee (GKO) ordered the Groznyy refineries to be dismantled and evacuated, again with some refinery equipment being sent to Blagoveshchensk[68]. This saved the equipment but also immediately reduced the amount of fuel, including aviation gasoline, going to the military. The GKO accordingly soon ordered increased production of vehicular gasoline, aviation gasoline, and other petroleum products at refineries in the safer parts of the country. To make sure everyone took the situation seriously, on 1 October the GKO ordered L.P. Beriya to "monitor and provide daily assistance to the People's Commissariat of the Oil Industry". Beriya was the ruthless head of the NKVD and in charge of the Soviet state security apparatus including the secret police and GULag. Beriya's "monitoring" could be deadly; as recently as January 1942 with Stalin's express approval and grant of extra-judicial authority, he had the NKVD sentence 17 Soviet

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64 https://magazine.neftegaz.ru/articles/nefteservis/543122-neftegazovye-vekhi-velikoy-pobedy-maloizvestnye-istorii-velikoy-otechestvennoy-voyny/

65 http://militera.lib.ru/h/kovalev_iv/07.html (from I.V. Kovalev; *Transport v Velikoy Otechestvennoy voyne (1941–1945 gg.)* [*Transport in the Great Patriotic War (1941–1945)*]; 1981).

66 A.K. Sokolov; "Neft i Voyna 1941–1945 gg." ["Oil and War 1941–1945"]; 2018; https://statehistory.ru/5779/Neft-i-voyna-1941–1945-gg/

67 Many works on the 1942 campaign simply ignore the pipelines. E.M. Malysheva ("*Rossiyskaya Neft i Neftyaniki v Gody Velikoy Otechestvennoy Voyny*" ["Russian Oil and Oil-Workers in the Years of the Great Patriotic War"]; 2008; http://economicarggu.ru/2008_4/10.shtml, in Russian) notes that the Soviets destroyed the pipeline in the Maykop area as part of their demolitions to prevent the Germans capturing oil infrastructure there.

68 Blagoveshchensk was more remote from the North Sakhalin oilfields than were the Far Eastern refineries at Krasnoyarsk and Komsomolsk-na-Amure, and the city had no oilfield in its region. It is unclear why refinery equipment was sent there, but multiple sources state this happened. I have also found no evidence that a refinery was actually established in Blagoveshchensk either during the war or immediately afterwards, and a short history of the city specifically states evacuated Soviet industry was not set up in the city, because of its proximity to the border with Manchuria and vulnerability to Japanese attack. My suspicion is that the equipment was sent to the city but later sent on to augment the already-existing Far Eastern refineries.

generals to death. With typical NKVD cruelty, they were executed the next month on Red Army Day, which celebrated the official founding of the Red Army on 23 February 1918[69].

All across the North Caucasus and Baku oil regions, the Soviets evacuated equipment, permanently closed down oil wells, prepared wells and refineries for demolition, and evacuated 11,000[70] oil workers and technicians. Since the Soviet Union was no longer shipping petroleum or petroleum products across the Black Sea, one of the Baku-Batumi pipelines, eight of its pumping stations, part of the Groznyy-Tuapse pipeline, and another short pipeline in the North Caucasus were dismantled and evacuated. (Also, new pipes for oil pipelines were in short supply, as the Ukrainian factories at Dnepropetrovsk and Mariupol that made oil pipes had terminated production[71].) After the Battle of Stalingrad, the Soviets used these resources plus US Lend-Lease equipment to build a 685-km (426-mile) or 655-km (sources disagree) pipeline from Astrakhan to Saratov up the Volga River valley[72]. Construction started in April 1943 and was finished in November of 1943. The pipeline could carry oil products and at least during the war was used primarily or solely to transport kerosene. This pipeline allowed the Soviets to send kerosene north without having to ship it by barge on the Volga.

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69 Some of these generals had been arrested in 1941 before the start of the war during an NKVD purge of the army. Others had been arrested during the war. Most were innocent of the charges (for example, being accused of being a Germany spy since he had been a Swiss Communist before emigrating to the USSR) or were victims of events out of their control (for example, losing most of his command's aircraft in the opening days of the German invasion). The USSR rehabilitated many of these general after Stalin died.

70 Some people in this 11,000 total were evacuated in 1941.

71 Although I have not yet found information on this, it seems likely these factories had been repurposed for military production, likely the production of mortar tubes. The factories most likely would have been evacuated out of Ukraine in 1941 as the Germans overran the region. Interestingly, some sources claim the Saratov-Moskva natural gas pipeline that began being laid in 1944 resorted to using mortar tubes for some of its construction due to pipe shortages.

72 http://www.hist.msu.ru/Labs/Ecohist/OB11/USSR/kostornichenko.html and https://magazine.neftegaz.ru/articles/nefteservis/543122-neftegazovye-vekhi-velikoy-pobedy-maloizvestnye-istorii-velikoy-otechestvennoy-voyny/

German forces in the Caucasus Mountains, 1942

By late August, the German advance was greatly slowing slow down in the North Caucasus, as German troops advanced into the difficult terrain of the Caucasus Mountains, as Soviet defenses stiffened, and as difficulties bringing supplies forward meant the German mechanized forces kept running out of fuel. In September, the German offensive reached the northwestern edge of the Malgobek-Mountain oilfield in the Caucasus Mountains and captured part of it, although as elsewhere the Germans did not capture any intact oil wells.

The Germans also approached the Groznyy oilfields and in August-September parachuted special operations teams into the region to link up with anti-Soviet Chechen rebels operating in the area. Many Chechens were restive under the Soviets, and small Chechen insurgent groups had been in rebellion against the Soviets even before the Germans invaded the USSR. The onset of war had cause the groups to grow, including armed Chechens deserting from the Red Amy, and the approach of the Germans in 1942 caused even some Chechen Communist Party leaders to abandon Groznyy and flee to the mountains. The Germans thus had somewhat realistic hopes that the Chechens rebels would them. One goal was to launch a surprise attack from the rear to capture the Groznyy oil refineries just before the German offensive was to reach the Groznyy oilfields. However, the German offensive stalled north of Groznyy, dooming the plan. Instead, in October, Luftwaffe bombing damaged or destroyed much of the oil industry infrastructure the Soviets had been unable to evacuate.

Grozneft Oil Production, 1940–1945 (thousand tons)

Year	Oil Production
1940	2,345
1941	3,046
1942	approximately 1,400
1945	approximately 850

The Germans also captured most of Novorossiysk, an oil terminal on the Black Sea, and bombed the oil facilities at Tuapse, another Black Sea oil terminal. The Soviets had earlier in 1942 evacuated Tuapse's refinery, so only the port and oil storage facilities were damaged.

In September 1942, the Soviets declared martial law across all of the Transcaucasia area, including the Baku oil center. Even though the Germans were still far away from Baku, their advance into the North Caucasus had caused some panic and desertion at Baku. Both railroad and Caspian Sea transportation began partially disrupted, with cargo including military weapons and supplies being sent to the wrong destinations or just abandoned. Some trains with food supplies were plundered by the people in the region. Under martial law, Soviet officials and security forces were sent in to restore order[73].

By late September, the German offensive in the North Caucasus had mostly petered out. The battle for control of Stalingrad siphoned off supplies and reinforcements that could have gone to the North Caucasus. One major problem for the Edelweiss offensive was getting supplies to the front line forces, particularly fuel to the mechanized units. The Germans essentially had only a single rail line running from Rostov-na-Donu to the front. Although the Germans regauged the line fairly quickly from Soviet broad gauge to German standard gauge, work to increase its capacity went slower. The Don River was also a supply bottleneck. The Soviets had destroyed all the bridges across the Don at Rostov, forcing the Germans to ferry supplies across the river until a new rail bridge was completed there in October. Luftwaffe air transports did fly fuel to the front, but not in sufficient quantity to maintain a continuous offensive. The slowing of the Edelweiss offensive due to supply difficulties allowed the Soviets to rebuild and reinforce their defenses. The German offensive was not quite spent, as forces sporadically lurched forward in places in October and

73 A.K. Sokolov; "Neft i Voyna 1941–1945 gg." ["Oil and War 1941–1945"]; 2018; https://statehistory.ru/5779/Neft-i-voyna-1941–1945-gg/

November. After the Soviets surrounded Axis forces at Stalingrad in November, the German forces in the North Caucasus went over to the defensive.

The Edelweiss offensive did manage to decrease Soviet oil and fuel production, but Baku, the main prize, remained completely untouched by the Germans. Why didn't the Germans bomb Baku's oil infrastructure in October when they bombed Groznyy's? Baku was general regarded as being very vulnerable to bombing, due to the density of its oil wells and the saturation of the ground with oil. The British and French, for example, had believed even a small bombing force could set off a massive conflagration at Baku, and in 1940 had drawn up plans to strike Baku when the USSR was a semi-ally of Germany. The Allies hoped this would not only end Soviet oil exports to Germany but also severely damage the oil-dependent Soviet economy. (The vulnerability of Baku to bombing may have been unrealistic. In 1905, ethnic rioting at Baku resulted in arson to the oilfields. While many oil wells were damaged, no massive conflagration occurred, even though the wells were densely packed and the ground saturated with oil.)

German bombers in the North Caucasus could have reached Baku. The standard explanation for them not bombing Baku is that German fighters did not have the range to escort the bombers over most of their route to Baku, so the bombers would have have been vulnerable to interception by Soviet fighters. However, this ignores the option of the Germans bombing Baku at night. For example, in June 1943, when the Germans did launch a night-bombing campaign against Soviet industrial and oil targets, unescorted bombers inflicted significant damage without taking heavy losses. (By June 1943, Baku was now out of range of German bombers.) More likely, the Luftwaffe was given only a few days to strike oil targets in October, and with bomber strength in decline after months of heavy operations, the Luftwaffe commanders chose to go after the closer, easier targets.

Baku's production did suffered nonetheless. Since the Soviets could no longer ship all of Baku's production of oil and refined oil products to the rest of the USSR, various oil facilities were evacuated and wells were shut down, often permanently. Production in excess of transport capacity was temporarily stored using makeshift, expedient methods, in hopes of being sent out later. Caspian shipping limitations also disrupted the evacuation of some equipment and oil workers. Azneft and Caspian Flotilla leaders blamed congestion at the port of Krasnovodsk on the eastern Caspian for the situation, but excuses were rarely acceptable in Stalin's wartime Soviet Union, and the local leaders were blamed for "complacency and carelessness in the matter of evacuation". Presumably they were arrested and replaced, but I do not know more of their stories.

By October 1942, the German Edelweiss operation had clearly failed for the year. German forces in the North Caucasus could not advance much against Soviet opposition, although in turn the Soviets were not strong enough to drive back the Germans. The Germans planned to improve their positions for the coming winter, in hopes of a renewed oil offensive in 1943.

The city of Stalingrad had proven to be a critical distraction, as more and more German resources and reinforcements were sent to fulfill Hitler's obsession with capturing Stalin's City. This effort also failed. Although the Germans captured about 90% of the city, they could not dislodge the Red Army entirely. Stalingrad was on the west back of the Volga, a major river, and the Germans did not try to cross the river and surround the city[74]. Despite the Luftwaffe making a major effort to interdict the Volga at Stalingrad, the Soviets consistently succeeded in moving reinforcements and supplies into the city, forcing the Germans into an endless battle of attrition that sapped their strength.

Not only was Stalingrad a distraction, a German capture of the city would have been entirely symbolic. The Germans had already obtained all the military benefit they could by reaching the Volga at the city, as this disrupted oil traffic on the river and cut Soviet rail communications running west from the city. The forces spent assaulting Stalingrad could have instead been sent to the North Caucasus (although supplying them all was an issue[75]). Baku would still have been out of German reach in 1942 unless an unlikely Soviet military collapse occurred, it is possible that the Germans could have captured the North Caucasus and reached the Caspian Sea, squeezing Soviet fuel supplies further by cutting the one remaining rail line from Baku to the rest of the USSR. Also, with the Luftwaffe not suffering attrition at Stalingrad, bombing Baku and attacking shipping on the Caspian Sea might have been practical, again reducing the ability of the Soviets to send fuel to the Red Army. While this in itself would not have won the war for the Germans, it could have put them in a much stronger position for the 1943 campaign.

Actually, even what the Germans did achieve in 1942 stressed the USSR. Had the Soviets been without allies, it is possible that Soviet offensive power would have been diminished enough to put the outcome of the war in question. As it was, Allied aid helped keep Soviet aircraft flying, Soviet factories producing, and the Soviet population from experiencing mass famine, while Allied forces battling the Germans elsewhere prevented the Germans from concentrating their full strength against the USSR.

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74 The Germans would have needed more forces than they had available at Stalingrad to try for an encirclement. Also, the prospect of crossing a defended major river must have been discouraging.

75 On the other hand, the Germans had concentrated a considerable number of their supply trucks to support the drive to Stalingrad and the operations there, and these trucks would have been very useful in the North Caucasus.

The decrease in oil production spurred the Soviets to expand the oil industry as fast as they could in the safer regions of the USSR. The "Second Baku" Volga-Urals region received particular attention, with the share of total oil production capital investment for this region increasing to 20% in 1941–1945 from 13% in 1938–1940. This was a big increase, since overall oil industry investment also increased, from 3.487 billion rubles in 1938–1940 to 5.566 billion rubles in 1941–1945, including 2.206 billion rubles for oil production and about 1 billion rubles for drilling[76].

The outbreak of war had placed huge demands on Soviet oil production, at both the oilfields and refineries. These facilities attempted to increase production as much as possible, straining their equipment, while using many thousands of initially-unskilled women and adolescents as replacements for the oil workers who went to fight the war. This situation resulted in many industrial accidents, sometimes double or triple a facility's peacetime rate. While the Soviet high command was willing to accept human injuries and deaths from the accidents, the resulting loss of oil products was unacceptable. Once the scale of the problem became clear, the Soviets began a drive to reduce the loss of oil products. For example, the Ufa refinery receive evacuated equipment from Groznyy and was soon celebrated for dramatically increasing production. However, it turned out that Ufa was achieving its "success" by overusing its equipment, leading to many accidents and loss of oil products. A "special commissar" from the oil industry was sent there to make things right.

Kazneftekombinat oilfields in the Kazakh SSR were supposed to increase production during the war, but oil production actually declined from 984,000 tons in 1943 to 801,000 tons in 1944. Since the GKO on 18 June 1943 had specifically ordered Kazneftekombinat to increase production in 1944, this was a serious problem. The central authorities blames Kazneftekombinat of lacking will power and being careless. However, it seems to me that lack of parts for repair and maintenance likely played a major factor, as Soviet industry prioritized war production over other manufacturing. This problem was also likely exacerbated by Kazneftekombinat in earlier years overusing their equipment to boost production, so that by 1944 much was in need of significant repair. However, the Soviets regarded all this as further evidence of Kazneftekombinat management being neglectful and institute "harsh measures to establish order and discipline". Apparently these measures did not include parts for repair and maintenance, as Kazneftekombinat's production declined again in 1945, to 785,000 tons.

76 A.K. Sokolov; "Neft i Voyna 1941–1945 gg." ["Oil and War 1941–1945"]; 2018; https://statehistory.ru/5779/Neft-i-voyna-1941–1945-gg/

Elsewhere in Central Asia, oil organizations in the Turkmen and Uzbek SSRs managed to increase oil production during the war. However, there was a major problem throughout Central Asia. Teenagers had been ordered to become oil workers in 1941–1942 to replace oil workers who went to fight the war. However, many of these teenagers found the work overwhelming, with its long hours and heavy manual labor. Many increasingly became undisciplined and then abandoned their jobs, fleeing to hide in the countryside. Labor desertion was a serious crime in the USSR, and the deserters were sentenced to long terms of imprisonment *in absentia*. However, since the Soviets were dealing with teenagers rather than adults, this if anything made the situation worse. In a rare tacit admission that the threat of severe punishment was not working for these people, the Soviets in 1944 announced an amnesty for labor deserters who voluntarily returned to work. Unfortunately, my sources do not say what happened next, but given how Stalinism worked, it seems likely that those who did return were eventually punished in some form.

In June 1943, the GKO allowed fuel producing organizations (the "nefts" like Azneft) and supply organization to be awarded for timely delivery of oil products. Receiving organizations at their discretion could provide financial rewards. This scheme backfired almost immediately in some places, as various commissariats and departments used their "discretion" to legally bribe complaisant managers of some nefts to give them priority deliveries at the expense of other organizations. My sources do not go into detail on how the Soviets dealt with this. Since the People's Commissariat of Defense was one of the organizations not getting their oil products on time, I suspect the problem was fairly quickly discovered and resolved.

A refinery at Syzran on the Volga River, construction of which began before the war, was completed in 1942, using refinery equipment evacuated from the Caucasus. The Tuapse refinery was evacuated and rebuilt at Krasnovodsk, a port on the eastern shore of the Caspian Sea. It went into operation there in June 1943, so that at least some of the oil produced at the Nefte-Dag oilfield could be processed locally. Existing refineries were expanded in Orsk (southern Urals), Ishimbay (south of the Urals), and Ufa (south of the Urals). Many of these likely used a mix of evacuated Soviet equipment and Lend-Lease American equipment. At least two brand-new refineries were built: at Gurev on shores of the northern Caspian Sea and at Kuybyshev on the Volga River. Both of these received Lend-Lease equipment, particularly refining units that would allow the production of high-octane aviation gasoline, a Soviet priority. However, Gurev and possible Kuybyshev did not begin production until after World War II ended in 1945.

The oil refinery at Gurev

Gurev (now Atyrau, Kazakhstan) serves as an example of why the Soviet oil industry could not rapidly expand via new construction. Although it was a rush project, time was still required for deliberative planning. The GKO ordered the building of a refinery at Gurev in April 1943. A site was chosen and tentatively approved in August, but the final decision to build a refinery there was only made in October 1943. Construction work then proceeded with 10,000 laborers[77] under the direction of Soviet engineers. However, the Soviets also had advice and assistance from the American engineering company E.B. Badger and Sons[78]. Most if not all of Gurev's refining equipment was supplied by American Lend-Lease[79]. The refinery, as Plant № 445, was not finished during the war. It began operations on 8 September 1945, six days after the formal surrender of Japan. Gurev's first product was vehicular gasoline, and the plant marked the birth of the refining industry in what is now Kazakhstan[80].

77 The history of the refinery does not go into detail about the nature of the 10,000 laborers. Given the size of the workforce and the nature of Stalin's USSR, probably most of the manual work was done by forced labor, likely some combination of GULag prisoners, "Labor Army" conscripts (Soviet citizens suspected of disloyalty either individually or by membership in a suspect ethnic group), and Axis prisoners of war.

78 As history would have it, in 1939 E.B. Badger and Sons was one of several companies the US government prohibited from supplying "certain countries", which included the USSR, with information or technology on how to produce "high quality aviation gasoline" or octane-boosting "blending agents". See G. Bernard Noble and E.R. Perkins (general editors); "Memorandum by the Chief of the Division of Controls (Green)"; *Foreign Relations of the United States Diplomatic Papers, 1939, The Far East, Volume III*; 1955; https://1991.history.state.gov/historicaldocuments/frus1939v03/d527. E.B. Badger and Sons is little known today but was an important engineering firm back then and contributed to the US Manhattan Project.

79 The Lend-Lease refining equipment is not mentioned in most sources on the Gurev refinery, but https://varandej.livejournal.com/877447.html states: *Тогда же началось строительство нефтезавода в самому Гурьеве, оборудование для которого поставлялось по ленд-лизу прямиком из США, от фирмы "E.B. Badger and Sons Co"*. [At the same time, the construction of an oil refinery began in Gurev itself, the equipment for which was supplied under Lend-Lease directly from the United States, from the company "E.B. Badger and Sons Co".]

80 unattributed; *70 let Atyrauskomu Neftepererabatyvayushchemu Zavodu* (*70 Years of the Atyrau Oil-Refining Plant*); undated (presumably 2015, 70 years after the plant became operational in 1945); https://www.anpz.kz/company/history/atyrau_refinery/.

Lend-Lease refining units allowing for production of high-octane aviation gasoline were also sent to existing refineries at Orsk in the Urals region and Krasnovodsk on the eastern shores of the Caspian Sea.

The Soviet Surge, Soviet Offensives November 1942-February 1943

The fortunes of war turned against the Germans in November 1942, when a Soviet offensive surrounded the Axis forces in Stalingrad. Further advances threatened to cut off the German forces in the Caucasus, which caused them to withdraw. In February 1943, the last resistance in the Stalingrad pocket was crushed, and German forces were mostly back to their June 1942 start lines. The Germans extensively damaged the rail lines as they withdrew, which the Soviets had to repair before bulk shipments of oil products could be railed north via the traditional routes. Similarly, the Germans extensively mined the Volga River, which was took well into the spring of 1943 to clear. The excess oil products stored at Baku began flowing north.

The Soviets were developing new oil and gas fields in the Volga-Urals region, their "Second Baku". A major oilfield was discovered near Kuybyshev (now Samara) in late 1943, and more oilfields were found nearby in the Tatar ASSR. Soviet investment in developing the Volga-Urals oil and gas field rose from about 10% of the industry's total investment in 1940 to 41.6% in 1942 and 55.8% in 1943.

In March 1943, soon after the Battle of Stalingrad ended, the USSR requested the USA to increase deliveries of petroleum products, including aviation gasoline, from 20,000 tons per month to 30,000 tons. This increase included deliveries of British aviation gasoline, particularly fuel refined in Abadan, Iran, and sent to the USSR over the "Persian Corridor" Lend-Lease route[81].

The Soviet oil industry suffered another blow from the Germans in 1943: a short strategic bombing campaign by the Luftwaffe in June. The Germans mostly used the Luftwaffe as a tactical air force, supporting the operations of the German ground forces. The Luftwaffe did occasionally bomb industrial targets but only launched two medium-sized raids on Moskva in July 1941. Otherwise, they flew frequent raids with quite small groups of bombers against Soviet industry in 1941–1942. These were more like nuisance raids than a serious campaign, and they failed to have any significant impact. The Moskva cracking plant may have been targeted in 1941 (the Soviets thought so), and the Mendeleev Refinery in the Yaroslavl region suffered some raids and damage. The only large strategic air attacks after the July 1941 Moskva raids were in October 1942. After the Germans failed to capture the Groznyy oilfields and refineries, they bombed Soviet oil infrastructure throughout the North Caucasus.

Some in the Luftwaffe and German high command had wanted to undertake a major strategic bombing campaign to strike industrial targets in the USSR, believing that this could seriously damage Soviet war production. In 1943, they briefly got their way. A lull had mostly settled over the Eastern Front, and the Luftwaffe was able to rebuild its strength. In June, the Luftwaffe launched numerous raids against industrial targets in the Volga River region. Soviet air defenses there were not used to this intensity of attack and performed poorly. The Mendeleev Refinery in the Yaroslavl region was damaged, although apparently not badly. The refinery at Saratov was badly damaged, being 80% destroyed. Gorkiy, an automotive, light tank, and engine production center, was a major target, with many sites there taking considerable damage. Light tank production ceased for several months, and a new model of engine about to go into mass production was canceled. Gorkiy also had oil

81 Apparently British fuel deliveries substituted one-for-one with the American Lend-Lease commitment, so the total amount of fuel being sent to the USSR did not increase. This was apparently was done to reduce the need to ship petroleum products long distances when the products were being made in Iran right next to the USSR.

storage facilities, which were damaged, and an oil refinery, which was targeted but apparently escaped significant damage.

When compared to the American and British strategic bombing of Germany, the German's short June 1943 strategic bombing campaign against the USSR achieved significant results in a remarkably short amount of time. Although Soviet-based sources only hint at it, the reason for German success was likely that the PVO, the Soviet air defense organization for the rear areas, was unprepared for this level of activity outside its main defense zones for Baku, Leningrad, and Moskva. With the Germans mostly launching only small, nuisance raids after July 1941, the Soviet high command likely reduced PVO manpower, fighter aviation, and perhaps antiaircraft guns to minimal levels, in order to reinforce the battle zone, where the Luftwaffe was most active. Thus, the German success was likely due to unpreparedness, and sustained operations would likely have had diminishing returns as the Soviets shifted resources to counter the bombing[82]. However, the Germans soon abandoned their strategic bombing campaign to prepare for the upcoming battle at Kursk, and the subsequent German defeat meant the Luftwaffe would not strategically bomb the USSR again[83].

82 The successful bombing of Gorkiy got the immediate attention of the Soviet high command, which sent in the security apparatus and secret police to find out what went wrong. The local PVO commander and the head of the GAZ factory were both demoted but apparently neither were executed, suggesting that they were scapegoats rather than at fault. Instead, the real problem was lack of resources, and the high command soon sent 100 AA guns, 250 AA machineguns, 100 searchlights, and 75 barrage balloons to bolster Gorkiy's air defenses.

83 The Luftwaffe did plan another bombing campaign, to strike Soviet electricity generation plants, but was never able to begin it. A last attempt in early 1945 to prepare for the campaign was thwarted by Allied strategic bombing.

Saratov Refinery under construction, 1930s

"How did you help Stalingrad today?" — 1942 Soviet slogan exhorting oil workers

In 1931, Saratov, a city on the Volga River, was selected as as site for a cracking plant, with construction beginning that summer. Gasoline production began in August 1934 when the first of several cracking units became operational at what was now called the Saratov Cracking Plant № 4. The plant refined oil brought north by barge up the Volga River from Baku and the North Caucasus. In 1935, it began refining oil from Volga-Urals oilfields to its east, but its main supply of oil was still from the south. A second cracking unit went on line in 1935, and the plant was renamed "Saratov Cracking Plant № 4 named for S.M. Kirov". By 1936, the plant had eight cracking units and was refining both light and heavy petroleum products including gasoline, kerosene, and diesel fuel.

In 1940, two cracking units were reconfigured to produce toluene, an ingredient for trinitrotoluene (TNT), an explosive. In 1941, isooctane production began, isooctane being one of the ingredients the Soviets used to raise the octane rating of their aviation gasoline. Before June 1941, the plant reached its full design output of 3.5 million tons of oil and gas products. During the war, the plant supplied fuel for the Red Army.

Natural gas fields had been discovered and developed near Saratov. Some sources on the plant claim that by 1940 two new units at the plant were processing natural gas into methane, propane, and butane. The 1940 is likely a mistake for 1942. Other sources are definite that Elshan, the first a major gas field near Saratov, was found in 1941 with with another major gas field being found there in 1942. The Soviets only built gas pipeline from Elshan to Saratov in September-October 1942.

In 1942–1943, German mining of the Volga and the Caspian Sea reduced the delivery of oil to the plant, lowering its output to 1.8 million tons in 1942. The Germans also occasionally bombed the plant. In June 1943 they launched major raids against it, destroying 80% of the plant. The work force suffered 800 deaths due to German bombing. The plant was rebuilt and resumed gasoline production in December 1943.

During the war, the Fergana Valley in Soviet Central Asia also underwent further oil exploration, with at least one new oil field being found there. A Fergana oilfield, perhaps this new one or perhaps one found in the 1930s, began production in 1943. Based on the remoteness of the valley to the rest of the USSR, I suspect development there proceeded slowly during the war, like it did in the Tatar ASSR. Tatarstan or the Tatar ASSR (now, the Republic of Tatarstan in the Russian Federation) was an under-developed oil area of the Volga-Urals region. The Shugur oilfield had been found there in 1940 but development proceeded very slowly until 1942, when the German summer offensive caused Soviet oil production in the North Caucasus and Transcaucasus to decline. In July 1943, oil extraction began at the Shugur oilfield. Further oilfields were found in Tatarstan starting in 1943, but it appears none of these were developed until after the war[84].

Oilfield development in the Tatar ASSR[85]

In 1944, new oilfields were found near Kuybyshev and in the Bashkir ASSR. Although Soviet-based sources often play up the wartime development of new oil centers, during the

84 After the war, the oil resources of the Tatar ASSR became increasingly important, prompting the Soviets to form Tatneft ("Tatar-Oil") in 1950.

85 The pictures are possibly from the Shugur oilfield, possibly in 1944–1945, as the this is the context of the Tatneft text in which they appear, although the pictures themselves are not identified for location or time. However, the quality of the photography suggests they were taken later, perhaps in 1950s after Tatneft was formed. See https://www.tatneft.ru/about-tatneft/history-of-tatneft-group/starting-with-the-first-oil-field-to-the-establishment-of-tatneft-company-1943---1990/discovery-of-romashkinskoye-oilfield?lang=en

war these new developments never came close to making up for Baku's lower output. Even as crash wartime projects with workers working 11-hour shifts, few days off, and with no vacations, it took time to develop oilfields into high-output centers. For example, as covered above, the Shugur oilfield was found in 1940, developed in 1942, and had its first producing well in July 1943. In March 1944, the Soviet government decided to expand the output of Shugur. With the central government having only limited resources to provide for the expansion, they assigned the development of the field to the Tatar ASSR. The Tatarstan government could provide manual workers and general construction equipment, but oil equipment and oil workers were in short supply. Drilling equipment was acquired by suspending exploratory drilling in other locations and using that equipment at Shugur. Oil workers and experts had to be sent to Shugur from other oil operations. The work went slowly until the war in Europe ended in May 1945. The Soviet government then soon renewed its interest in Shugur and sent personnel and resources there with the goal of boosting production by the end of the year. However, Shugur was in a somewhat remote location with no existing means to move its oil in bulk to refineries. The Tatar ASSR had to build an oil pipeline to Klyavlin, the nearest rail station. This seems to be about 25 km (15.5 miles) away from the oilfield, but construction encountered "difficulties", which I suspect means it was not completed in 1945.

In 1940, the Volga-Urals region produced 6% of the USSR's oil; in 1945 it produced 14.6% of the total, although some of this increase was simply due to the decline of production in the North Caucasus and Transcaucasus. This Volga-Urals "Second Baku" did became much more productive after the war.

In addition to developing the Volga-Urals region, the Soviets also tried to revive the North Caucasus and Baku regions. For example, on 20 April 1943 the GKO ordered the Groznyy region to restore oil production "in the shortest possible time" and to increase the production of gasoline and kerosene. However, oil equipment evacuated from the region was not returned, so Groznyy's recovery depended on deliveries of new equipment from domestic production and Allied aid. Groznyy's refineries were restored to their 1940 levels of production some time in 1945. Redevelopment of Groznyy's oilfields proceeded slowly, and Groznyy oil extraction did not reach the level of 1940 until after 1955. (Groznyy's refineries likely were being used to process some of Baku's output, as they had previously done.)

In August 1944, a Soviet offensive broke into Romania, prompting the country to surrender and change sides, declaring war on Germany. The Soviets dominated the country and controlled Ploeşti (now spelled Ploieşti), a significant oil production and refining center. In 1944 or 1945, they built a 225-km (140-mile) pipeline to carry petroleum products from Ploeşti to Reni on the Danube River. From there, they shipped the products up the river to supply the Soviet military fighting in central Europe. This helped the Soviets' final offensive to capture Wien (Vienna) in April 1945. Also in April, the Soviets linked up with the western Allies in central Germany and in May captured Berlin. In total collapse on all active fronts, Germany surrendered days later. Stalin had won his war of engines against Hitler, and the USSR was now a global superpower rivaled only by the USA.

Red Army soldier raising the Soviet flag on top of the German Reichstag, 2 May 1945
(E.A. Khaldey; *Znamya Pobedy nad Reykhstagom* [*Victory Banner over Reichstag* but typically translated as *Raising a Flag over the Reichstag*]; 1945.)

At least from the Battle of Stalingrad in 1942, the combination of Soviet fuel production and Allied fuel aid supplied the Red Army with sufficient fuel for its operations. Allied aid helped the Soviets with fuel supplies, particularly aviation gasoline, and gasoline additives. About half of wartime Soviet aviation gasoline (on my estimate, 51.1%) was from Allied aid, and the rest was from Soviet domestic production. (Aviation gasoline will be covered in more detail in the part on Soviet gasoline.) American Lend-Lease also significantly helped the Soviets with oil extraction and oil refining. The Soviets had mostly stopped making oil extraction and refining equipment during the war[86], so this was a big help.

Allied aid sent many aircraft, tanks, and other vehicles to the USSR. While all were needed and used, some did add fuel requirements that the Soviets could not meet, such as fighters that used 100-octane gasoline, or had trouble supplying in the quantity needed, such as gasoline-guzzling tanks that required aviation-grade fuel. In theory, Allied aid aircraft were

86 In 1945, with the USSR converting to a peacetime economy, the USSR only managed to produce 7% of the amount of oil industry equipment it made in 1940, despite this becoming a priority after Germany was defeated in May 1945. This implies that annual production of oil industry equipment was lower in 1942–1944, likely 5% or less.

flown using Allied-aid 100-octane gasoline, which the Soviets called B-100. In practice, the situation was different, as least for non-fighter Allied-aid aircraft. For example, the Soviets received many A-20 twin-engine bombers from Lend-Lease, which the Soviets called the "Boston" based on the British designation. The bombers were supposed to use 100 octane gasoline but were frequently flown using a mixture of B-100 and B-78 (Soviet 78-octane gasoline). B-78 could be boosted to a maximum of 95 octane if Soviet additives were available (my sources on the Soviet Boston do not mention if additives were used), but even this meant the aircraft were flying on a mixture less than 100 octane. They thus had lower performance than they should have had. At times, the Bostons did not have any B-100 at all and instead used a mixture of B-78 and B-70 (Soviet 70-octane gasoline, which could be boosted to a maximum of 88 octane). This reduced performance even more. Soviet Boston pilots of course did not like the lower performance and to compensate flew their aircraft hard, above their safe operating limits. This improved performance a bit but significantly increased maintenance and repair issues[87]. You may occasionally encounter Soviet-based sources denigrating their Bostons; keep in mind that the many of the problems were caused by using the wrong fuel and over-flying them. (I have not seen any sources that state the Soviets flew their Allied-aid fighters with inadequate octane, but I have not researched this much either.)

Even American trucks could be a problem. Lend-Lease sent 100,000 highly-appreciated Studebaker all-wheel-drive (6x6) trucks to the Soviets. However, these trucks required 78-octane gasoline. B-78 gasoline was the Soviets' best grade of aviation gasoline, at 78-octane, and the Soviet struggled to provide enough of this just for their air forces. It appears the Soviets sometimes used their 70-octane KB-70 fuel, which diminished the Studebakers' performance and led to some maintenance issues, although some sources claim the Studebakers handled "lower quality" fuel fairly well. Of course, these fuel problems were nothing compared to what the Soviet faced in 1941. By 1945, Red Army mechanized and aviation forces swept into the heart of central Europe powered by a combination of Soviet and Lend-Lease fuel[88].

87 https://vpk-news.ru/articles/36638

88 It seems the USSR quickly had fuel shortages again after the war. In the late 1940s-early 1950s the USSR was importing an estimated 2–4 million tons of petroleum per year from Romania, two-thirds that country's rather small production.

An SU-76M of the 1st Belorussian Front refueling in 1944

The Soviets lost many thousands of tanks and aircraft in 1941, with very heavy losses occurring in the opening weeks of the German invasion. Industrial evacuation then decreased the output of tanks and aircraft throughout 1941 and well into 1942. From the second half of 1942 and thereafter, tank and aircraft production greatly ramped up, and the Red Army became increasingly mechanized as the war went on. This increased the fuel intensity of major operations, the amount of fuel consumed per day. Although given my emphasis on "tanks and aircraft" here, it was actually the trucks that consumed the most fuel. Trucks were used to tow large weapons and especially to haul supplies from the railheads (and waterways) to the front lines, and vehicular gasoline was the most-consumed fuel in Soviet operations, 44% of all fuel at the Battle of Kursk and 56% of all fuel at the Battle of Berlin. (Aviation gasoline was the second most-consumed fuel.) The following table shows fuel consumption for some Soviet major operations.

Fuel Consumption of Selected Soviet Major Operations (thousand tons)

Operation	Time Period	Days	Total Fuel Consumption	Average Daily Fuel Consumption
Moskva Defense and Counteroffensive	30 Sept. 1941–30 April 1942	213	294	1.1
Stalingrad Defense and Offensive	17 July 1942–2 Feb. 1943	201	149	1.0
Kursk Defense and Counteroffensive	5 July 1943–23 Aug. 1943	50	156	1.4
Berlin Offensive	16 April 1945–8 May 1945	23	150	8.8
Manchurian Offensive	9 Aug. 1945–2 Sept. 1945	25	51	2.0

Source: V.G. Martynov and N.N. Golunov; "Neftegazovye vekhi Velikoy Pobedy: Maloizvestnye Istorii Vekikoy Otechestvennoy Voyny" ("Oil and Gas Milestones of the Great Victory: Little- Known Stories of the Great Patriotic War"); *Neftegaz.RU* April 2020.

The Berlin Offensive was extremely fuel intensive because huge forces were concentrated for the operation and were ordered to take the city as quick as possible.

Soviet forces in the Manchurian Offensive moved great distances in a short amount of time, hence the higher daily fuel consumption compared to most European operations.

While the Red Army did not have systemic fuel shortages in 1943–1945, it might not have had all the fuel it could have used. Soviet offensives in 1943–1945 typically saw the onset of a massive assault with high-intensity combat, resulting in a large advance as defeated German forces fell back or were destroyed. Often, such an offensive was then followed by a long pause until a new offensive was launched. These pauses were when reinforcements, replacements, and supplies were brought forward, damaged rail lines and roads were repaired, airfields repaired or built, and so on. Perhaps one factor in some pauses might have been that Soviet fuel reserves were depleted. Further large-scale offensive activity might not have been sustainable until more fuel was made by Soviet refineries and delivered by Lend-Lease. If so, then while the Red Army had enough fuel for the offensives it did launch, it might have been able to launch more offensives had it had more fuel.[89]

During the war, the Soviet oil industry expanded existing refineries, built new ones, built oil pipelines, and started the country's first long-distance natural gas pipeline (as will be covered in the part on Soviet natural gas). The 1942 German offensive caused oil production to decline in the North Caucasus and at Baku. This stimulated the Soviets to increase production elsewhere, including using new-to-the-Soviets techniques such as turbo drilling (about three times faster than regular drilling), flooding oil formations with water to increase production, and a form of fracturing rock to re-invigorate production[90]. New oilfields were found and some were begun to be developed. The Soviets discovered 34 new oil and gas fields during the war, although very many of these were not developed until after World War II. The Soviet oil industry managed, albeit with significant Allied aid in aviation gasoline, to supply enough fuel to power Soviet offensives from late 1942 through 1945 to total victory over the enemy.

89 This is pure speculation on my part, but the phrasing of Soviet-based sources leaves this possibility open. Wording like "Soviet offensives had all their fuel they needed" can have a different sense than "Soviet forces had all the fuel they needed."

90 The sources I've seen claim these techniques were "innovations", with no mention of foreign origins. It seems to me very possible the techniques actually came from more advanced oil industries, with the Soviets acquiring them through foreign contacts or Lend-Lease aid. I have not researched this, however. Also, the fracturing technique was used for conventional oilfields. Hydraulic fracturing ("fracking") for oil and gas production in shale had not yet been developed anywhere.

By 1945, the Soviet oil industry's oil production was recovering from its mid-war low, but it still was only 77.8% of the 1940 level. This was, however, a better situation than in many other Soviet industries: Soviet mining and metallurgy were at 40% of their 1940 levels, steel production was at 45%, and electric power generation was at 52%. The ending of the war in Europe in May 1945 caused the Soviets to begin converting their economy to peacetime purposes, reducing military production and increasing production of equipment to rebuild the country. Many factories were ordered to increase equipment needed by the oil industry, but conversion to this production took time. For example, production of oilfield equipment increased in 1945 but was still only 9% of 1940's production.

By late 1945, with Japan also defeated and no prospect of major war in the short term, now-surplus military equipment was sent to the civilian economy. The oil industry, for example, received diesel engines from T-34 tanks, using them to run drilling rigs.

In 1946, the USSR resumed its five-year plans to guide the economy, and the fourth plan of 1946–1950 called for the oil industry to reach 114% of 1940's oil production. While this might seem a modest goal, it actually required the industry to reach 183% of 1945's oil production by 1950, a major increase. Revisions of the plan in following years required the oil industry to reach even higher production goals. The plan also called for construction of new refineries and an increase in the production of high-quality refined products, including high-octane aviation gasoline and octane-boosting additives. The wartime USSR had received significant Allied aid in these two categories but now wanted to become independent of foreign supplies. The plan overall was a success, with Soviet oil production exceeding 1940's level in 1948, 1941's level in 1949, and the plan's revised goal in 1950.

Soviet poster proclaiming success of the fourth five-year plan (1946–1950)

Obyem produktsii promyshlennosti sssr dostig v 1950 g. **173%** *k urovnyu 1940 g.*
/ vmesto 148% po planu /
PYATILETNIY PLAN PEREVYPOLNEN!

Volume of industrial production of the USSR in 1950 reached **173%** of 1940 level
/ instead of 148% according to plan /
FIVE YEAR PLAN OVERFULFILLED!

4.A.3 Gasoline

A Studebaker US6 6x6 truck in Soviet service

Lend-Lease sent over 150,000 Studebaker cargo trucks to the USSR, about 100,000 6x6 versions and the rest 6x4. Studebaker had rated both versions to carry or tow 2.5 tons of cargo. The Soviets rerated them for 4 tons of cargo, and Soviet field forces were known to have overloaded them with

5 tons at times. (Trucks were in short supply, so the Red Army frequently overloaded all their domestic and foreign truck models, even though this could lead to maintenance problems and damage.) The Soviets highly admired the Studebaker, *Studebeker* in Russian, for its all-terrain ability, its ruggedness, and its ability to carry a lot of cargo. *Studer* became not only the Red Army nickname for the truck but the wartime ideal for a good truck in general. After Lend-Lease ended, the Studer remained in demand, and the post-war Soviet automotive industry made their own version by copying the Studebaker as much as practical.

Studebakers were the workhorse trucks for hauling supplies from the railheads to the front line forces. Some were used to tow weapons, and some were adapted to mount Katyusha rocket artillery rails, with versions capable of firing 48 M8 82mm rockets, 16 M13 132mm rockets, or 12 M31 300mm rockets. About 400 Studebaker 6x6 U5 fuel tanker trucks were sent to the Soviets, who found them so useful that they converted some of their Studebaker cargo trucks into tanker trucks. Studebaker trucks were supposed to use 78-octane gasoline, which was the Soviets' top grade of aviation gasoline and in short supply. Apparently at times the Soviets substituted their more-plentiful 70-octane aviation gasoline.

Note: I have no location or date for the above photography, but it was probably taken in 1945 in Eastern Europe, likely soon after the end of the war. The building to the right of the Studebaker's cab has a sign ending in "LAVIA" in the Latin script, so the truck likely was in an Eastern European country (or Germany) rather than in the USSR, Bulgaria, or parts of Yugoslavia where Cyrillic scripts were used. "ПОБЕДЫ!" in Cyrillic ("POBEDY!") is written on the truck's hood, meaning "VICTORY!". The truck is most likely in the Red Army's artillery branch, since it is towing an antitank gun.

The 1920s Soviets made gasoline (called *benzin* by the Soviets; petrol by some Commonwealth countries). Since the USSR of the time only had a few thousand motor vehicles and aircraft, the country consumed relatively little gasoline. Most Soviet gasoline was exported to earn foreign currency.

Civilian vehicles like trucks, buses, and cars used Soviet vehicular-motor gasoline, as did some military vehicles like armored cars and light tanks (although light tanks with more powerful engines used aviation gasoline). In 1929, there were three grades of gasoline:

- Heavy Groznyy gasoline, which had been the only Soviet gasoline as of 1921. It, however, had poor starting qualities and low detonation resistance (and so caused knock for engines with higher compression ratios). Sometime before 1929, after the appearance of the other two grades of gasoline, Heavy Groznyy was only supposed to be used in a mixture of 70% Heavy Groznyy and 30% either of the other two.
- Light Groznyy gasoline, appearing some time between 1921 and 1929.
- Baku gasoline, also appearing some time between 1921 and 1929.

In the 1920s, these grades of gasoline were not rated for octane, as the Soviets had not adopted the octane rating system yet. Before the invention of octane ratings, it was well known that some grades of gasoline did not work well with some engines, causing them to knock. No one knew why for sure or could even predict if a grade of gasoline would work with a model of engine except by trying to run the engine with that grade. In fact, even "grade" of gasoline is a bit misleading, as an oil company's gasoline could differ depending upon the crude oil it was refined from and which refinery made it. This situation caused problems, particularly in World War I with aircraft, so after the war considerable research occurred on this issue. In the early 1920s, ethyl alcohol and tetraethyl lead (TEL) when added to gasoline were both found to reduce knock, but full understand of the situation was only resolved in 1926. That year, Dr. Graham Edgar devised the octane rating system, and in 1927 his paper on the subject led to the adoption of octane ratings around the world.

Soviet oil industry technicians followed this development and at some point determined and standardized octane ratings for the grades of Soviet gasoline. One source speculates, on less than comprehensive evidence, that the Soviets did not rate their gasoline for octane before the middle or late 1930s. This is perhaps possible for Soviet vehicular gasoline but not for Soviet aviation gasoline, as 1930s models of aircraft increasingly needed standardized, high-octane gasoline.

By 1941 there were five or six grades of vehicular gasoline (one source claims five grades but lists six, perhaps not counting winter gasoline as a grade):

- Grade 1, Light Groznyy gasoline.
- Grade 2, Heavy Groznyy gasoline.
- Cracking "Internal" gasoline. The implication of "Internal" is that it was used domestically. Cracking gasoline grades were made using modern cracking technology.
- Cracking Groznyy "Export" gasoline. The implication of "Export" is that it was exported to earn foreign currency. This was true of the early 1930s but by the late 1930s the Soviets were exporting little gasoline, given their growing domestic demand.
- Cracking Baku "Export" gasoline.
- Winter gasoline, at 63 octane. This gasoline likely had a higher vapor pressure to handle cold weather better than the other grades of gasoline, but Soviet-based sources I've seen do not go into details. Based on American "summer" gasoline vs. "winter" gasoline, perhaps the Soviets added butane to increase vapor pressure. If so, then

winter gasoline might not count as a grade of gasoline, since in theory any other grade of gasoline could have been treated to make it. A side effect of adding butane would be to increase the octane rating, although higher octane by itself has no benefit or penalty in cold weather. Since the standard grades of Soviet vehicular gasoline were 56 octane, 63-octane winter gasoline is consistent with the addition of butane. According to another source, this gasoline was usable down to -55°C (-67°F), while German gasoline was usable only down to -10°C to -15°C (14°F to 5°F)[91].

One source states that 1941 Soviet vehicular gasoline was 56 octane[92] but doesn't go into details on gasoline grades. Other than 63-octane winter gasoline, presumably this means all the other gasoline grades were 56 octane[93].

As covered in the overview of the Soviet oil industry, the Soviets increasingly had shortages of gasoline from the mid-1930s. This included vehicular gasoline, but the growing lack of high-octane gasoline was a particular problem for Soviet military aircraft. Low-octane gasoline was acceptable for the low-compression, low-performance engines used in Soviet cars, trucks, and some older light tanks. To achieve better power and performance, high-compression engines were developed. These engines typically were created for new models of aircraft and were thus known as aviation engines, and so the gasoline that fueled them was called aviation gasoline. High compression made these engines much more vulnerable to premature gasoline detonation ("knock"), which lowered performance and could damage or ruin engines. High-octane aviation gasoline was thus required to reduce or prevent knock.

Many aviation engines went on to be used for new models of tanks, which also needed powerful engines. However, the most powerful aviation engines went to the newest aircraft models, which accordingly needed the highest-octane aviation gasoline. Tanks could use grades of aviation gasoline with lower octane ratings.

91 E.A. Kozlovskiy; "Istoriya Gornogo dela Mineralno-Syrevye Resursy v Velikoy Voyne, Chast 1" ("Mining History of Mineral Raw Materials in the Great War, Part 1"); http://geomar.ru/articles/history/357-mineral-resources-in-great-war.html

92 https://zen.yandex.ru/media/id/5e364b0053de5721ccf77ee1/toplivnyi-krizis-v-sovetskoi-aviacii-nakanune-voiny-5fd42d630b82510af58ffa5e

93 In the 1940s, apparently only after the war, the Soviets produced A-56, A-66, A-70, and A-74 grades of vehicular gasoline. At this time, they also introduced designations for vehicular gasoline in the form of A-##, with A standing for *Avtomobilnyy* (Automotive) or perhaps *Avtomobil* (Automobile) and ## for the octane rating. A-56 was the standard vehicular gasoline, used by Soviet trucks, buses, passenger cars, and so on. A-66 was a winter gasoline for use in low and extremely-low temperatures and for use in Siberia and the Soviet Far North. A-70 and A-74 were for the very few foreign cars imported into the USSR, plus the Soviets' few, specialty ZiS-110 and ZIM vehicles. (ZiS-110 and ZIM each were limousines for officials with variants such as ambulances and staff cars.) Later, as the Soviet automotive industry grew, other grades were introduced, which I do not cover.

Fuel tanker trucks at a Soviet airfield

The picture shows Soviet Il-2 Shturmovik attack bombers being refueled at an undated, unidentified location, although the presence of what seems to be a BZ-41 tanker truck indicates it was taken during the war.

The tanker truck in the right foreground seems to be a BZ-41 refueling tanker truck, with a BZ-35 to its left. Both models were developed based on the 6x4 ZiS-6 truck. (BZ-41 production ceased in October 1941 when the ZiS factory making the tanker truck was evacuated from Moskva. When ZiS truck manufacturing resumed in 1942, the BZ-41 was not put back into production. By this time, the Soviets were receiving highly capable Studebaker 6x4 trucks, some of which came as tanker trucks and others of which the Soviets converted from general cargo trucks to tanker trucks.)

In the background, the two tanker trucks on the right are possibly some submodel of the BZ-39, but I can't tell which (original BZ-39, modernized BZ-39M, or wartime simplified BZ-39M-1). All BZ-39s were developed based on the 4x2 ZiS-5 truck. I do not know what the two trucks in left background are, but they do not seem to be tanker trucks. Perhaps they are ZiS-5 trucks modified for aircraft maintenance use.

At some point in the 1930s, the grades of Soviet aviation gasoline were designated as B-##, where B stood for *Benzin* (Gasoline) and ## was the octane rating. When advanced cracking technology became available, a "K" (for *Kreking*, Cracking) was added before the B, e.g., KB-70. The octane rating was the same as or equivalent to Motor Octane Number (MON) or the "lean mix" octane for aircraft. MON by how it is defined tops out at 100. By 1940, the Soviets had five grades of aviation gasoline in quantity production:

- B-59. Although rated as aviation gasoline, B-59 was little better than the 56-octane grades of vehicular gasoline and was only usable with the oldest, most undemanding aircraft engines. For example, the Soviet U-2/Po-2 night harassment biplane with its low-horsepower M-11 engine used B-59. (The M-11 was a 1920s design originally at 100 horsepower, but subsequent models achieved 150 horsepower.) B-59 was also used for Soviet gasoline-engine light tanks.

- B-70 was much better than B-59 but was still only fit for older aircraft, such those using the M-17 engine, a 680-hp engine designed in the late 1920s based on the German BMW VI engine. However, octane-boosted B-70 could be used with more modern aircraft. Octane-boosting additives are covered later.
- KB-70 was a 70-octane gasoline made by modern Soviet cracking plants. Other than octane, KB-70's characteristics were not quite technically as good as B-70. KB-70 thus was supposed to be used for ground vehicles like the tanks rather than for aircraft. Whether the sometimes-careless field forces were diligent in avoiding fueling aircraft with KB-70 is an open question.
- B-74 was a grade made for newer (but not the most modern) models of Soviet aircraft.
- B-78 was the top aviation grade available to the field forces. B-78 actually came into two slightly different version, B-78b from Baku and B-78g from Groznyy. Although the octane number was the same, other characteristics of the two grades of gasoline were a bit different. It is unclear from my sources how much the field forces knew or cared about the two versions, as it seems it was all just "B-78" to them. All modern Soviet aircraft as of 1941 required B-78: the Er-2 (aka Yer-2) medium bomber, the Il-2 shturmovik, the Il-4 medium bomber, the LaGG-3 fighter, the MiG-3 high-altitude fighter, the Pe-2 attack bomber, the Su-2 light bomber, and the Yak-1 fighter. B-78 was not only the top grade of Soviet aviation gasoline in 1941, it was the top grade throughout the entire war.

For many grades of aviation gasoline, in addition to the "lean mix" (or "lean burn") octane rating, there was also a "rich mix" (or "rich burn") octane rating. The rich mix rating measured the effective octane when used with aircraft engine superchargers. A supercharger compressed and blew air into the engine, to compensate for the decreased air pressure and thus lesser amount of oxygen at higher altitudes (oxygen being absolutely essential to burn the gasoline). Without a supercharger, an engine at higher altitudes would not receive enough oxygen, decreasing its horsepower and performance.

Pilots could use full emergency throttle to realize significant speed boosts from their superchargers, but only for short periods of time (otherwise engine overheating, damage, and failure could occur). This was particularly useful for fighters in air combat. Some countries designated their aviation gasoline as lean#/rich#, such as 100/130 for the western Allies' early-war "100 octane" aviation gasoline and 100/150 for the best western Allied aviation gasoline, only available in limited supply in the later war years. The Soviets did not include rich mix octane ratings in their aviation gasoline designations.

The prewar Soviets must have been aware of rich mix octane ratings, as they closely followed foreign oil-industry and aviation developments. Also, modern Soviet aircraft engines as of 1941 had supercharges, so knowing the rich mix octane ratings would have been very helpful in determining performance. However, I have yet to find rich mix octane ratings for the wartime grades of Soviet aviation gasoline, despite spending some time in this endeavor. The best I have found so far is a 1955 book[94] listing five grades of Soviet aviation gasoline in use in 1954. According to another source[95], the Soviets developed the top four grades (all but B-70) soon after the end of World War II.

- B-100/130. This would be the equivalent of wartime Allied-aid 100/130 aviation gasoline, known as B-100 during the war.
- B-95/130. This would be the equivalent of wartime Allied-aid 95/130 aviation gasoline, known as B-95 during the war.
- B-93/130. Wartime B-78 was able to be boosted to a maximum of 93 octane using additives. As sheer speculation without no confirmation from any source, perhaps B-78 boosted to 93 octane was similar to post-war B-93/130 and thus had a rich burn octane rating of 130.
- B-91/115. Wartime B-78 and B-74 were able to be boosted to around 92 octane with additives. Again as sheer speculation, perhaps these grades of gasoline boosted this way were similar to post-war B-91/115 and thus had rich burn octane ratings of 115.
- B-70. Note the post-war designation has no rich-burn octane rating, nor does a table of aviation gasoline specifications in the 1955 book give a rich burn octane rating for B-70. (The tables does for the other four grades.)

While B-78 was the Soviets' most important aviation gasoline, the Soviet oil industry had difficulty making it in quantity. By about 1939–1940, just 4% of Soviet aviation gasoline output was B-78. This was a major problem, as 20% of all Soviet combat aircraft produced from 1939 to the start of the war in June 1941 were modern types[96] needing high-octane gasoline. Since the Soviets simply did not have enough B-78, they greatly restricted its use.

94 V.S. Rybalchik, S.V. Polyakov, and V.F. Gerasimenko; *Teoriya Porshnevykh Aviatsionnykh Dvigateley* [*Theory of Piston Aircraft Engines*]; 1955.

95 https://www.chem21.info/info/1467261/

96 17,745 combat aircraft were produced from 1 January 1939 to 22 June 1941, including 3,719 modern types.

One consequence of this was the Soviets reduced combat training for new pilots of modern aircraft. Soviet pilot training by 1940 was already inadequate (likely because the Soviets were expanding their air forces rapidly). After completing their initial training courses, new pilots regardless of their ability to fly were sent to combat air units, where they were expected to learn combat flying[97]. In May 1941, new pilots for modern aircraft had on average only 12 hours of combat training. So, when the war broke out, the lack of 78-octane gasoline meant that many pilots of the newest Soviet aircraft were quite inexperienced, which must have resulted in high losses.

A related problem applied to already-experienced pilots transitioning from older aircraft to modern models. Typically by this time, when a Soviet air unit had its aircraft upgraded, the unit was not withdrawn from the field for reequipping and retraining. Instead, the new models just trickled in, and individual pilots transitioned to these aircraft as best they could[98]. This could be quite difficult, such as when an air unit upgraded from slow, highly-maneuverable I-153 biplane fighters to high-speed monoplane fighters. Even transitioning from the faster I-16 monoplane fighters to the more-demanding modern fighters was a challenge, often resulting in many accidents. Although sources I've seen do not cover this, the shortage of B-78 must have reduced the flying time of transitioning pilots, hindering their ability to master their new aircraft.

B-78 was the Soviets' best aviation gasoline, but the latest generation of Soviet fighters (LaGG-3, MiG-3, and Yak-1) really needed gasoline with a higher octane rating to achieve their best performance. As early as 1930, for example, the US Army Air Corps[99] required its aviation gasoline to be 87 octane and later that decade some USAAC aircraft began using 92-octane gasoline[100]. By the end of the 1930s, American fighters were using 100-octane gasoline.

97 By 1941 before the war began, most pilots being sent to combat units had the minimal training the Soviets deemed sufficient to fly under "combat conditions" during day time in good weather. However, they still needed to learn many aspects of actual combat flying. Due to the shortness of training, only a few new pilots could handle bad weather or night operations. Some arrived at combat units able to fly but not under combat conditions. A few could not even manage this, arriving at their combat units so poorly trained that they were judged incapable of flying at all until they had been trained more.

98 Sometimes all they had to go on were technical manuals for the new aircraft, which were written by and for technicians and were difficult to understand by field personnel who mostly had mediocre literacy. This situation resulted in very high accident rates for pilots transitioning to the new aircraft, particularly to some of the new fighter models. When peacetime aircraft losses reached alarming levels due to accidents, the Soviets finally formed some experienced demonstration teams to help pilots master the new models.

99 The USAAC became the US Army Air Forces in June 1941 and after the war in 1947 became an independent military service, the US Air Force.

100 In comparison, US Navy aircraft had gasoline with octane ratings of 70, 73, 80, and 83 in 1935. US commercial airlines were using 73-, 80-, and 87-octane grades of gasoline, with 91 octane being required in 1936 with the appearance of the DC-3. *Source:* Alexander R. Ogston; "A Short History of Aviation Gasoline Development, 1903—1980"; *SAE Transactions* vol. 90 (1981).

100-octane gasoline was at first difficult to make, which slowed its adoption outside the US[101]. However, the same fighter with its engine adjusted to use 100-octane gasoline received a significant performance increase over 87-, 89-, 95-, or 95-octane gasoline. Britain and Germany both realized this. In 1939 the British Royal Air Force was using 87-octane gasoline, but by 1940 British fighters were in the process of transitioning to 100-octane gasoline ("BAM 100" or "100/130"), which gave a noticeable performance boost. A Spitfire Mk I fighter using 100-octane gasoline was 28–34 miles per hour (45–55 km/h) faster up to 10,000 feet (3,050 meters) altitude than when it used 87-octane[102]. For another example, most of Germany's aviation fuel came from synthetic gasoline with octane ratings of 89 and 95, but the Germans learned to boost it to 100 octane by use of additives.

Obviously, modern Soviet aircraft would have performed better with 87-octane gasoline than with B-78, and much better with 100-octane. The Soviets actually made a tiny amount of 100-octane gasoline, but in such restricted supplies that all was used for testing purposes and propaganda, such as record-breaking flights across the North Pole.

The highest-octane grades of gasoline were made possible by octane-boosting additives, particularly tetraethyl lead (TEL, "leaded gasoline"), which came into use in the 1920s. The Soviets, who always followed foreign technology, were well aware of additives, and they developed their own as a partial solution to achieve higher-octane fuel. The Soviets made two additives, R-9 (55% TEL, 35% ethyl bromide, 10% monochloronaphthalene; colored with red dye) and B-20 (55% TEL, 35% ethyl bromide, 10% dichloroethane[103]; colored with blue dye), each of which could be added at a rate of 1-to-4 cubic centimeters per kilogram of gasoline to boost octane. Each cubic centimeter added after the first one had diminishing returns, so it was not worthwhile to use more than four per kilogram. R-9 was preferred because it fouled spark plugs less than B-20, but B-20 was used when R-9 was not available. As the following table shows, all grades of aviation gasoline achieved significant octane boosts from the additives, allowing several to get into the 90s. None came close to 100 octane, however.

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101 100-octane gasoline was developed in the USA in the mid-1930s but was difficult and expensive to make. Later that decade a British discovery allowed for mass production. A US company made use of this discovery in 1938, followed by US and British companies further developing efficient manufacture of 100-octane gasoline.

102 The Spitfires' engines had to be modified to use 100-octane gasoline, so it wasn't as simple as just pouring in the new fuel and taking off.

103 Dichloroethane was readily available, as the Soviet chemical warfare industry made the chemical as a solvent for the production of mustard gas, the Soviets' main (albeit unused) chemical warfare agent during World War II. This perhaps accounts for why B-20 was made when R-9 had superior characteristics.

Soviet Aviation Gasoline Grades with Additives

Type	Base Octane	Type with Additives	Boosted Octane	% Gain over Base Octane	% Gain over Previous Level
B-59	59	1B-59	73	123.7%	123.7%
		2B-59	78	132.2%	106.9%
		3B-59	81	137.3%	103.9%
		4B-59	82	139.0%	101.2%
B-70	70	1B-70	80	114.3%	114.3%
		2B-70	85	121.4%	106.3%
		3B-70	87	124.3%	102.4%
		4B-70	88	125.7%	101.2%
B-74	74	1B-74	85	114.9%	114.9%
		2B-74	88	118.9%	103.5%
		3B-74	90	121.6%	102.3%
		4B-74	92	124.3%	102.2%
B-78	78	1B-78	87	111.5%	111.5%
		2B-78	92	117.9%	105.8%
		3B-78	93	119.2%	101.1%
		4B-78	95	121.8%	102.2%

When octane-boosting additives became available, boosted gasoline was designated as "#[K]B-##", with the first # being the number of cubic centimeters of additive per kilogram of gasoline.

It is unclear from sources I've seen exactly when these additives became available. They seem to have been developed in the 1930s and were definitely available in 1941. But, like B-78 aviation gasoline, they were available only in limited quantities.

Soon after the war began, the State Defense Committee (GKO) on 17 July 1941 authorized the use of benzene to boost octane in aviation gasoline. Benzene was not ideal, as its residues could build up and clog an engine, reducing its operational life. Use of benzene might have been just a temporary, emergency measure, but I have not yet found information on when or if the Soviets phased out its use.

Four days later on 21 July, the GKO authorized the use of ethyl alcohol (aka ethanol) with gasoline. Unlike advanced petrochemical additives for gasoline, the Soviets could easily obtain ethyl alcohol... from their vodka industry.

Delivery trucks at the Moskva Distillery Factory

The Moscow State Wine Warehouse № 1 was established in 1901. Although called a "wine warehouse" it was a distillery and made alcoholic beverages, including several kinds of vodka. Shortly after the outbreak of World War I in 1914, the Russian government banned most alcohol production and sales, including for civilian and military use[104].

The factory curtailed much of its alcoholic beverage production (some was allowed to continue, particularly for sale to France) and switched to making alcohol-based medicines. Spare room at the distillery became a hospital.

The ban on alcohol led to the development of a vast black market, which soon expanded to sell cocaine and other drugs, bread and other food (which became in short supply in the war), and other hard-to-obtain items. The black market was one of many factors that eroded trust in the Russian government, along with heavy war losses, inflation, and food shortages. Two revolutions

104 This included vodka, and Imperial Russian Army, to the great dismay of many of its soldiers, officially fought the war "dry" despite previously having had the reputation as being one of the most drunken armies in Europe. All other major European combatants issued alcohol rations to their soldiers. Russian sobriety did not make up for many semi- or fully-illiterate soldiers, many incompetent officers, and poor strategy, so the outnumbered, schnapps-drinking German Army frequently defeated the Russians. To be fair, unlike most other "wet" combatants, the Germans did not issue alcohol to troops on the front line, only in the rear. Of course, some soldiers saved their rations for later… Also to be fair, some Russian soldiers found ways to obtain alcohol at all times, despite the Russian government staging a drive for civilians to donate books for wholesome entertainment of the troops. (Yes, the book drive really happened.) While the Germans frequently defeated the Russians, the Russian in turn frequently defeated the Austro-Hungarians. When the Russians achieved a breakthrough, some Russian soldiers, perhaps many, abandoned the advance and their duties to loot and immediately drink all alcohol they could capture. This perhaps helps explain why when the Germans showed up to rescue the Austro-Hungarians, they halted and sometimes threw back the Russians.

in 1917 put the Soviets in power. They continued the alcohol ban until after they won the Russian Civil War against their many opponents. The black market of course continued to flourish, despite the Cheka (the Soviet secret police) having extrajudicial authority to arrest, torture, imprison, or execute black marketeers and any other enemies of the state like speculators, corrupt officials, and counter-revolutionaries. In August 1923, the Soviets rescinded the ban. This not only weakened the black market but soon brought in substantial revenues for the state through legal sales of alcohol.

The Moscow State Wine Warehouse № 1 was back in business, under new state management. At some point under Soviet control, it became the Moskva Distillery Factory (*Moskovskiy Likero-Vodochnyy Zavod*; literally, the "Moskva Liquor-Vodka Factory"). Vodka was official again, after having hid in the black market from 1914 to 1923. Perhaps in 1938 or 1940, V.G. Svirida at the distillery developed the recipe for the Stolichnaya vodka brand. (The history of the distillery claims 1940, but other sources claim 1938 for the recipe and its Soviet trademark.) Limited Stolichnaya production supposedly did not begin until 1941, at Leningrad which was then besieged by the Germans[105], and mass production did not start until 1943 or 1944 (sources disagree), with Stolichnaya becoming internationally famous after the war.

In June 1941, the Germans invaded the Soviet Union, and the distillery was soon helping the war effort. On 22 July 1941, the Luftwaffe launched a medium-sized bombing raid on Moskva. The distillery's main building was hit and was badly burnt. The distillery workers quickly restored production. During the war, the distillery continued to make alcoholic beverages, particularly vodka. Vodka helped finance the war, since all proceeds from vodka sales to Soviet civilians went to the state. Vodka helped fight the war, since each Red Army soldier was allocated 100 grams (about 3.5 ounces) per day. It was perhaps just a coincidence that the dry Imperial Russian Army lost the war to the wet Imperial German Army, but, "*Luchshe perebdet, chem nedobdet*" ("Better to be vigilant beyond necessity than to be not vigilant enough"; a Russian saying meaning "Better safe than sorry"). Perhaps to encourage the troops, Stalin himself set an example with numerous late-night drinking sessions with his top Party and government buddies[106].

The distillery directly contributed to the war effort in other ways. It made medical alcohol and ethyl alcohol, which was used as a gasoline additive. It assisted in the production of "incendiary bottles" or "fire bottles" (*ognennye butylki*), later called incendiary grenades. In many other countries, these were called Molotov cocktails, but the Soviets did not use that term, as it was invented by the Finns in derision of the USSR during the Winter War of 1939–1940. These bottles used gasoline and (later) other petroleum products, which with luck when smashed on a German tank could set its gasoline fuel tank on fire, knocking it out.

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105 I cannot figure out if this Leningrad claim is propaganda or if the Soviets actually decided to let the city make a new kind of vodka, even though they could not send enough food or fuel there. After all, the Soviets in 1942 did stage a special performance of Shostakovich's new opus, Symphony No. 7 ("Leningrad"), over loud speakers along the front lines, to let the Germans know Leningrad's spirit was not broken.

106 Stalin sometimes insisted that when he drank a shot, everyone did so, too. Stalin drank lots of shots. At least once and likely more often, Stalin was drinking less-potent Georgian wine while everyone else had vodka. Stalin also required his drinking companions to go to work the next day at the usual time and for the usual long shift, no matter how late the drinking session lasted or how much was consumed.

The distillery at first used wine and vodka bottles for the incendiary bottles, but Soviet incendiary bottle technology became increasingly advanced during the war with specially-designed containers and self-igniting bottles. Despite being a risky, very-short-range weapon, these easy-to-make incendiary bottles were important to the Soviets in 1941 and parts of 1942 as an antitank weapon, as the Soviets lost huge amounts of more-effective antitank rifles and antitank guns in 1941. Later in 1942, Soviet military production recovered from evacuating out of the path of the enemy, and better antitank weapons relegated the incendiary bottle to an emergency weapon.

Although Soviet vodka helped finance the war and fight the war, its special moment came when the war ended. On 9 May 1945 at 1:10AM, Soviet radio stations announced to the Soviet public the surrender of Germany. In very many places, very many free citizens took to the streets to celebrate Victory Day, which became a day-long drunken party fueled by vodka. By 10 May, in many cities including Moskva, all stores had run out vodka. THE SOVIET UNION HAD RUN OUT OF VODKA! Well, that's the legend. It's not quite true; the stores may have run out but there was still some vodka in the warehouses, and the Red Army supply chain still had plenty on its way to the troops.

I believe the use of ethyl alcohol was intended to extend the supply of both vehicular and aviation gasoline, but it also had the effect of boosting octane. However, ethyl alcohol has a lower energy density than gasoline, so mixing it into aviation gasoline would have reduced aircraft range, an undesirable side effect. Ethyl alcohol is also corrosive to rubber and some metal parts and must have damaged Soviet engines, since they were not designed for use with this additive. Like benzene, ethyl alcohol might have been just a temporary, emergency measure, but I have not yet found information on when or if the Soviets phased out its use.

Allied aid helped the Soviets with octane-boosting petroleum products, often called "light gasoline fractions". The Soviets blended these into their aviation gasoline to achieve significantly higher octane ratings. The Soviets chose to boost B-70, most likely because they could produce it in quantity, but unless boosted it was only good for older aircraft. The Soviets created three mixtures, each of which boosted B-70 from 70 to about 95 octane. 4B-78, the Soviets' best grade of aviation gasoline boosted to its maximum with Soviet R-9 or B-20 additives, was also 95 octane, so Allied light gasoline fractions allowed Soviet B-70 match 4B-78's octane rating. Although I have not found a Soviet-based source that goes into this, I speculate that 95-octane became the Soviets' standard for their best aircraft. Mixing Allied light gasoline fractions into B-74 or B-78 might have yielded octane ratings in the high 90s above 95. However, this would have only yielded small amounts of above-95 gasoline, since B-74 and B-78 were produced in relatively small amounts. The Soviets would have had to adjust Soviet aircraft engines to use the differing levels of octane (like the British had to when they went from 87 octane to 100), which would have been a maintenance burden, or, likely, some field forces would have just ignored this, wasting the above-95 gasoline.

Soviet Octane-Boosting Mixtures

Mixture	**Ingredients**
Mixture № 1	60% B-70 20% isooctane 20% neohexane
Mixture № 2	60% B-70 20% alkylbenzene 20% neohexane
Mixture № 3	60% B-70 32% isooctane 8% isopentane

Sources: A.A. Meilya; "VI. Goryuchee dlya Budushchey Voyny: Planirovanie Obespecheniya Goryuchim Vooruzhennykh Sil SSSR na 1941 Voennyy God Kak Primer Narodnokhozyaystvennogo Mobilizatsionnogo Planirovaniya" ["VI. Fuel for a Future War: Planning the Supply of Fuel to the Armed Forces of the USSR for the 1941 War Year as an Example of Peoples'-Economic Mobilization Planning "]; *Mobilizatsionnaya Podgotovka Narodnogo khozyaystva SSSR* [*Mobilization Preparation of the Peoples' Economy of the USSR*]; 2004. http://militera.lib.ru/research/melia_aa/10.html

and

V.N. Kostornichenko; "Neft v Ssisteme Lend-Liza: Neftyanoy Soyuz SSSR i SShA v gody Vtoroy Mirovoy Voyny" ["Oil in the Lend-Lease System: the Oil Union of the USSR and the USA during World War II"]; *Ekonomicheskaya Istoriya*, Obozrenie, Vypusk 11 [*Economic History*, Overview; Edition 11]; Trudy Istoricheskogo Fakulteta Mgu 32 [Proceedings of the Faculty of History, MSU (Moskva State University)]; 2005. http://www.hist.msu.ru/Labs/Ecohist/OB11/USSR/kostornichenko.html

These mixtures all used "№ #" designations and not "#B-##" designations.

Allied aid also supplied a small amount of vehicular gasoline to the USSR, 242,200 tons, which Kostornichenko puts as 2.8% of Soviet domestic production of vehicular gasoline. However, this gasoline was much higher octane than Soviet vehicular gasoline (56-octane gasoline and 63-octane winter gasoline). For example, the highest octane vehicular gasoline the USA made during the war seems to have been 80-octane, which was higher octane than even the best Soviet aviation gasoline. The US also made grades of vehicular gasoline with octane ratings in the 70s, and I am not sure which grads of gasoline the US sent. One possibility is that the US sent 78-octane vehicular gasoline, as this was the octane required for the 100,000 US Studebaker trucks sent to the USSR[107] and could also have been used for

107 80-octane gasoline was definitely used for Allied military purposes elsewhere, and in 1943 the US government warned the US public about impeding shortages of high-octane vehicular gasoline for civilian use. (OFFICE OF WAR INFORMATION: This

gasoline-engine tanks. Kostornichenko does not mention the octane of Allied-aid vehicular gasoline but implies it is high, as "these supplies were also very valuable for the Red Army, which received a large amount of automotive equipment under Lend-Lease…. The rational use of equipment obtained from abroad was hampered by a chronic shortage of petroleum products".

Allied aid supplied the Soviets with substantial amounts of aviation gasoline. About half of wartime Soviet aviation gasoline (on an estimated order of 51.1%) was either Allied-aid aviation gasoline itself or light gasoline fractions, which as covered above were mixed into Soviet B-70 to raise its octane rating. The Soviets received what they called B-95 (95 octane, 95/130) and B-100 (100 octane, 100/130) aviation gasoline from the Allies. Some of the Allied-supplied B-100 aviation gasoline was used with Allied-aid aircraft the Soviets received, since these required 100 octane for best performance. However, the Soviets sometimes used lower-octane gasoline blends with at least some of these aircraft.

The Soviets could use their R-9 and B-20 additives with Allied B-95 gasoline to raise its octane rating. I strongly suspect this rarely happened, since these additives were needed for Soviet aviation gasoline. (If my speculation on 95-octane becoming a standard for the best Soviet aircraft is correct, then the Soviets would also have had no strong reason to raise B-95's octane rating.) Instead, B-95 and B-100 were often blended into some grades of Soviet aviation gasoline to raise their octane ratings.

Report on CIVILIAN GASOLINE SUPPLY is ADVANCE RELEASE: For WEDNESDAY MORNING Papers, October 13, 1943; http://plainshumanities.unl.edu/homefront/homefront.docs.0015).

Besides "super-premium" 80-octane gasoline, the wartime US certainly made "regular" at 70 octane, "premium" at 77 octane, and "less-than-regular" at 50 octane for older engines. It is extremely unlikely the US sent 50-octane gasoline to the Soviets, since the Soviets made their own 56-octane gasoline in quantity. Since the Studebaker truck required 78 octane, it seems possible that a super-premium grade of gasoline at this octane was made or perhaps blended from 77- and 80-octane gasoline grades.

Allied-Aid Aviation Gasoline Deliveries, 1941–1945 (millions tons)

Category	Deliveries	Notes
US-aid aviation gasoline	570,029	This is net deliveries. 604,185 tons (666,000 short tons) were delivered to the USSR but 34,156 tons (37,650 short tons) were then redirected elsewhere. 88% of this was 100-octane gasoline[108]. Presumably the other 12% is 95-octane gasoline, but the sources do not go into details here.
US-aid light gasoline fractions	664,300	(732,300 short tons). Almost all of this was mixed into Soviet aviation gasoline to raise its octane rating and hence counts as aviation fuel.
British-aid aviation gasoline from Abadan, Iran, refinery	13,336	
British-aid light gasoline fractions from Abadan, Iran, refinery	818,370	Almost all of this was mixed into Soviet aviation gasoline to raise its octane rating and hence counts as aviation fuel.
Other British-aid and Canadian-aid aviation gasoline	512,000	
Allied-aid Total	2,578,035	

Source: Boris V. Sokolov; "The Role of Lend-Lease in Soviet Military Efforts, 1941–1945"; *Journal of Slavic Military Studies*, vol. 7, No. 4; December 1994.

Abadan in Iran was a major refining center for the British. It was also very important for Lend-Lease as it was the western Allies' refinery that was closest by far to the USSR. Once the cargo capacity of the "Persian Corridor" Lend-Lease route was built up, it saved time and shipping capacity to send the Soviets oil products from Abadan rather than from other refineries. However, Abadan could not supply all Soviet needs as well as British ones in the area, so oil products from Britain, Canada, and the US were also sent to the USSR, including using the Northern Route to Murmansk and Arkhangelsk and the Pacific Route to Vladivostok.

(British fuel deliveries from Abadan substituted one-for-one with the American Lend-Lease commitment to the USSR, so this may be why some Soviet sources consider fuel from Abadan to be *Lend-Liza* (Lend-Lease). Alternatively, some Soviet-based sources seem to call

108 V.N. Kostornichenko; op. cit. Technically the 88% "had an octane number above 99" as that accorded to how the wartime Soviets grouped octane ratings, but that is just another way of saying 100 octane. Unfortunately, Kostornichenko does not supply octane ratings of British-aid and Canadian-aid aviation gasoline. However, Boris V. Sokolov states that over 97% of Allied aid "had an octane rating of 99 and higher", which given the US 88% is only possible if all US-aid light gasoline fractions, British-aid aviation gasoline from Abadan, British-aid light gasoline fractions from Abadan, and other British-aid and Canadian-aid aviation gasoline were 100 octane.

all Allied aid *Lend-Liza*, including the substantial British and Canadian aid that were sent to the USSR outside the US-Soviet Lend-Lease protocols.)

Total Supplies of Soviet Aviation Gasoline, 1941–1945 (tons)

Year	Total	Wartime	Notes
1941	1,269,000	776,000	776,000 is an estimate. See the notes at the end of the table for how I calculated it. All year-based totals include both Soviet domestic production of aviation gasoline and Allied aid of aviation gasoline and light gasoline fractions.
1942	912,000	912,000	
1943	1,007,000	1,007,000	
1944	1,334,000	1,334,000	Year of highest supply during or before the war.
1945	1,017,000	1,017,000	For simplicity, all of 1945 Soviet production and Lend-Lease deliveries are counted as wartime, even though World War II ended on 2 September 1945. See the notes below for a discussion of this.
Total	5,539,000	5,046,000	This includes Soviet domestic production and Allied aid.
Allied-aid	2,578,035	2,578,035	This only includes Allied aid.
Allied-aid %	n/a	51.1%	51.1% is an estimate of the Allied aid during the war. (If Soviet pre-war production for 1941 is included, Allied aid is 46.5% of Soviet total aviation gasoline, but this does not accurately reflect wartime efforts.)

Sources: Mostly from Boris V. Sokolov; "The Role of Lend-Lease in Soviet Military Efforts, 1941–1945"; *Journal of Slavic Military Studies*, vol. 7, No. 4; December 1994, which itself uses *Narodnoe Khozyaystvo SSSR v Velikoy Otechestvennoy Voyne 1941–1945 gg.* (*People's Economy of the USSR in the Great Patriotic War 1941–1945*), a once-secret 1959 statistical compilation of the Soviet wartime economy for the Soviet government. Sokolov just halves 1941's production to 634,500 to approximate 1941 wartime production (22 June-31 December 1941, slightly over half a year), but I use the likely more-accurate 776,000 tons for the second half, as explained below.

The yearly figures in the table, such as 1,269,000 tons for 1941, include Allied-aid deliveries. *People's Economy* lists this figure but does not explicitly state that it includes Allied aid. However, a different table in *People's Economy* lists "912.2 thousand tons" of aviation gasoline for 1941, which, although unexplained, seems to be Soviet domestic production for 1941[109].

109 The summary tables for People's Economy lists yet another figure for 1941 aviation gasoline production, 927,000 tons, but I strongly suspect this is an error, perhaps a compilation mistake. I thus use the 912,200 tons figure from the Fuel Industry

1,269,000 tons minus 912,200 tons is 356,800 tons, which implies that this is Allied aid in 1941. I do not know the exact total amount of Allied aid for 1941 from other sources, but I believe at a minimum it has to be at least 250,200 tons. The US supplied 132,000 tons of aviation gasoline through September 1941 and at least 20,000 tons of aviation gasoline per month for the next three months (estimated US minimum total 192,000 tons). The British started supplying aviation gasoline in late August 1941, and, although I do not know the amount, I posit 15,000 tons of aviation gasoline per month for four months (estimated British total 60,000 tons). Combining the two figures yields 252,000 tons. This is off by 104,800 tons from the 356,800 tons figure. One possibility is that the 104,800 tons is light gasoline fractions, which might not have shown up as aviation gasoline in Allied accounts but was counted as such by the Soviets.

It is very likely that Soviet domestic production of aviation gasoline was higher in the first half of 1941 than in the second half, as was the case for almost all other 1941 Soviet industrial or resource-extraction production. The Soviets were still at peace and expanding their economy in the first half of 1941. The German invasion and Soviet mobilization of manpower disrupted many parts of the economy in the second half of 1941, leading to lower production. So, I have modeled 1941 aviation gasoline production as:

CP = (.5 * PP * GP) + (.5 * PP * GP * DF), or in summary,

CP = (first half 1941) + (second half 1941)

where

CP is 1941 current domestic production, 912,200 tons,

.5 is for half a year's production,

PP is the previous year's domestic production, 889,000 tons,

GP is the peacetime growth percentage for 1941's production compared to 1940's, which is unknown (since the second half of 1941 was affected by the war), and

DF is the disruption factor of the war, which also is unknown and only applies to the second half of the year.

I set DF at .85. Aviation gasoline production was undoubtedly disrupted to some degree by the war[110], and total Soviet gasoline production (which includes both vehicular and aviation gasoline) was certainly disrupted in 1941, as figures from *People's Economy* show: total

section.

110 Some production must have been lost due to the evacuation of Ukrainian oil refineries (at Odessa and Kherson) in the summer of 1941. Also, Soviet mobilization of manpower very likely made the oil industry workforce less efficient, as experienced oil workers sent to war were replaced by inexperienced workers, mostly teenagers and women. This is known to have reduced production in other industries, and there is no reason to suppose the oil industry was different. Also, reduced production elsewhere in the economy would have adversely affected the oil industry, reducing the supply of parts the industry needed to maintain full production.

(The oil industry was a strategic defense industry, which meant that many oil industry occupations were exempt from conscription. However, very many men in the industry volunteered to join the Red Army, so the industry was still strongly affected by Soviet mobilization. Overall, 20% of the personnel in the People's Commissariat of the Oil Industry went into the military, including 45% of the oil drillers and 60% of their assistants.)

gasoline production for the Soviet economy was 2,702,400 tons in 1941, only 88.3% of 1940's production (3,060,700 tons).

All this allows GP to be calculated, yielding 110.9%[111]. I included GP to be a check on my various assumptions and deductions; if GP is too high, then something in the reasoning is wrong. A GP of 110.% corresponds to a one-year growth rate of 10.9%. For a major, expanding industry, this is well within bounds of what the Soviets could achieve, and the Soviets were certainly trying hard to expand their output of aviation gasoline. (Note that this growth rate of 10.9% is what the Soviets might have achieved had actual production for the second half of the year not been disrupted by the war. The actual 1941 growth rate was (912.2–889)/889 * 100 = 2.6%.)

Finally, the equation yields an estimated Soviet domestic production of 493,000 tons for the first half of 1941 and 419,000 tons for the second half. 1,269,000 tons 1941 total minus 493,000 tons for the first half of 1941 is 776,000 tons for the second half, which would include all Allied aid in 1941.

As for 1945, the Soviet war against Germany and its allies ended in May 1945. However, Lend-Lease kept flowing to the USSR, even though it was not (yet) at war with the last member of the Axis, Japan. The Soviet Union had secretly promised to enter the war against Japan three months after the war against Germany ended, so the USA continued to send Lend-Lease to the USSR[112]. The Soviets entered the war against Japan in August 1945 and ended operations on 2 September 1945 when Japan formally surrendered. With the war over, Lend-Lease officially ended on 2 September, and ships en-route to the USSR were recalled. (The US Congress in 1945 had passed a law prohibiting Lend-Lease from being used for post-war reconstruction.) However, Lend-Lease soon resumed!

The Soviets were highly displeased that Lend-Lease had ended so abruptly. They had negotiated their Lend-Lease needs with the USA in 1944, resulting in the fourth Lend-Lease protocol, and they wanted to receive its full amount. The US administration, unaware that Stalin was already intending to expand Soviet power at the expense of his erstwhile allies and his promises to them, sought an accommodation. In October 1945, the US negotiated a "pipeline agreement" that allowed delivery to the USSR of Lend-Lease already "in the pipeline" (previously-agreed-upon Lend-Lease for the USSR that had already been made

111 As people experienced in statistics might point out, my projected 110.9% growth rate for 1941 over 1940 is a very simplified model, as it ignores compounding effects within a year's production. Since the peacetime refining industry was expanding, peacetime production for the second half of the year might have been even higher than production in the first half of the year, resulting in an even-higher annual growth rate, perhaps on the order of 116%. However, a more sophisticated model would depend upon more data than I have available (for just one example, would significant new refining capacity have come on line in the second half of the year?).

112 American critics of the Truman administration called for Lend-Lease to the USSR to end in May 1945, as the USSR was no longer at war with Germany and was not at war with Japan. This temporarily caused the Truman administration some discomfort, since they could not reveal the actual reason for the continuation of Soviet Lend-Lease (that the USSR was going to enter the war with Japan). However, the Lend-Lease Act gave the President wide discretion over who received Lend-Lease and did not require Lend-Lease to go only to belligerents.

but not delivered, or was in the process of being made). This was not the full amount agreed to in the fourth protocol (as anything not yet in production was excluded), but it was still substantial aid. I believe this must have entailed further deliveries of aviation gasoline. Thus, from an Allied-aid perspective, all of 1945 should be included.

The Soviets began shifting to a peacetime economy in May 1945 soon after the war with Germany ended. Various categories of military production began to decline. It is unclear, however, whether production of aviation gasoline was affected. Sources I've seen do not go into this. Given than production of aviation gasoline was both a priority and a bottleneck for the Soviets, a logical supposition is that they might have continued aviation gasoline production at full refining capacity, at least until their storage facilities were full, and they might well have decided to expand storage facilities to build up a large strategic reserve.

In September 1945 with the defeat of Japan, the Soviets accelerated their shift to a peacetime economy. Again it is unclear whether aviation gasoline production was affected. With military operations ended, the Soviets would have needed far less aviation gasoline for their tanks and aircraft. However, the ending of Lend-Lease in September would have concerned the Soviets about their supplies of aviation gasoline, since so much came from Lend-Lease. Even with the resumption of Lend-Lease in October, it would have been clear to the Soviets that Allied aid would soon end. Again, a logical supposition is that they might have continued aviation gasoline production at full refining capacity. These "logical suppositions" are speculation on my part with no confirmation or refutation so far from Soviet-based sources that I've seen.

So, it is possible that Soviet domestic aviation gasoline production may have started to decline at least from September 1945 if not from May 1945. However, it is also possible that the Soviets continued full production of aviation gasoline throughout 1945 to build up strategic reserves. Without better sources of information, I find it impossible to guess Soviet aviation gasoline production in the final months of 1945. This is another reason I include all of 1945 production and deliveries as wartime.

In 1942, the Soviets managed to increase their production of B-78, although they made less than what they had planned. One problem was that they intended to make quantities of B-78 (and KB-70) by advanced catalytic cracking. This was a new technology for the Soviets that their refining industry was having trouble mastering. As of July 1942, the industry had been unable to produce a single ton of B-78 by catalytic cracking[113]. The short-term solution to the B-78 shortage was to rely on Lend-Lease octane-boosting additives more, and in July 1942 the GKO ordered the People's Commissariat of Foreign Trade to import many thousands of tons of additives starting in September.

113 http://alternathistory.com/goryuchaya-problema-sovetskoj-aviatsii/

During the war, less than half of Soviet aviation gasoline sent to the military came with additives already mixed in. Instead, Soviet forces in the field often received gasoline and the additives separately. According to one source, about 53% of the time, the field forces themselves mixed the additives into the gasoline. This in theory was an efficient way to achieve whatever particular octane they needed at the moment. However, some have speculated that the sometimes-careless field troops did not always mix the additives exactly to specifications, so the actual octane and thus performance they achieved likely varied.

Most 1930s gasoline-engine Soviet tanks, which were mostly light tanks, used aircraft engines in order to obtain sufficient power. They used aviation gasoline, the B-59 and B-70 grades, but did not need higher-octane gasoline. When cracking technologies became available, the Soviets made a 70-octane KB-70 gasoline, but its other characteristics were not quite technically as good as B-70. KB-70 thus was supposed to be used for tanks rather than for aircraft.

By the start of the war, the Soviets' modern medium and heavy tanks all had diesel engines and used diesel fuel. However, the Soviets had a huge tank park of older tanks, which required great amounts of aviation gasoline. In the initial years of the war, particularly in 1941–1942, the disruption of the Soviet economy due to manpower mobilization and evacuation of industry meant the Soviets could not make medium and heavy tanks in the numbers they needed. Instead, they made thousands of gasoline-engine light tanks as a substitute for medium tanks. When diesel-engine medium tanks became plentiful in 1943, the Soviets made fewer light tanks but made more gasoline-engine light self-propelled guns, so Soviet ground forces to the end of the war needed large quantities of aviation gasoline. Soviet-based sources that I've examined do not break down how much aviation gasoline went to the ground forces as opposed to the air forces.

Many Allied-aid tanks supplied to the USSR during the war also used gasoline aircraft engines for the same reason the Soviets used them: power. This included many Allied-aid medium tanks[114]. This led to numerous instances of the Soviet tank-evaluation specialists and the field forces complaining about the gas-guzzling nature of these tanks. These complaints can seem like ingratitude, since the Soviets themselves had plenty of gasoline-engine light tanks. However, a Soviet T-60 weighed 5.8 tons while a Lend-Lease M4A2 weighed 33.3 tons, so a substantially greater amount of fuel was required for the medium tank than for the light tank.

114 The US made both gasoline and diesel versions of its M4 Sherman tank, and the Soviets received both versions.

Allied-aid concentrated on supplying aviation gasoline to the Soviets, which made sense since the Soviets had great difficulties in making very-high-octane gasoline. The converse of this is that Allied aid supplied relatively little vehicular gasoline to the Soviets, only 242,200 tons or about 2.8% of Soviet domestic production of vehicular gasoline. However, all of this almost certainly had an octane rating between 70 and 80, making it the equivalent of Soviet aviation gasoline. Very likely, this Allied-aid vehicular gasoline was used for gasoline-engine tanks and, at least some of the time, the Lend-Lease Studebaker trucks.

The Soviets also captured enemy stockpiles of gasoline, particularly in 1944–1945 during their offensive advancing into eastern Europe, central Europe, and Manchuria. The Soviets called these captures “trophy gasoline”. However, the Axis was very short of gasoline and tried to preserve all they could from capture. The USSR gained only 82,800 tons of trophy aviation gasoline to September 1945, a tiny amount compared to what they made and what Allied aid supplied. I do not have a source on how much trophy vehicular gasoline they captured; likely it was more than aviation gasoline.

4.A.4 Diesel Fuel

Note: Diesel fuel is a form of fuel oil and is sometimes known as “diesel oil”. During World War II, the US used both terms but “diesel oil” seems to have been used more, at least in US government documents. “Diesel oil” can be a bit confusing as it sounds like it should be similar to “motor oil” or “engine oil”, which are engine lubricants, but diesel oil is a fuel. Diesel engines use engine oil for lubrication, oils that can withstand the high compression ratios of these engines.

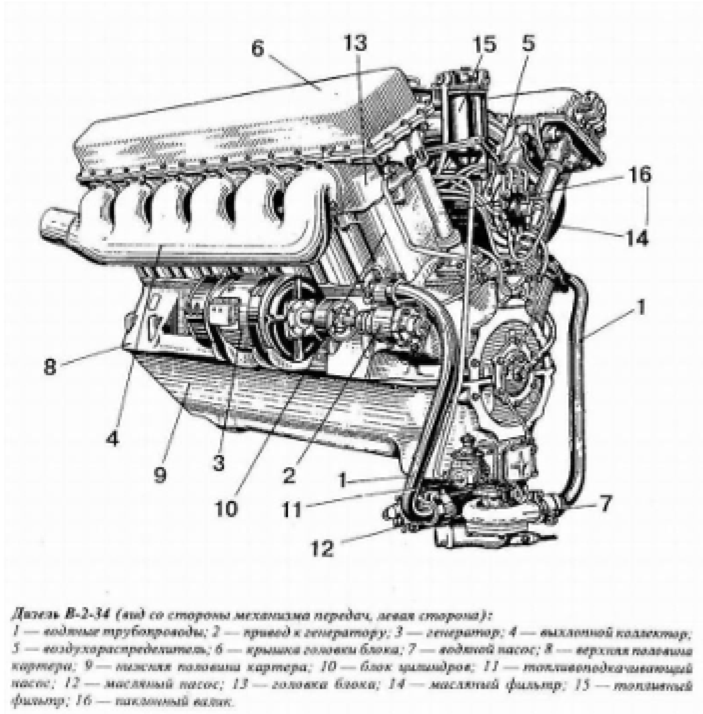

Diagram of the V-2–34 diesel engine

The family of V-2 engine models powered most of the modern Soviet tanks and self-propelled guns in World War. Designed, developed, and initially produced at the Kharkov Locomotive Factory, many tens of thousands were made at various factories, in several models:

V-2: 500 horsepower. Original model, used for the BT-7M fast light tank.

V-2–34: 500 horsepower. V-2 modernized and used for the T-34 medium tank.

V-2K: 600 horsepower. V-2 version for the KV heavy tanks.

V-2V: 375 horsepower. V-2 version for the Voroshilovets prime mover, typically used as an artillery tractor capable of towing loads up to 16 tons and sometimes as a recovery vehicle.

V-4: 300 horsepower. A redesign for the advanced T-50 light tank, only 75 of which were built before the wartime Soviets decided to concentrate light tank production on the much-less-effective but much-easier-to-build T-60 light tank.

V-2IS: 520 horsepower. A redesign for the IS-1 and IS-2 heavy tanks.

All told, V-2 models and derivatives powered the KV-1, KV-2, KV-1s, KV-85, IS-1, IS-2 heavy tanks; the T-34 and T-34–85 medium tanks; the BT-7M and T-50 light tanks; the Voroshilovets prime mover; the SU-85, SU-122, SU-100, SU-152, ISU-122, and ISU-152 medium and heavy SPGs.

The Soviets became interested in diesel engines in the early 1930s. Later that decade, the Soviet military came to prefer these engines because they used diesel fuel (*dizelnoe toplivo*), which was much safer than gasoline. After observing how gasoline-engine tanks could catch fire in combat during the Spanish Civil War[115], the Red Army liked the fact that diesel fuel was far less likely to catch on fire and explode. While good design and manufacturing

115 Especially when hit with improvised gasoline bombs (aka petrol bombs, later to become famous as Molotov cocktails from the Winter War of 1939–1940).

minimized the risk of gasoline fires in most country's tanks[116], Soviet gasoline-engine tanks were more vulnerable because of low-quality Soviet manufacturing. Poorly-made fuel lines, seals, engine fittings, and fuel tanks coupled with poor maintenance and repair regimes meant gasoline leaks were more likely for Soviet tanks, increasing the risk of fire and explosion in combat. The Soviets began several projects to create diesel engines for tanks, trucks, tractors, and even multi-engine bombers[117]. Most of these engines turned out to be very difficult for the Soviets to develop, taking many years. Some outright failed, like a truck diesel engine.

Work on a diesel engine for heavy bombers began in 1931. The project eventually created a working engine, but it was a failure for its intended use. The development team could not raise the engine's horsepower to the required 1,000–1,500-hp range needed for an aircraft. However, the project was saved by the Red Army's desire for a diesel tank engine, which did not need such high horsepower. Work continued. In late 1937, many years into the project with the engine still not ready, the project leader was arrested, imprisoned, and in early 1938 executed by the NKVD[118]. A new leader was installed. The engine was then soon "finished" and entered production in 1939 in three models: the 500-hp V-2 for the BT-7M light tank and the T-34 medium tank, the 600-hp V-2K for the KV-1 and KV-2 heavy tanks, and the 375-hp V-2V for the Voroshilovets artillery tractor. (Other versions were developed later.) I put quotes around these engines being "finished" because they had some serious problems that, together with low-quality Soviet manufacturing, meant they wore out quickly. The goal was for the diesel engine to last for 200 hours of use before needing to be replaced. Even this was a somewhat low goal, as Soviet gasoline engines like the M-17F were expected to last for 250 hours. The earliest production batches often failed after just an almost-unacceptable 50 hours of use; by the start of the war improvements raised this to a

116 Instead of gasoline fires, a much bigger issue for most countries was a tanks' ammunition exploding when it got hit in combat. This concern, for one example, eventually led to M4 Sherman tanks using wet storage of ammunition rather than dry storage. The gasoline-engine models of US M3 Stuart light tank gained a reputation for its fuel igniting when the tank was hit in combat. This is correct, but it should be noted the M3 was mainly supposed to be used for reconnaissance purposes. When used as a battle tank, its weak armor made it vulnerable to enemy tank and antitank fire.

117 Due to the nature of diesel combustion, WW2-era diesel engines had to be built much stronger than gasoline engines. Instead of having spark plugs, the engine used very high compression to cause the fuel to self-ignite. Diesel engines needed to be built robustly to withstand their high engine pressures, which in the WW2 era made them much heavier than gasoline engines with comparable power. This (among other factors) made them impractical for many aircraft and small ground vehicles like passenger cars and light or medium trucks. To save weight, the Soviets built some of their diesel engines using lighter-but-more-expensive aluminum rather than steel. Even these engines were impractical for most aircraft other than large multi-engine bombers. This is how the T-34 tank ended up with an aluminum diesel engine: the engine originally was intended for a bomber.

118 This was K.F. Cheplan (24 May 1899–11 March 1938). After Stalin's death and Krushchev's rise to power, Cheplan was rehabilitated in 1956 during de-Stalinazation.

still-disappointing 100 hours; during the war further improvements raised this to a mediocre 150 hours. However, these were the official ratings, and engines often failed sooner than this[119]. During Soviet offensives even late in the war, Soviet tank strength sometimes rapidly declined as the Soviet-made diesel engines of their tanks wore out. Since gasoline engine of the Lend-Lease M4 Sherman tank was highly reliable, many of the elite Soviet armored units used the M4 instead of the T-34.

Nonetheless, the V-2 engine models allowed the Soviets to put diesel-engine tanks into mass production. Besides safety, diesel engines had another advantage over gasoline engines: greater fuel economy. For example, as the following table shows, diesel fuel was the least-consumed fuel at the Battle of Kursk, one of the largest tank battles in history.

Average Daily Fuel Consumption by the Soviets at the Battle of Kursk (tons)

Fuel Type	Daily Consumption	Percentage	Notes
Vehicular Gasoline	602	44%	Fuel for gasoline-engine trucks, staff cars, etc., but not tanks or SPGs.
Aviation Gasoline for Aircraft	406	30%	
Tractor Fuel	134	10%	Fuel for artillery tractors and similar equipment. See tractor fuel in the kerosene section for a discussion of what this fuel was.
Aviation Gasoline for Tanks and SPGs	125	9%	Fuel for gasoline-engine tanks and SPGs. Mostly or completely B-70/KB-70.
Diesel Fuel	100	7%	Fuel for diesel-engine tanks and SPGs
Total	1,367	100%	

Source: V.G. Martynov and N.N. Golunov; "Neftegazovye vekhi Velikoy Pobedy: Maloizvestnye Istorii Vekikoy Otechestvennoy Voyny" ("Oil and Gas Milestones of the Great Victory: Little- Known Stories of the Great Patriotic War"); *Neftegaz.RU* April 2020.

Fuel consumption covers both the Soviet defensive and offensive periods of the battle, from 5 July to 23 August 1943 (50 days of operations).

119 A T-34 sent to the USA in 1942 for testing experienced engine failure after just 72.5 hours of use, 14.05 hours of which were with no load on the engine. The tank traveled only about 665 km (415 miles) and suffered 14 breakdowns. Soviet tests of V-2 diesel engines in 1943 showed them reliable for only 300–400 km (185–250 miles) of use, averaging 26 breakdowns per 1,000 km. By 1945–1946, improvements meant the engines were good for 1,200–1,500 km of use, with only 9 breakdowns per 1,000 km. (https://nvo.ng.ru/history/2000–06–02/5_diesel.html: "Dizel V-2: Letopis Konstruirovaniya i Dovodki" ["Diesel V-2: Chronicle of Design and Development"].

Total aviation gasoline (for both aircraft and gasoline-engine tanks and SPGs) would be the combination of the two separate categories, 531 tons/day (39% of total consumption).

1,367 tons per day for 50 days yields a total of 68,350 tons of fuel for the Kursk battle. The authors elsewhere state the total Soviet fuel consumption for the Kursk operations was 156,000 tons, with the same time span. Yet another source states the fuel consumption was 204,000 tons. I suspect the discrepancies are explained by which forces are included for the battle, such as whether or not forces for the Soviet Belgorod–Kharkov Offensive Operation that liberated Kharkov in August are counted, which the Soviets often count as part of the Kursk operations and would justify the 156,000 tons figure. Similarly, the 204,000 tons figure looks likely to include the Soviet Western Front, which began the Battle of Smolensk on 7 August, an operation the Soviets usually did not count as part of the Kursk operations.

The Soviets themselves anticipated high fuel consumption during the summer of 1943 and in April 1943 ordered the stockpiling of more than 100,000 tons of fuel in the fronts near Kursk in anticipation of the battle[120]. However, German air attacks on the Saratov refinery in June badly damaged the refinery and destroyed fuel reserves intended for the fronts, prompting the Soviets to take emergency measures to send other fuel to the fronts.

Besides the V-2 family of diesel engines, the Soviets mass produced a different, lower-horsepower diesel engine for agricultural tractors and artillery prime movers. Although the V-2 diesel engine failed as an aircraft engine, the Soviets developed another diesel aircraft engine, which was used for the Er-2 and Pe-8 bombers, although only a few of these aircraft were produced (only a few hundreds total). The Soviets also developed diesel-electric locomotives, but these were not made in quantity until after World War II. The Soviets also had some diesel-engine ships and gunboats, but it is unclear from my somewhat scant research on them if they used diesel fuel or some other fuel oil.

As with gasoline engines, the mass production of diesel engines strained the Soviet oil industry. Diesel fuel production could not keep up with the increase in the diesel-engine vehicle park. Another fuel shortage thus resulted. By 1941 but before the war began, the Soviet military only had about 45% of the diesel fuel it needed. Since the Red Army’s most modern tanks, the T-34, KV-1, and KV-2, all had diesel engines, outright lack of diesel fuel many have been another of the many factors that rendered these tanks much less effective than they might have been at the start of the war in 1941.

120 https://9may.rosneft-azs.ru/

Soviet Diesel Fuel Production, 1940–1945 (tons)

	1940	1941	1942	1943	1944	1945	Total	Wartime Total, Estimate
Diesel Fuel	629,000	936,000	209,000	478,000	535,000	518,000	3,305,000	2,170,000

Source: Narodnoe Khozyaystvo SSSR v Velikoy Otechestvennoy Voyne 1941–1945 gg. (*People's Economy of the USSR in the Great Patriotic War 1941–1945*), a once-secret 1959 statistical compilation of the Soviet wartime economy for the Soviet government.

For the estimated total of Soviet wartime diesel fuel, to estimate the wartime production in 1941 (the second half of the year), I use the same formula as with aviation gasoline. This suggests 1941's wartime production was on the order of 430,000 tons. (As far as I can tell, no Allied-aid diesel fuel arrived in 1941, which simplifies things.) As with aviation gasoline and for the same reasons, I include all of 1945 as wartime.

The Soviets were well aware of their need for diesel fuel. Like with aviation gasoline, they had ambitious peacetime plans to expand production. 1941 diesel fuel production was 149% that of 1940 and likely would have been even higher had the war not broken out in mid-1941[121]. 1942's production was adversely affected by the course of the war. Since all modern Soviet medium and heavy tanks had diesel engines, diesel fuel was absolutely necessary for Soviet mechanized warfare, and the Soviets went to great lengths to boost production from the low point of 1942.

As with gasoline, the outbreak of war in 1941 meant that the Soviet military and defense industries had top priority on receiving diesel fuel from the refineries. Only 9.9% of Soviet diesel fuel production went to the military and defense industries in 1940. In 1941, 42.5% of production went to the military and defense industries, rising to a maximum of 71.2% in 1943. All other economic sectors that used diesel fuel had to greatly ration its use or switch to other fuel sources. Many if not all models of Soviet diesel engines could use some other fuels, such as kerosene or some grades of fuel oil, although care had to be taken with some of the alternative fuels to ensure the engine remained properly lubricated. Even with proper care, using kerosene in place of diesel fuel would have reduce the power and range of diesel engine vehicles.

As far as I can tell, diesel fuel substitution seems to have involved Soviet diesel-engine tractors in agriculture using kerosene. I have yet to see a source claiming that Red Army diesel-engine vehicles used kerosene, although it might have been possible to blend some

121 Almost 161% per my formula. This would have been a huge increase, but the Soviet effort to make diesel fuel in quantity was in its early stages, when large gains typically could be achieved.

kerosene into the diesel fuel to extend diesel fuel supplies[122]. Perhaps the Red Army used kerosene in extreme emergency situations when diesel fuel was not available, but I have yet to see any information on this, either. If you come across examples of this, please let me know.

Unlike aviation gasoline, which the Soviets depended upon Allied air for about half their supply, the Soviets were virtually self-sufficient in diesel fuel, receiving a total of about 200,000 tons of diesel fuel from Lend-Lease, a quite small amount (9.2%) compared to estimated Soviet wartime production. Since I have often pointed out how reliant the Soviets were on Allied aid for aviation gasoline, I want to emphasize that the Soviets being essentially self-sufficient in diesel fuel was a major accomplishment. While safety was a major reason the Red Army chose diesel engines for their medium and heavy tanks, a major side benefit was that diesel engines had greater fuel economy than gasoline engines. Had they stuck with gasoline engines for tanks, as the other major powers in World War II mostly did, the many thousands of Soviet medium and heavy tanks and SPGs fielded in the war would have all required aviation gasoline, further greatly straining Soviet supplies of this fuel.

Although actual Allied aid in diesel fuel was small, another benefit of diesel's fuel economy was the potential for Allied aid to fairly easily replace lost Soviet diesel fuel production if this had been necessary. Had the Germans more aggressively attempted to damage the Soviet oil industry in 1942 (rather than attempting to capture it intact), it is possible that Soviet diesel fuel production would have been much lower than it was in 1942–1943. However, the relatively small amounts required to replace this lost production look to be withing bounds of what Lend-Lease could quickly handle. For a hypothetical example, assume a 1942 German campaign of bombing, sabotage, and other operations against the Soviet oil industry, which was greatly concentrated at Baku and the North Caucasus, managed to reduce 1942's actual diesel fuel and gasoline production by 50%. Lend-Lease would only have had to supply about 100,000 tons of diesel fuel to make up the "extra" lost production. In comparison, to make up a similar extra lost production for gasoline, Lend-Lease would have had to provide about 800,000 tons of vehicular gasoline and 450,000 tons of aviation gasoline, significant amounts that would have taken time to accomplish.

The Germans captured some Soviet diesel fuel during their 1941 offensives against the USSR, although it is unclear how much they obtained. However, German military vehicles

122 It also might have been possible for the Soviets to blend some gasoline into diesel fuel, but gasoline, especially high-octane aviation gasoline, was itself in short supply in 1941.

including tanks and German supply trucks had gasoline engines and could not use diesel fuel. (A few large, multi-engine German aircraft had diesel engines, mostly Ju 86 high-altitude reconnaissance-bombers and long-range floatplanes and flying boats. I do not know if any captured diesel fuel went to these aircraft.) The Germans, however, captured many diesel-engine T-34 tanks and managed to put a number into German military service. At least some of the fuel for these tanks came from captured Soviet stocks.

4.A.5 Fuel Oil

Soviet oil storage tank, supposedly at Syzran in the 1940s

Fuel oil consisted of heavy fuels refined from petroleum: everything heavier than gasoline, naphtha, and kerosene. (Diesel fuel technically is a fuel oil but I cover it separately because of its importance to the Red Army. The following remarks about fuel oil exclude and are not always applicable to diesel fuel.) Fuel oil was used in furnaces (for heating) and boilers (for heating and/or steam power). The density and viscosity of many grades of fuel oil made them poor fuels for small vehicle motors, although diesel engines could used some grades of fuel oil. The Soviet had several grades of fuel oil (although these might be post-war classifications):

- F5 Fleet Fuel Oil, used to power ships. This was the least viscous of all Soviet fuel oils (relative viscosity of no more than 5% at 50°C). Users were allowed to mix in kerosene, up to 22% of the total. (Fleet fuel oil was the Soviet term. In other countries it was known as marine fuel oil, bunker fuel oil, or other similar terms.)
- F12 Fleet Fuel Oil (relative viscosity of no more than 12% at 50°C), again used to power ships. Users were allowed to mix in kerosene, again up to 22% of the total.

- Grade 40 Boiler Fuel (relative viscosity of no more than 40% at 50°C), used in ship boilers, small stationary boilers, and industrial furnaces.
- Grade 100 Fuel Oil (relative viscosity of no more than 100% at 50°C, corresponding to a relative viscosity of no more than 15.5% at 80°C[123]), used in large stationary boilers.
- Grade 200 Fuel Oil was the most viscous (relative viscosity of no more than 200% at 50°C, corresponding to a relative viscosity of 6.5%-9.5% at 100°C). This was sent to large consumers of fuel oil via pipelines from the refineries[124].
- MP Fuel for Open-Hearth Furnaces, which was similar to Grade 100 Fuel Oil. Open-hearth furnaces were used in steel-making, and vaporized MP fuel was used to heat the furnaces. (Some countries used natural gas in these furnaces, but the 1930s-1940s Soviets did not, as their natural gas industry was in its infancy.) MP stands for *Martenovskaya Pech* ("Martin Furnace"). German-born Carl Wilhelm Siemens of Britain invented the regenerative furnace, and Pierre-Émile Martin ("*Marten*" in Russian) developed this into the open hearth furnace for steel-making. (The principle for the open hearth furnace was called the Siemens-Martin Process in most countries, but the Soviets seemed to have just called it the Martin Furnace.)

Fuel oil could be further classified as low-sulfur, sulfurous, or high-sulfur. Fuel oil made at cracking plants was further called "cracking fuel oil" to distinguish it from fuel oil made by traditional refining methods.

Fleet fuel oils and boiler fuel were important for the Soviet Navy's ships and submarines, as well as for the Soviet civil maritime fleet. By 1940–1941, the Navy was encountering shortages of these fuels due to its attempts to build a large strategic fuel reserve. War with Germany quickly rendered the Soviet Navy a distinctly secondary service, mostly restricted to assisting the Red Army. Fuel oil was relatively easy for the Soviet oil industry to make, with wartime annual production at 5–9 million tons per year. Total wartime production was on the order of 28 million tons. Most fuel oil went for industrial use, heating, and rail transportation (steam locomotives using fuel oil). The Soviet Navy, with its restricted operations and priority on receiving fuel to support the war effort, did not have systemic fuel shortages during the war.

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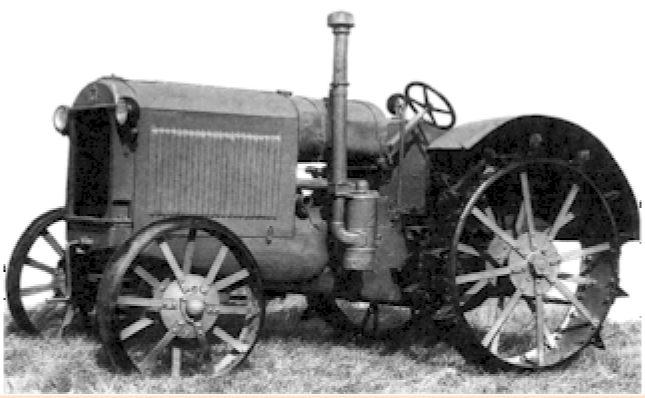
123 Soviet fuel oil classification for relative viscosity was based on 50°C, hence the 100% and 200% for Grades 100 and 200. Higher temperatures were typically used for actual operations, hence the second set of relative viscosity ratings for these grades.

124 I suspect the Soviets added a solvent to this fuel oil to make it flow more easily through pipelines. The solvent would have been removed at the destination and reused for future pipeline transport. I know the 1930s-1940s Soviets used this arrangement for some petroleum products, but I have not done the research to confirm if it was used for Grade 200 Fuel Oil.

The Soviet civil maritime fleet, like the Navy, was mostly on restricted operations to assist the Red Army. One notable exception was when Japan went to war in December 1941 against the British Empire and Commonwealth, the Netherlands, and the USA. Significantly, Japan did not go to war with USSR. Significant Allied aid was flowing from Canada and the US across the Pacific Ocean to the Soviet port of Vladivostok and had to pass very close to the Japanese home islands to reach its destination. Western Allied ships thus would have been extremely vulnerable to Japanese attack, but neutral Soviet ships were exempt. All Pacific-route Allied aid quickly shifted to Soviet ships[125]. The ships of course had priority on receiving fuel.

The Soviets were self-sufficient in fuel oil. They did receive about 167,000 tons of fuel oil from Lend-Lease, but this was only about 0.5% of Soviet wartime production. I speculate (with no confirmation from any source I've seen) that most if not all Lend-Lease fuel oil was provided to fuel Soviet cargo ships in North American ports as they took on Allied-aid cargo.

4.A.6 Kerosene



STZ 15/30 (aka STZ-1) agricultural tractor with a kerosene engine

Kerosene was a fuel the Soviets used for heating, lighting, and cooking. Kerosene had become a dominant fuel in Russian Empire of the late 19th Century, but its importance was somewhat diminishing in the USSR, especially for lighting. From the early 1920s, the Soviets pursued an ambitious plan to bring electricity to important parts of the country. However, the USSR was a huge country with vast rural areas, where in the 1920s-1940s it was often far too expensive to electrify. Kerosene remained crucial to the many places without electricity.

125 As you might wonder, the Soviet civil maritime fleet in the Pacific did not have enough ships to take over all the Allied aid cargo being sent across this ocean. To increase Soviet cargo capacity, a number of US cargo ships were transferred to the Soviets in 1942 under Lend-Lease and crewed by the Soviets.

Kerosene also remained important in many places with electricity, too, for heating or cooking. For example, Moskva, the Soviet capital, mostly used electricity for lighting and coal for heating, but many people continued to use kerosene for cooking. (Moskva only began to switch to natural gas for heating and cooking after the war, when the Soviet natural gas industry began significant development.) Kerosene lamps also remained as back-up lighting in places with electric lights. Soviet light bulbs were sometimes in short supply, perhaps especially for civilian residences. When a light bulb burned out and no replacement bulb was available, people resorted to kerosene lamps.

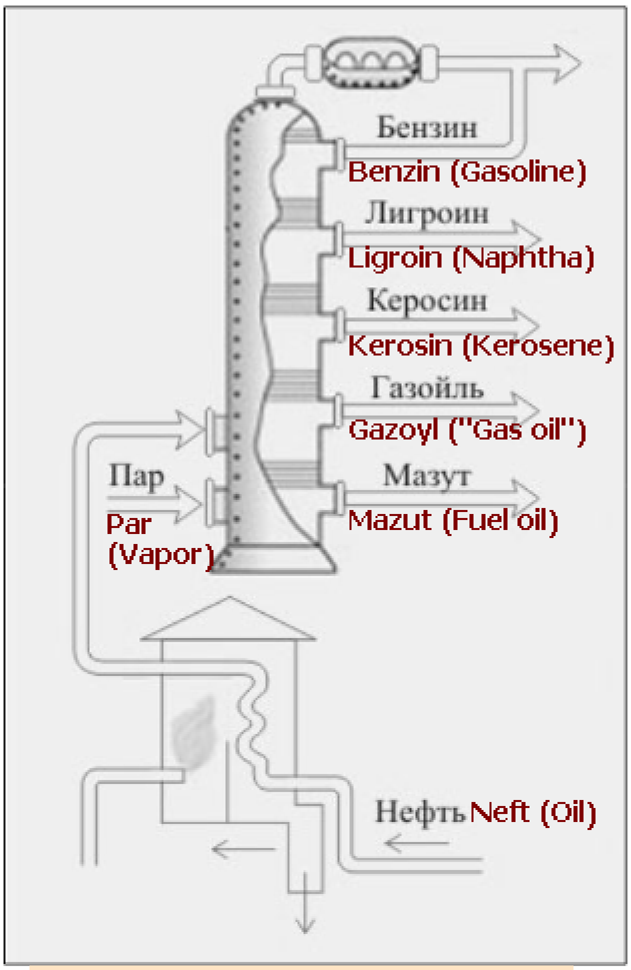
The Soviets also used some kerosene as engine fuel. Diesel engines could run on a mix of diesel fuel and kerosene, and some could use just kerosene as long as proper precautions were taken to ensure the engine remained properly lubricated. Diesel engines using kerosene, however, had lesser power and traveled lesser distances than with diesel fuel. During the war, the Red Army had priority on receiving diesel fuel, so many Soviet diesel-engine tractors in the agricultural sector ran on kerosene or a mix of kerosene and diesel fuel. As far as I can tell, the Red Army did not use kerosene much or at all in its diesel-engine tanks.

The Soviets could use kerosene with low-compression gasoline engines. The vast majority of Soviet-made automobiles and trucks used such engines, as did some agricultural tractors. Kerosene has a much higher flash point than gasoline, so a Soviet gasoline engine needed to be warmed up first before it could burn kerosene efficiently. At least some vehicles had two fuel tanks: a small tank with gasoline for starting and warming up the engine, and a regular tank with kerosene for all other operations. The vehicle operator used a manual switch to change to the kerosene tank once the engine was warm.

Some Soviet tractors made in the 1920s had kerosene engines. I have not researched these much, as few were around by 1941. Based on the history of 1920s Soviet gasoline engines, these kerosene engines were likely imported foreign engines and Soviet copies of these engines. The 1930s Soviets designed their own kerosene tractor engine. Mass production of the engine began at the Kharkov Tractor Factory in May 1932, followed by production as various other tractor plants including the Stalingrad Tractor Factory. Kerosene was a useful fuel for tractors. Although both gasoline and diesel fuel had greater energy densities then kerosene, this did not matter as much for low-speed agricultural tractors. Kerosene was also relatively easy and cheap for the Soviet oil industry to make, again making it attractive for agricultural use. Soviet industrialization was greatly ramping up production of gasoline-engine trucks and other vehicles, which meant demand for vehicular gasoline was soon going to soar. Using kerosene-engine tractors thus put less pressure on gasoline supplies.

The Soviets from the 1930s made a fuel they called *traktornoe goryuchee,* "tractor fuel". Most Soviet-based sources just refer to tractor fuel without covering what type of petroleum product it is. However, the *Great Soviet Encyclopedia* of 1936 specifically states that one of the uses of kerosene is *traktornoe goryuchee*. Another source uses the phrase "*kerosin traktornyy*" ("tractor kerosene") and clearly means it the same as *traktornoe goryuchee*. I have yet to find further specifics, such as if tractor fuel was specially formulated for use in engines, like "tractor vaporizing oil" and "power kerosene" were in some countries in the 1930s-1940s.

4.A.7 Naphtha



Russian-language oil refining diagram[126]

Note the presence of "ligroin" (naphtha) between gasoline and kerosene. "Gas oil" is an inexpensive, low-grade diesel fuel that can only be used in low-speed diesel engines.

126 Source: unattributed; "Fraktsionnyy Sostav Nefti i Metody Vego Izucheniya" ("Fractional Composition of Oil and Methods of Study"); Institut Geologii i Neftegazovykh Tekhnologiy (Institute of Geology and Oil-Gas Technologies); Kazan (Volga-Region) Federal University; 2013; https://kpfu.ru/docs/F1900922370/Frakcionnyj.sostav.nefti.pdf

Naphtha was known to the Soviets as *ligroin*, *nafta*, and *tyazhyolyy benzin* (heavy gasoline). (In Russian, both *ligroin* and *nafta* mean “naphtha”. In many other languages “ligroin” is used for a different petroleum product than naphtha.) Naphtha was intermediate in weight between gasoline (lighter) and kerosene (heavier), hence its occasional Soviet name of heavy gasoline. (In the USA, naphtha is also called camp fuel and “white gasoline”.)

Naphtha was used somewhat similar to kerosene for lighting and cooking (in the US, its name “camp fuel” came from its use in camp lanterns and camp stoves). Again like kerosene, the Soviets used naphtha as an engine fuel, particularly for agricultural tractors.

When the Soviets achieved catalytic cracking ability, Soviet cracking plants converted naphtha into gasoline. Naphtha has a much lower octane rating than gasoline but catalytic conversion produced high-octane aviation gasoline, which the Soviets greatly needed. Catalytic conversion of naphtha into aviation gasoline was one way the Soviets increased gasoline production during the war[127]. Although this sounds significant, no source I’ve yet seen details how much naphtha went to catalytic cracking plants nor how much aviation gasoline was actually derived from naphtha.

I have found few sources even in Russian that go into much detail on Soviet wartime use of naphtha. It was certainly used as vehicle fuel, both in the military and in the civilian economy. Most likely its military use was mainly for tractors sent to the Red Army to tow weapons and other loads. One source on the consumption of fuel in the Soviet Berlin offensive of 1945 just lumps naphtha in with tractor fuel (“*Kerosin traktornyy i ligroin*”, literally “Tractor kerosene and ligroin” but meaning “Tractor fuel and naphtha”)[128].

4.A.8 Soviet Oil and Liquid Fuel Production Data

Note: The source for the following tables is (directly or indirectly) *Narodnoe Khozyaystvo SSSR v Velikoy Otechestvennoy Voyne 1941–1945 gg.* (*People’s Economy of the USSR in the Great Patriotic War 1941–1945*); a 1959 formerly-secret statistical compilation by the Soviet government. I refer to this work as *People’s Economy* for short.

127 A.K. Sokolov; “Neft i Voyna 1941–1945 gg.” [“Oil and War 1941–1945”]; 2018; https://statehistory.ru/5779/Neft-i-voyna-1941–1945-gg/. Sokolov states the Soviets managed to raise the share of gasoline in petroleum refining from 20% to 30–35% during the war and implies that catalytic conversion of naphtha played important role in this. However, no specific information is given on how important catalytic conversion of naphtha actually was.

128 V.F. Vorsin and V.I. Zhumatiy; “Tylovoe Obespechenie Krasnoy Armii v Berlinskoy Strategicheskoy Nastupatelnoy Operatsii” [“Logisitics of the Red Army in the Berlin Strategic Offensive Operations”]; https://history.ric.mil.ru/upload/site177/rVMm8fCwCL.pdf

Soviet Oil Production

Oil Production (including gas condensate), thousands of tons						
	1940	1941	1942	1943	1944	1945
Total	31,121	33,038	21,988	17,984	18,261	19,436
Percentage of 1940	100%	106%	71%	58%	59%	62%

Oil Production (including gas condensate) by Union-Republic, thousands of tons						
	1940	1941	1942	1943	1944	1945
Azerbaijan SSR	22,231.0	23,541.0	15,739.2	12,715.4	11,871.2	11,540.5
Russian SFSR	7,039.0	7,525.9	4,501.6	3,436.9	4,432.3	5,675.1
Kazakh SSR	697.0	864.9	867.8	981.7	799.6	788.0
Turkmen SSR	587.2	630.3	578.9	465.2	634.6	628.9
Ukrainian SSR	352.8	165.3	0	0	93.0	250.0
Uzbek SSR	119.2	196.3	189.7	280.3	339.9	477.8
Georgian SSR	41.2	57.5	56.1	57.5	46.3	36.4
Tajik SSR	29.8	29.1	26.3	21.7	22.1	20.0
Kyrgyz SSR	23.8	27.7	28.3	25.0	22.0	19.4

Notes: The Azerbaijan SSR contained the Baku oilfields. The Russian SFSR contained the North Caucasus oilfields and the Volga-Urals "Second Baku" oilfields. The Kazakh SSR contained the Emba oilfields in the northeastern region of the Caspian Sea. Most of the Ukrainian SSR's oilfields had come from Poland when eastern Poland was annexed by the USSR in 1939. Many of these union republics also had smaller or less-developed oilfields than the ones mentioned here.

Several union republics experienced declining oil production at some point during the war. The decline in the Ukrainian SSR and some of the decline in the Russian SFSR was the result of German conquest of oilfields there. The decline in the Azerbaijan SSR and some of the decline in the Russian SFSR was the result of the Soviets evacuating equipment and taking measures to prevent the Germans from capturing intact oilfields. Of the other six oil-producing union republics, only the Uzbek SSR saw increasing production throughout the entire war. The other five experienced declines at some time. This was due to the wartime Soviets both decreasing production of oil extraction equipment in favor of military production and overusing existing oil extraction equipment to the point where it frequently broke down.

The above table lists the nine union republics of the USSR with significant oil production. By the time Germany invaded the Soviet Union in 1941, the USSR had 16 union republics. The following seven had little or no oil production: the Armenian, Belorussian, Estonian, Karelian-Finnish, Latvian, Lithuanian, and Moldavian SSRs. (The Estonian SSR had oil shale deposits, which is covered in the Solid Fuels section.)

"Gas condensate" is natural-gas condensate (aka natural gasoline) and some naphtha (which was also produced from crude oil).

Soviet Liquid Fuel Production

	1940	1941	1942	1943	1944	1945
Liquid Fuel Production, thousands of tons						
Total Gasoline, of which:	4,435	4,306	2,537	2,782	3,792	3,159
...Vehicular Gasoline	3,476	2,983	1,611	1,763	2,440	2,126
...Aviation Gasoline	889	1,269	912	1,007	1,334	1,017
Kerosene	5,553	4,497	1,906	2,742	3,156	3,231
Diesel Fuel	629	936	209	478	535	518
Motor Fuel	1,459	1,313	306	535	419	528
Bulk Fuel Oil	9,858	9,211	5,305	5,236	7,011	6,051
Liquid Fuel Production, percentage of 1940						
Total Gasoline, of which	100%	97%	57%	63%	86%	71%
...Vehicular Gasoline	100%	86%	46%	51%	70%	61%
...Aviation Gasoline	100%	143%	103%	113%	150%	114%
Kerosene	100%	81%	34%	49%	57%	58%
Diesel Fuel	100%	149%	33%	76%	85%	82%
Motor Fuel	100%	90%	21%	37%	29%	36%
Bulk Fuel Oil	100%	93%	54%	53%	71%	61%

Note: I am unsure what Soviet "motor fuel" (*motornoe toplivo*) actually was. The term is used in *People's Economy* without explanation, and Soviet sources on the war do not use it, except in a generic sense of any or all fuels for motors. (Modern Russian-language sources use "motor fuel" as reference to gasoline.)

I speculate "motor fuel" might have been naphtha (*ligroin* or *nafta* in Russian), the only major refined petroleum product not mentioned by specific name in the table. Naphtha was used as a fuel for vehicles, particularly some models of tractors used both in the civilian economy and the military.

One source on Soviet wartime topics speculates that "motor fuel" was what the Soviets called *gazoyl*, "gas-oil". The Soviets obtained several types of gas oil through distillation, processing, or cracking of petroleum or petroleum products, although at least some of these methods were not used in bulk until after the war. The Soviets added "atmospheric gas oil" (made by atmospheric distillation) to diesel fuel, and processed "light gas oil" (made from cracking processes) into a diesel fuel additive. Possibly gas oil could have been used as a motor fuel, but overall I suspect naphtha was more like what the Soviets called motor fuel.

Soviet Vehicular Gasoline Supply (thousands of tons)

	1940	1941	1942	1943	1944	1945
Total USSR (excludes exports)	3,060.7	2,702.4	1,862.3	1,817.0	2,424.0	2,718.2
Total for Defense	668.5	1,126.6	1,271.3	1,279.0	1,794.2	1,484.0
Percent for Defense	21.8%	41.7%	68.3%	70.4%	74.0%	54.6%

Notes: Defense includes People's Commissariat of Defense (Red Army), People's Commissariat of the Navy (Soviet Navy), and others commissariats related to defense or the defense industry.

Warning: The Total USSR figures here do not seem to agree with the figures in Soviet Liquid Fuel Production above. It is not clear why this is. The "excludes exports" phrase, which is not defined, does not explain it, as sometimes this number is higher that the one in Soviet Liquid Fuel Production, which does not say it "excludes exports". Nonetheless, I take the percentages for defense as indicative overall of the Soviet effort.

Soviet Diesel Fuel Supply (thousands of tons)

	1940	1941	1942	1943	1944
Total USSR (excludes exports)	315.8	430.8	414.0	441.8	431.9
Total for Defense	31.2	183.2	257.1	314.8	256.7
Percent for Defense	9.9%	42.5%	62.1%	71.2%	59.4%

Notes: Defense includes People's Commissariat of Defense (Red Army), People's Commissariat of the Navy (Soviet Navy), and others commissariats related to defense or the defense industry.

Warning: The Total USSR figures here do not seem to agree with the figures in Soviet Liquid Fuel Production above. It is not clear why this is. The "excludes exports" phrase, which is not defined, does not explain it, as sometimes this number is higher that the one in Soviet Liquid Fuel Production, which does not say it "excludes exports". Nonetheless, I take the percentages for defense as indicative overall of the Soviet effort.

Soviet Aviation Gasoline Supply (thousands of tons)

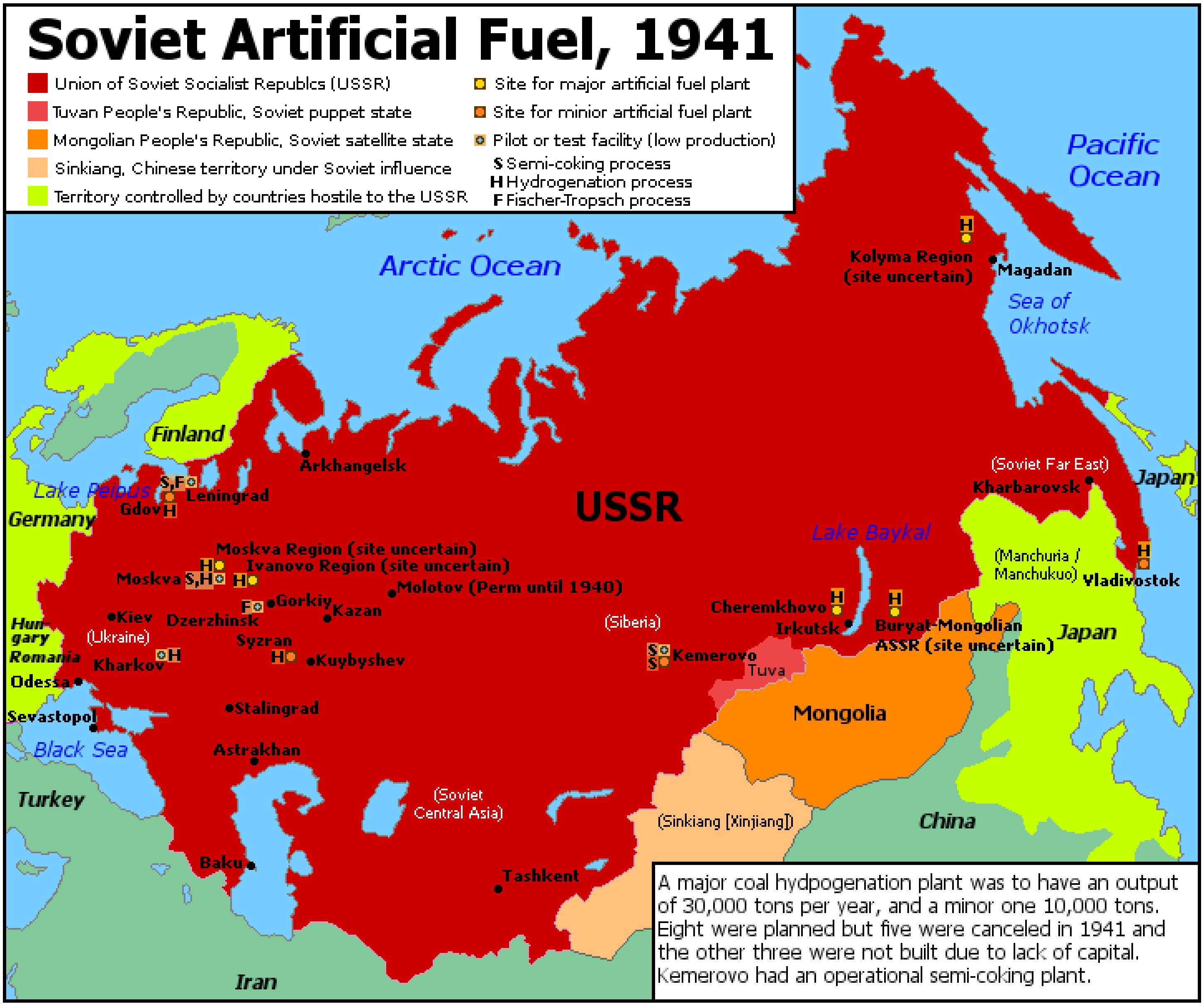
	1941	1942	1943	1944	1945
Total USSR	912.2	926.7	1,024.2	1,316.6	947.5

Total for Defense	828.6	840.2	999.6	1,289.0	910.1
Percent for Defense	90.8%	90.7%	97.6%	97.9%	96.1%

Notes: Defense includes People's Commissariat of Defense (Red Army), People's Commissariat of the Navy (Soviet Navy), and others commissariats related to defense or the defense industry.

Warning: The Total USSR figures here do not seem to agree with the figures in Soviet Liquid Fuel Production above. It is not clear why this is.

4.B Synthetic Liquid Fuels



Even with the construction of modern cracking plants, Soviet oil refineries could not keep up demand for liquid fuels. The Soviets went from exporting about half their oil in the 1920s to exporting little by the late 1930s, as the Soviet economy was now consuming petroleum products in quantity[129]. In August 1939, Germany and the USSR negotiated a commercial agreement which included German import of Soviet oil. From this point until 22 June 1941, when Germany invaded the USSR, the Soviets only exported oil to Germany and Italy[130].

Much of the output of Soviet oil refineries still came from outdated technologies (direct distillation and atmospheric-vacuum distillation). This resulted in heavy oil products being produced much more that light oil products, whereas the Soviets needed more light oil products, particular for vehicle gasoline, aircraft gasoline, and lubricants.

This lack of fuel prevented some vehicles from being utilized as planned. Many collective farms and state farms were now mechanized and relied on gasoline-engine tractors. To extend their gasoline supplies, they mixed in other substances including benzene, naphtha, methanol, kerosene, and sulfate turpentine. If possible due to necessity, some of these substances were used completely in place of gasoline. (The Soviets also made diesel-engine tractors, but diesel fuel also was in short supply, also prompting substitutions. The Soviets developed a kerosene engine for some tractor models to lessen the demand on other fuels.)

The inability to produce enough gasoline, particularly high-octane aviation gasoline, persuaded the Soviet leadership to start building synthetic fuel plants to make “artificial” gasoline and other fuels. Development of the technology to make synthetic liquid fuels from coal was already being pursued in some advanced industrial countries, and Germany in particular had been building artificial fuel plants since the 1920s. Converting coal into artificial gasoline would become an important source of fuel for the Germans during the war and was particularly important for the German supply of high-octane aviation gasoline.

The Soviets tracked the development of artificial fuel technology throughout the industrialized world by means both legal and illegal (industrial espionage). Since the USSR had plentiful coal deposits, the Soviets were particularly interested in the production of artificial gasoline from coal.

This would have been an expensive way for the Soviets to produce gasoline: the plants were costly both to build and to operate. Gasoline from them would be on the order of three to

129 Exporting oil to earn foreign currency was likely less important in the late 1930s, as the USSR was now developing its own industrial and technological equipment based mostly on its earlier imports of advanced technology.

130 The German-Soviet commercial agreement did not include Italy, but the Italians were importing Soviet oil as a result of the 1933 Italian-Soviet non-aggression pact.

five times more expensive than gasoline produced from petroleum. However, the technology had a number of attractions for the Soviets:

- Artificial fuel plants would not only boost the overall supply of gasoline for the USSR, they would also guarantee a supply of greatly-needed aviation gasoline.
- They could be built in very many places, as the USSR had numerous coal deposits. This would allow local production of synthetic gasoline in remote places far from Soviet oilfields and refineries. For example, the Soviet Far Eastern region needed gasoline and other petroleum products. Oil extracted on the nearby Sakhalin Island was always insufficient to meet the demand. The Soviets had to send fuel to the Far East over several thousands of kilometers of rail lines, which was expensive to do and tied up rail capacity. Greater supplies of gasoline, however, would allow the Far Eastern region's economy to grow faster. Since this region had many coal deposits, it was a prime site for an artificial gasoline plant.
- Another reason to build artificial gasoline plants was for security. Azerbaijan's Baku oil fields, by far the pre-war Soviets' biggest source of oil, was in an ethnic minority region near the Soviet borders and thus vulnerable to separatism as well as enemy conquest or bombing. Indeed, in 1918 Azerbaijan briefly became independent and then had its oil fields occupied by the British military, which beat a German military expedition also seeking to capture them. The Baku fields stayed out of Soviet control until 1920, when the Red Army swept through the region. In contrast, most artificial gasoline plants could be located in safe areas. Of the eight plants the Soviets decided to build, only two were near border areas at risk of invasion by strong military forces: Vladivostok, vulnerable to the Japanese, and Gdov by Lake Peipus, vulnerable to the Germans.

Soviet research on making artificial fuels from coal began in 1929 under chemists N.M. Karavaev and I.B. Rapoport. Starting in 1930, pilot plants using the simple, "semi-coking" method of processing coal were set up in Moskva, Leningrad, and Kemerovo (in Siberia). Semi-coking involved a process similar to that for making coke (coking coal), with the distilled liquids created by semi-coking[131] being processed into liquid fuels.

The problem with semi-coking, however was low output and low-quality artificial fuels. Coal hydrogenation, a more technically challenging process, could produce high-quality

131 Full coking turned 4.5% of the coal (by weight) into liquids, but semi-coking achieved 10%.

fuels. Accordingly, in 1931 and 1932, research laboratories on coal hydrogenation were set up in Moskva and Kharkov.

The Soviet effort expanded in 1933 with the creation of the All-Union Scientific-Research Institute for Artificial Liquid Fuel and Gas (***V**sesoyuznyy **N**auchno-Issledovatelskiy **I**nstitut **G**aza i **I**skusstvennogo Zhidkogo Topliva* aka VNIGI). VNIGI had centers in Moskva and Novosibirsk and received the assistance of other scientific institutes in Moskva and Kharkov.

The Kemerovo semi-coking plant was upgraded in 1935 to a production facility processing 300 tons of coal per day. Likely all its output was consumed locally, reducing the need to transport liquid fuels to this Siberian region by rail. However, other semi-coking production facilities were not built, as semi-coking was inefficient, requiring 12 to 20 tons of coal to produce just one ton of liquid fuel[132]. At these rates, the Kemerovo plant likely had an annual output of about 5,000–9,000 tons of fuel per year. In comparison, small hydrogenation plants were planned to produce 10,000 tons of fuel per year.

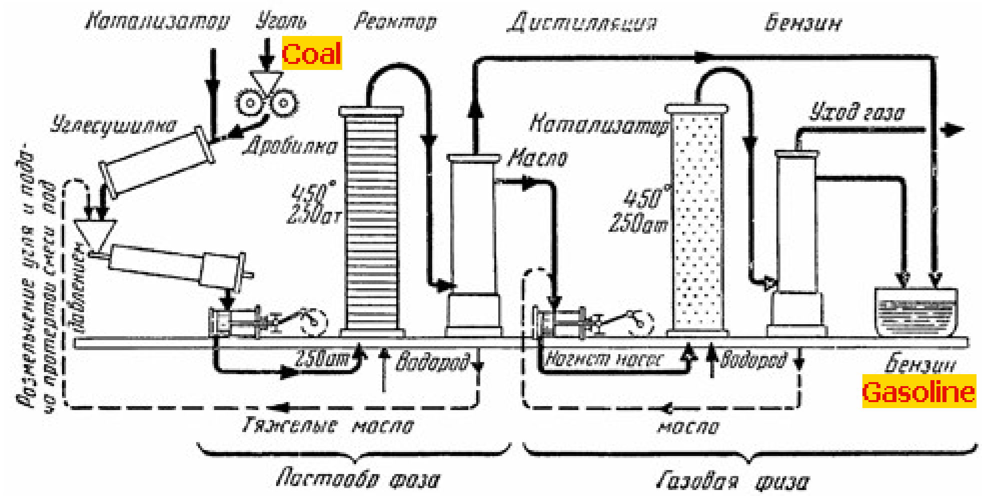
In 1937, a low-output pilot plant that hydrogenated brown coal was set up in Moskva, followed in 1939 by a low-output pilot plant in Kharkov that hydrogenated coal tar. Hydrogenation was a more efficient process than semi-coking, requiring 7 to 8 tons of coal to produce one ton of liquid fuel. Coal hydrogenation produced a wide range of liquid fuels: heating fuel (fuel oil), diesel fuel, vehicular gasoline, and aviation gasoline. It also produced hydrocarbon gas, which could be used like natural gas, and several compounds that could be used in the chemical industry. Coal hydrogenation was one of the main ways the Germans made artificial fuel in the war

Starting in 1934, VNIGI and another institute researched the Fischer-Tropsch process. Using coal as a raw material, this process synthesized carbon monoxide gas (CO) and hydrogen gas (H_2) into liquid fuel. Pilot plants began testing this process in 1937 at Leningrad and Dzerzhinsk[133]. This method required 6 to 7 tons of coal to produce one ton of liquid fuel. While this synthesis required the least amount of raw materials of the three processes, its gasoline was only low octane and required benzene to be added. It did, however, produce high-quality diesel fuel. The Soviets decided not to put the Fischer-Tropsch into mass

132 The inefficiencies of semi-coking could be offset a bit. The resinous by-products of semi-coking, which amounted from 60% to 80% of the inputs, could be used in a coal hydrogenation plant to make low-quality vehicular fuel. The Soviets, however, did not pursue this line to any signification degree. Although I've seen no explanation, it is likely the capital costs would have been high (both semi-coking and hydrogenation would be required), only to make less-desirable low-quality fuel.

133 Dzerzhinsk was a small city that grew up around an explosive factory and became a major chemical manufacturing center, including making chemical warfare agents for the Soviet military.

production. In contrast, Fischer-Tropsch was another main way the Germans made artificial fuel in the war.



A Russian-language diagram on coal hydrogenation

The diagram actually covers the German coal hydrogenation process, but the Soviet process would have been very similar. Coal is crushed to a dust, dried, and treated into a paste for processing with coal tar and a catalyst. The mixture is sent into the reactor chamber along with hydrogen gas (H_2), where hydrogenation occurs under high temperatures of 400–600° C (in the diagram, 450° C [842° F]) and high pressures of 250–300 atmospheres (in the diagram, 250 atmospheres). This turns the coal paste into synthetic oil, which is then distilled into gasoline, coal tar, other fuel products, and waste products. The coal tar is retained to treat the coal input.

By 1939, the Soviets had enough research and development experience to decide to proceed with mass production of artificial fuels by coal hydrogenation and, apparently, oil shale hydrogenation (see the comments in the Gdov point below). That year, the Soviets ordered the construction of eight hydrogenation plants with a planned total output of 200,000 tons of synthetic gasoline per year at:

- **Vladivostok in the Soviet Far East, Siberia, Russian SFSR (30,000 tons/year; coal hydrogenation).**
  Vladivostok was vulnerable to being surrounded and perhaps captured by Japanese forces attacking west from Manchuria. It was also possible for the Japanese to make making amphibious landings east of the port, protected by the Imperial Japanese Navy, which was overwhelmingly stronger than the Soviet Pacific Fleet. All Soviet Far Eastern oil refineries were located inland far from Vladivostok, so perhaps the artificial fuel plant was intended to give the port city a local supply of fuel. (Coal was already being mined near Vladivostok, as can been seen on the Soviet Coal Basins map.) Fortified regions covered all avenues of approach from the Manchurian border. As the

main base of the Soviet Pacific Fleet, the port itself was extensively fortified, greater than the more-famous Soviet Black Sea naval base, Sevastopol. It seems likely the Soviets hoped to withstand a Japanese siege of the Vladivostok area, and an artificial fuel plant there could help keep the defense supplied with fuel.

- **Cheremkhovo near Lake Baykal in Siberia, Russian SFSR (30,000 tons/year; coal hydrogenation).**
  The region around Lake Baykal together with the city of Irkutsk was a resource-extraction and industrial area, including a military aircraft factory built at Irkutsk in the 1930s. An artificial fuel plant here would have helped the region develop faster and lessen the need to rail in fuel from elsewhere, as well as supply the nearby Soviet Transbaykal Front.
- **Gdov by Lake Peipus in the western Russian SFSR (10,000 tons/year; presumably oil shale hydrogenation).**
  Gdov was close to Leningrad, a major industrial center, military base, and naval base; presumably Gdov's production would have gone to Leningrad. As far as I can determine, the area around Gdov has no significant coal deposits. However, it does have high-quality oil shale deposits, and the Soviets had been studying the hydrogenation of oil shale from at least 1935. My conclusion is that the Gdov plant would have hydrogenated oil shale instead of coal. Another possibility is that the Soviets would have railed coal to the Gdov plant. However, this makes much less sense, as there were many locations to build a plant near Leningrad that would have been more secure than Gdov, which in 1939 was on the western Soviet border with Estonia.
- **Syzran on the central Volga River in the Russian SFSR (10,000 tons/year; oil shale hydrogenation).**
  Like Gdov, the Syzran area as far as I can determine has no significant coal deposits but does have oil shale deposits. These deposits have a distinctive chemical composition and can be processed not only into fuel but also into phenol, toluene (for explosives manufacture), and other important chemicals. I speculate part of the reason Syzran was selected for a plant was for phenol production. The Soviets used phenol in oil refining, and Syzran was conveniently located in the Volga-Urals "Second Baku" oil region. Another possibility is that the Soviets would have railed coal to the Syzran plant. However, this makes far less sense, as the only attraction for a plant at Syzran was to make the extra chemicals from oil shale.

I note in passing that the only two “minor” (10,000 tons/year) hydrogenation plants were in oil shale areas. All the “major” (30,000 tons/year) hydrogenation plants were in coal areas.

- **The Moskva region of the Russian SFSR (30,000 tons/year; coal hydrogenation).**
The Moskva region was heavily industrialized and had significant military forces, so it needed substantial amounts of fuel.

- **The Ivanovo region east of Moskva in the Russian SFSR (30,000 tons/year; coal hydrogenation).**
The Ivanovo region was also heavily industrialized with significant military forces, so it too needed substantial amounts of fuel.

- **The Kolyma region in northeastern Siberia of the Russian SFSR (30,000 tons/year; coal hydrogenation).**
The Kolyma region was very remote, in northeastern Siberia far from any large city, important industrial center, or even a rail line or paved road. The only significant access to the region was by sea during warm weather to the port of Magadan, as the adjoining Sea of Okhotsk froze over during the long, cold winters. However, the region had considerable natural resources including gold and coal. By the 1930s the NKVD was extensively developing the area using the slave labor of tens of thousands of GULag prisoners. GULag and climate conditions both were brutal, leading to high death rates, with the prisoner-built road from Magadan to the region nicknamed the “Road of Bones”. Work in the mines was even harsher and was widely regarded among the prisoners as an unofficial death sentence due to overwork and insufficient food. (This belief was well justified. One of the NKVD commanders at Kolyma is reputed to have said, “We have to squeeze everything out of a prisoner in the first three months — after that we don't need him anymore”[134].) Given the region’s remoteness, an artificial fuel plant there would have allowed the region develop faster and lessen the need to bring in fuel from elsewhere. The region did not have any substantial military or naval forces, so the Soviet military would not have used fuel from this plant.

- **An unnamed location in the Buryat-Mongolian Autonomous Soviet Socialist Republic of the Russian SFSR (30,000 tons/year; coal hydrogenation).**
The Buryat-Mongolian ASSR was located in southern Siberia mostly southeast of Lake Baykal and north of Mongolia. It had significant coal reserves under development. It

134 Aleksandr I. Solzhenitsyn (Thomas P. Whitney, translator); *The Gulag Archipelago*, Vol. 2; 1974.

was also an important defense zone in case of Japanese aggression, so the plant would have supplied fuel to the Red Army's Transbaykal Front.

Notice that all hydrogenation plants were located in the Russian SFSR, even though some other union republics had significant coal reserves, particularly the Kazakh and Ukrainian SSRs.

200,000 tons of artificial fuel per year was not a large amount. In contrast, Germany's first synthetic fuel plant opened in 1927 with a production capacity of 90,000 tons per year. By 1939, German synthetic fuel capacity was 1,500,000 tons per year. By early 1944, German capacity had reached about 5 million tons per year, although actual production in the first four months of 1944 was about 1.43 million tons, corresponding to an annual production rate of 4.3 million tons[135]. German production subsequently declined in 1944 due to Allied bombing. However, much of the Soviet synthetic fuel production from hydrogenation would have been aviation-grade gasoline. The Soviet oil industry was only producing about 900,000 tons of aviation gasoline per year in 1940–1941 (889,000 tons in 1940; perhaps 912,000 tons in 1941), which was insufficient to supply the needs of the Soviet military. Another 100,000 or more tons per year of aviation gasoline from hydrogenation would have been most welcome.

The Soviets found construction of the hydrogenation plants difficult, and none were operating by 1941. Some time that year, likely after the war broke out and financial resources had to be devoted to the war effort, the Soviets canceled construction of five plants. Construction supposedly was to continue for the other three, but none were ever completed. Another source claims that construction of all plants ceased during the war due to lack of capital.

Neftegaz.RU, a Russian business publication on the oil and natural gas industry, states that the wartime Soviets had two coal hydrogenation plants in production, without giving many other details. These must be the low-output pilot plants at Moskva and Kharkov.

In 1945, the Soviets captured some German artificial gasoline plants in Poland and Germany. At least four were dismantled and sent back to the USSR, and at least one of these went into production for a time, at Kemerovo.

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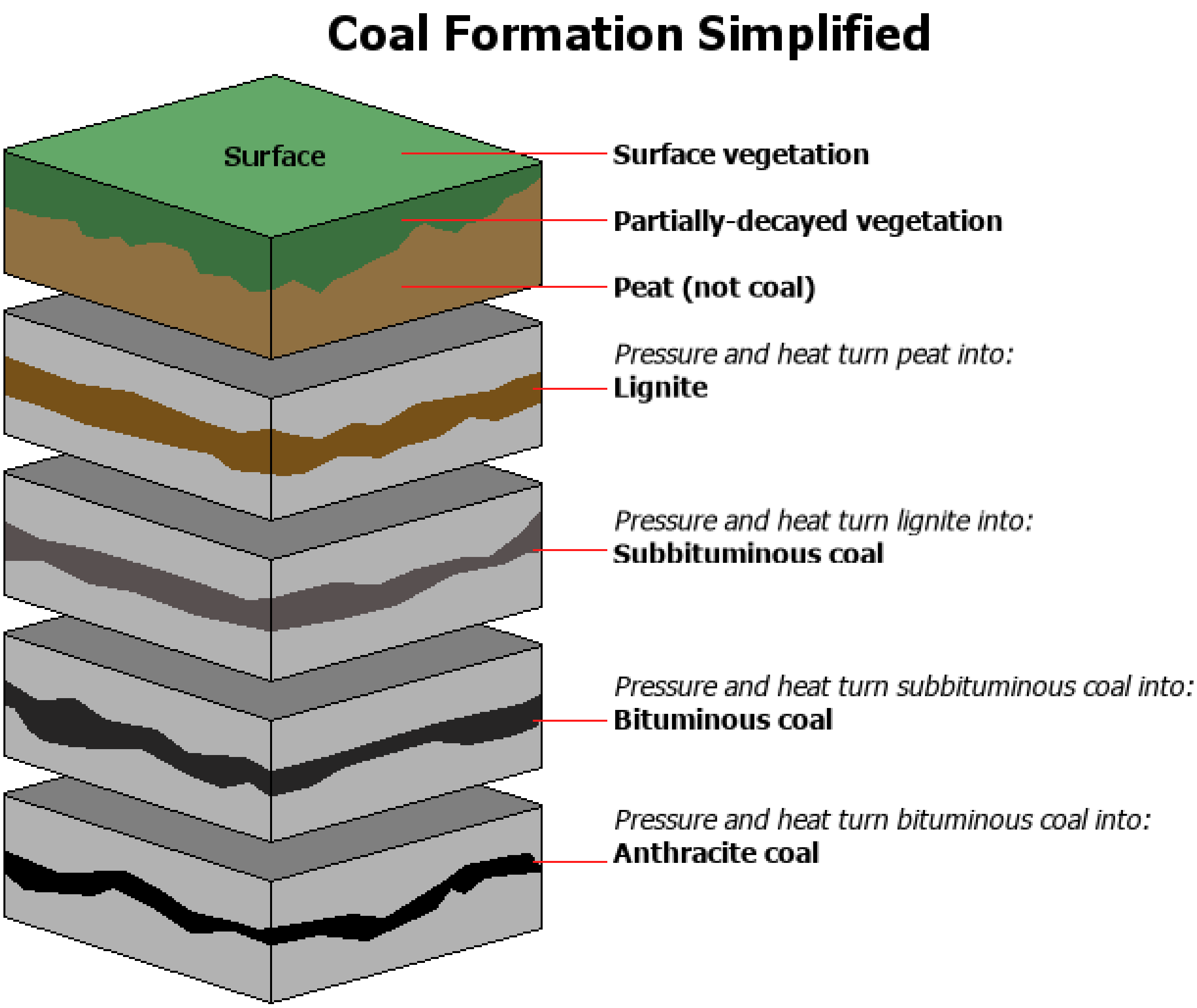
135 Raymond G. Stokes; "The Oil Industry in Nazi Germany, 1936–1945"; *The Business History Review* Vol. 59 No. 2; 1985; https://www.jstor.org/stable/3114932

5 Mined Solid Fuels

5.A Coal



Coal formation simplified (*Warning:* Do not try this at home!)

Coal Types (Carbon content is for dried coal.)

The following types use the generalized American/Canadian coal classification scheme. See below for notes on the Soviet scheme.

Lignite contains 65%–70% carbon. Lignite coal deposits usually were not subjected to extreme heat or pressure during formation, making lignite crumbly ("soft") and with the highest moisture content of all coals. It thus has the lowest energy content of all coals, making it unsuitable for many industrial uses where high temperature and fuel economy are needed. Lignite also has a quite unpleasant odor when burned, so although it was used for residential heating, better grades of coals were much more preferred. *Further Details:* In the American scheme, lignite is divided by quality into two grades.

Subbituminous coal typically contains 70%–76% carbon. It has a lower energy content than bituminous coal and is often used as fuel for electricity-generating plants. *Further Details:* In the American scheme, subbituminous coal is divided by quality into several grades.

Bituminous coal contains 76%–86% carbon. Bituminous coal has the second-highest energy content and is used in the iron and steel industries and for electricity generation. Bituminous coal with the proper characteristics is also used to make coke (coking coal), which is needed in steel making to maximize the productivity of blast furnaces. *Further Details:* In the American scheme, bituminous coal is divided by quality into several grades.

Anthracite contains 86%–92% carbon. It has the highest energy content (and thus heating value) of any type of coal, but it is also the least abundant form of coal, comprising only about 1% of all coal grades. It has so few volatile materials that it is difficult to ignite and must be burnt in specially-designed boilers. It was used in steel making until coking coal (see bituminous above) came into widespread use. Anthracite is still used for some heating, industrial, and electricity-generation purposes. *Further Details:* In the American scheme, anthracite is divided by quality into two grades.

Soviet Coal Types

Brown Coal (*buryy ugol*) consists of **lignite and (most) subbituminous coal**. Since Soviet sources rarely distinguished between lignite and subbituminous coal, it is often impossible to split mentions of brown coal into its two American types. The ways the Soviets ranked subtypes of brown coal and Americans subtypes of subbituminous coal meant that what the Americans considered high-quality subbituminous coal was the lowest-grade hard coal in the Soviet system[136]. **In this work, I always use "brown coal" in the Soviet sense to mean lignite and (most) subbituminous coal**. *Further Details:* The Soviets rarely if ever used the term "subbituminous" except in foreign works translated into Russian. They did use the term "lignite" (*lignit*) but usually as a synonym for "brown coal". Occasionally, they used "lignite" in sense of the American scheme, to distinguish it from the rest of "brown coal" (subbituminous coal), which they also sometimes called "black lignite". Yes, black lignite was brown coal! In the Soviet scheme, brown coal is divided by quality into three grades.

Hard Coal (*kamennyy ugol*) consists of **bituminous coal and anthracite**, per the 1979 edition of the *Great Soviet Encyclopedia*. Per above, the Soviets included what the Americans considered to be high-quality subbituminous coal as hard coal. Sometimes the Soviets excluded anthracite from their hard coal classification. **In this work, I always use "hard coal" in the broadest Soviet sense to mean high-quality subbituminous coal, bituminous coal, and anthracite.** *Further Details:* The Soviets rarely if ever used the term "bituminous"

136 This information comes from an analysis of the Soviets post-war ranking system, but I suspect the pre-war system was the same. See https://pubs.usgs.gov/of/2001/ofr-01–104/fsucoal/html/readme.htm for more details, particularly Table 1.

except in foreign works translated into Russian, and even then often translated "bituminous coal" as "hard coal" or "coal". In the Soviet scheme, hard coal is divided by quality into several grades.

Anthracite (*antratsit*) means the same as anthracite in the American/Canadian scheme. Since anthracite must be burnt differently than bituminous coal (as covered earlier), the Soviets sometimes placed anthracite in its own group, separate from hard coal. *Further Details:* In the Soviet scheme, anthracite is divided by quality into several grades.

Other Coal Classification Schemes

In the World War II period, many countries or empires had their own schemes to classify coal, sometimes with a confusing overlap of terms having different meanings. Also, there were many informal terms use for coal, also with no consistent usage. I mention some common ones in hopes of helping you avoid confusion.

"Brown coal" in some schemes just means lignite, rather than lignite and subbituminous coal.

"Soft coal" and "hard coal" have a variety of meanings, depending upon which types of coal went into each category. Sometimes, only anthracite is hard coal (or "black coal"); sometimes, all coals except lignite are hard coals or black coals.

Some schemes had additional types of coal, like a category between anthracite and bituminous. Some coals were named for their primary usage, like steam coal, stoker coal, and thermal coal.

Coal-Like Fuels

Although not considered a type of coal, ***peat*** is a coal-like fuel formed from compressed dead and partially-decaying organic matter. If peat is buried for millions of years, geological heat and pressure can turn it into coal. Peat is covered separately in its own section.

Oil shale is a shale rock containing kerogen and bitumen. If oil shale is subjected to geological heat and pressure for millions of years, the kerogen can turn it into crude oil and natural gas. Oil shale is covered separately in its own section.

5.A.1 Coal in the Russian Empire

Although the Russian Empire was mostly an agricultural economy, the country's immense size meant it had substantial natural resources including many coal basins. Coal was little used in the empire until the second half of the 19th Century. By 1866, railroad construction in Russia was quite disappointing, with a little more than 5,000 km (3,100 miles) of rail lines in operation, with the vast majority of the rails and most of the steam locomotives being imported. The Russian government took measures to improve the rail network and to increase domestic production of rail equipment. By 1880, Russian had over 22,500 km (14,000 miles) of rail lines, with growing domestic production of rails and locomotives. Coal became an important fuel both for the locomotives and for the factories producing the rail equipment. The rail network kept growing, and by 1905 Russia had about 50,000 km (31,000 miles) of rail lines.

Despite the demand for rail equipment, Russian heavy industry only grew slowly in much of the second half of the 19th Century. Government reforms late in the century quickened development. Several reforms made Russia attractive to foreign investors and companies, with the result that capital, entrepreneurs, and experts flowed into the country and helped to begin an industrial revolution. The pace quickened again in the early 20th Century, particularly after Russia allowed the formation of syndicates in the metal industry (1902) and for coal mining (1906)[137]. Coal was a very important fuel for industry, railroads, and heating of some cities, although the large Russian oil industry made inroads in all these areas with fuel oil and kerosene, and the vast Russian forests also provided firewood for heating and for fueling some locomotives.

Russian Empire Coal Production (million tons)

Year	Production	% Increase
1860	0.30	-
1865	0.38	127%
1870	0.69	182%
1875	1.70	246%
1880	3.29	194%
1885	4.27	130%
1890	6.01	141%
1895	9.10	151%
1900	16.16	178%
1905	18.67	116%

137Nooa Nykänen; thesis, “Industrial Clusters in the Russian Empire 1860 - 1913”; 2015; https://helda.helsinki.fi/bitstream/handle/10138/155056/nykanen_gradu_2015.pdf?sequence=1&isAllowed=y

1910	25.43	136%
1913	36.05	142%

Source: Manabu Suhara; "Russian Industrial Statistics"; *RRC Working Paper Series* No. 66; 2017; https://www.ier.hit-u.ac.jp/rrc/Japanese/pdf/RRC_WP_No66.pdf

1913 was the last full year of peace before World War I began in 1914. Although Suhara does not go into details, the rapid expansion of coal production in 1870–1880 (albeit from a very small base) must have been mainly due to the expansion of the Russian railroads.

The 142% increase in just three years from 1910 to 1913 (and from a moderately large base) is rather impressive, indicating that considerable investment was occurring. Had World War I not broken out in 1914, which led to the destruction of the Russian Empire, it seems possible that Russia might have achieved a level of industrialization 15 years earlier than what the Soviets achieved in the 1930s, and without GULag slave labor, destruction of masses of "class enemies", and starvation caused by inept collective agriculture.

Note: Various sources gives different numbers for 1913 coal production, such as 29 million tons or 32 million tons. Suhara's 36 million seems to be the most recent research.

Although the growth of Russian coal production was rapid, the Russian coal industry was not a major world producer, unlike the Russian oil industry.

World Coal Production 1913, Selected Countries (million tons)

Country	Production	% of USA
USA	517	-
Great Britain	292	56.5%
Germany	192	37.1%
Austria-Hungary	60	11.6%
France	41	7.9%
Russia	36	7.0%
Belgium	23	4.4%
Japan	21	4.1%
India	18	3.5%
Canada	15	2.9%
China	14	2.7%

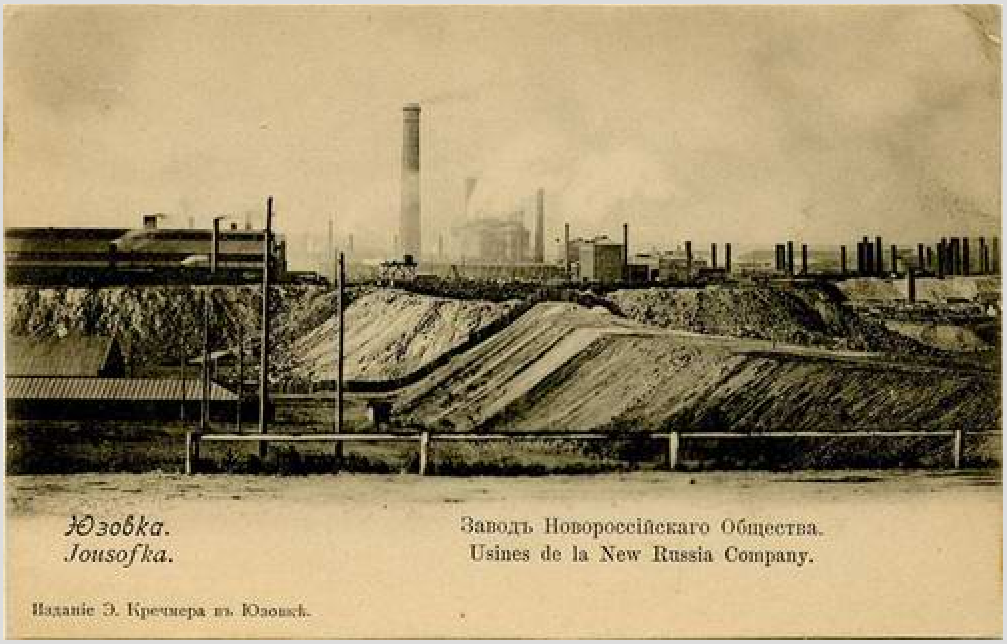
Australia	13	2.5%

Note: This table was compiled from various sources, most of which substantially but not completely agree (e.g., France's production is sometimes cited as 40 instead of 41, and the difference is not due to rounding). Production for Britain is domestic production of the home country, the United Kingdom of Great Britain and Ireland, and does not include colonies or other possessions. Note that India (which at the time included what is now India, Pakistan, Bangladesh, and Myanmar [Burma]) is listed in its own, although the entire region was directly or indirectly controlled by Britain.

Britain, the US, and Germany were leading coal exporters, with Britain by far the largest exporter. Russia exported little or no coal and during World War I actually imported some British coal, delivered to Arkhangelsk in the Russian far north.

Although coal was mined in many places in the Russian Empire including near Moskva, in Central Asia, and in several places in Siberia, the empire's most important coal basin by far was the Donbass (from ***Don**etskiy **Bass**eyn*, Donetsk Basin) in southeastern Ukraine and nearby areas. The Donbass had billions of tons of high-grade coal suitable for industry and was in a region with a large population that could provide workers for mines and factories. The region also had good communications, with rails, rivers, canals, and the Black Sea all allowing manufactured products to be easily sent to other regions. In the late 1800s, the Donbass thus developed into Russia's prime coal mining region and a major industrial center.

Sidetrip: John Hughes and Yuzovka



A view of Yuzovka, the industrial city founded on the Donetsk River by John Hughes of Great Britain

John Hughes was a British engineer, inventor, and businessman born in Wales. He became very successful in Britain and went on to do business with the Russian Empire. In 1870, he went to Russia together with the equipment to found a metal works, taking about a hundred skilled British metal workers and miners with him. He established his enterprise on a site along the Donets River in what is now Ukraine. It grew into a self-sufficient industrial center with coal and iron mines, a metal works, a brickyard, a railroad equipment factory, and other facilities like housing, schools, and a hospital. His British workers, their families, and local Ukrainian and Russian employees and their families all lived in a settlement at the site. Considerable immigration from Wales also brought in many more British workers and their families.

"John Hughes" was a bit difficult to pronounce or spell in Russian and was adapted as "Dzhon Yuz". His settlement grew into a major industrial town called Yuzovka, named after him. (It is sometimes rendered as Hughesovka in English.) Continual industrial success meant the town had about 50,000 inhabitants around the start of the 20th Century, and it officially became a city in 1917 with a population of about 70,000. Yuzovka was temporarily controlled by Germany after the Treaty of Brest-Litovsk in 1918 allowed the Central Powers to occupy

Ukraine. It was then fought over in the Russian Civil War after Germany withdraw in defeat at the end of World War I. The Soviets won the civil war and in 1924 renamed the city Stalin with its train station named Stalino.

Just weeks earlier, Vladimir Lenin had died in January 1924, and the city of Petrograd (formerly Sankt-Peterburg, "St. Petersburg") was quickly renamed Leningrad in his honor. The Soviets decided to do something similar with Yuzovka. *Stalin* means "Steel" in Russian and Yuzovka's new name celebrated both its industrial status as a steel-making center ("Steel will be our symbol") and also the future dictator of the USSR, Iosif Stalin ("Renaming the city of Yuzovka to Stalin is quite acceptable, since his [Lenin's] steely follower is his assistant comrade, STALIN"[138].

The city being Stalin and the rail station being Stalino soon caused endless confusion. The 1920s USSR had a terrible long-distance road network with very few motor vehicles as well as a tiny air transport fleet mainly for government and military use. Other than local farmers, the vast majority of people traveled by rail to visit the city, and the first thing they saw on arrival was the Stalino station. People naturally began calling the city "Stalino" rather than "Stalin". Soviet postal authorities accepted mail for both Stalin and Stalino, and the city's post offices sometimes canceled stamps with markings using "Stalino" instead of "Stalin". Sometime in the period 1929–1931 "Stalino" won out as the city name. (Some sources without documentation claim "Stalino" was officially chosen in 1929, but it took a few years for the change to be adopted everywhere.)

The city's population declined during the Russian Civil War but recovered during the rebuilding of the country in the mid-1920s, surpassing 100,000 in 1926. Massive industrialization across the USSR from the late 1920s turned Stalino in a major manufacturing center, with over 250,000 people in 1933, over 450,000 in 1939, and over 500,000 in 1941.

1941, however, was a disaster for Stalino. The Germans invaded the USSR in June, smashed the Red Army in Ukraine in September, and a German-Italian force occupied Stalino in October. Before the fall of the city, the Soviets evacuated some of its mining equipment and many of its factories, workers, and their families to safer places further east. By 1943, the city is estimated to have had only 175,000 inhabitants.

138 "Mezhdu Yuzovkoy i Donetskom" ("Between Yuzovsk and Donetsk"); https://infodon.org.ua/uzovka/615

The Germans were intent on not only destroying the Soviet state but also erasing symbols of Communism, so they renamed the city back to Yuzovka. The Soviets of course ignored this. Even among the Germans the city's restored name was not well known, and German mail sent to military and occupation personnel in the city was typically addressed to "Stalino". Nobody apparently told Hitler about this.

In September 1943 the Red Army liberated the city, and the Soviets began rebuilding it as a major mining and industrial center. By 1951, Stalino's population had surpassed 500,000 again. In 1961, as part of the USSR's drive to de-Stalinize the country, Stalino was renamed Donetsk, after the river that flows by the city. At its height, Donetsk's population exceeded one million.

In 1991, the USSR broke up. The Ukrainian SSR became Ukraine and was the national government over Donetsk. Like in Russia, Ukraine's low-quality manufacturing went into decline, and Donetsk's population dropped below one million.

In 2014 as part of Russia's attempt to destabilize Ukraine, Russian-speaking insurgents in the Donetsk region together with Russian political and military assistance proclaimed a Donetsk People's Republic with the city of Donetsk as its capital. The DPR is not recognized as a legitimate country other than by Russia and its puppet states. Internationally, Donetsk is regarded as Ukrainian territory illegally occupied by Russia. Donetsk no longer contributes to the Ukrainian economy but is now integrated into the Russian economy.

The start of World War I in 1914 soon resulted in industrial and mining problems for Russia. Instead of the expected short war ending victoriously for Russia and its allies, the conflict stalemated into a grinding war of attrition. The Russian military needed great amounts of weapons and vast stocks of ammunition. Russian industry was increasingly directed to supply the war effort, and supply of metal products to the civilian economy decreased, causing economic problems. For one example, the Russian oil industry could not get enough steel-using equipment to maintain oil production, which began to decline in 1916. For another example, the Russian railroads received fewer rails and other products they needed for maintenance and repair, which resulted in a growing decline in rail capacity. By 1917, the railroads could not carry all the fuel and goods the Russian economy needed, which exacerbated the ongoing collapse of the economy. Further, Russian attempts to finance the war resulted in high inflation and food shortages, damaging the economy and impoverishing many people. Two revolutions in 1917 saw the Tsar swept away and then the Soviets seizing power. The resulting Russian Civil War was a further calamity, damaging or destroying very many industrial and mining operations. The Soviets won the civil war in 1920 and began to rebuild the country's factories and mines.

5.A.2 The Soviet Coal Industry

"Coal is the veritable bread of industry; without it industry comes to a standstill; without it the railways are in a sorry state and can never be restored…";
—V.I. Lenin, 1 April 1920 speech at the First All-Russia Congress of Mineworkers

Largest Actively-Mined Soviet Coal Basins of the 1920s-1940s

Basin	Approximate Location	Coal Deposits (billion tons)	Coal Types (American Classifications)	Year Significant Mining Began
Kansk-Achinsk	Krasnoyarsk region, Siberia, Russian SFSR	67	Bituminous Lignite	1903
Kuznetsk, Kuzbass (***Kuz**netskiy* ***Bass**eyn*)	Kemerovo region, Siberia, Russian SFSR	42	Anthracite Bituminous Subbituminous	1851
Donets, Donbass (***Don**etskiy* ***Bass**eyn*)	Southeast Ukrainian SSR-southwest Russian SFSR	34	Anthracite Bituminous	1880s
Karaganda	Karaganda region, Kazakh SSR, Central Asia	7	Bituminous	1932
Pechora	Arctic area of Urals region including Vorkuta, Russian SFSR	7	Bituminous	1931
Podmoskovnyy ("Near Moskva"), Mosbass (*Pod**mos**kovnyy* ***Bass**eyn*)	Mostly west of Moskva, Russian SFSR	5	Subbituminous Lignite	1855
Ekibastuz	Pavlodar region, Kazakh SSR, Central Asia	3	Bituminous	1890s
Irkutsk	Irkutsk region, Siberia, Russian SFSR	3	Anthracite Bituminous Subbituminous Lignite	1896
Lena	Lena River basin, Siberia, Russian SFSR	2	Bituminous	1930
Bureya	Khabarovsk region, Far East, Siberia, Russian SFSR	1	Bituminous	1939
South Yakutsk	Southern Yakut ASSR, Siberia, Russian SFSR	1	Bituminous	1849 (modernized from 1933)

Source: "World Coal Resources and Reserves"; *Concise Guide to World Coalfields;* International Energy Agency, Coal Research; 1983, plus independent research for when mining began.

All mentions of the sizes of coal basins refer to the amount of coal reserves of the basins and not the geographical extent of the basins. “Year Significant Mining Began” is not always the year mining first began. For example, the Karaganda basin saw small-scale mining in the 19th Century to supply a local copper smelter, but at some point mining ceased. In 1929, the Soviets created an organization to mine coal at Karaganda, which surveyed the area and dug exploratory mines in 1930–1931. In 1932 Karaganda went into operation with production mines, and hence 1932 is given as the year that significant mining began.

Other Huge Basins: The USSR also had some coal basins with immense coal reserves that remained undeveloped or nearly so during the 1920s-1940s. One was the Tunguska basin in north-central Siberia. Most of the basin was in very difficult terrain in harsh Siberian climatic conditions, with no roads, railroads, or usable waterways to transport the coal to Soviet coal consumers. The Soviets accordingly concentrated on developing more-accessible basins. One small part of Tunguska was developed, at Norilsk on the northwestern edge of the basin. Norilsk had significant mineral deposits, particularly nickel, and grew into a mineral extraction and refining center using the local coal resources. Access to Norilsk was by a narrow-gauge rail line built by GULag forced labor in 1936–1937[139]. The post-war Soviets developed some southern parts of the Tunguska basin to provide fuel for electric generation plants, but the greater part of the basin is still undeveloped as of 2021.

Similarly, the USSR also had the huge Taymyr Coal Basin in the extreme Siberian Arctic, on the Taymyr Peninsula by the Arctic Ocean. Taymyr was even less accessible than the Tunguska. The basin has high-quality coal including anthracite. As of 2021, the basin is not being mined yet, but development is underway to begin production perhaps by 2023, despite major environmental concerns about this project. The considerable melting of the Arctic Ocean during the summer in recent times is increasingly making it possible to ship coal from Taymyr, and India in particular is interested in procuring Taymyr coal for industrial use.

Large Coal Basins: In addition to the coal basins listed in the table, the USSR had many somewhat smaller coal basins with significant reserves, although less than the huge basins. Many of these basins were quite economically important. For example, the Kizel (or West Urals) coal basin near the city of Perm (called Molotov in 1940–1957) in the Urals fueled the industrialization of this region in the 1930s. During World War II, availability of coal from this basin allowed the Soviets to evacuate many factories to the Urals region, making it a major armaments center. Similarly, a coal basin by Chelyabinsk in the southern Urals turned this city into an industrial center in the 1930s and then into a major armaments center during the war. Chelyabinsk was nicknamed *Tankograd* (Tank City) for the huge number of tanks made there during the war.

Smaller Coal Basins: The USSR had numerous small coal basins, some of which were important for the local economy. For example, the Dnepr brown coal basin in Ukraine,

139 After the war, the rail line was rebuilt to Soviet broad gauge.

mostly west of the Dnepr River and south of Kiev, had been mined since 1861, but only as fuel for the local area. Under the 1920s-1930s Soviets, the basin was developed a bit more to provide brown coal for some Ukrainian electricity generating plants, but more extensive development of the basin only began in 1951 using open-pit mining.

Small coal basins or deposits were widely distributed throughout the USSR. While the Transcaucasus region of the USSR was famed for Baku's immense oil reserves, the region also had many small coal deposits that were used locally, including for some electricity generation. While the northern part of Soviet Central Asia had huge coal basins, the southern part had only small coal deposits, which saw small-scale mining for local use.

Early in their rule, the Soviets confiscated without compensation all private coal mining enterprises, like they did all other important private enterprises including in the oil, industrial, and resource-extraction sectors. Since the Soviets were not exporting coal, confiscation caused them few international problems, unlike what happened with the export-oriented Soviet oil industry of the early 1920s. Coal mining enterprises were organized as trusts (*trasty*, singular *trest*). Trusts were grouped into combines (*kombinaty*, singular *kombinat*), which handled distribution of the mined coal, overall planning, and implementation of Party and government directives. Although I am not sure, I suspect trusts were grouped under combines on a regional basis.

Donbass, Serdtse Rossii (Donbass, Heart of Russia)
1921 Soviet poster

Although multiple sources claim the image is a 1921 Soviet poster, it shows the Donbass connected to places in 1921 that are in independent Estonia and Poland. Place names on the map are consistent with the period 1914–1924, as for example it shows Petrograd (formerly Sankt-Peterburg until 1914 and then Leningrad from 1924). Assuming 1921 is correct, then the poster appears to be using the status of the Donbass during the Russian Empire. This would make some sense, as in 1921 the Donbass was still badly damaged from the Russian Civil War and would not have been able to adequately supply all the locations shown on the map.

As with the Russian Empire, the Donetsk Basin was the Soviets' most important coal basin. The Donbass was badly damaged in the Russian Civil War, with 1921 coal production of just 4.6 million tons, only a fraction of 1913's production. Donbass coal mining recovered after the civil war, reaching 37 million tons in 1930, about 76% of the USSR's total coal production.

Another import coal basin in the western USSR was the Podmoskovnyy Basin or the Mosbass, which was mostly to the west of Moskva. This basin had brown coal, which the Soviets used for several purposes, particularly for steam locomotives and as a cheap heating fuel. In 1918–1920 during the Russian Civil War, the Soviets often lacked access to coal from the Donbass or oil products from the North Caucasus and Baku, so Podmoskovnyy coal was often used for fuel in the Soviet heartland from Sankt-Peterburg to Moskva and nearby areas. Major Soviet development of Podmoskovnyy began in the 1920s during the GOELRO electrification drive, to provide brown coal for many of the electricity generating stations being built in the northwestern USSR. This coal basin was in a quite wet area, so the problem of reliably preventing the mines from flooding was an engineering challenge. In 1928 1.1 million tons was mined at Mosbass, rising to 9.9 million tons in 1940, the last year of peace before the Germans invaded. Once the Donbass was producing significant amounts of coal again, the Soviets often mixed Mosbass brown coal and Donbass hard coal together for use as locomotive fuel.

The Soviet coal industry had great potential for expansion, since the USSR contained many coal basins. Further, most of the country had not been geologically surveyed, which was the Soviets' main way to find coal deposits. Even as late as 1933, geological surveys covered only 25% of the county, with detail surveys covering only 10%. The Soviets had a major effort to increase geological surveys, and by 1936 45% of the county had been surveyed for minerals, although some findings were from general surveys rather than detailed ones. Soviet coal reserves rose significantly as the surveys were completed. In 1928, the Soviets had 385 billion tons of coal reserves; by 1937 the Soviets had 1.7 trillion tons of "available" coal reserves, of which 630 billion tons were "proven"[140]. Even a seemingly well-developed basin like the Donbass saw its coal reserves increase, from 59.6 billion tons in 1928 to 240.6 billion tons by 1956.

The Soviets included all coal they found in their reserves, even if they thought they could not mine some of it. I have not found a figure for how much of the 1930s-1940s Soviet coal reserves were mineable. However, about 90% of Soviet 1956 coal reserves were mineable (7.7 trillion mineable out of 8.6 trillion total), so it perhaps a similar percentage was applicable for the 1930s-1940s Soviets. "Mineable" meant that the coal could be mined in some way, but not that it was necessarily economically worthwhile to mine it. For example, the vast Taymyr coal basin and almost all of the vast Tunguska coal basin were mineable but were not mined by the 1930s-1940s Soviets, because the basins were located in very remote, poorly-accessible areas with extremely harsh climates.

Underground mining was by the far the main method the Soviets used in this period to extract coal, as was the case for the earlier Russian Empire. In 1928, on the order of 98–99% of all Soviet coal came from underground mines. From 1928, surface mining (open pit mining

140 Charles Winfield Laythe; thesis, "The Dynamics of the Soviet Coal Industry: A Geographic Interpretation"; 1962.

or strip mining) were used at some coal basins, mostly in Siberia. By 1940, about 95% of Soviet coal came from underground mines and 5% from surface mining. The percentage of surface mining rose during the war, but this might mostly have been due to the Soviets' loss of the Donbass with its many underground mines.

Mining technology changed significantly for the 1930s-1940s Soviets. At first, the vast majority of Soviet coal had been dug by manual labor and brought out by animal power. In 1928, 88.6% of Soviet coal was extracted in this way, and only 11.5% by mechanized methods. As Soviet industrialization ramped up, mines were increasingly electrified for mechanical mining and transportation of coal. By 1940, human and animal power extracted only 24.8% of Soviet coal, and mechanical means handled the other 75.2%. This was a significant accomplishment and showed the priority the Soviets placed on coal. Coal was the most-important fuel for Soviet industrial development, and modernization of coal mining was important for both Soviet economic development and propaganda. It is perhaps no coincidence that the Stakhanovite movement began with coal mining. These were workers who achieved at least 150% of quota in their work shifts.

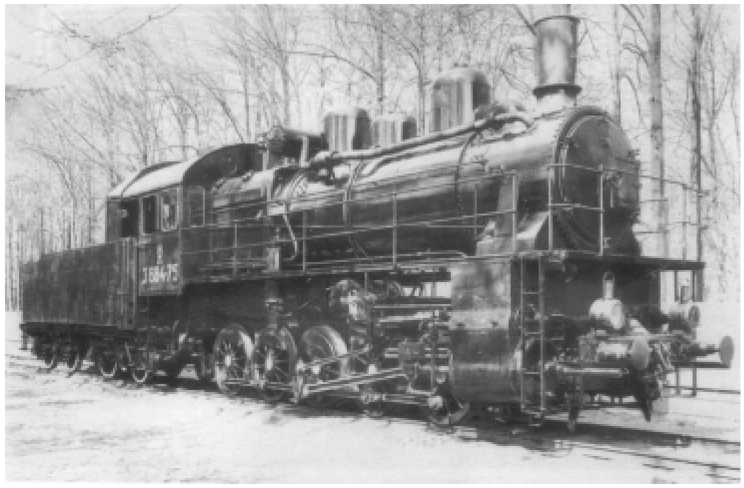
Throughout the 1920s-1940s, the Soviet railroad system was the biggest consumer of coal (almost 30% of all coal in 1940, its year of peak consumption). This is despite the fact that some steam locomotives used fuel oil instead of coal, and some rail lines were electrified for use with electric locomotives. (Diesel locomotives only became significant for the Soviets after the war.) During the war, the loss of coal from the Donbass forced the Soviets to use, at least temporarily, firewood for many steam locomotives, despite the lower efficiency that entailed.

After the railroads, the two biggest coal consumers were the ferrous metal industry (almost 25% in 1940) and the electricity generation sector (about 12% in 1940).

Despite mechanization supplanting much manual labor, the great expansion of the Soviet coal industry and development of new coal basins meant that the Soviet coal mining workforce constantly increased in the 1930s. Coal mining was restricted only to men until 1931, when to increase the supply of workers the Soviets authorized women to work in selected mines. In 1938, the Soviets expanded the number of mines when women could work[141]. The coal industry itself was a major consumer of coal, using about 9% of coal production to fuel its operations in 1926. (I have not seen 1940 figures, but likely they were

141 One source claims women were allowed to work in coal mines in general in October 1940, but it is unclear if the source is correct. Perhaps this is a mistake for the 1938 expansion of locations for women coal miners.

between 6% and 9% due to modernization and electrification of the coal industry. By 1956, for example, the coal industry consumed only about 6% of coal production.)



A Soviet Series E (“backwards E”) locomotive

The Soviet Union and the earlier Russian Empire had two different models of steam locomotive that both translate into English as “Series E”. One was the *Серии Е* (Series E, using the forwards “*E*” letter) and the other was the *Серии Э* (Series E, using the backwards “*Э*” letter). The locomotive in the picture is a Series backwards-E, specifically a submodel Eu (“*Эу*”). This particular locomotive was photographed in 1929 soon after it had been manufactured at the Kolomna Machine-Building Factory (renamed in 1935 the V.V. Kuybyshev Locomotive Factory), popularly called just the “Kolomna Factory” throughout Soviet times.

Many other industries also used coal. Coal was also used in many cities as a heating fuel and on many collective or state farms where the processing of agricultural products required heat. Since many of these locations were not near coal mines, the Soviets had to bring coal to these consumers, by rail or water transport. On average throughout the 1930s, a ton of Soviet coal traveled roughly 650–700 km (roughly 400–450 miles) to reach its consumption site. Since the distance coal was transported never fell below 650 km in the 1930s despite Soviet coal production increasing dramatically, the railroads were moving large amounts of coal. This perhaps was one of the reasons the railroads themselves used so much coal. In fact, some rail lines were built primarily for coal transport, such as the line from Ukhta to Vorkuta in the Arctic, allowing coal of the Pechora basin to be sent south year-round.

During the industrialization drive of the 1930s, the Soviets extensively developed many coal basins. By 1940, even though Donbass coal production had more than doubled in a decade to 83.3 million tons, it was now producing only 50% of the USSR’s coal, down from 76%.

The greater Urals area was developed from 1928. That year, coal basins in the region produced 2.0 million tons of coal, about 60% hard coal and 40% brown coal. By 1940, 11.7

millions were produced, with more brown coal being produced (about 60%) than hard coal (about 40%). Urals coal helped fuel the industry of the region, especially in and around the cities of Perm (called Molotov in 1940–1957) and Chelyabinsk, which were near coal basins. However, the Urals had significant mineral deposits at Sverdlovsk (now Ekaterinburg) and iron deposits at Magnitogorsk, cities without nearby coal fields. Both cities, along with the rest of the Urals as needed, used coal brought in from other regions, particularly the Kuzbass and Karaganda.

Prior to 1928, the Kuzbass in south-central Siberia had only been seen modest development, to meet local needs and to fuel locomotives on the Trans-Siberian Railroad. From 1928, the Kuzbass was more extensively developed, as it had more coal than the Donbass and at least equaled the Donbass for the quality of its coal. It was extensively mined for hard coal, which had a quality well suited for processing into coking coal. Mineral surveys increased the Kuzbass's known reserves from 250 billion tons in 1928 to 450 billion tons by 1937. Mining operations were almost exclusively underground until after the war, unlike operations at some other Siberian coal basins, and production rose from 2.6 million tons in 1928 to 21.1 million tons in 1940. Besides its local and locomotive uses, Kuzbass coal was sent to the Urals region.

The Karaganda coal basin also had huge reserves of high-quality coal suitable to become coking coal. The basin was in the northern part of Soviet Central Asia, in a low-population region of the Kazakh SSR. The climate was dry steppe, with dry, hot summers but cold winters. The climate and lack of population meant that Karaganda was extensively developed by GULag forced labor, and GULag prisoners in other locations feared being sent to mine coal in the hot summer hell of Karaganda as much as they feared being sent to mine coal in the frozen winter hell of Arctic Vorkuta.

Karaganda had seen small-scale underground coal mining under the Russian Empire, mainly for local and railroad use. The Soviets confiscated the mines without compensation in 1918, but the region fell to British forces intervening in Central Asia during the early part of the Russian Civil War. Upon withdrawing, the British flooded the mines and demolished the surface facilities. Karaganda thereafter remained insignificant until 1932. In 1929–1931, the Soviets established an organization to find and mine Karaganda coal. Coal production began in 1932 with 0.7 million tons being mined. By 1940, production was 6.3 million tons. Almost all (98+%) of the coal mined in this period was hard coal. The main uses of Karaganda coal were to fuel locomotives on the railroads of Central Asian and to help fuel industries in the Urals region (up to 55% of Karaganda coal went to the Urals).

The Soviets had several south-central Siberian coal basins east of the Kuzbass, particularly the Kansk-Achinsk and Irkutsk basins west of Lake Baykal, and a smaller basin in the Buryat-Mongolian ASSR in the Transbaykal area. The basins' remoteness from major coal consumers meant that they were developed almost exclusively as a local source of fuel for industry, electricity generation, locomotives on the Trans-Siberian Railroad, heating, and processing of agricultural products. The region around Irkutsk northwest of Lake Baykal was industrializing in the 1930s, so coal production in these basins increased from 1.0 million tons in 1928 (about 70% hard coal and 30% brown coal) to 8.5 million tons in 1940 (about 80% hard coal and 20% brown coal).

The Buryat-Mongolian ASSR (now the Republic of Buryatia in the Russian Federation) was part of the Transbaykal Military District (later the Transbaykal Front), with significant military forces guarding the Soviet border adjacent to northeast Manchuria against a possible Japanese invasion. Aircraft and vehicles of these forces needed liquid fuels, particularly gasoline, but there were no oilfields or refineries in the region[142], so all liquid fuel had to be brought in via the Trans-Siberian Railroad from distant locations. The ASSR did have coal, however. Had Soviet plans for building synthetic fuel plants to hydrogenate coal into liquid fuels been realized, some of the coal from the Buryat-Mongolian ASSR would have gone to a plant there producing 30,000 tons of liquid fuels per year. The great majority of this fuel mostly likely would have supplied Red Army forces stationed in the Transbaykal region.

Coal was mined in the Soviet Far East and North Sakhalin Island for local use including electricity generation and locomotives. The Far East was industrializing in the 1930s, so coal production went from 1.0 million tons per year in 1928 (about 55% brown coal and 45% hard coal) to 6.5 million tons in 1940 (about 75% brown coal and 25% hard coal).

Germany invaded the USSR in June 1941. Coal was needed more than ever, to fuel war production of aircraft, tanks, other vehicles, weapons, ammunition, and all the other products the military needed to fight the war. Despite the development of many coal basins in the 1930s, Soviet coal production was still greatly concentrated in the Donbass, which was a heavy blow when the Germans overran the area in October 1941. The Soviet evacuated some mining equipment but had to destroy much before retreating, flooding the mines to deny them as much as possible to the Germans.

The loss of coal from the Donbass almost immediately impacted much of the western USSR including Moskva itself. Various factories and electricity generation plants in the Moskva

142 Oil and gas fields were found in the Irkutsk region north of Lake Baykal only in the final quarter of the 20th Century.

region depended on Donbass coal, and the city itself used much Donbass coal for heating. The Germans in 1941 also overran much of the Podmoskovnyy Basin west of Moskva during their drive to take the Soviet capital, making the coal situation at Moskva particularly acute. Lack of coal may have been a factor for why the Soviets decided to evacuated the equipment of two regional coal-fueled power plants, while leaving all regional peat-fueled power plants in place.

Like in the oil industry, the outbreak of war in 1941 meant many men in the coal industry joined the Red Army to fight the enemy. They were extensively replaced by women. Again like in the oil industry, almost all of these women were unskilled and had to learn on the job. Also, elderly retired coal miners returned to work, and adolescent boys and girls as young as 15 were also used in the industry. Work shifts were extended to 10 hours per day, the work week was six or seven days, and any voluntary time off of vacations were not allowed.

If one source is to be believed, 86% of all miners were women and girls at least at one point during the war[143]. I have not been able to confirm this, but supposedly a 1943 Soviet directive called for replacing 80% of the men in the coal industry with women[144]. Women continued to work in the coal mines after war. In 1957, the Soviets issued a decree to replace women with men in the coal mines, although in some places it took at least to 1966 before the decree was fully implemented.

Kosogorova Maria Prokhorovna of the Soviet coal industry

This picture of Prokhorovna is mostly a propaganda photo. Prokhorovna was a high-ranking official in the coal industry. She entered a coal mining institute in 1932 and thereafter became an engineer and manager in the industry, rather than a shift worker in the mines. In 1940, she became head of the Ziminka coal mine in the Kemerovo region of Siberia. In 1942, her mine won an award for being the best Soviet coal mine. In January 1943, to celebrate the opening of an overland supply

143 https://soviet-postcards.com/post/188251992466/female-coal-miners-in-the-ussr-female-labor-in

144 https://www.rbth.com/history/333092-day-in-life-of-soviet-female-miner

route into besieged Leningrad, Prokhorovna organized a socialist competition to over-fulfill the mine's coal quota, with proceeds of the over-production to go to Leningrad. As part of the competition, Prokhorovna worked three shifts at the coalface mining coal with a jackhammer, posing for the above picture. She later temporarily left the industry to work in the Communist Party. In 1944, she returned and went to the Donbass to help restore the coal mines there. Although Prokhorovna may only have worked three shifts with a jackhammer, there were many women coal miners during the war who actually mined coal every shift.

The Soviets in 1941–1942 evacuated many factories and some mining equipment out of the war zone to safer locations further east, including to the central Volga River valley, the Urals, Siberia, and Central Asia[145]. Most factories were sent to populated regions either near developed coal deposits or at already-existing industrial centers. The local population together with millions of evacuated Soviet civilians became factory workers, miners, and other laborers for the evacuated factories. Often, forced labor from the GULag and the conscript "Labor Army" was used to expand coal production during the war for these expanding industrial centers.

The Soviets halted the German offensive at the gates of Moskva, and their winter counteroffensive starting in December 1941 pushed the Germans back. They regained many parts of the Podmoskovnyy Basin over the winter of 1941/1942, although much of the mining equipment had either been evacuated or destroyed in the autumn of 1941. Rendering the underground mines themselves unusable was relatively easy, since they were extremely prone to flooding. Whatever mines the Soviets failed to flood during their hasty withdrawal were flooded by the Germans when they in turn fell back in the winter of 1941–1942.

With the Germans occupying the Donbass, the Podmoskovnyy was the only major coal basin in the western USSR under Soviet control. The Soviets accordingly went to great lengths to restore coal production at Podmoskovnyy as fast as possible, and the basin reached its 1940 level of production before the end of 1942. The Soviets thereafter continued to develop Podmoskovnyy, which produced 20.0 million tons of coal in 1945[146], slightly more than double 1940's 9.9 million tons. Podmoskovnyy coal thus partially replaced the loss of the Donbass, although Podmoskovnyy brown coal was typically less useful than Donbass high-quality coal.

145 Early in the war, the Soviets believed that the Red Army would halt the invaders in the western USSR and evacuated some factories to Leningrad, Moskva, and some other cities that the Germans later threatened or captured. Many of these factories had to be evacuated again as the Germans approached.

146 Charles Winfield Laythe; thesis, "The Dynamics of the Soviet Coal Industry: A Geographic Interpretation"; 1962.

A major priority for the Soviets during the war was to increase coal production in the Urals region, since many heavy industry and armaments factories were evacuated there in 1941–1942. Urals' coal output increased to 25.0 millions tons by 1945 (roughly 67% brown coal and 33% hard coal), more than double 1940's output of 11.7 million tons.

The Soviets in theory could have completely replaced the loss of the Donbass by rapidly developing the Kuznets Coal Basin (the Kuzbass, from ***Kuz**netskiy Ugolnyy **Bass**eyn*, Kuznetsk Coal Basin) in Siberia. The Kuzbass in 1941 was already the second largest coal producer in the USSR. It had greater coal reserves than the Donbass and produced a similar range of high-quality coal. However, the Kuzbass only saw a relatively modest wartime increase in production (when compared to the Urals), from 21.1 millions tons in 1940 to 28.9 million tons in 1945. This was due to the remoteness of the Kuzbass from most major coal consumers in the western USSR. Kuzbass coal would have had to be transported by rail for 2,500 km (1,550 miles) or more to the many Soviet cities and factories west of the Urals that formerly used Donbass coal. This would have overwhelmed the capacity of the Soviet rail system. Instead, the Kuzbass was developed only to supply the needs of industry in the nearby Kemerovo region and in the somewhat-close Urals region. Soviet cities and factories in the west had to make do with local coal resources or switch to other fuels. For some examples, Moskva at first largely switched to firewood for heating, various coal-burning electric plants switched to peat, and Kuybyshev eventually switched to natural gas for heating, electricity generation, and industrial use.

Coal production at Karaganda almost doubled during the war, from 6.3 million tons in 1940 to 11.2 million tons in 1945. Brown coal was mined more extensively, rising from 2% of Karaganda's production in 1940 to 22% in 1945. While Karaganda's hard coal was mined underground, Karaganda's brown coal was extracted through surface mining. Karaganda coal continued to help fuel the industries in the Urals region.

Coal production in the remote Lake Baykal-Transbaykal region actually declined during the war, from 8.5 million tons in 1940 to 7.6 million ton in 1945. I have not yet seen a reason given for this decline. I speculate that the Soviets sent their limited production of coal mining equipment to more-important coal-producing regions. Without sufficient equipment for repair and maintenance at the mines, coal production in the Baykal region would have declined. Since essentially all the coal produced in the region was used locally or for Trans-Siberian locomotives, the Soviets likely judged the region could scrape by on its own[147].

147 The speculated lack of coal mining equipment is consistent with other decisions the Soviets made for the region during the war. For example, agriculture in the Irkutsk region was badly impacted, with many tractors being sent to the Red Army, followed by fuel shortages for the remaining equipment. See "Selskoe khozyaystvo Irkutskoy Oblasti v gody Velikoy

Likely, local shortages of coal were made good by increasing the amount of firewood taken from the abundant forests in the region.

The Soviet Far East and North Sakhalin Island saw a modest increase in coal production during the war, from 6.5 million tons in 1940 to 7.0 million tons in 1945 (about 70% brown coal and 30% hard coal). Unlike the Lake Baykal-Transbaykal region which saw production decline, the Soviets likely supplied enough equipment to increase Far Eastern production because of the region's strategic value. The Soviet Far East port of Vladivostok was the entry point for Allied aid being shipped across the Pacific. Since roughly half of all Allied aid to the USSR was sent across the Pacific, the Soviet Far East was a vital rear area in the USSR's war effort.

The year 1942 was the nadir of Soviet coal production. At 75.5 million tons, it was slight less that half of 1941's 151.4 million tons. The Donbass was firmly in German control, but all other important coal basins except the Podmoskovnyy were well beyond the reach of German panzers or even Luftwaffe bombers. Losing the Podmoskovnyy again to the Germans would have been inconvenient but not fatal to the Soviets, but in any event the Germans in 1942 wanted Soviet oil, not coal. With the remaining coal mines safe and Soviet industry by March 1942 strongly recovering from the many factory evacuations of 1941, Soviet military production greatly increased throughout the rest of the year. Since coal was in short supply, Soviet war industries received priority for coal, and other coal consumers had to get by as best they could with what was left over. While 1942's gross industrial output was only 77% that of 1940, the last full year before the war, 1942's military production was 186% that of 1940.

As the German offensives stalled at Stalingrad and in the North Caucasus in the autumn of 1942, the Germans were unable to destroy Soviet aircraft, tanks, and weapons as fast as the Soviets were making them. The Red Army's offensive strength grew, and in November 1942 the Soviets at Stalingrad launched the first of many victorious offensives against the Germans. The breakthrough from the Stalingrad offensive saw Soviet forces approach the Donbass by February 1943, but a German counteroffensive threw them back.

The Germans upon capturing the Donbass in Ukraine in October 1941at first had just left the coal mines in ruins. The German high command still believed the USSR was on the verge of collapse. Their interest in Ukraine was its agricultural products and manganese ore output, which were to be sent to Germany. Ukrainian iron ore and coal were not needed back in

Otechestvennoy Voyny" ("Agriculture of the Irkutsk Region during the Great Patriotic War"); https://irkobl.ru/sites/agroline/Archive/selxozvoina.php

Germany. Nor were they needed in Ukraine, which was to be deindustrialized[148]. By 8 November 1941, however, doubts about Soviet imminent collapse crept into some in the German high command, and the occupation authorities in Ukraine were told to revive Ukrainian iron and coal mining operations. They, however, were able to accomplish little at first, likely in part due to both to the Soviet winter counteroffensive of 1941–1942 and the harshness of that winter.

Although the winter counteroffensive petered out in stalemate, the fact that the Soviets could launch and sustain it convinced many in the German high command in early 1942 that the war would be prolonged. They increasingly saw the need to rebuild Ukrainian industry to support the German war effort. In May 1942, the Germans decided to restore Ukrainian iron ore and coal mining, steel production, and the manufacture of ammunition.

Coal was key to the realization of all of these plans for Ukraine. Further, with the Dnepr hydropower station destroyed, the Germans had a great shortage of electricity in Ukraine, which hindered their goals of exploiting its resources. They had a few operational coal-fueled power stations in Ukraine, but with the Donbass in ruins the Germans were forced to rail in coal from German Silesia. The cost of transporting this coal was three times the cost of the coal itself. So, restoring Donbass coal would also help with electricity in Ukraine.

148 Kim Christian Priemel; "Occupying Ukraine: Great Expectations, Failed Opportunities, and the Spoils of War, 1941–1943"; *Central European History* Vol. 48 No. 1; 2015; http://www.jstor.org/stable/43965115.

Germans inspecting the destroyed surface facilities of
the Kochegarka coal mine at Gorlovka in the Donbass[149]

The Germans sent 1,800 mining specialists to oversee Donbass reconstruction and used about 110,000 Soviet citizens to work in the Donbass mining operations: about 90,000 civilians (of which about a quarter were women) and about 20,000 Soviet prisoners of war[150]. Due to massive mistreatment of the Ukrainians, the Germans by now found few people truly willing to work for them.

Many Ukrainians at first favorably viewed Germany as their liberator from brutal Soviet rule. Even as late as November 1941, when Germany began the Eastern-Workers (*Ostarbeiter*) program, many Ukrainians still had much good will towards Germany, despite Germany's harsh occupation polices. Some in the German high command began the Eastern-Workers program when they realized the USSR was not going to collapse soon. Facing a prolonged war, they decided to increase Germany's agricultural and industrial production by sending workers from the occupied eastern regions, particularly Ukraine, to Germany. At first, about 80% of Ukrainian Eastern-Workers were volunteers. However, it soon became well known that the Germans were treating Eastern-Workers very poorly. Even their initial rail journeys to Germany were in cattle cars without food or sanitation facilities. Once in Germany, very poor working and living conditions were common, with no right to quit their jobs, return

149 *Source:* https://en.topwar.ru/176659-donbass-vzorvali-do-nemcev.html

150 https://journals.openedition.org/monderusse/9348. The 90,000 number may have been the maximum effort. Priemel (see previous footnote) puts the Donbass non-German workforce in March 1943 at 65,000, including 8,200 Soviet POWs.

home, or seek redress for poor treatment. Eastern-Workers who protested or caused problems were often beaten or otherwise punished. The Eastern-Workers program thus was one of the starting points of what became a vast system of slave labor throughout Germany.

In the first half of 1942, Ukrainians increasingly refused to volunteer to work in Germany. In turn, the Germans began mass forced deportations of Ukrainians to Germany. Against this backdrop, the Germans decided to rebuild Ukrainian mines and factories using Ukrainian labor. Unsurprisingly, there were few Ukrainians willing to work in Ukraine for the Germans. Most Ukrainians were coerced to work, either simply outright or through a system that linked workers' food rations to labor with no right to quit their German-assigned jobs. When possible, many workers in Ukraine would simply desert their work places and hide in the countryside. Some, mostly later in the war, would join the Soviet-controlled partisans fighting the Germans[151]. Desertion was so bad at some places that the Germans had to resort to fencing in and guarding the workers.

Nevertheless, work proceeded. Some of the Donbass mines were drained and mining equipment was brought in. Eventually, the Germans were able to mine about 5 million tons of coal from the Donbass, about 5% of the basin's 1940 production. The coal was used for industrial production at the partially-restored Ukrainian factories. Some mills began making steel in October 1942. By May 1943, according to one source, a factory began ammunition production. The Germans were particularly interested in making ammunition for their most common calibers of artillery: 10.5-cm rounds first, soon to be joined by 15-cm rounds and 21-cm rounds. According to another source, production of 10.5-cm rounds only began in August 1943, with deliveries of the first 150,000 rounds to start in September. It is unclear how many 10.5-cm rounds were actually produced before production had to be abandoned.

Had the Germans held the Donbass longer, no doubt coal, steel, and ammunition production all would have increased. This was not to be. It took the Soviets seven months from February 1943 and victory at the Battle of Kursk in July to finally mount an offensive that retook the Donbass. In September, the Donets Basin was Soviet again. And, once again, in ruins. The Germans flooded the mines and demolished the mining facilities before they withdrew. Almost anything they could cart off, including mined coal, was sent to Germany, along with many Ukrainian forced workers who were unable to escape from the Germans.

Flooding the mines was quite easy to do, as all that was necessary was to destroy the mines' pumps. The Germans also destroyed the regional electricity generation plants, so the Soviets

151 Some, particularly in the part of western Ukraine that had been part of Poland in 1939, would instead join the Ukrainian nationalist partisans, who at times would fight the Germans, the Soviets, and the Poles.

had to restore electricity before they could pump out the mines. The Donbass had to be rebuilt all over again. Some production did not resume until months later in 1944, once the first mines were cleared of water, and the Donbass did not regain its 1940 level of coal production until 1949.

The Donbass serves as an example of Germany's self-defeating policies during the war. Had the Germans planned to restore Ukrainian mines and factories from the outset in 1941, these would have come into production at least six months sooner than they did. While earlier artillery ammunition production in Ukraine would not have tipped the war in Germany's favor, similar policies throughout the German-occupied Soviet territories, together with a more-humane treatment of the conquered populace and Soviet POWs could have added significant contributions to the German war effort in 1942, possibly at least prolonging the war for years. It is fortunate for the world this did not happen.

During the war, the Soviets increased mechanization of coal mining when they could, although military production took precedence over making things like mining equipment. In 1941, the Soviets were unable to evacuate all of the larger underground mining machines threatened with German capture and mostly destroyed or ruined the ones they abandoned (often by letting the mines flood). They were unable to fully replace the losses of these capital-intensive machines: their stock of "heavy mining machines" went from 3,421 in 1940 to just 2,815 in 1945. However, the stock other machines increased: for example, belt conveyors for mined coal went from 2,920 in 1940 to 3,374 in 1945. New machines were introduced, with conveyors for mining scrap going from 0 in 1940 to 2,049 in 1945. Some, perhaps a lot, of this equipment came from Allied wartime aid. American Lend-Lease in particular provided mining equipment, some electric locomotives for hauling coal out of mines, and even about 25,000 tons of anthracite and bituminous coal. Since 25,000 tons was a tiny amount of coal (0.03%) compared to Soviet coal production even at its wartime lowest (75.5 million tons in 1942), this American coal must have had a special use. One possibility is that some of the Soviet transport ships carrying Allied aid across the Pacific used coal, and coal used at American ports to refuel the ships was counted as Lend-Lease. Some World War II transport ships did use coal (for example, the British ordered a series of 60 American-made Liberty Ships that used coal instead of fuel oil), but I do not know if these Soviet ships burned coal.

Coal Miner Productivity (tons per day per worker)

Year	*Country*	*Underground Mine Productivity*	*% of USA*	*Surface Mine Productivity*	*% of USA*
1928	USA	4.45	-	11.0	-
1928	USSR	1.10	24.7%	-	-
1940	USA	4.41	-	14.18	-
1940	USSR	1.29	29.3%	2.89	20.4%
1945	USA	4.57	-	14.03	-
1945	USSR	0.87	19.0%	3.56	25.4%

Source: Charles Winfield Laythe; thesis, "The Dynamics of the Soviet Coal Industry: A Geographic Interpretation"; 1962.

Despite Soviet mechanization of coal mining in the 1930s, their coal mines remained a very labor-intensive industry until well after World War II. The table above shows how much more productive the more-mechanized American coal mines were. Although the size of and conditions in GULag were a Soviet state secret, these productivity figures likely include GULag forced labor used in coal mining. (The Soviets, for example, publicly released some productivity figures for coal basins like the Pechora, which were primarily mined by GULag slave laborers, without ever mention the GULag connection.) Lathe's text on productivity shows no awareness of forced labor. Since the GULag used manual labor much more extensively than non-prison operations did, it is most likely that coal miner productivity at non-prison mines was higher than the figures show.

The low productivity for Soviet underground mines in 1945 is likely due to several causes:

- The loss of mining equipment at the Donbass and Podmoskovnyy coal mines during the war, coupled with Soviet limited production of new mining equipment, meant less mechanization in Soviet coal mining.
- Some wartime coal mining was done by conscripts of the Soviet "Labor Army", comprised mostly of people and ethnic groups suspected of possible disloyalty to the USSR. The Labor Army was essentially forced labor and was often used in low-productivity manual labor like GULag prisoners were used.
- After the Soviet victory at Stalingrad in early 1943, the Soviets began to take prisoner significant numbers of Axis soldiers, particularly Germans. During the war, the Soviets

considered German soldiers collectively guilty for Germany's harsh occupation policies and massive war crimes in the USSR, without any requirement for individual proof of guilt. German POWs were most often used as forced labor. They often worked in debilitating conditions even worse than those of the GULag, particularly for paucity of food and very minimal medical care. Some German POWs were forced to mine coal, and their productivity must have been minimal.

- In the summer of 1944, with the Red Army advancing into Balkan countries and nearing the easternmost borders of 1939 Germany, victory over Germany seemed certain. In August, the Soviets decided that, as part of reparations for the war, ethnic Germans, including women and older adolescents, would be involuntarily deported to the USSR as forced laborers to assist in Soviet reconstruction. In December, the first deportations of Germans began. They were not, however, citizens of Germany. They were the *Volksdeutsche* of Balkan countries, ethnic Germans whose ancestors had moved to these areas centuries ago. In 1945, as the Red Army advanced into Germany itself and the German-settled parts of western Poland, German civilians from these areas were also deported. On the order of 270,000 people were sent in this way and forced to work in the USSR, mostly as manual laborers. Some of them were sent to mine coal, and their productivity must have been low.

It it unclear if Soviet coal productivity statistics actually include the forced labor of German POWs and German deportees. Since GULag labor seems to be included in the statistics, I suspect it is equally likely that German POW and deportee labor is included.

The course of World War II, particularly the loss of coal from the Donbass, caused the Soviets to redouble their efforts to develop coal basins in safe regions, particularly in the Urals, Siberia, and Central Asia. Even after the war, this program continued. One consequence of this was that the distance a ton of coal had to travel on average to reach its consumers increased in the post-war period. Although cost of production was low in these areas due to increasing use of surface mining, the cost of transportation remained high. The Soviets accepted this as a price for better security of their vital coal supplies[152].

Russian and Soviet Coal Production (million tons)

Year	Coal Production
1913 (Russian Empire)	36.05 (29.1)

152 Charles Winfield Laythe; thesis, "The Dynamics of the Soviet Coal Industry: A Geographic Interpretation"; 1962. Laythe's source for this is "Soviet industry moves east"; The Economist; 16 June 1951.

1922 (Russian SFSR)	11.3
1928 (USSR)	35.5
1932 (USSR)	64.4
1937 (USSR)	128.0
1940 (USSR)	165.9
1941 (USSR)	151.4
1942 (USSR)	75.5
1943 (USSR)	93.1

1944 (USSR)	121.5
1945 (USSR)	147.0

Sources: Partly from (no author listed) "Die Kohlenproduktion der UdSSR seit 1945" ("The Coal Production of the USSR since 1945"); *Ost-Probleme* Vol. 4, No. 5 (2 February 1952); https://www.jstor.org/stable/44923758. This source gives 1940 production as 166.0, but multiple other sources set it as 165.9.

1922, 1941, 1942, and 1944 production comes from "Istoriya Gornogo dela Mineralno-Syrevye Resursy v Velikoy Voyne, Chast 1" ("Mining History of Mineral Raw Materials in the Great War, Part 1"); E.A. Kozlovskiy; https://gaf3hl5frm635os3fkb544egme--geomar-ru.translate.goog/articles/history/357-mineral-resources-in-great-war.html

36.05 for 1913 is from Nykänen's 2015 thesis; "Istoriya Gornogo" gives it as 29.1.

1943 production comes from M.R. Akulov; dissertation, "Promyshlennoe Osvoenie Sibiri v gody Velikoy Otechestvennoy Voyny" ("Industrial Development of Siberia during the Great Patriotic War"); 1967.

5.B Peat

Note: Peat can be classified as swampy peat and forest peat[153]. Forest peat is ignored here, as how it forms depletes its combustible lignins and carbohydrates, making it worthless as fuel. The Soviets used swampy peat as a fuel.

Soviet civilians transporting peat

Peat, called *torf* (turf) in Russian, is partially decayed vegetation and other organic matter formed in bogs, peatlands, and other wetlands where abundant water, acidity, and lack of oxygen prevent complete decomposition. The waterlogged organic matter builds up and is

153 J.P. Andriesse; Section 3, "Formation of Peats"; *Nature and Management of Tropical Peat Soils*; (Food and Agriculture Organization of the United Nations); 1988; http://www.fao.org/3/x5872e/x5872e05.htm#3.%20FORMATION%20OF%20PEATS

compressed, forming peat. Research indicates it takes 600–2,400 years to form 1 meter (3.3 feet) of peat depending upon conditions, with an average of 1 meter per 1,500 years. Peat is not classified as coal but can be the first stage of coal formation. If a peat deposit is buried by natural processes, heat and pressure over millions of years can turn it into various grades of coal.

Peat can be excavated, dried, and then used for various purposes, particularly as a solid fuel. Dried peat typically is 50–60% carbon, which is less than that of lignite, the lowest-grade coal.

In Europe, conditions in the cooler regions of the continent's north favored formation of many bogs and thus peat. Historically, countries here used peat as a fuel, and some like Ireland and Finland still use considerable amounts of peat as a heating fuel. The Russian Empire and its successor the USSR had extensive peatlands. In the Russian Empire, peat was used locally, mostly in rural areas, being extracted by "hand carving" (manual labor) and then stacked in a sunny place to dry. In 1865, commercial, machine-based peat enterprises began, and some peat was then used as a fuel in cities near peatlands, competing with coal, kerosene, and wood. Overall peat use was low in Russia, with about just 1.7 million tons being mined in 1913. By 1918, with the Russian Empire collapsed and the Soviets fighting a civil war for control of the country, peat production dropped to about 1.1 million tons (but just 10.7% by hand carving), its lowest point for the entire 20th Century.

The Soviets won the civil war in 1920 and begin a mass electrification drive in 1921. Peat was one of the major fuels chosen in this plan, and many peat-fueled power plants were built near peat deposits. By 1930, power plants using peat generated about 40% of Soviet electricity, although this declined to about 20% by 1940, as new plants using other fuels or hydropower came on line. The Soviets modernized the production of peat at large deposits, using a variety of mechanical excavation and drying methods. However, the Soviets also extensively used manual labor to mine peat. In 1930, about 8.1 million tons of peat were mined, 24.1% by manual labor. By no coincidence, the growth of manual peat extraction was driven by the massive expansion of GULag forced-labor camps and colonies at this time. Since prisoners were not paid for their labor, they were a cheap, albeit inefficient, way to produce peat. Peat production reached almost 32.1 million tons in 1940 (18.7% produced by manual labor), of which about 13.4 million tons were used to fuel power stations.

Peat mining for power stations was supervised by *Glavtorf* (from ***Glav****nyy* ***Torf****yanoy Komitet*, Main Peat Committee), a part of the People's Commissariat of Electric Stations. However, peat became such an important fuel in the 1930s that many other industrial and defense-related people's commissariats had their own peat organizations.

During the war, Soviet peat production was disrupted by the German invasion, as productive peatlands in the Belorussian, Estonian, Latvian, Lithuanian, and Ukrainian SSRs were all lost, plus some peatlands in the western and northwestern Russian SFSR. Some peatlands were recovered when the Soviets drove the Germans back from Moskva during the winter of 1941/1942, but more peatlands, mostly in the Voronezh region of the central-western Russian SFSR, were then lost in 1942 during the German summer offensive. The offensive, however, mostly advanced into southern Russia between the Black and Caspian Seas, which was not a major peat-producing area.

Peat was one of the essential fuels for Soviets electricity generation. It could be used as a heating fuel and could serve in some facilities as a substitute for coal. The Germans had captured the Donbass in October 1941, which seriously reduced the Soviets' supply of coal. Like firewood, peat if locally available was often substituted for coal for heating and other fuel needs.

The Soviets tried to offset their loss of peatlands by increasing production in the remaining ones and beginning peat production at undeveloped sites. Much of this effort was done by manual labor using traditional peat extraction and drying methods, since machinery was in short supply. Like Soviet coal production, wartime Soviet peat production never recovered to its 1940's level (about 32.1 million tons). In 1942, peat production was at its wartime lowest, about just 14.6 million tons. This circumstance in part led, in August 1942, to the Soviets requiring civilians to perform mandatory labor service. This work included peat mining, particularly in the Kursk, Oryol, Tambov, and Voronezh regions. Peat was also extracted by the forced labor of the "Labor Army", a separate organization of semi-prisoner civilians. By 1944, peat production recovered to it wartime high of about 22.9 million tons (of which 26.2% was extracted by manual labor), about 71.6% that of 1940. Peat production soon surpassed the 1940 level in the immediate post-war years.

Under the right conditions, wildfires in peatlands are possible. Some peat fires can be very difficulty to extinguish, as underground seams of smoldering peat can persist for long times and reignite in the spring after being unseen all winter. Excavated peat that is drying can also catch fire. During the war, the Soviets were concerned that the Germans might bomb working peatlands with incendiary bombs, and they researched ways to put out resulting fires. The Germans, however, did not mount any serious bombing campaign (if any at all) against peat producing facilities, nor have I seen any evidence they even considered doing this. The Germans perhaps did not fully realize how important peat was to Soviet electricity generation. Destroying the peat enterprises near major industrial cities might have adversely affected Soviet electricity generation, which in turn would have decreased military production. However, in 1942 the Germans were still intent on conquering large parts of the USSR rather than destroying its economy, and they mostly used their Luftwaffe to support the operations of their ground forces.

Various peatlands captured by the Germans were put back into production, to supply fuel for the local economy, which was in turn used to support the German war effort. As the Germans were driven out of the USSR in 1943–1944, they destroyed these peat production facilities as they retreated. For example, almost all peat production facilities of the Belorussian SSR were severely damaged in 1944 and had to be rebuilt before significant peat production could resume there.

Russian and Soviet Peat Production (million tons)

Year	Total Production	By Hand Carving	% by Hand Carving
1913 (Russian Empire)	1.688	0.131	7.8%
1918 (Russian SFSR)	1.093	0.117	10.7%
1920 (Russian SFSR)	1.390	0.190	13.7%
1925 (USSR)	2.718	0.308	11.3%
1930 (USSR)	8.076	1.949	24.1%
1935 (USSR)	18.486	2.532	13.7%
1938 (USSR)	26.272	3.862	14.7%
1939 (USSR)	29.406	4.109	14.0%
1940 (USSR)	32.056	5.993	18.7%
1941 (USSR)	27.040	2.947	10.9%
1942 (USSR)	14.645	3.222	15.2%
1943 (USSR)	21.251	5.185	24.4%
1944 (USSR)	22.938	6.010	26.2%
1945 (USSR)	22.4	?	?

Sources: All years except 1945 are from V.I. Markov; *Periody Razzvitiya Torfyanoy Promyshlennosti Rossii* (*The Periods of the Development of the Peat Industry in Russia*); 2012. 1945 is from Jan J. Solecki; master's thesis, "Fuel Balance and Atomic Energy in the USSR"; 1961. Solecki does not provide production information about hand carving in 1945.

5.C Oil Shale

Oil shale processing processing plant at Kohtla-Järve, Estonia, 1937

The Soviet Union annexed Estonia in 1940 and confiscated the oil shale processing plant at Kohtla-Järve (*Kokhtla-Yarve* in Russian), possibly renaming it the oil shale processing combine. In the war, the Soviets badly damaged the plant during their retreat from Estonia in 1941. The Germans partially restored the plant to produce liquid fuel for the German armed forces, but they in turn largely destroyed the plant when they retreated from Estonia in 1944. The Soviets that year reorganized the shale gas industry there as the First Estonian Oil Shale Industry in Kokhtla-Yarve but made no effort at the time to revive the industry. This changed in 1945, when the Soviets began to rebuild Kohtla-Järve plant as well as the rest of the Estonian oil shale industry. Work on a shale gas production unit at the Kohtla-Järve site began in 1946 and became operational in 1948, the same year a pipeline opened to carry shale gas from Kohtla-Järve to Leningrad. Shale gas is unconventional natural gas (mostly methane) and was thus used the same as conventional natural gas. In 1949, the Kohtla-Järve plant became the Kokhtla-Yarve Oil-Shale-Processing Combine; in 1960 the Kokhtla-Yarve Oil-Shale-Processing Combine in the name of V.I. Lenin.

5.C.1 Introduction

Oil shale is a sedimentary rock that forms when the organic remains of plants and animals fall to the bottom of a body of water or swamp, where they mix with mud and are buried in a low-oxygen environment. The vast majority of this organic matter comes from plankton (both phytoplankton, microscopic plants, and zooplankton, microscopic animals), and not dinosaurs as is sometimes claimed or joked about. Over time, the organic remains are buried, compressed, and heated in the earth. The mud turns to shale, and the organic matter becomes kerogen, a waxy substance, and bitumen, a dense, highly-viscous hydrocarbon. This creates a shale oil deposit.

With further time, pressure, and higher heating, depending upon conditions, kerogen can become petroleum (crude oil), natural gas, or both. Natural gas formation requires more heat than crude oil, so some oilfields have little or no natural gas. The oil and gas can remain trapped in the shale, which in Soviet times was not worth effort to try to extract, other than the 1948 shale gas plant at Kohtla-Järve in the Estonian SSR. The oil and gas can also migrate into geological formations from which extraction is easier to do via conventional oil and gas wells.

Oil shale is thus the precursor to petroleum and natural gas. However, oil shale itself can be mined and used as a solid fuel. In some countries including the Russian Empire and the USSR, oil shale was used in steam locomotives and industrial furnaces, often as a substitute for coal.

Oil shale can be processed to produce liquid hydrocarbons ("shale oil"). These can be refined for use as a liquid fuel, including gasoline, diesel fuel, and marine fuel oil. Oil shale can also be processed to produce gaseous hydrocarbons like natural gas, which can be used as is or processed into products like ethane, propane, and butane.

5.C.2 Russian and Soviet Oil Shale: Modest Beginnings

Oil shale, "rocks that burned", had been known in various places in the Russian Empire at least since the 17th Century, although they were little utilized, likely because wood, peat, and coal were easier and cheaper to acquire. Local use of oil shale began in the 19th Century, in the part of the empire that would become the country of Estonia. However, even there oil shale was only used to a limited extent, as large-scale development of the deposits was judged to be too expensive to create a profitable industry.

Russian interest in oil shale revived in the 20th Century. A plant to process Estonian oil shale into a liquid shale oil fuel was proposed in 1910, although only research was undertaken at the time. World War I broke out in 1914, and by 1916, Russian oil production began to decline. A growing Russian steel shortage meant the oil industry could not get enough equipment to maintain production. Facing a fuel shortage, the Russian Empire started projects to develop Estonian oil shale as a fuel for the Baltic and Petrograd (formerly Sankt-Peterburg) regions and to develop other oil shale deposits as a fuel for the Moskva region. These projects were disrupted by two revolutions in Russia in 1917, ending with the Soviets in power and Estonia struggling to become independent.

During the ensuring Russian Civil War, the Soviets at times lost access to all major oilfields. the Donbass coal mining center, and the Estonian oil shale deposits. They thus became interested in developing oil shale deposits in the Volga River valley for liquid fuel. In the early 1920s, oil shale distillation projects began at Syzran on the Volga and soon went into small-scale production. However, by now the civil war was won, and it was less expensive and quicker to rebuild the coal and oil industries than to build a major oil shale industry almost from scratch. Although sources I've seen do not go into details, it seems very likely that the distillation plants only produced low-quality liquid fuel, as obtaining high-quality fuel from oil shale would be a Soviet goal in the 1930s and 1940s.

5.C.3 Soviet and Estonian Oil Shale: Growth, War, and Renewal

The 1920s Soviets began extensively mineralogical surveys of the USSR and found various oil shale deposits in addition to existing ones. One, the Gdov oil shale deposit, was found in 1926 along the border of Estonia and had high-quality oil shale similar or identical to the kukersite deposits in Estonia.

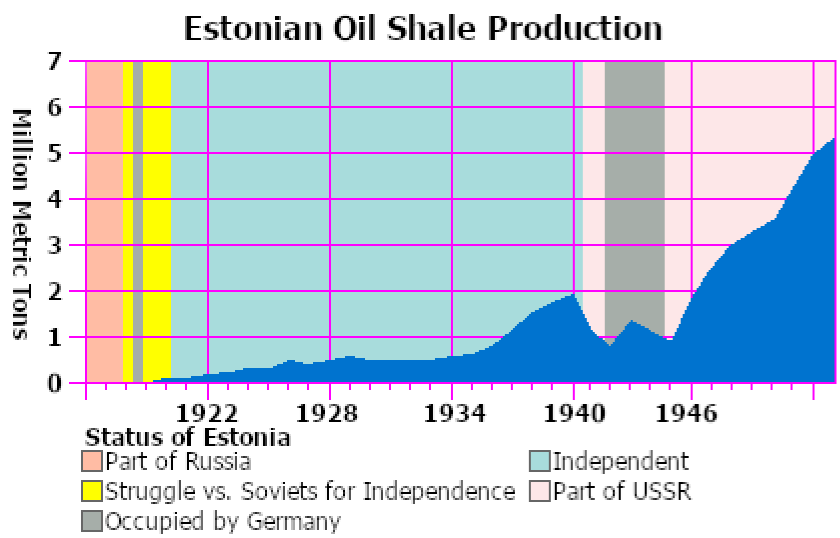
In 1930, with the USSR now industrializing on a massive scale, the Soviets decided to develop secondary fuel sources like peat, oil shale, and low-grade coal to meet local energy needs[154]. (Peat had already been developed as an important fuel for electricity generating stations, and the 1930 decision caused further development.) Some oil shale deposits were mined to provide solid fuel for electric power plants and for other industrial uses. Although the sources I've seen are not explicit on how this oil shale was used, it must have been burned in furnaces and boilers. Since most Soviet oil shale deposits contained high levels of sulfur, which was not removed from the solid fuel, the combustion of oil shale created sulfur dioxide and other sulfur oxide pollutants. Air and water resources near oil shale combustion sites were polluted, which could cause human health problems and environmental damage. As with most other pollutants, the Soviets prioritized economic development at the expense of health and environmental issues.

The high-quality Gdov oil shale deposit was special, as it had lower levels of sulfur than other Soviet oil shale. The Soviets started digging a pilot mine at a site near the border with Estonia on 9 April 1930. In the mid-1930s, this developed into a mining town named Slantsy (*slantsy* being the Russian word for "shales" and "slates").

154 A.A. Brovina, L.P. Roshchevskaya, M.P. Roshchevskiy; "Issledovaniya Goryuchikh Slantsev v Komi ASSR v gody Velikoy Otechestvennoy Voyny: Opyt Professora D.N. Kursanova" ("Research on Oil Shale in the Komi ASSR during the Great Patriotic War: The Experience of Professor D.N. Kursanov"); 2020; https://nbpublish.com/library_read_article.php?id=33117

The 1930 decision did not led to significant processing of oil shale into liquid fuels, as the sulfur would have had to be removed during processing into high-quality liquid fuels like gasoline. This was not out of concern for health or the environment. Instead, excessive sulfur in gasoline or diesel fuel can create corrosive sulfuric acid in internal-combustion engines, which could damage the cylinders and reduce the engines' performance and working lives. Soviet technology at the time was not capable of inexpensively removing sulfur from oil shale during processing into high-quality liquid fuel.

The Gdov shale oil was suitable for processing into to liquid fuel and shale gas. This would lead to Gdov being selected for an oil shale hydrogenation plant in 1939 and for shale gas production there after the war.



Partly derived from: John R. Dyni; *Estonian Oil Shale Industry Yearbook 2019*; Statistical Office of Estonia

Estonia had large reserves of oil shale, including kukersite, which was a high-quality, low-sulfur oil shale. Estonian industry significantly developed kukersite deposits in the 1920s-1930s, using it as a solid fuel for locomotives, heating, and electricity generation. Kukersite was also processed to make liquid fuels, particularly marine fuel oil and gasoline. The sulfur content of kukersite apparently was low enough to allow it to be processed into gasoline without having to remove the sulfur[155]. (Marine fuel oil was burnt in boilers, so the sulfur issue was not a mechanical problem, although sulfur compound pollution from ship boilers

155 Most sources do not go into details on desulfurization of liquid fuels made from 1930s Estonian oil shale. The best I've found is a modern statement is "these fuels would not meet modern environmental regulations because desulfurization, denitrogenation and deoxygenation were only performed to a minor extent, if at all"; Zachariah Steven Baird, Heino Rang, and Vahur Oja; "Desulfurization, Denitrogenation and deoxygenation of Shale Oil"; *Oil Shale*, Vol. 38 No. 2; 2021; https://kirj.ee/wp-content/plugins/kirj/pub/OS-2–2021–137–154_20210521213624.pdf

was and still is a problem.) Significant amounts of liquid fuels made from oil shale were exported, with Germany being the biggest customer.

In 1937, Soviet chemists confirmed that it was possible for the USSR to make vehicular gasoline, aviation gasoline, naphtha, and diesel fuel from oil shale, all these being liquid fuels in high demand in the USSR. The Soviets still did not have an inexpensive way to remove sulfur from their oil shale, so this finding did not result in the construction of plants to to process of oil shale into liquid fuels.

In 1939, the Soviets decided to build eight hydrogenation plants to make synthetic liquid fuel, as covered in an earlier section. Most of the plants hydrogenated coal, but two, at Gdov near Estonia and at Syzran along the central Volga River, were located at oil shale deposits. The plants ultimately were not built due to the outbreak of the war in 1941. The Gdov plant would have used Lake Peipus oil shale, which was similar to the high-quality, lower-sulfur deposits in Estonia.

Syzran's oil shale, however, was high-sulfur. Since removing sulfur from oil shale still remained a problem for the Soviets, it is unclear what would have occurred at the Syzran plant. Syzran's oil shale deposits had a chemical composition that also allowed the production of important chemicals like phenol and toluene. I speculate that the Syzran plant would have produced liquid fuels like fuel oil, rather than high-octane gasoline. Fuel oil could be used in boilers and furnaces without sulfur being a major problem (other than atmospheric sulfur compound pollution, which was not a concern to the Soviets). The other valuable chemicals would also be produced at the plant.

Syzran was located in the Volga-Urals oil region, which the Soviets wanted to develop into a "Second Baku". Syzran production of phenol, which was used in Soviet oil refining, would have helped the region's refineries. Toluene is used for the manufacture of TNT (trinitro***toluene***), which the Soviet military greatly needed as its high explosive chemical of choice. (TNT comprised 93% of all Soviet high explosives in the Great Patriotic War[156].)

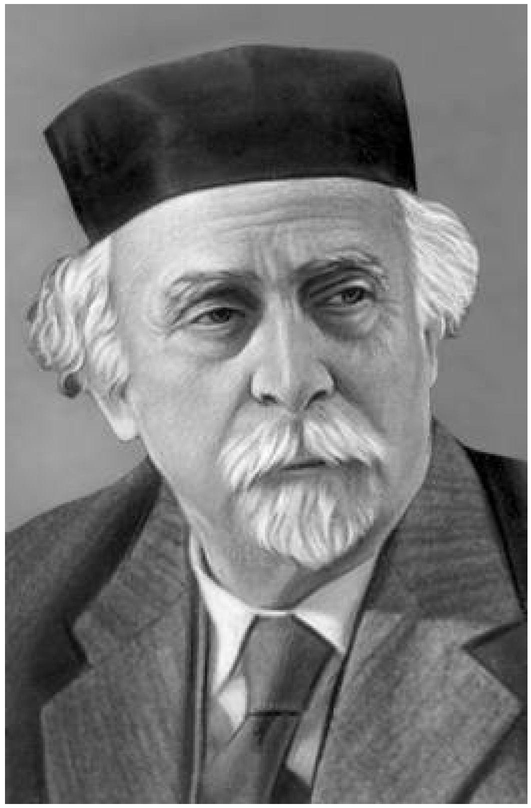
In 1940, Estonia was annexed into the USSR as the Estonian SSR, with the Soviet state confiscating the oil shale industry. In June 1941 Germany invaded the USSR and by early

156 V.N. Skvortsov and A.M. Sudarikov; "Nekotorye Problemy Sovetskogo Proizvodstva Trotila Nakanune i v gody Velikoy Otechestvennoy Voyny" ("Some Problems of Soviet Production of TNT on the Eve of and During the Great Patriotic War"); Bulletin of the Leningrad State University named for A.S. Pushkin, Vol. 4 No. 4; 2011; https://cyberleninka.ru/article/n/nekotorye-problemy-sovetskogo-proizvodstva-trotila-nakanune-i-v-gody-velikoy-otechestvennoy-voyny
Note: The university's name, Leningrad State University, is not a mistake, even though the city of Leningrad was renamed Sankt-Peterburg in 1991.

July had already penetrated into southern Estonia. It took the Germans almost until the end of August to clear the rest of Estonia of Soviet forces, giving the Soviets time to demolish much of the Estonian oil shale industry before they retreated.

During the war, the Soviet military had a huge need for liquid fuels, which brought renewed interest in processing Soviet oil shale deposits into these fuels. The Soviet economy also greatly needed solid fuels, particularly after the loss of coal from the Donbass in October 1941. This also brought Soviet attention to using oil shale as a solid fuel at locations where it was abundant. Part of an institute of the Soviet Academy of Sciences had been evacuated to the Komi ASSR, which lay just west of the Urals Mountains in the northern Russian SFSR. The ASSR had important oil shale deposits, which the Soviet scientists there studied for use as both liquid and solid fuels. The ASSR extensively used firewood, and the researchers determined that solid-fuel oil shale could replace firewood in large furnaces in the Komi area. The furnaces, however, would have had to be modified to handle the great amounts of ash produced by the combustion of oil shale. It is unclear if oil shale actually became a significant solid fuel in the Komi ASSR during the war, as after proclaiming the success of the research, my source omits any mention of its actual use there. I suspect it wasn't used much. Although my source is modern, it relies on Soviet-era information, and the Soviets were often masters at proclaiming success (can use oil shale in furnaces!) while hiding less-positive aspects (didn't actually use oil shale in furnaces).

The scientists at Komi also researched using Komi oil shale to make liquid fuels. Although this was possible, once again the sulfur prevented development of processing plants. Finally, in 1943, the Soviets turned to their world-class chemist, N.D. Zelinskiy, for a solution.



Nikolay Dmitrievich Zelinskiy, 6 February 1861–31 July 1953

Zelinskiy had been born in the Russian Empire and studied science, mathematics, and chemistry in Russia and Germany before becoming a professor of chemistry in Russia. While in Germany in the 1880s, Zelinskiy accidentally made mustard gas while exploring the polymerization of sulfur dichloride, partially poisoning himself. Zelinskiy was not the first to discover mustard gas, but perhaps his accidental exposure to what would be become one of the most deadly chemical warfare agents of World War I primed him for his wartime contribution.

Back in Russia, Zelinskiy became a professor at the prestigious Imperial Moskva University, on invitation of D.I. Mendeleev, the creator of the periodic table. Zelinskiy made many important discoveries in organic chemistry and the chemistry of hydrocarbons (petrochemistry). He invented an artificial rubber substance that the Russian Empire would use during World War I to replace hard-to-get, expensive natural rubber for tubing, face masks, and many other purposes. It was not durable enough, however, to be used as a replacement for vehicle tires. In 1915 during the war, Germany began using chlorine gas and other chemical weapons against the Russians, and in response Zelinskiy created the world's first effective activated-charcoal respirator. When coupled with Kummant's face mask, the Zelinskiy-Kummant gas mask was highly protective against chemical weapons. Cronyism and incompetence in the Russian government, however, delayed Russia from mass producing this mask, saddling the Russian troops with a rather ineffective alternative mask that resulted in many chemical casualties.

After the Russian Empire dissolved into revolution, the Soviets took over and formed the Soviet Union. Under the Soviets, Zelinskiy remained a chemistry professor and researcher at Moskva, with his institution being renamed Moskva State University. In the 1920s, Zelinskiy was perhaps the Soviets' number two chemist. He once again created an artificial rubber substance, better than the previously one because it was also durable enough for use as tires. Almost better still, it was relatively inexpensive to make, using ethyl alcohol made from potatoes as a raw material. Best of all, the USSR already had a large industry skilled in making ethyl alcohol from potatoes, the vodka industry. Zelinskiy's artificial rubber would go on to make the tires, hoses, gaskets, and other products the Red Army would use in World War II.

I say Zelinskiy was perhaps the Soviets' number two chemist because V.N. Ipatev (sometimes spelled Ipatieff in English) held the top spot, "the head of our chemical industry" according to Lenin. After Lenin's death, however, Stalin took over and began persecuting real and imagined enemies. Ipatev was demoted and, seeing the ultimate fate of others in similar circumstances, found a way to flee the USSR in 1930. Ipatev's son, V.V. Ipatev, was also a Soviet chemist but fell under suspicion because of his father's defection. The son was arrested in 1941, sent to the GULag on a 10-year sentence, released in 1946, and died in his late 50s in 1955, his health having deteriorated after his arrest.

V.N. Ipatev became a chemist in the USA and was instrumental in catalyst research that made high-octane gasoline possible, first at 81 octane and eventually at 100 octane. The USSR was only capable of making tiny amounts of 100-octane aviation gasoline and during the war depended upon imports of American and British 100-octane aviation gasoline. Ipatev's story seems to me encapsulate the tragedy and loss potential of Stalin's USSR: Ipatev fled growing persecution in the USSR, was instrumental in creating 100-octane gasoline in the West, a fuel the USSR needed but could not make in quantity. Unable to learn from its mistakes, the USSR then also squandered the talents of Ipatev's son by sending him to the GULag.

Zelinskiy remained in the USSR working in organic chemistry and petrochemistry. He headed the effort to build a strong organic chemistry system in the Soviet Academy of Sciences. During the war, he worked on the chemical needs of the Red Army and made improvements to Soviet aviation gasoline and lubricants. By 1943, when Zelinskiy was in his early 80s, he moved on to work with coal, peat, and oil shale.

Zelinskiy solved the sulfur issue, making it practical to desulfurize both oil shale and coal. His industrial method removed the sulfur in the form of hydrogen sulfide gas. As a bonus, the gas itself could be processed to make elemental sulfur for subsequent industrial uses, such as sulfuric acid production. The Soviet at last could turn their oil shale deposits into high-quality liquid fuels, including high-octane aviation gasoline. As far as I can tell, however, the war ended before the Soviets finished building processing plants that used this process. After the war, the Soviets extensively used the process as they developed a large oil shale industry.

During the German occupation of Estonia, the Germans redeveloped parts of the oil shale industry there to produce fuel for the German military. As the Soviets did in 1941, the Germans in turn destroyed much of this industry when they retreated from Estonia in 1944.

Starting in 1945, the Soviets again redeveloped and later greatly expanded the Estonian oil shale industry, although most work occurred after the war ended.

6 Gas Fuels

The Soviets had a small natural gas industry with some industrial and regional use of gas. They also used coal gas and developed “wood gas” (synthetic gas) in 1930s. During the war they even used some hydrogen as a fuel for a specialized purpose, perhaps the first practical use of hydrogen as a fuel anywhere. For the Soviets, natural gas was just a minor source of energy until after the war, and the other gases were insignificant sources of energy.

6.A Natural Gas

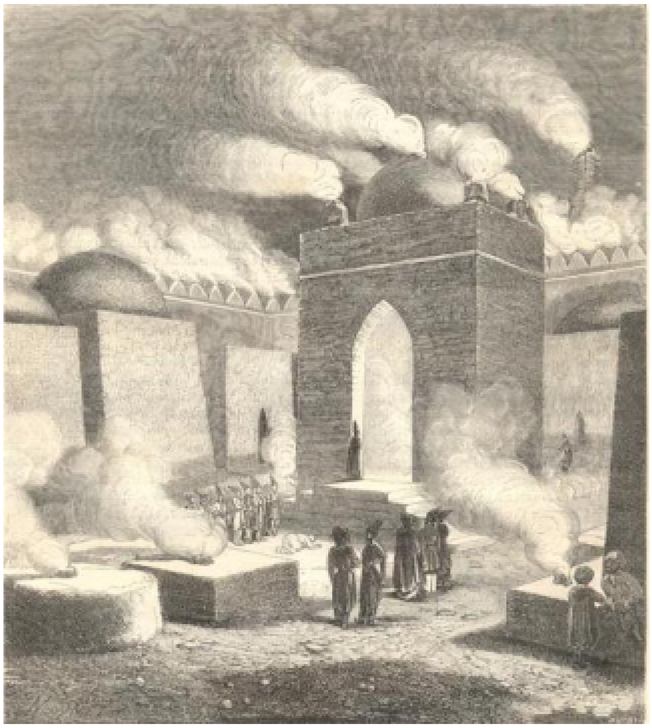
Natural gas (*prirodnyy gaz*) contains many gaseous some liquid hydrocarbons. Its primary component is methane, typically ranging from 70% to 90% of the gas, followed by ethane, in much smaller amounts. Other gaseous hydrocarbons in natural gas include propane and butane in even smaller amounts than ethane. Some liquid hydrocarbons, called natural gas liquids (NGLs) in English, are also present, consisting of all heavier hydrocarbons including pentane, hexane (a major component of gasoline), heptane, and so on. Natural gas also contains small amounts of contaminant gases and liquids including water, nitrogen, carbon dioxide, oxygen, hydrogen sulfide, and sometimes helium.

Raw natural gas needs to be processed into dry natural gas by removing the water, most of the other contaminants, and the NGLs. When the Soviets separated the NGLs out of natural gas, they typically called the resulting liquid fuel “natural gas condensate” and used it like a low-octane gasoline. Dry natural gas can burned as-is or further processed to separate out some of the ethane, propane, and butane, resulting in a final gas approximately 94% methane, 5% ethane, and the rest being small amounts of propane, butane, and nitrogen.

Natural gas is divided into two categories, “conventional” and “unconventional”. These categories have nothing to do with the composition of natural gas. Instead, they in essence depend on how difficult (and hence expensive) it is to extract natural gas from various types of underground deposits. Conventional natural gas is found at natural gas fields and some oilfields where it can be easily extracted by traditional drilling technologies. The gas in the fields may be under sufficient pressure to flow up through the wells in quantity, or the wells can easily pump out the gas. Most Soviet gas was conventional natural gas, including all gas extracted before and during World War II.

Unconventional natural gas is more difficult and expensive to extract. The gas is locked in shale beds or coalbeds, and its extraction usually requires special technology. Most of this technology was commercially developed only in the 1970s, in the USA. The late 1940s Soviets, however, did tap one source of unconventional natural gas, as covered below.

6.A.1 Conventional Natural Gas



The Fire Temple (Ateshgah) of Baku (19th Century illustration)[157]

"Eternal flames" fed by natural gas seeps occurred in the Baku area from ancient times and were were important to some religions in the region. The Ateshgah of Baku was located on the Absheron Peninsula of the Caspian Sea, not far from what became the city of Baku. The temple was likely built in the 17th or early 18th Century on the site of an eternal flame, with Hindus and Zoroastrians using the temple. In the second half of the 19th Century, the development of the Baku oil fields began to weaken the pressure of the gas flowing to the temple, dimming the light of its flames. With the light gradually dimming more over time, the temple was abandoned as a place of worship by the end of that century, although it remained a tourist destination. The temple's flame finally went out in 1902, mostly ending the tourist trade. It remained an occasional subject of historical research until 1925, after which it was mostly ignored for decades. The temple reopened again in 1975 after restoration work, with its "eternal flame" deriving from piped-in gas. (English-language sources claim for some unknown reason that 1969, not 1902, was the year the flame was extinguished, but this is not supported in other sources. Perhaps 1969 was the year restoration of the temple began, in which case English-language sources likely mistook the start of restoration with the ending of the flame.)

The Russian Empire did not develop any natural gas fields but worked some oilfields that also had natural gas. Natural gas was produced as a byproduct of oil extraction at these

157 Drawing by Jean Pierre Monet; published in *Le Tour du Monde*; 1860.

fields, but use of natural gas in the Russian Empire was almost insignificant. Some was used locally near where it was produced. Starting in the second half of the 19th Century, the most important use of the Empire's natural gas was to power oil refineries at Baku.

Oil exploration in the Russian Empire had found both natural gas near Saratov in the Volga region in the late 19th Century. Russian companies showed no interest in developing Saratov's gas.

When the Soviets came to power in 1917–1918, they at first expressed interest in developing natural gas. In practice, however, they developed already-existing energy industries: coal, oil, and peat, as it was likely quicker and cheaper to do so. Like the Russian Empire, the Soviet Union for most of the first half of the 20th Century made only very limited use of natural gas, again for local use and for powering Baku's refineries.

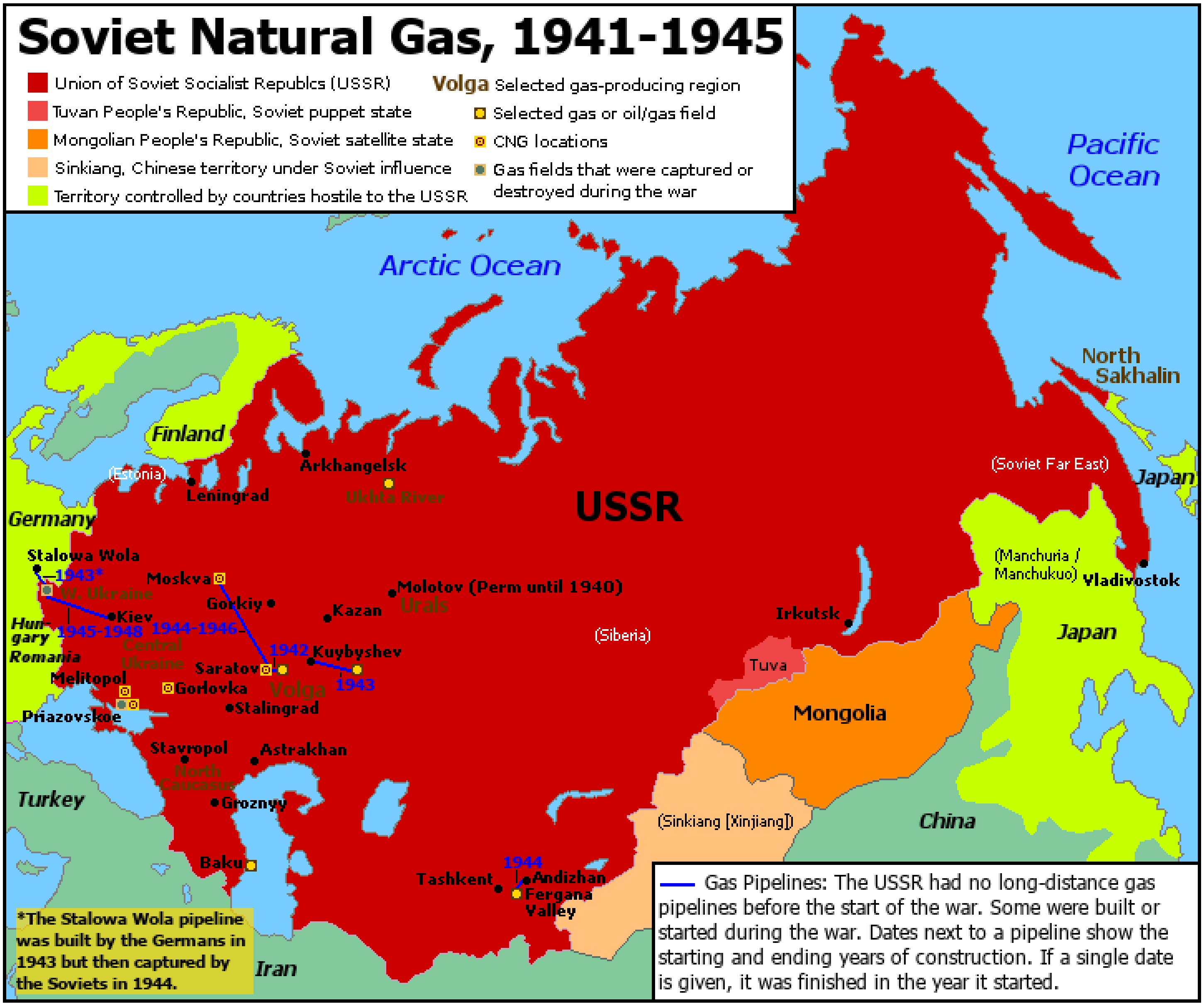
As the Soviets surveyed their country for oil and mineral deposits, they found major natural gas fields in the Volga-Urals area starting in 1929 and in the Ukhta River region in the 1930s. Despite finding these resources, the 1930s Soviets did not build a single long-distance gas pipeline that would have allowed major exploitation of these gas reserves. Soviet natural gas production in the early 1930s was about 10–15 million cubic meters per year. While this might sound like a lot, in comparison US natural gas production in 1930 was about 53,900 million cubic meters, several orders of magnitude larger.

Some Soviet natural gas was developed during the 1930s industrialization drive, reaching about 3,200 million cubic meters in 1940 (for comparison, the US produced about 77,400 million cubic meters that year[158]). Still without any long-distance pipeline network, the Soviets used their natural gas locally near where it was produced. In addition to powering the refineries, Baku's gas was also used to fuel local steam boilers[159].

Gas fields were also discovered in the Uzbek SSR and other places in Central Asia, but development of them was quite modest. Only in 1944 was a short pipeline built to bring natural gas to the Uzbek city of Andizhan (now Andijon, Uzbekistan, but often spelled Andijan in English) from a local oilfield in the Fergana Valley, marking the start of growing urban use of natural gas in Central Asia.

158 About 75,200 million cubic meters after processing into dry natural gas. It is unclear from my sources if Soviet production figures are for raw or dry natural gas.

159 Rebecca Lindsay Hastings; dissertation, "Oil Capital: Industry and Society In Baku, Azerbaijan, 1870- Present"; 2020.



In the mid 1930s, oil and gas were discovered in central-eastern Ukraine in the Sumy and Poltava regions and near Priazovskoe in the Zaporozhye region of southern Ukraine. Central Ukrainian gas was not exploited before the war except for research purposes. Priazovskoe was developed into a producing gas field by 1936. In 1937, an experimental compressed natural gas (CNG) filling station was built in the Zaporozhye region to fuel vehicles converted to run on CNG[160]. I suspect Priazovskoe natural gas was used for all CNG experiments. I further speculate that the gas was compressed and bottled at Priazovskoe itself, as I have as yet found no evidence that any gas pipeline was laid from Priazovskoe to any city.

160 https://www.naftogaz-europe.com/subcategory/en/NaftogazHistory

The late-1930s USSR became very interested in using CNG as a vehicle fuel. Vehicular gasoline was increasingly in short supply due to the massive expansion of the Soviet truck fleet, and using CNG in place of gasoline in some vehicles could reduce demand for gasoline. In addition to the Zaporozhye region, experimental CNG vehicles and filling stations were tested in 1937–1938 at a few places. The vehicles were conversions of existing trucks, often a 1.5-ton cargo capacity gasoline-fuel GAZ-AA or GAZ-MM truck. Gas cylinders were installed under the trucks, and the weight of the CNG system reduced the truck's capacity to 1.1 tons. The trucks' engines produced lower horsepower when running on natural gas rather than gasoline. A GAZ-55 went from 50-hp on gasoline to 42-hp on natural gas. Despite the lower cargo capacity and horsepower, the trucks ran fine, so the tests were judged successful.

In the next phase of the experiment, some CNG filling stations were built in 1939 in Moskva, Melitopol, and Gorlovka (now, Horlivka, Ukraine)[161]. I believe filled CNG cylinders must have been transported by rail or water to Moskva, as there was no nearby natural gas production, nor was there a gas pipeline to the city at the time. The closest source of natural gas for Moskva would have been Priazovskoe in southern Ukraine, so presumably the gas came from there. The other two locations, Melitopol and Gorlovka, were in eastern and southern Ukraine near Priazovskoe and presumably got their CNG from that field[162].

Some GAZ-44 and ZiS-30 trucks were manufactured as CNG trucks for these cities. The GAZ-44 was an adaptation of the 1.5-ton 50-hp GAZ-MM and like the converted GAZ-MMs was a 1.1-ton, 42-hp CNG truck. The ZiS-30 was an adaptation the 3-ton ZiS-5 gasoline-fueled truck. The weight of the CNG system reduced the ZiS-30 to 2.5 tons of cargo capacity. The GAZ-44 and ZiS-30 were made only in small numbers, less than 200 total, as the program was still experimental[163]. Some buses were also adapted to use CNG. While CNG vehicles ran fine, the CNG buses were judged "unprofitable" (likely meaning operating expenses were higher and passenger capacity lower than gasoline-powered buses because of the weight of the CNG fuel system).

CNG vehicle and filling station equipment was expensive, but this was because it was custom-made rather than being mass produced. The Soviets at some point planned to

161 http://www.gazpronin.ru/USSR.html

162 I've only found minimal information on the Priazovskoe gas field. I suspect it just had modest reserves of gas, hence the lack of information on it. It is not shown on the 1975 map covering Soviet natural gas, strongly suggesting it was exhausted by then.

163 Since the GAZ-44 never went into mass production, its designation was later reused for another vehicle that had nothing to do with CNG trucks: the post-war GAZ-44 military truck. The ZiS factory itself did not reuse ZiS-30, but an armaments factory that also used ZiS=# designations used ZiS-30 for a 1941 emergency self-propelled antitank gun.

introduce mass CNG production with the construction of 1,000 CNG filling stations and conversion of many trucks to CNG, but the outbreak of war in 1941 canceled this plan. Although sources I've seen do not mention the fate of the existing experimental CNG systems, the Soviets likely evacuated or perhaps destroyed the ones in Ukraine in 1941 before the Germans could capture them. The fate of the Moskva system is unclear, but I suspect loss of the Priazovskoe gas field forced the system to shut down. CNG trucks at Moskva and any evacuated from Ukraine would very likely have be converted to using gasoline, since the Soviets needed all the trucks they could get.

Prewar Poland in its southeastern region had oil and gas fields and a thriving oil and gas industry. The Poles had also built some short-distance gas pipelines in the area to serve local needs, especially to Lwow (later, Lvov in the USSR and now Lviv in Ukraine), the regional capital, and Tarnow, a small city. In September 1939, the USSR occupied and annexed eastern Poland soon after Germany invaded that country. The former Polish oil-and-gas region became part of the western region of the Ukrainian SSR, and the oil-and-gas industry was confiscated by the Soviets without compensation. Its natural gas continued to be used locally.

The city of Tarnow was in the part of Poland that went to Germany. The pipeline to Tarnow technically became the USSR's first international pipeline. However, I have so far found no evidence that any gas was sent to Tarnow in the period between the Soviet annexation of eastern Poland in 1939 and the German invasion of the USSR in 1941. While the Soviet Union exported significant amount of oil to Germany during the two countries' semi-alliance, the Germans apparently were not interested in importing ex-Polish natural gas. The Soviets, on the other hand, were interested in this gas. They developed the gas resources of this region, with 1940's gas production being double that of 1938[164]. This turned the Ukrainian SSR in the USSR's second largest natural gas producer, at 495.1 million cubic meters in 1940, relegating Russian SFSR production of 209.9 million cubic meters to third place. (The Azerbaijan SSR was the largest producer at 2,498.1 million cubic meters.)

On 22 June 1941 Germany invaded the USSR. In the opening two weeks of the war, the Germans captured the western Ukrainian oil and gas fields. Stalin only announced a scorched earth policy against the invaders on 3 July 1941. Before then, some Soviet region government officials established their own partial scorched earth policies. The western Ukrainian oil and gas fields took some damage, although it is not clear how much was caused by scorched earth tactics and how much from the fields just being in the battle zone.

164 Oksana Voytyuk; "The Gas Sector of Ukraine: Past and Future"; *Wschodnioznawstwo* (*Eastern-Studies*), Vol. 14 No. 4; 2021.

They were not extensively damaged, however, and the Germans soon returned them to production in 1941. Some of the oil was refined into fuel for Germans forces in the east while the rest was sent to Germany. The gas continued to supply the local economy, which was subjugated to the German war effort.

As the summer progressed, the Soviets became skilled at evacuation valuable infrastructure and destroying what remained to prevent the Germans from exploiting it. Thus, the Priazovskoe gas field of southern Ukraine was wrecked by the time the Germans captured it in October 1941. Although the Germans eventually put the destroyed central Ukrainian oil field they captured at Romny back into production, I have found no evidence so far that they ever attempted to do anything with the Priazovskoe gas field.

The lost of western Ukraine and Priazovskoe in 1941 deprived the USSR of all Ukrainian natural gas production, which was about 15% of the Soviets' total production. However, other than a tiny amounts supplying CNG for the Moskva CNG experiment, all of this gas was consumed had been consumed locally, in territories lost to the Germans. This meant the loss of Ukrainian gas had almost no impact on the part of the USSR still under Soviet control.

The USSR's interest in natural gas increased after Germany overran the Donbass coal mines in the autumn of 1941. This event disrupted a significant portion of the Soviet coal industry and created energy shortages for industries and cities using Donbass coal, including at Moskva. While little seems to have been done during the winter of 1941/1942, 1942 saw renewed Soviet prospecting for gas fields. Also in 1942, the Soviet oil industry proposed to bring natural gas from fields near Saratov to Moskva via an approximately 800-km (500-mile) gas pipeline. Stalin eventually approved the project, and construction of the pipeline began in September 1944.

As 1942 progressed, the USSR was facing a growing energy crisis. In addition to the loss of Donbass coal in 1941, Soviet oil production was now declining due to the German summer offensive. The German offensive also hurt Soviet natural gas production. As covered in the section on the Soviet oil industry in 1942, the German advance into the North Caucasus caused the Soviets to shut down considerable oil production at Baku in the Azerbaijan SSR. Since natural gas was produced as a byproduct of Baku oil production, gas production at Baku also declined, from 2.84 billion cubic meters (88% of Soviet total production) in 1941 to 1.58 billion cubic meters in 1942. It continued to decline in 1943 and 1944, reaching just 0.96 billion cubic meters in 1944 (30% of Soviet total production) before slightly increasing in 1945. The Soviets responded by dramatically increasing natural gas production in the Russian SFSR, which rose from 0.47 billion cubic meters in 1942 to 0.73 billion cubic meters in 1943 and in every war year thereafter, reaching 1.49 billion cubic meters in 1945 (46% of Soviet total production). While Russian SFSR gas expanded the most by far, many other SSRs in the USSR also either expanded gas production or began gas production or the first time. The Soviet developed the natural gas resources near industrial regions to supply factories with energy, with short-distance pipelines being built to carry the gas.

One natural gas field was developed in the Ukhta River region during the war. Its gas had a unique distinction for the Soviets: hundreds of millions of cubic meters of it were deliberately burnt at Ukhta just to produce soot. The Soviets needed soot as a raw material for their production of artificial rubber. It was far cheaper to burn the gas at Ukhta and transport the resulting soot than it would have been to send the gas itself to the factories.

Saratov in the Volga region became a major natural gas center during the war. In 1941, a major gas field was found at Elshan near Saratov, with another major gas field being found there in 1942. The Soviets built a 23-km (14-mile) gas pipeline from Elshan to Saratov in September-October 1942. The gas was used throughout the city to power the oil refinery, the electricity generating station, and various enterprises including bakeries. (Bread was a major component of Soviet food rations, so bakeries were important energy consumers.) Authorities in the Saratov region in 1942 ordered some of the local gasoline-fueled trucks to switch to CNG, so that some of Saratov's gasoline supplies could go to the Red Army. The first trucks were converted to CNG within a month of the decision being made, but it is unclear how many trucks were actually converted. It is also unclear where the CNG equipment for the trucks and filling stations came from. I suspect Saratov reused any remaining equipment from the 1930s CNG experiments.

Kuybyshev (now Samara, Russian Federation) on the Volga River became an important industrial and government center during the war. Industries were evacuated there in 1941–1942, and about 75% of the Il-2 shturmovik attack bombers were made at the city during the war. In October 1941, with the Germans threatening to capture Moskva, many Soviet governmental bodies and cultural institutions were evacuated to Kuybyshev from the capital. An underground complex, informally called Stalin's Bunker (*Bunker Stalina*) was ordered built in the city as a major command center and air raid shelter in case Stalin, the State Defense Committee, and Stavka had to relocate from Moskva[165]. When the German

165 Work did not begin until February 1942 and was finished that October. The complex was officially accepted as operational on 6 January 1943. The bunker could accommodate 600 people and was designed to withstand the explosion of 2-ton bombs. The existence of the bunker was a state secret for a long time. When it did become known, propaganda claimed it had been built by Moskva and Kharkov metro (subway) workers and Donbass miners. In actuality, much of the manual work was done by the forced labor of GULag prisoners. Work proceeded continuously around the clock, with two 12-hour shifts per day. Stalin's

offensive subsequently stalled, Stalin and the key Party, government, and military bodies remained in Moskva. Kuybyshev remained a back-up capital until the summer of 1943, when the evacuated government bodies returned to Moskva.

Construction of the natural gas pipeline to Kuybyshev, 1943[166]

This is a propaganda photo of Stakhanovite-level workers digging the trench for the Kuybyshev natural gas pipeline, captioned "*Na stroitelstve gazoprovoda N.G. Matrokhin i M.N. Chelidronova (brigada tov. Poletayeva, zavod KINAP) vypolnyayut normu vyrabotki na 300 protsentov*" ("During construction of gas pipeline, N.G. Matrokhin and M.N. Chelidronova (of Comrade Poletaev's Brigade from KINAP plant) fulfill production rate by 300 percent"). Actual work conditions were much more arduous than shown.

Kuybyshev's growing importance meant it had increasing energy needs. The Soviets decided to meet this with with natural gas, as gas fields had been discovered in regions east of the city. Starting January 1943, a 180-km (112-mile) pipeline was built from the gas fields to Kuybyshev, going into operation in September 1943. Manual labor for the construction was mainly provided by forced labor of 3,000 GULag plus conscripted local civilians, including women and children. Civilian labor was treated better than the GULag prisoners but demanding quotas were set, with it being a crime punishable by an 8-year prison sentence to leave the worksite without authorization. Motorized construction equipment was mostly lacking, so the project simply substituted manual labor, such as excavating 1.8 million cubic meters (63.6 million cubic feet) of soil for the pipeline's trench[167].

From September 1943, natural gas was used in Kuybyshev for industrial production, electricity generation, heating, and, eventually, oil refining. Construction of an oil refinery

Bunker predated the *Führerbunker* (Führer's Bunker) of Hitler, which was ordered to be built on 18 January 1943.

166 https://samara-tr.gazprom.ru/about/history/

167 https://magazine.neftegaz.ru/articles/nefteservis/543122-neftegazovye-vekhi-velikoy-pobedy-maloizvestnye-istorii-velikoy-otechestvennoy-voyny/

began in 1943, but the refinery only began operations some time in 1945, perhaps after the war with Germany had ended. From September 1943 to June 1945, Kuybyshev used about 260 million cubic meters (9,180 million cubic feet) of natural gas, equivalent to 370,000 tons of coal. The Kuybyshev pipeline was the precursor to the Soviet long-distance natural gas network, although the Soviets traditionally considered the later Savatov-Moskva trunk line as the start of the network[168].

September 1943 also saw the Soviets liberate the Priazovskoe gas field in southern Ukraine. Reconstruction of the location into a producing gas field began either that year or in 1944, and it may have resumed limited production 1944 (sources I've seen on Priazovskoe are not specific enough on this point).

In 1944, the Soviets regained the western Ukrainian natural gas fields that the Germans had captured in 1941. Although the Germans damaged some of the natural gas infrastructure there as they retreated, the Soviets quickly got the fields back into production, with the Ukraine SSR producing 197.6 million cubic meters of gas in 1944 (about 40% of the Ukraine SSR's 1940 production and about 6% of Soviet total gas production for 1944). The Ukrainian gas fields underwent massive expansion in 1945, producing 776.9 million cubic meters of gas that year (about 157% of the Ukraine SSR's 1940 production and about 24% of Soviet production for 1945).

Given the Soviets' wartime interest in natural gas, they decided to build an approximately 500-km (300-mile) gas pipeline from the western Ukrainian gas fields to Kiev, the capital of the Ukrainian SSR. Construction of this pipeline began in 1945 before the war with Germany ended[169], but it was only completed in 1948. Although sources I've seen do not go into details, very likely little or no American Lend-Lease equipment was available for this pipeline, delaying its completion. The Soviet decision to build the pipeline came after the Soviets had submitted their Lend-Lease requests in the fourth (and as it turned out final) American-Soviet Lend-Lease protocol. The completion of the Kiev pipeline was celebrated as another major milestone in the growing post-war Soviet natural gas industry. Soon, the Soviets decided to extend this network about another 1,000-km (600 miles) to Moskva itself. This extension went into operation in 1951[170].

168 A possible reason was the Saratov-Moskva pipeline was proposed in 1942, before the Kuybyshev pipeline. Alternatively, a pipeline to Moskva had great propaganda value as being the start of the Soviet gas network.

169 Most sources do not state when construction actually began, but one Russian-language one states "before the end of the war", which for the Russians would be the war with Germany. A chronological source on Ukrainian natural gas lists the formation of the organization to build the pipeline in 1945, hence my conclusion that the pipeline began in 1945 before the surrender of Germany. A Ukrainian Wikipedia article implies the pipeline was started in 1946, but this seems incorrect.

170 Per Högselius; *Red Gas*; 2013.

The liberation of the western Ukraine fields and nearby areas in Poland also gained the Soviets a long-distance gas pipeline network, courtesy of Germany. In 1943, the Germans built a 200-km (125-mile) pipeline to bring natural gas to Stalowa Wola in German-occupied central Poland, a steel town the Germans were exploiting[171]. In August 1944, the Soviets captured Stalowa Wola and the German-built pipeline. Possibly the Soviet advance was so fast that the steel mill and pipeline were captured before the Germans could extensively damage them, as both seem to have become operational again fairly quickly. Before the end of 1944, the Soviets were sending gas to Stalowa Wola. Since this location was west of the 1941 Soviet border in Soviet-liberated Poland, the Soviets considered the provision of gas to Stalowa Wola the USSR's first exports of natural gas[172]. This was a modest start to the USSR eventually becoming a major gas supplier to European countries.

As mentioned above, construction of the Saratov-Moskva gas pipeline began in September 1944. The pipeline, however, only went into operation in 1946, after World War II had ended. As with most large wartime construction projects, forced labor of GULag prisoners was extensively used, providing 80% of the labor. Civilians along the path of the pipeline were also conscripted for labor on the project and were held to the "same standards" as the prisoners, which meant demanding work quotas and long shifts. Motorized construction equipment was mostly lacking, requiring most of the work to be done by manual labor.

Equipment and natural gas technology from American Lend-Lease provided "direct assistance to the construction of the Saratov-Moscow gas pipeline"[173]. Some of this equipment almost did not arrive, as by US law Lend-Lease ceased at the end of World War II. For the US, the war ended on 2 September 1945 with the formal surrender of Japan, and ships carrying Lend-Lease supplies were immediately recalled to the US. However, a 15 October 1945 agreement with the USSR allowed the continued delivery of Lend-Lease materials that had not yet been delivered but had already been produced or were in the process of being produced. I speculate that waiting for the last of the US equipment was the

171 The Polish government created Stalowa Wola, which means "Steel Will", as a steel mill town in 1937. The plan was to build a major industrial center in central Poland, away from the dangerous borders with Germany and the USSR. At some point before the war, the mill became operational. Its products including artillery for the Polish Army. Stalowa Wola went to Germany in the Nazi-Soviet partition of Poland. The Germans renamed the location Stählerner Wille (still meaning "Steel Will") and built a forced-labor camp there to provide workers for the mill.

172 Per Högselius; *Red Gas*; 2013.

173 V.N. Kostornichenko; "Neft v Ssisteme Lend-Liza: Neftyanoy Soyuz SSSR i SShA v gody Vtoroy Mirovoy Voyny" ["Oil in the Lend-Lease System: the Oil Union of the USSR and the USA during World War II"]; *Ekonomicheskaya Istoriya, Obozrenie, Vypusk* 11 [*Economic History*, Overview; Edition 11]; Trudy Istoricheskogo Fakulteta Mgu 32 [Proceedings of the Faculty of History, MSU (Moskva State University)]; 2005. http://www.hist.msu.ru/Labs/Ecohist/OB11/USSR/kostornichenko.html

reason the pipeline did not go into operation until 1946, although sources I've seen neither confirm nor deny this.

Although Soviet natural gas faced serious challenges in 1941–1941, it ended up having a good war. Unlike Soviet coal production and oil production, which only recovered to the pre-war 1940 level in the years after the war ended, Soviet natural gas production ended the war at a higher level than it was in 1940: about 3.3 billion cubic meters, 102% of 1940's production.

The Stavropol-Moskva natural gas pipeline under construction in the 1950s[174]

This was a multi-line pipeline with the first two lines bringing gas to Moskva in 1956 and the third becoming operational in 1957. As the picture shows, motorized construction equipment was now plentiful, unlike for the wartime pipeline projects.

The Soviets discovered numerous new gas fields during World War II, many of which were not developed until after the war. These laid the foundations for the USSR to become a major natural gas producer. One natural-gas priority for the 1940s-1950s Soviets was bringing gas to the country's three largest cities, Moskva, Leningrad, and Kiev. Parts of the story on Moskva and Kiev have been covered above. Leningrad was the last to get natural gas. However, starting in 1948 shale gas, an unconventional natural gas, was produced at plant by the Estonian oil shale deposits and was piped to Leningrad. The city's conventional natural gas would have to wait until the 1950s. In 1951, what for a time would be Europe's

174 https://stavropol-tr.gazprom.ru/about/history/

largest natural gas field was discovered in the Stavropol territory of the North Caucasus. The gas was soon being exploited in the local region, and in 1954–1956 a multi-line pipeline connected Moskva to the gas field, making the city at the time the largest natural gas consumer in the world. In 1959, an extension of the pipeline to Leningrad went into operation[175].

Soviet Natural Gas Production (billions of cubic meters)

	1940	**1941**	**1942**	**1943**	**1944**	**1945**
Total	3.219	3.555	2.071	1.847	2.422	3.278
Percentage of 1940	100%	110%	64%	57%	75%	102%

Source: Narodnoe Khozyaystvo SSSR v Velikoy Otechestvennoy Voyne 1941–1945 gg. (People's Economy of the USSR in the Great Patriotic War 1941–1945, aka *"People's Economy")*; a 1959 formerly-secret statistical compilation by the Soviet government.

Notes: According to "Istoriya Gornogo dela Mineralno-Syrevye Resursy v Velikoy Voyne. Chast 1" ("Mining History of Mineral Raw Materials in the Great War, Part 1"); E.A. Kozlovskiy; Soviet natural gas production in billions of cubic meters was just 0.03 in 1922 and 0.3 in 1928.

Soviet Natural Gas Production by Union-Republic (millions of cubic meters)

	1940	**1941**	**1942**	**1943**	**1944**	**1945**
Total	3,219.1	3,555.0	2,071.0	1,847.0	2,422.0	3,278.0
Azerbaijan SSR	2,498.1	2,840.1	1,583.4	1,090.4	962.3	976.7
---Azerbaijan % of total	77.6%	88.2%	49.2%	33.9%	29.9%	30.3%
Ukrainian SSR	495.1	299.2	0	0	197.6	776.9
---Ukrainian % of total	15.4%	9.3%	-	-	6.1%	24.1%
Russian SFSR	209.9	403.3	472.8	731.4	1,229.9	1,494.8
---Russian % of total	6.5%	12.5%	14.7%	22.7%	38.2%	46.4%
Turkmen SSR	9.2	2.0	3.8	5.4	11.7	14.9
---Turkmen % of total	0.3%	0.1%	0.1%	0.2%	0.4%	0.5%
Kazakh SSR	3.9	4.8	4.3	10.1	8.6	4.9
---Kazakh % of total	0.1%	0.1%	0.1%	0.3%	0.3%	0.2%

175 Stavropol gas was used in many other places in the USSR beside the big cities. For example, another pipeline was built east from the gas field connecting to Groznyy, so that the refineries in the area could be powered by this gas. https://stavropol-tr.gazprom.ru/about/history/

Uzbek SSR	0.7	3.1	4.9	9.7	11.9	8.9
---Uzbek % of total	0.0%	0.1%	0.2%	0.3%	0.4%	0.3%
Tajik SSR	2.2	2.5	1.8	0	0	0.8
---Tajik % of total	0.1%	0.1%	0.1%	-	-	0.0%
Kyrgyz SSR	0	0	0	0	0	0.1
---Kyrgyz % of total	-	-	-	-	-	0.0%

Source: People's Economy. Note that this table is in millions of cubic meters, while the prior one is in billions of cubic meters.

The loss of Ukrainian SSR gas production during most of the war was due to the German conquest of the area. The decline in Azerbaijan SSR production was due to Soviet measures in response to the German 1942 offensive.

The temporary decline in gas production in both the Turkmen SSR and Tajik SSR was likely due to existing gas fields becoming depleted before new ones came online, but my sources do not go into this.

6.A.2 Unconventional Natural Gas

The 1920s-1940s Soviets had deposits of unconventional natural gas but with two exceptions did not use them due to expense and the lack of efficient extraction technologies.

One unconventional natural gas is **shale gas** (almost all methane, a little ethane, and possibly a little propane and butane), available at various shale beds and oil shale deposits. Important Soviet deposits were in the Baltic, Lake Baykal, Arctic Pechora, and Volga regions. However, in most deposits shale gas is scattered in small pockets that are quickly exhausted by conventional extraction methods. Today, shale gas is extracted mainly by hydraulic fracturing ("fracking") technology, which was commercially developed first in the USA in the 1970s.

The Soviets acquired the Estonian oil shale deposits when they annexed Estonia in 1940. They lost them to the Germans in 1941 but regained them in 1944. Back in 1916, Russian Empire research on the high-quality kukersite form of Estonian oil shale showed that it was quite suitable for use as a solid fuel (oil shale), liquid fuel (shale oil), and gas fuel (shale gas). On 10 June 1945, with the war with Germany won and Estonia under firm Soviet control, the Soviet government decided to build a processing unit to make shale gas at the Estonian Kohtla-Järve oil shale plant and to send it to Leningrad via pipeline. They also decided to build another shale gas processing unit at Slantsy in the high-quality Gdov oil shale deposit, just over the border from Estonia in the Russian SFSR. Slantsy's gas would also be sent to Leningrad.

At first, many German prisoners of war were used as forced laborers for building the Kohtla-Järve mines, plant, and pipeline. They were mostly replaced over time with workers from the Russian SFSR, part of a significant settlement of ethnic Russians in Estonia that comprises about a quarter of Estonia's current population.

The Kohtla-Järve processing unit and pipeline became operational in 1948. Likely the Slantsy unit and pipeline went on-line at the same time, but I have not found definitive information on this yet. Later, in the early 1950s, Kohtla-Järve shale gas was piped to various cities and towns in northern Estonia.

Another unconventional natural gas source is **coalbed gas** (almost all methane, a little ethane, and sometimes tiny amounts of propane and butane). Coalbed gas is also called coalbed methane, coal seam gas, and other names. The age-old danger of "gas" in underground coal mines comes from coalbed gas, which can suffocate miners and cause mine explosions. Traditional coal mining methods sought to minimize this danger by venting the gas to the surface or draining it into boreholes. Important Soviet coalbed gas deposits were at the Kuznets, Donets, Pechora, Lena, Irkutsk, and South Yakutsk coal basins that the Soviets of this time were mining for coal, plus some undeveloped coal basins. The 1920s-1940s Soviets did not extract any coalbed gas. Commercial extraction of coalbed gas only seriously began in the late 1970s, first in the USA.

6.B Petroleum Gas

One of the petroleum refineries at Groznyy in the North Caucasus produced a propane-butane petroleum gas mixture as a waste product of its operations. Putting the gas under pressure turned it into a liquid, making a form of liquefied petroleum gas (LPG). The Soviets were naturally interested in a way to use LPG as a vehicle fuel. In 1936, as a part of their CNG fuel project that created the GAZ-44 and ZiS-30 CNG-fueled trucks, they began experimenting with adapting existing vehicles to use LPG.

The LPG project generated a fair amount of interest, as it seemed a gasoline engine using LPG might only suffer a 4% horsepower reduction[176], whereas the same engine with CNG

176 http://denisovets.ru/nami/namipages/natisg40.html (in Russian).

could have its horsepower reduced by up to 16%. There were numerous technical challenges to the project, as (pressurized) LPG needed to be stored in enough quantity on the LPG vehicle, and the gas needed to be depressurized before reaching the engine. Since depressurizing LPG cooled the gas, a heat exchanger was needed to maintain the gas at the proper temperature for the engine. The engine itself did not need to be modified, but it needed a special carburetor.

By 1939, several experimental vehicles were ready for testing. However, LPG was not yet available from the Groznyy refinery, so the test institute created its own propane-butane LPG for testing purposes. By 1941, the project was ready to be scaled up, and Groznyy LPG was now available. In April, GAZ modified 50 new GAZ-MM trucks with 50-hp gasoline engines to become GAZ-45 LPG trucks. Testing revealed that Groznyy LPG was much inferior to the specially-made LPG used in the earlier tests. The GAZ-45 had much reduced performance compared to the GAZ-MM. LPG development continued, but the project was canceled soon after Germany invaded the USSR in June 1941. The Soviets would resume LPG work after the war, with the first mass produced LPG truck, the GAZ-51B, appearing in 1950.

6.C Wood Gas

Soviet gas-generator trucks in the lumber industry

The gas generators, where the wood gas is produced, are the long vertical cylinders outside the cabs of the trucks. A wood-gas vehicle actually had two cylinders. The taller cylinder is the firebox where the wood gas was made. The smaller one contained some of the filters that cleaned the gas so that it would not foul the engine.

"Wood gas" (an early version of what is now called synthetic gas or syngas) was another gas fuel the Soviets used. The Soviets developed a gas generator that created combustible gases from carbon-containing solid materials such as wood, charcoal, coal (particularly low-quality brown coal), peat, or agricultural plant waste like straw or even sunflower husks. Tree bark, pine cones, and sawdust were also used. The source materials had to contain carbon, be dry, and be in chucks or formed into briquettes. The gas generator processed the source material using incomplete combustion (by controlling the flow of oxygen-containing air) to make the wood gas, which the Soviets sometimes called "generator gas" and other countries called "producer gas". This gas contained carbon monoxide (21% of the total), hydrogen (16%), and methane (1%). (The rest of the produced gas was not combustible: 53% nitrogen and 9% carbon dioxide.)

Actually, a generator device (a gas generator or a "gasifier") for making this type of gas had been developed in the 19th Century. Its application to power vehicles mostly waited, however, until the aftermath of World War I. In the meantime, energy-dense gasoline, which was refined from crude oil, had become the fuel of choice for vehicles and aircraft. However, various countries in the war did not have oilfields on the territories. All of the Central Powers in World War I suffered great shortages of gasoline due to the Allies blockading their imports. Others, such as France, had to purchase gasoline at great expense, since its price rose during the war due to high demand for the fuel. After the war, several countries developed wood gas as an alternative fuel, since carbon-containing substances like wood, charcoal[177], or coal were readily available. In the early 1920s, Austria seems to have been the first to start research on wood-gas vehicles, but France, Germany, and the USSR all soon had their own wood-gas programs. Later, many countries in Europe and throughout the world would use wood-gas vehicles[178].

While making wood gas may have been a 19th Century technology, using it efficiently in an internal combustion engine of a vehicle was an engineering challenge. One key development was to increase the flow of gases through the gas generator, such as using suction from the

177 Charcoal was a tricky fuel for gas generators. It was an attractive fuel since it had higher energy content than wood. However, it had to be kept dry, but charcoal readily absorbs water in humid conditions.

178 Various sources include the USA, at the time the world's leading oil producer and refiner, and Canada in the list of users of wood-gas vehicles. This is technically correct but perhaps misleading: the US had a total of six wood-gas vehicles and Canada two. See T.B. Reed and A. Das; *Handbook of Biomass Downdraft Gasifier Engine Systems*; 1988.

engine or an electric fan. This increased the production of wood gas. Another issue was that untreated wood gas did not burn cleanly. Tar residues from the combustion of the gas would build up in the engine and render it unusable. A practical wood-gas cleaning system was required, such as a purifier device or filters. (The tar problem also meant that hardwoods like beech, birch, and oak were better to use than resinous woods like fir, pine, and spruce.) Yet another problem was that wood gas came out of the gas generator hot and therefore not very dense. A practical cooling system was thus usually needed to increase the density of the gas for efficient use in the engine. This in turn, however, meant the cooler added extra more to the already-heavy gas generator and its carbon fuel, further reducing the cargo capacity of a wood-gas vehicle.

The first step in getting a wood-gas vehicle ready to drive was to load the firebox of the gas generator with fuel and ignite it. It then typically took a Soviet gas generator 7–9 minutes to begin producing enough wood gas to drive the vehicle[179].

In addition to getting the gas generator working, another issue was that the vehicles were very difficult to start using wood gas when the engine was cold. The typical solution to this was to start the vehicle using liquid fuel. The Soviet GAZ-42, for example, came equipped with a small reserve of gasoline that the vehicle operator used to start the engine and warm it up, which could take 10–15 minutes. The operator would then carefully turn a valve that switched the fuel supply from gasoline to wood gas. Apparently, at least for the GAZ-42 trucks, it was tricky to switch to wood gas, and inexperienced drivers could easily stall the vehicle instead. Soviet gas-generator vehicles could be cold-started using wood gas, but this required a very skilled driver and 30–40 minutes[180]. Wood-gas vehicles were simply not “hop in and drive away” vehicles.

By the late 1920s and early 1930s, various countries were making wood-gas vehicles. However, gasoline was now usually in good supply and relatively inexpensive, as the shortages and price increases of World War I had receded. There wasn’t a major market for wood-gas vehicles in most countries. The exceptions were countries that lacked oilfields but wanted some degree of fuel autonomy. By the mid-1930s, these were: Finland and Sweden, both of which had extensive forests; Fascist Italy, which was concerned that its oil imports might be subject to sanctions after its invasion of Ethiopia[181]; and Nazi Germany, which was

179 https://dieselpunk.livejournal.com/38344.html

180 https://rim3.ru/comauto/news/gazogeneratornye-truzheniki/

181 The League of Nations did impose sanctions on Italy in 1935–1936 but did not embargo oil or coal. Since only League members would adhere to the sanctions, oil was not embargoed because Italy could have just purchased oil and coal from non-member states, particularly oil from the USA.

rearming for war and wanted to avoid the crippling gasoline shortage that affected Imperial Germany in the previous war. World War II, with its resulting shortage of gasoline in many places, greatly increased the number of countries that used wood-gas vehicles. During the war, Germany was by far the greatest user of wood-gas vehicles, with about 500,000 in use. Some other countries had several tens of thousands of these vehicles, including Sweden (circa 70,000), Australia (~70,000), France (~65,000), Sweden (~60,000), Finland (~45,000), likely Italy[182]… and the Soviet Union (perhaps on the order of 50,000–100,000 trucks and 25,000 or more tractors).

Soviet research on gas generators began in 1923, and in 1927 a 1.5-ton truck was the first to be converted to use a gas generator. Research and development proceeded slowly because the Soviet government was little interested in wood gas and devoted few resources to the effort. The 1920s USSR had very few motor vehicles and such an abundance of gasoline production that it was a major gasoline exporter.

In 1928, a 3.5-ton truck was the second truck to be fitted with a generator. That year, both trucks were driven between Leningrad and Moskva as proof that the concept worked. Research and development of gas generators continued, still at a slow pace. In 1934, seven gas-generator trucks drove from Moskva to Leningrad and back in a demonstration where they proved they could operate fine in rain, snow, and fog weather, and on icy roads[183]. By now, Soviet industry was manufacturing motor vehicles faster than the oil industry could expand gasoline production, so this finally sparked interest in wood-gas vehicles. Not only could wood-gas vehicles help lessen the demand for gasoline, they could also save the expense of shipping gasoline to remote regions. In 1935, the Soviet government decided that many trucks and tractors in the Soviet lumber industry would eventually convert to wood gas. The lumber industry was ideal for wood gas, since it operated in remote areas where near-endless supplies of wood were available.

Soviet gasoline engines of this time only needed minimal adaption to use wood gas as fuel: replacing the carburetor with an air/wood-gas mixer and increasing the engine's

182 I have not found how many gas generator vehicles Italy had. After the mid-1930s, the initial enthusiasm for wood gas seems to have declined, especially for passenger cars. By 1938 there were about 1,000 wood gas trucks and 500 wood gas buses in service. However, it seems very likely many vehicles including passenger cars were converted to wood gas during the war, especially during the German occupation. The German military got top priority for gasoline, and little gasoline was available for civilian use, particularly in German-occupied lands. I would expect several tens of thousands of Italian vehicles ended up using wood gas, but I have not found a source covering this yet.

183 https://histrf.ru/read/articles/gazgeny-avtomobili-na-drovah. *Warning:* This source may not be complete accurate, as it claims the ZiS-14 along with the ZiS-13 and ZiS-21 was a gas-generator truck. I have found no evidence that the ZiS-14 in general used gas generators, although the possibility remains open that a few might have been specially converted to use wood gas.

compression ratio. Wood gas could also be used in adapted diesel engines, but the Soviets had no diesel-engine trucks yet, since their attempts to create diesel truck engines had not yet succeeded. (The Soviets did produce a diesel-engine tractor, which had a submodel using wood gas. This is covered below.)

The 1930s Soviets began to mass produce gas generators for trucks. The weight of the generator, depending upon model, was about 300–440 kg (660–970 lbs). A load of fuel for the generator was another 100 kg. At least some wood-gas trucks had to have their suspensions strengthened to handle the weight of the gas generator. All this substantially reduced the cargo capacity of the vehicles. Also, if a wood-gas vehicle was operating along a route without a ready supply of fuel for refueling the generator, the vehicle had to carry multiple loads of fuel, significantly decreasing cargo capacity.

Wood gas was not an energy-dense fuel like gasoline, so vehicles powered by gas generators were slow and low-powered. The gas generators were also somewhat difficult to maintain, requiring some technical knowledge on the part of the vehicle drivers. Although my Soviet-based sources do not go into details, French wood-gas "*gazogène*" (gasifier) vehicles of about the same time needed daily maintenance (cleaning out ash, taking care of the gas purifier, cleaning nozzles and other parts to remove slag) and weekly maintenance (cleaning filters and other parts). Many Soviet truck drivers were poorly educated and poorly motivated. When left without proper supervision (as was often the case), some did not take maintenance seriously, and their gas-generator trucks accordingly broke down more often than they should have. Further, Soviet filters were rather low quality and did not clean the wood gas particularly well even when properly maintained, eventually resulting in damage to the engine's cylinders and valves[180]. Unmaintained filters could greatly speed this deterioration.

At first, existing 1.5-ton GAZ-AA trucks and 3.5-ton ZiS-5 trucks were modified to use wood gas. Based on the experience of these conversions, dedicated models of gas-generator trucks were then designed. The first production ZiS "*gazgen*" (Soviet slang for a gas-generator truck) entered production as the ZiS-13, with 900 being made. Because the gas-generator system was bulky, the ZiS-5 chassis was not used. Instead, an elongated chassis was used like that use for the ZiS-8 bus and ZiS-11 firetruck. The gas generators ZiS used had a heavy, bulky set of coarse filters. All told, the cargo capacity of the ZiS-13 was only 2.5 tons, a full ton less than that of the ZiS-5.

There were some design defects with how the gas generator was attached to the ZiS-13 chassis. Also, the longer chassis caused problems when the truck operated in the countryside on the many low-quality dirt roads there. The Soviets attempted to redesign the ZiS-13 using the shorter ZiS-5 chassis, but the resulting ZiS-18 was a failure and not put into mass production. A new effort to use the ZiS-5 chassis and fix the generator attachment defects succeed in the creating the ZiS-21 model, with over 15,000 being made. The weight problem remained, and the ZiS-21 only had a cargo capacity of 2.5 tons, like the ZiS-13.

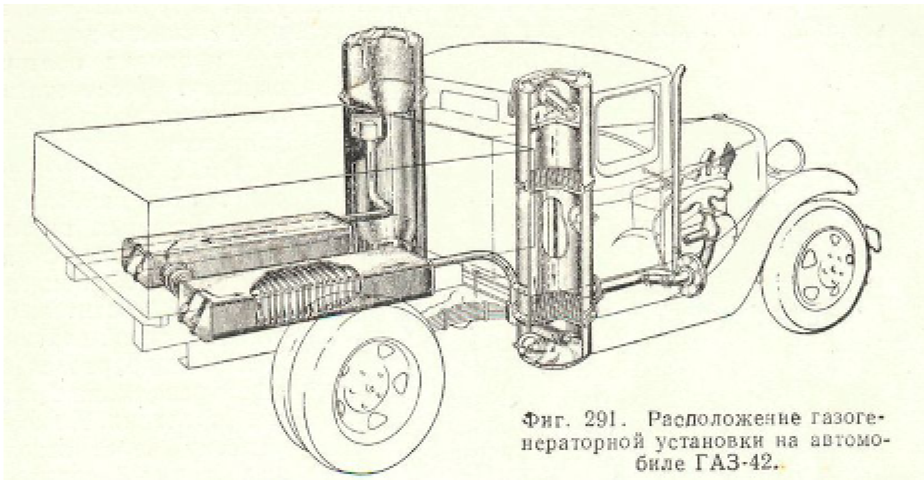


Diagram of a GAZ-42[180]

The cylinder on the left produced the wood gas. The gas then flowed through a system under the truckbed, consisting of a set of coarse filters that served to clean the gas a bit and to cool it, increasing its density. The gas then flowed through the cylinder on the right, which contained fine filters that cleaned the gas more extensively. The gas finally flowed into the engine. ZiS wood-gas trucks had a similar layout.

The GAZ *gazgen* entered production as the GAZ-42. The GAZ-AA had a 40-hp engine, which for the GAZ-42 was reduced to about 32-hp when using wood gas. At some point, the GAZ-MM became the basis for the GAZ-42[184]. The GAZ-MM had a 50-hp engine but outwardly was indistinguishable from the 40-hp GAZ-AA (and hence many World War II photos captioned the GAZ-AA may well have been the GAZ-MM, and vice-versa). This engine delivered about 34–35 horsepower for the GAZ-42 when using wood gas. The cargo capacity of the GAZ-42 was about 1.2 tons, compared to 1.5 tons for the GAZ-AA/MM. Almost 34,000 GAZ-42 *gazgeny* were made, although this includes about 2,000 made in 1945–1946 after the war with Germany had ended[185]. No sources I've found so far break down how many GAZ-42 came with 40-hp engines vs. 50-hp engines, but likely the vast majority of GAZ-42s had the 50-hp engine, since the GAZ-MM entered production in 1938[186]. The GAZ-42 also had a

184 http://denisovets.ru/gaz/gazpages/gaz42.html

185 Derived from information in https://rim3.ru/comauto/news/gazogeneratornye-truzheniki/

186 I speculate that the 50-hp engines were first reserved for the GAZ-MM, since their use with gasoline would deliver the most benefit. Only when mass production of this engine ramped up sufficiently would I expect them to be used for the GAZ-42. Most likely some more-detailed source on GAZ trucks covers this, but none that I have seen so far.

40-liter (10.5-gallon) fuel tank allowing the truck to operate for long distances using gasoline instead of wood gas when needed.

The GAZ factory also made the GAZ-43, a variant of the GAZ-42 with a gas generator designed to run only on coal. This allowed the generator to be smaller and lighter. However, the vehicle could only be used in places where there was a ready supply of coal, like in many Soviet cities. This ruled out using the vehicle in remote regions other than at coal basins. Only a few GAZ-43 trucks were made, all in 1938–1941.

Besides saving gasoline, there was another reason the Soviets made extensive use of inefficient wood-gas vehicles. The GULag was designed to exploit the forced labor of its prisoners at as little cost to the state as possible, even though this typically resulted in inefficient work. Since many GULag camps were in remote, forested locations, a truck that didn't need gasoline was almost the ideal GULag vehicle: inefficient trucks for inefficient slave laborers.

An operational issue with wood-gas trucks was that the gas generators needed to be refueled frequently. For the Soviets, this typically was every 60–80 kilometers (roughly, every 40–50 miles). If fuel for refueling the generator would not be available along the route of the truck, the truck would have to carry extra loads of fuel, further reducing its usable cargo capacity[187]. In forested remote areas of the USSR, the Soviets sometimes addressed the refueling issue by building wood chunk depots every 50 kilometers (31 miles) along *gazgeny* routes. Most sources do not go into details on who provided the wood chunks, but one source claims that five lumbering enterprises in the GULag specialized in the production of wood chunks for gas-generator vehicles[180]. Most likely these enterprises dried the chunks in kilns so that they would become usable quickly, rather than undergoing a lengthy seasoning process[188].

Beside the GULag enterprises specializing in wood chunks, other GULag camps which used wood-gas vehicles made their own wood chunks. In places where GULag-made wood chunks may not have been available for wood-gas vehicles, I suspect local civilians likely would have been required to provide the wood.

187 According to *Manuel Pratique des Automobiles a Gazogène* (*Practical Manual for Gasifier Automobiles*) published in France in the 1930s, a French gas generator required 100 kilograms (220 pounds) of wood every 100 kilometers (62 miles). (*«Oui, je reçois un kilomètre par kilogramme»*.) Soviet gas generators likely had similar wood consumption rates. (In comparison, a modern wood-gas passenger car with an improved gas generator can go 100 kilometers on 30 kilograms of wood. This car was built in Sweden in 2010 based on a Volvo 240.)

188 Kiln drying can take just days, while seasoning can take six months to a year, sometimes more for some types of wood. Since some GULag camps kiln-dried the wood for their own vehicles, it seems very likely the GULag enterprises specializing in making wood chunks also used kilns, although I have not found any information on this so far.

In 1939, the Soviets decreed that all trucks in the logging industry and a significant fraction of tractors in agriculture and trucks elsewhere were eventually to use gas generators, in order to reduce gasoline consumption. However, these goals had not been remotely achieved when war broke out in 1941.

The KhTZ-2TG tractor, the wood-gas version of the SKhTZ-NATI tractor

The Soviets made many models of tractors, using two basic layouts: wheeled and caterpillar (or "continuous") tracked. Wheeled tractors were intended for civil use (mainly agriculture). Caterpillar-tracked tractors were intended for both civil use (agriculture and lumbering in particular) and military use (towing weapons and hauling cargo). In 1941, heavy wartime losses of all types of equipment including trucks and tractors forced the Soviets to send many wheeled tractors to the military.

Some sources on Soviet gas-generator vehicles claim the Soviets only made experimental wood-gas agricultural tractors but did not proceed to mass produce them. This is incorrect. The Soviets developed three wood-gas tractors:

- The SG-60, a wood-gas version of the caterpillar-tracked S-60 tractor (also know as the *Stalinets*-60, meaning Stalinist-60). The S-60 had a 60-hp engine that ran on naphtha. In 1936, its manufacturer, the Chelyabinsk Tractor Factory, adapted a gas generator for use with the tractor. Wood gas reduced the engine power by an unspecified amount, perhaps to 70–80% based on the horsepower reduction of 40-hp and 50-hp run on wood gas. Only 264 wood-gas SG-60s were made, as this model soon went out of production in favor of the more-powerful SG-65.
- The SG-65, a wood-gas version of the caterpillar-tracked S-65 tractor (also know as the *Stalinets*-65, Stalinist-65). The S-65 went into production in 1937 at the Chelyabinsk Tractor Factory as the Soviets' first mass-produced diesel tractor. It had a 65-hp engine that ran on diesel fuel (together with a 20-hp gasoline engine for starting the tractor).

Chelyabinsk created an improved gas generator for use as the SG-65, with 7,365 being made in 1937–1941. There were some advantages and disadvantages to using wood gas in diesel engines. One disadvantage was that a small amount of diesel fuel had to be constantly added to the wood-gas/air mixture to cause ignition. One advantage was that, compared to a gasoline engine, there was less power loss when running on wood gas, because of the engine's high compression ratio[189]. (The actual horsepower reduction for the SG-65 is not specified in my sources.) Also, when more power was needed, in theory the amount of diesel fuel being used could be increased, although I am not sure if the Soviets designed the ability to use variable amounts of diesel fuel into their gas-generator tractors.

- The KhTZ-2TG, a wood-gas version of the caterpillar-tracked SKhTZ-NATI tractor (which was also known as the KhTZ-3 and KhTZ-NATI). The SKhTZ-NATI had a 52-hp that ran on kerosene. In 1938, its manufacturer, the Kharkov Tractor Factory, adapted a gas generator for use with the SKhTZ-NATI, creating the KhTZ-2TG, of which about 16,000 were made in 1938–1941. Use of wood gas reduced the performance of the tractor compared to its parent model, with the engine only generating 45 horsepower. The tractor was preferentially used for lumbering operations and agriculture in the northern regions of the USSR.

The Soviets also built some stationary gas generators to make wood gas. I have found little information about them. At least some were diesel engines equipped with gas generators. Likely some, perhaps many, were insulated with firebrick[189], assuming the Soviets followed the practices of other countries. I have found no information on what they were used for, and most of the following is speculation. They were larger than the gas generators designed for vehicles and thus produced more wood gas per load of fuel. Since they ran an engine of some sort, these generators must have powered stationary liquid-fuel engines at some remote industrial enterprises to save both fuel and the cost of transporting it there. I do not know how many stationary gas generators the 1930s-1940s Soviets had. The Soviets ceased production of wood-gas/diesel stationary gas generators in 1962[190], six years after they ended wood-gas vehicle production. This suggests that stationary gas generator were more important to the Soviets, and perhaps there were a fair number of them.

During the war, the Soviet military and defense industries had top priority in receiving liquid fuel, particularly gasoline and diesel fuel, leaving little for the civilian economy. The Soviets thus continued to produce gas-generator trucks. Most other Soviet truck production

189 T.B. Reed and A. Das; *Handbook of Biomass Downdraft Gasifier Engine Systems*; 1988.

for non-military purposes ceased, so that the automotive factories could make light tanks and light SPGs. GAZ-42 production continued throughout the war and into 1946. ZiS-21 production, however, ended in the autumn of 1941, when the ZiS factory was evacuated from Moskva during the German drive on that city.

Some sources claim the Soviets kept the *gazgeny* in production to send to the Red Army, but this seems partly or mostly incorrect. The Red Army wanted gasoline-fueled trucks because of their higher speeds and higher cargo capacities. Instead, the *gazgeny* seem to have been mostly sent to the "deep rear", releasing gasoline-fueled trucks there to go to the military. It is possible that some *gazgeny* were used in the Soviet supply services, particularly likely in the remote northern regions facing Axis forces operating from Finland and in the Arctic.

The Axis cut land communications to Leningrad in September 1941, beginning a years-long siege of the city. Leningrad could only receive limited amounts of supplies via Lake Ladoga. To conserve gasoline there, about half of Leningrad's trucks were converted to use gas generators. Local facilities in Leningrad built the generators using whatever materials they could scavenge. Many civilian trucks and many military trucks of the Army's Leningrad Front and the Navy's Baltic Fleet were converted to use generator gas.

Gasoline remained in short supply in 1942 throughout the USSR, as Soviet oil production declined during the German summer lunge towards Soviet oilfields and refineries. The Soviets decreed, possibly in July, that the GAZ-42 was prohibited from using gasoline. Apparently GAZ-42 operators were often using gasoline (when they could get it) instead of wood gas, to improve the performance and range of their trucks.

Also in July, the Soviets ordered a renewed effort to convert civilian trucks and tractors to use gas generators. Regional and local governments were ordered to make their own gas generators using local materials. Mass production of gas generators had ceased when the war broke out, as the factories converted to military production. During the war, local repair shops and various facilities made gas generators from whatever materials they could obtain. One major problem was that the fireboxes of the mass-production models had used heat-resistant steel, all of which was now going to military production. (Some fireboxes substituted aluminum for some of the steel, but aluminum was also critical to military production.) The repair shops instead built fireboxes from other materials such as lower-grade steel, cast iron, and even ceramics. These improvised fireboxes must have been heavier than heat-resistant ones, making the vehicles even heavier, slower, and with lower cargo capacities. Soviet-based sources I have seen do not go into details on this, other than one source stating that these vehicles were quite inefficient.

The need for local authorities to build their own gas generators meant the process of converting vehicles to use wood gas at first proceeded slowly in many places, particularly in 1942–1943. One issue, not covered in gas-generator sources I've seen, is that the wartime Soviets had a massive effort going on to gather scrap metal from the civilian economy for reuse in the war effort. This could have reduced local resources available to build gas generators. Many more trucks were converted in 1944–1945, perhaps because the demands on the rear areas to support the war effort were not as severe now that the Soviets were decisively winning the war.

The effort to make improvised gas generators for vehicles extended to rear-area military-related facilities. For example, the Murmansk shipyards made gas generators. The shipyards had considerable metal-working abilities since they were major repair centers for Soviet warships, civilian ships, and auxiliary vessels in the Arctic. During the war, some improvised stationary gas generators were also built by local facilities, but, as with the pre-war stationary gas generators, I have found very little information about them.

Many GULag camps converted all their vehicles to use gas generators during the war. Camps at Kolyma in the remote Siberian Arctic did this, for example. The prisoners cut all the wood their gas-generator vehicles needed and built built kilns to dry it.

I have so far been unable to discover how many trucks and tractors were converted during the war to use gas generators. Given the scale of the effort it must have thousands of trucks and tractors. Total wood-gas truck production and conversions through to the end of the war were likely on the order of 50,000–100,000 trucks: 900 ZiS-13 *gazgeny*, about 15,000 ZiS-21 *gazgeny*, about 32,000 GAZ-42 *gazgeny*, which roughly totals 48,000, plus an unknown number of wartime conversions of various truck models. One source[190] states that "in the USSR by 1945 10% of all cars were gas-generating, while the share of gas-generating cars and tractors in the forest industry was close to 100%". From the way this is phrased, I am certain the word "cars" does not mean passenger cars. Instead, it very likely means "automotive vehicles" (cars and trucks but not tractors or tanks) and possibly might just mean trucks[191]. It

190 Alena Aleshina; "From Resinous Wood Distillation to Hydrogen Energy (Questions of the History of Pyrogenation)"; IOP Conference Series: Materials Science and Engineering; Nov. 2019; https://www.researchgate.net/publication/337226916_From_resinous_wood_distillation_to_hydrogen_energy_questions_of_the_history_of_pyrogenation#pf5

191 I believe the quote derives from an unlisted Russian-language source. In Russian, *avtomobil* means "automobile" or car. However, the Russian source likely instead used the word *avtomobilnyy*, which means "automotive" and usually refers to cars and trucks collectively but in some works is sometimes used to mean truck-like vehicles but not car-like vehicles. The similarity of *avtomobilnyy* to *avtomobil* causes all sorts of problems when translating Russian into English, with "car" often being used in mistake.

almost also certainly applies only to Soviet-made trucks and not to the hundreds of thousands of trucks the Soviets received from Allied aid.

I estimate that the Soviet truck fleet at the start of the war in June 1941 was on the order of 960,000 trucks. The Soviets made another 205,000 trucks during the war (through May 1945), for a total of 1,165,000 trucks. Many thousands of trucks were lost during the war, due to combat (especially in 1941), breakdowns, and other causes. For sheer convenience, I assume the 1945 Soviet-made truck fleet thus was one million vehicles. If the 10% figure in the quote above is applicable, then a maximum of about 100,000 Soviet trucks used wood-gas in 1945.

Total wood-gas tractor production and conversions through to the end of the war were likely on the order of 25,000–50,000 tractors: about 250 wood-gas S-60 tractors, about 7,400 wood-gas S-65 tractors, about 16,000 KhTZ-2TG tractors, which roughly totals 23,500, plus an unknown number of wartime conversions of various tractor models. Assuming the tractor conversion effort was proportionate to the truck conversion effort (a huge assumption), then a maximum of about 50,000 Soviet tractors used wood-gas in 1945.

The wartime Soviets also converted some ZiS city passenger buses to run on wood gas, converting them back to gasoline after the war ended. I do not know how many buses were converted, but I suspect several hundreds were involved.

The Soviets also made experimental wood-gas locomotives[190] but did not put any into production. I do not know when the experiment was done; I speculate it could have been in 1942, during the coal shortage resulting from the German's 1941 capture of the Donbass coal mines. While wood-gas locomotives sound (and were) inefficient, some countries developed them, and not just locomotives but also self-propelled wood-gas passenger rail carriages. France developed both types from the mid-1930s, apparently as a way to reduce fuel costs on marginal rail lines. They also developed wood-gas switcher locomotives. The Italians also developed wood-gas passenger rail carriages in the mid-1930s, likely in case League of Nations sanctions embargoed Italian coal imports because of Italy's invasion of Ethiopia[181].

At least there were no wood-gas airplanes. Just kidding, of course there was at least one model! The Swiss Comte AC-4 sports plane of the 1920s could use wood gas, or at least advertising for the plane claimed it could[192]. As far as I can tell, the plane was not equipped with a gas generator, which of course would have added too much weight. Instead, the wood gas seems to have been produced at the airfield in a stationary gas generator. A tank of wood gas was used in the plane, allowing the plane to fly for about an hour. Given that

192 http://www.douglas-self.com/MUSEUM/TRANSPORT/prodcar/prodcar.htm#ae

the Soviets wasted considerable resources in multiple failed attempts to develop steam-powered aircraft (yes, true!), it is almost surprising that the Soviets did not try to develop some wood-gas aircraft. The ubiquitous, light U-2 biplane (aka the Po-2), many of which often operated from crude runways in remote areas, seems to me like an idea candidate for wood gas. The horsepowers of the various engine models for the U-2 were comparable to those of the AC-4, so a wood-gas U-2 seems technically possible.

The Soviets also made gas-generator ships and boats or converted existing vessels to use wood gas. These were mainly tugboats and river vessels[190]. I have no numbers on how many vessels were involved, however.

During the war, the Germans extensively converted armored vehicles in their training establishment to use wood gas (and other similar fuels like coal gas), to save gasoline for the fighting forces. They had wood-gas training tanks, training assault guns, and training halftracks. The Soviets did not do this. They did develop some experimental gas-generator AFVs at some point[190], but they did not put them into production nor as far as I can tell convert existing training AFVs to use wood gas. One possible reason for this was that in 1941-1942 the Soviet military was so busy fighting to halt the Germans that developing wood-gas training vehicles was a time-wasting diversion of effort. From 1943 on, it wouldn't have been a pressing necessity like it was for the Germans.

In 1945, with planning for the postwar economy in progress, the Soviets decreed that 70% of the vehicles hauling lumber should use gas generators by 1950. One reason for this was that the Soviets still had gasoline shortages due to the wartime disruption of the oil industry, which would continue in the immediate post-war years. The GAZ-42 was kept in production into 1946, and the ZiS-21 was put back in production as the ZiS-21A[193], based on the ZiS-5V. The ZiS-5V was a stripped-down version of the ZiS-5 made during the war to save materials and speed production. About 18,000 ZiS-21A trucks were made after the war. GAZ and ZiS also designed and produced some new models of gas-generator trucks in the late 1940s and early 1950s.

After the death of Stalin, the Soviet leadership finally realized the inefficiency of using gas-generator vehicles and ended their production in 1956. Since the post-Stalin Soviets were also reducing the size of the GULag, one of the prime users of wood-gas vehicles no longer needed as many. Existing wood-gas trucks continued to be used in remote areas until they wore out, with the last of them finally being removed from service in Siberia in the late

193 Beyond the factory, the ZiS-21A was often just called the ZiS-21, as most Soviets were not too particular with submodel designations.

1970s. Gas-generator vehicles were also phased out in the decade after the war in almost all other countries, also because of their inefficiencies. Today, as far as I know, only one country extensively uses wood-gas vehicles: North Korea, whose *Sungri*-58 (Victory-58) uses a gas generator.

6.D Coal Gas

Coal gas, also known as town gas or city gas (*Stadtgas* to the Germans, who extensively used it) is a combustible gas made from coal. Various cities in the Russian Empire used coal gas to fuel their outdoors street lamps. The Russians called coal gas "lighting gas" (*svetilnyy gaz*, sometimes translated as "luminous gas") and often just "gas" (*gaz*) until natural gas came into widespread use,. Russian cities with coal gas had earlier used kerosene lamps for street lighting, and some went on to use a mix of coal gas and kerosene.

The Russians began to use coal gas in the mid-19th Century. Typically, a private company would contract with a Russian city to build, supply, and operate a coal-gas pipeline network the city's outdoor lighting. The company would build a coal-gas plant that processed coal without oxidizing it, creating a combustible gas mixture containing hydrogen, carbon monoxide, methane, and ethylene, as well as some non-combustible gases. Sometimes the company sold the gas to the city at below the cost to make it, basically as advertising in hopes that some city dwellers would want to connect to the network and have their own coal-gas lights in their homes. However, in some places, people resisted using coal gas, fearing explosive or poisonous accidents were likely to occur.

Besides actual coal gas, the Russians used other lighting gases made from wood, oil, and a combination of wood and oil, but coal gas comprised the great major of Russian lighting gases. The biggest user by far was the city of Sankt-Peterburg ("St. Petersburg"). Lighting gas was only a minor industry in the Russian Empire. Less than 25 cities used it, and in 1891 more city gas was produced for the German city of Berlin than lighting gas was produced for the whole of Russia[194].

The Soviets confiscated the existing coal-gas plants and networks when they took over the country in 1917–1920. However, they were not interested in investing their scarce resources to build up a coal-gas industry. Instead, the Soviets decided to replace coal gas lighting with electric lighting, which depended upon their plans to build power plants and grids in many important parts of the country. By 1929, according to one source, Moskva was the only

194 D.L. Rakhmankulov and F.K. Dzhafarovl; "Iz Istorii Iskusstvennykh Goryuchikh Gazov" ("From the History of Artificial Combustible Gases"); 2005; http://ogbus.ru/files/ogbus/authors/Rahmankulov/Rahmankulov_1.pdf

Soviet city that still in the process of converting its outdoors lighting from coal gas to electricity. The last of Moskva's coal-gas and kerosene street lamps were replaced in 1932. This was the end of the Soviet coal gas industry.

In the mid-1930s, the Soviets had a growing gasoline shortage. It was possible to run internal-combustion engines using coal gas instead of gasoline, but as far as I can tell the Soviets did not seriously consider this option. Perhaps they did some experimental work was in this area, but no widespread deployment of vehicular coal gas occurred. I speculate the Soviets were not interested in investing their resources to build new coal-gas plants, especially since they had two different vehicular gas technologies under development: condensed natural gas and wood gas.

GAZ-43, a gas-generator vehicle that used anthracite to make coal gas[195]

The GAZ-43 truck technically was a coal-gas vehicle. However it did not get its fuel from a coal-gas plant. Instead, it made its own coal gas from anthracite using a specially designed gas generator based on those that made wood gas. These vehicles were used at Soviet coal basins that produced anthracite. The truck was based on the 1.5-ton GAZ-MM and like the wood-gas GAZ-42 only had a cargo capacity of 1.2 tons because of the weight of the gas generator system. The 50-hp engine delivered 22–24 horsepower when using coal gas. Most sources claim only a few GAZ-43 trucks were made in 1938–1941, while one source claims 592 were made in 1939, with the implication that this was the only production run of the truck. No source I've seen covers why anthracite was used, as the Soviets had much-more abundant supplies of bituminous coal and brown coal. I suspect it was because high-quality anthracite was difficult to ignite and had to be used in specially-designed furnaces and boilers, unlike the other grades of coal. This would have limited general use of anthracite and thus made it a good selection for a coal-gas vehicle.

195 https://rus-texnika.ru/gaz-43.html

During World War II, many countries with gasoline shortages resorted to converting some motor vehicles to use coal gas, by adding one or more large coal-gas storage tanks on the vehicle and adjusting the engine to burn coal gas instead of gasoline. These vehicles would refuel as needed from the urban coal-gas network. Germany, with its great wartime shortage of gasoline, used coal gas for numerous civilian vehicles and even some military vehicles.

6.E Hydrogen

An abundant supply of hydrogen is available though electrolysis of water (H_2O), and it can be easily burnt with oxygen in the air to produce copious energy, with only water as a byproduct of combustion. In the 19th Century, various inventors in many countries thus became interested in using hydrogen gas (H_2) as a fuel. Hydrogen was popularized in fiction of the time, particularly as "the fuel of the future" in *The Mysterious Island* by Jules Verne. Issues with hydrogen gas as a fuel, however, prevented its widespread adoption during 19th and 20th Centuries (and so far even today): Hydrogen gas is somewhat difficult to store and handle, as the tiny gas molecules can readily leak into the air through very small cracks and openings. Hydrogen is dangerously explosive when it mixes with air if the mixture accidentally or deliberately comes in contact with a flame or spark. Hydrogen can be expensive to make in large quantities, as a main industrial process to production it uses large amount of often-expensive electricity. Another industrial process, natural gas reformation (aka steam-methane reformation), which was developed before World War II, requires an ample supply of natural gas. (Modern industrial technologies to produce hydrogen also include other methods of natural gas reformation and using biomass.)

Although hydrogen gas was rarely used as fuel in the 20th Century, because of its great buoyancy it was often used in balloons and dirigibles, despite the dangers of explosion. One of the most deadly tasks for aviators in World War I was to attack enemy hydrogen-filled observation balloons. Indeed, most fighter aces of that war rarely volunteered to be balloon-busters, a dangerous mission that most attracted extreme daredevils. The only practical alternative to hydrogen was inert helium, which could not explode. However, most countries found helium either far too expensive to use or not even available at all.

In the interwar years, observation balloons were mostly replaced by observation aircraft, although the Red Army used both observation aircraft and balloons in World War II. In that war, many countries used hydrogen-filled barrage balloons to help protect cities from low-flying enemy aircraft. The balloons' function was to lift the actual defenses: steel cables running from the ground to the balloons, which typically were held at about 2,000–4,500 meters (6,500–15,000 feet) altitude. Low-flying aircraft risked being damaged or crashing when colliding with these cables. The Soviet air defense organization, the PVO, used many barrage balloons, with particularly large deployments of them at the major cities of Moskva and Leningrad.

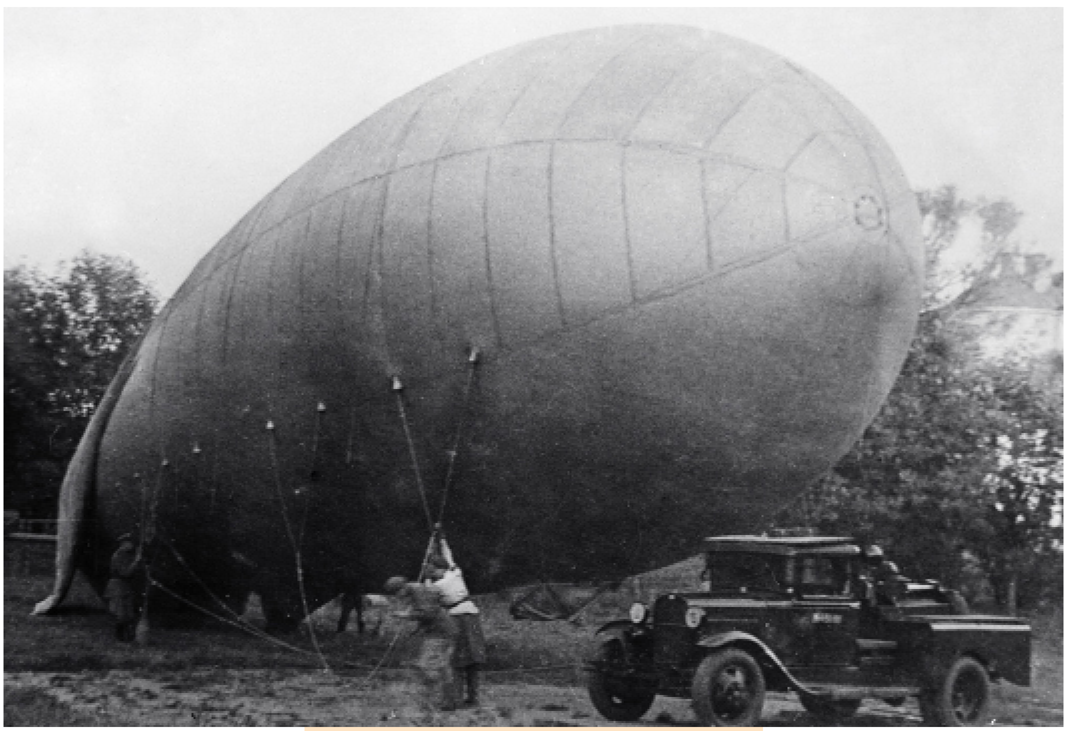
The Soviets built special tanker trucks to hold hydrogen gas for filling the balloons and special winch trucks to raise and lower the balloons. The winch trucks were typically 40-hp gasoline-engine GAZ-AA trucks with truckbed-mounted winches that operated using power from the engine. Soviet barrage balloons slowly leaked hydrogen and took in regular air, which reduced their buoyancy and make them potentially explosive. In fact, the Soviets called the mixture of hydrogen and air "detonating gas" (and also "dirty hydrogen"). When about 17%[196] of a balloon was filled with air, which occurred after about 25–30 days of use, it had to be refilled with hydrogen. The balloon was winched down to the ground, the detonating gas was vented off into the air, and the balloon was refilled with hydrogen.

The Germans invaded the USSR on 22 June 1941 and by September 1941 were besieging Leningrad, cutting off all overland communications to the city. The city faced many supply difficulties, include an immense gasoline shortage. B.I. Shelishch had been drafted into the Red Army on 23 June 1941 as an automotive mechanic in a barrage balloon unit of the Leningrad PVO. Facing a lack of gasoline for the winch trucks, Shelishch first successfully ran a winch using electricity from the city's grid rather than power from the truck's engine. However, Leningrad's electricity was also in short supply and was reserved only for hospitals and some vitally-needed industry. Shelishch then managed to find a way to run a winch on a winch truck using a balloon's detonating gas. Some of the detonating gas was captured in the truck's fuel tank and used to run the engine, which was adjusted for the gas. Shelishch claimed he got the idea for this from reading Jules Verne.

Shelishch's first attempt worked, at least until a spark or flame from the engine went down the fuel line and ignited the detonating gas in the fuel tank. The tank exploded, giving Shelishch shell shock. Shelishch solved this problem by installing a water seal between the engine and fuel tank. Everything succeeded in the next test. All 200 winch trucks in Leningrad were converted to run their winches with detonating gas. When using this gas, an engine delivered 20 horsepower (half its horsepower on gasoline), experienced less wear and tear on its components, and could be run in an enclosed structure since its exhaust was harmless water vapor. As Leningrad entered winter, the PVO discovered engines started easier in cold weather on detonating gas than on gasoline.

196 Another source claims 15%–20%.

A balloon first had to be winched down before its detonating gas could be collected. Shelishch or the Leningrad PVO found a way to power the winch with detonating gas or hydrogen for this step. The sources I've seen do not go into details on how this was managed. One possibility is that detonating gas from a balloon was not only collected in the truck's fuel tank but also in separate cylinders for use with other balloons. Another possibility is that some hydrogen gas intended for refilling a balloon was used to power the winch. Overall, the first option would have been the most efficient use of resources, as it would have reserved all the "clean" hydrogen for filling balloons, with the dirty hydrogen running the winches. In any event, the Leningrad PVO certainly used separate cylinders containing either detonating gas or hydrogen, as they ran a vehicle for 200 hours off cylinders as part of a demonstration and test of the system.



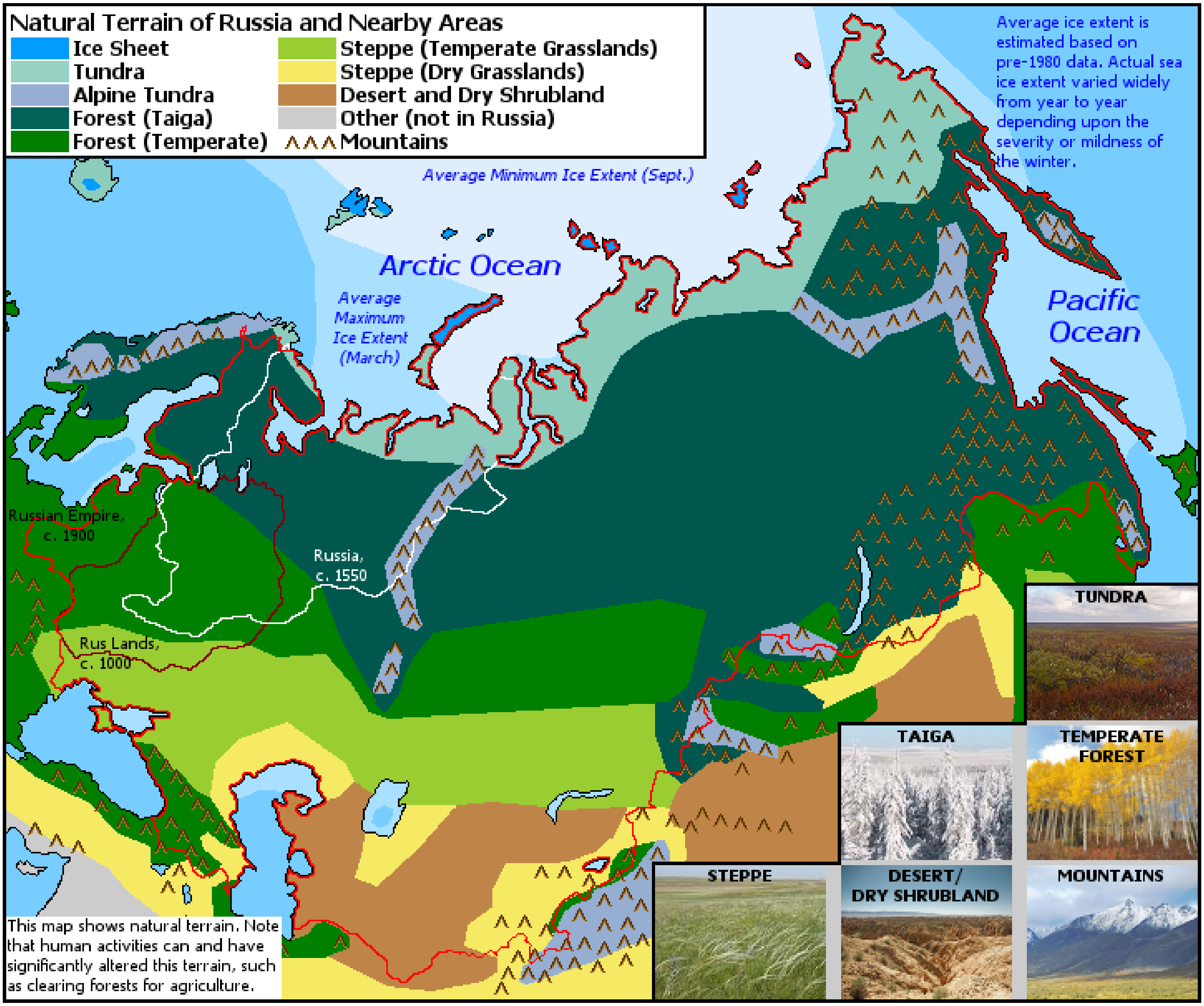
A Soviet barrage balloon in 1942

Shelishch was awarded the Order of the Red Star for his invention. In 1942, he was sent to Moskva to show that city's PVO how to convert their 300 winch trucks to use hydrogen. He submitted his invention for a patent[197] and was promoted twice, ending the war as a technician senior lieutenant. After the war, Shelishch worked in automotive transport and

197 Soviet patents of the 1930s–1950s did not give the inventors any property rights, since inventions were state property. A patent conferred official recognition and some rewards for the inventor. Monetary rewards were supposedly based on the savings the invention caused for its industry. This is a simplification of Soviet patents; see https://ir.lawnet.fordham.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1729&context=flr for more details. Also note that Soviet patents changed significantly in the 1960s, which is not covered in the cited document.

earned a university degree. In the 1970s when the USSR was working on hydrogen energy projects, he gave a lecture on his experiences with hydrogen at the Soviet Academy of Sciences. He died in 1980 at the age of 71. As far as I know, even though it was limited to powering only winches, this was the only significant use of hydrogen as a fuel by any country in the war.

7 Firewood



Going back far into prehistoric times, firewood was the traditional fuel of many of the lands that became the Russian Empire and then the USSR. There were extensive forests across much of the northern half of the country and in the Caucasus Mountains. The people who lived in these regions extensively used wood as building material and as fuel for heating, cooking, and other productive activities[198]. Despite the development of coal, oil, and peat as

198 Steppe and desert dwellers used firewood when it was available, such as from trees along rivers and lakes in the steppe. Where firewood was not available, dried dung and to a lesser degree animal bone were traditional fuels. Firewood was prized

fuels, firewood remained a very important cooking and heating fuel in the 1930s-1940s USSR, not only in the countryside but sometimes for many city dwellers as well.

The Soviets had developed a large lumber industry in the 1920s–1930s. Firewood was not its major product. Instead, it produced logs, railroad sleepers, sawn wood, and wood resins and oils. Its products were used for building materials, pulp, paper-making, plywood and other engineered wood[199], and so on.

Leningraders! Everyone Collect Firewood!
Poster; I. Bystrov; 1942

After war broke out with the Axis in June 1941, firewood became even more important and was a strategic asset for supporting the war effort. The Germans overran coal mines and peat producing facilities in the western USSR in 1941, and the Finns overran peatlands in their area of operations. The Soviet lumber industry was also adversely affected by the war in 1941. The Germans and Finns both occupied many logging operations in the western USSR, particularly in the Belorussian SSR, the Karelo-FFinnish-Karelian SSR, the northwestern Russian SFSR, and the northern Ukrainian SSR. Almost one third of Soviet sawmilling

but often difficult or expensive to obtain and thus often used as an easily-lit starter fuel for the other fuels. (Animal fat was also used as a starter fuel.)

199 Engineered wood, essentially a form of plywood, was particularly important for Soviet military aviation. The fuselages of many aircraft, particularly the Soviets' best fighters, were made with engineered wood. While metal fuselages were lighter, wood was a strategic material of which the Soviets knew they would always have ample supplies during a war.

installations were occupied[200], although the Soviets evacuated or destroyed lumbering and sawmilling equipment as much as possible to prevent its capture. However, the lumber industry had an advantage over capital-intensive industries like coal and oil: logging could be done by human power using hand tools and logs transported by animal power or by water as timber rafts.

In 1942, Soviets lost more peatlands and suffered considerable disruption of oil production and refining in the Caucasus. Production of coal, peat, and oil dropped significantly. So did firewood production, but firewood's percentage of Soviet energy production in 1942 actually rose to 18.9% from 13.5% in 1941 due to the deeper declines in coal and oil production.

Part of the Soviet response to the loss of coal, oil, and peat was to increase the use of firewood, and not just for cooking and heating. On various rail lines, steam locomotives switched from coal to firewood. Similarly, many river boats switched from coal or fuel oil to firewood. Some industrial enterprises that used boiler houses switched from coal to firewood. Firewood did not burn as hot as these other fuels, so it was a less efficient fuel.

Industrial processes that required high heat could not use firewood, and the available coal and peat were mostly reserved for these factories as well as for electricity generation. Coal became a scarce fuel for heating in many cities in the western USSR, especially in 1941–1942, with the populace having to substitute firewood. For example, when the Donbass coal mines were lost in October 1941, Moskva lost one of its main suppliers of coal and extensively switched to firewood for residential and office heating starting that month.

Overall, the Soviet lumber industry supplied 400 million cubic meters of firewood (roughly 14,000 million cubic feet or 110 million cords) to the Soviet economy during the war, with 70 million cubic meters being used for rail and river transport[201]. Firewood is bulky, and the Soviets could not afford to devote significant railroad capacity to hauling firewood. Instead, firewood was cut in the forests closest to the places that needed the wood, minimizing rail transport. In many cases, protected woodland reserves near cities were opened up for firewood harvesting.

Where practical, firewood was also carried on barges operating on rivers and canals, but this was not possible during the long Soviet winters in the many regions where the water froze.

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200 Robert M. Bone; The Growth of the Soviet Lumber Industry and Exports; *The Forestry Chronicle*, Vol. 42 No. 3; 1966; https://doi.org/10.5558/tfc42222-3

201 Source: "Lesnoe Khozyaystvo v gody Velikoy Otechestvennoy Voyny" ("Forestry during the Great Patriotic War"); http://www.vniilgisbiotech.ru/index.php/ru/71–75-let/281-lesnoe-khozyajstvo-v-gody-velikoj-otechestvennoj-vojny

Soviet women in the lumber industry

Almost all non-prisoner military-age men in the lumber industry were drafted into the Red Army in 1941 to fight the war. To replace them, the Soviets mobilized women, the elderly, and schoolchildren. In emergencies, civilians in cities and towns were given hand tools and sent to nearby forests to cut wood. The October 1941 heating fuel crisis in Moskva was averted in this way, with 40,000 people, mostly women and girls, being sent to cut wood. These people stayed in the forests cutting wood and living there in rough huts. In Leningrad, which was besieged by the enemy, the civilian population had to cut firewood in nearby forests to use as fuel for all sorts of purposes.

The 1941 German offensives had particularly hurt the Soviet coal industry, with the Soviets' top coal basin, the Donbass being lost. Much of the Podmoskovnyy basin west of Moskva was also loss, although significant parts were regained in the Soviet winter counteroffensive of 1941/42. Summer 1942 saw a new, dangerous German offensive that targeted the Soviet oilfields and refineries in the North Caucasus and Transcaucasus regions, where most of the Soviets' oil was produced. Although the Soviets held on to most of the oilfields, oil production nonetheless fell significantly. In August 1942, the Soviets instituted mandatory labor service for most adult and adolescent civilians, and harvesting firewood for state or community use (rather than for personal use) was one of the service's many tasks.

Similarly, the Soviets formed what was unofficially called the "Labor Army". Its members were forced laborers consisting of individuals and entire ethnic groups whose loyalty the Soviets mistrusted. Some in the Labor Army harvested firewood.

All these efforts greatly increased the amount of firewood being produced by 1943. That year, firewood produced 21.5% of Soviet energy needs, the first and only time its energy share exceeded 20%. After 1943, firewood production did not increase (it actually declined slightly) while production of other forms of energy, particularly coal and oil, increased. Nonetheless, firewood continued to be used for many purposes, especially for heating and cooking, throughout the entire war.

Soviet Firewood as Fuel (million tons fuel equivalent)

Year	**1940**	**1941**	**1942**	**1943**	**1944**	**1945**
Total all energy sources	237.7	222.0	119.2	136.0	158.5	185.0
Firewood MTFE	34.1	30.0	22.5	29.3	28.8	28.4
Firewood %	14.3%	13.5%	18.9%	21.5%	18.2%	15.4%

Source: Narodnoe Khozyaystvo SSSR v Velikoy Otechestvennoy Voyne 1941–1945 gg. (*People's Economy of the USSR in the Great Patriotic War 1941–1945*); a 1959 formerly-secret statistical compilation by the Soviet government. MTFE is Million Tons Fuel Equivalent, a measure based on a 7,000 kilocalorie unit. Other Soviet energy sources were coal, oil, peat, natural gas, and oil shale.

Firewood MTFE dropped in 1941–1942 due to mobilization of manpower from the lumber industry and from other effects of the war. Even though firewood MTFE dropped to its lowest point in 1942, its percentage of total energy MTFE actually rose above its 1940 prewar level. This was due to Soviet oil and coal production being adversely affected by the war. Measures to increase firewood production, particularly mandatory labor service of civilians, greatly increased the supply of firewood in 1943–1945.

8 Electricity

Electrical Terms

Watt (W). This is a measure of power: the rate at which electricity is generated or the rate at which an electric device consumes electricity. For example, an old-style incandescent 40-watt light bulb consumes 40 watts of electricity, while an old-style 60-watt light bulb consumes 60 watts, 1.5 times the rate of a 40-watt bulb. How much energy an electric device actually consumes depends upon how long it is run (see Watt hour).

Watt hour (Wh). This is a measure of energy: the amount of power generated or consumed over one hour. For example, an old-style incandescent 40-watt light bulb when left on for an hour consumes 40 Wh of electricity.

KW. Kilowatt, one thousand watts.

KWh. Kilowatt hour, one thousand watts of electricity generated or consumed for one hour. Many power companies charge their customers in the number of kilowatt hours they use in a period of time, such as a month.

MW. Megawatt, one million watts.

MWh. Megawatt hour, one million watts of electricity generated or consumed for one hour.

GW. Gigawatt, one billion watts.

GWh. Gigawatt hour, one billion watts of electricity generated or consumed for one hour.

Power Plant, Power Station. A facility that generates electricity.

Thermal Power Plant, Thermal Electric Station. A facility that generates electricity by burning fuel. Heat from the fuel boils water in a boiler, with the resulting steam driving steam turbines connected to electricity generators. There are several varieties of thermal power plants, but the 1920s–1940s Soviets used the form described here.

TETs. A Soviet abbreviation for *Teploelektrotsentral*, Thermal Electric Station. The term was later replaced with the second meaning of GES (see below).

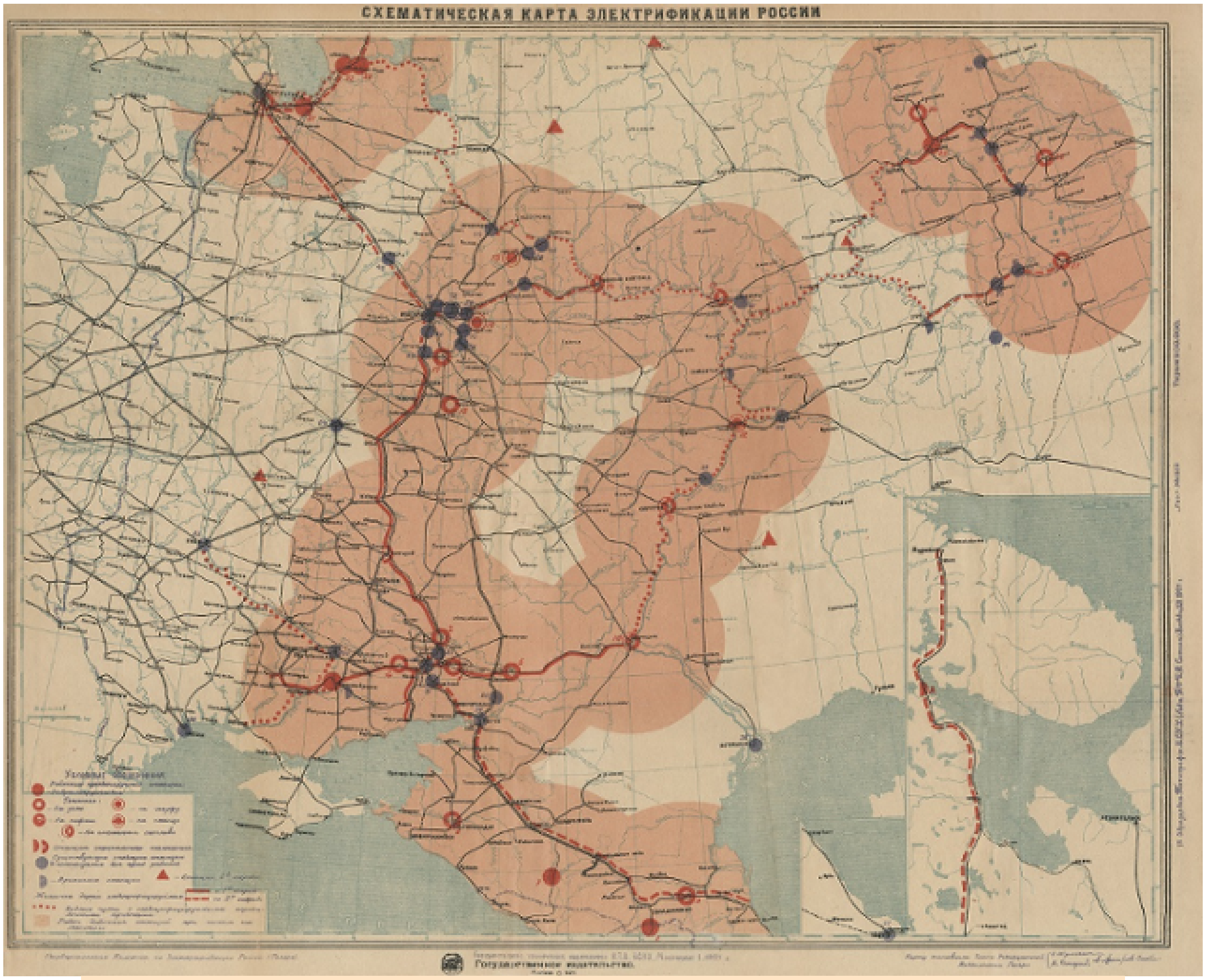
Hydropower Plant, Hydropower Plant. A facility that generates electricity by water power. Typically, a river is dammed to form a reservoir, and water from the reservoir drives the hydraulic turbines connected to electricity generators. There are several varieties of hydropower plants, but the 1920s–1940s Soviets used the form described here.

GES. A Soviet abbreviation with two meanings:

Gidroelektricheskaya Stantsiya, Hydroelectric Station.

Gosudarstvennaya Elektricheskaya Stantsiya, State Electric Station. This terminology replaced the earlier term Tets (see above). Although I have not seen a reason given for changing TETs to GES in any source I have seen so far, I speculate someone in the Soviet bureaucracy decided it was more convenient to use GES for both types of power plants.

Hydropower Turbine, Hydro Turbine, Water Turbine. These are alternate names for a hydraulic turbine.



Schematic map of planned electrification of Soviet Russia, GOELRO, circa 1920

In addition to the regions shown on the map, electrification projects were also planned for Western Siberia (off map to the east) and Turkestan in Central Asia (off map to the southeast).

"Communism is Soviet power plus the electrification of the whole country, since industry cannot be developed without electrification."
– Vladimir Lenin, in *Our Foreign and Domestic Position and Party Tasks*; 1920[202].

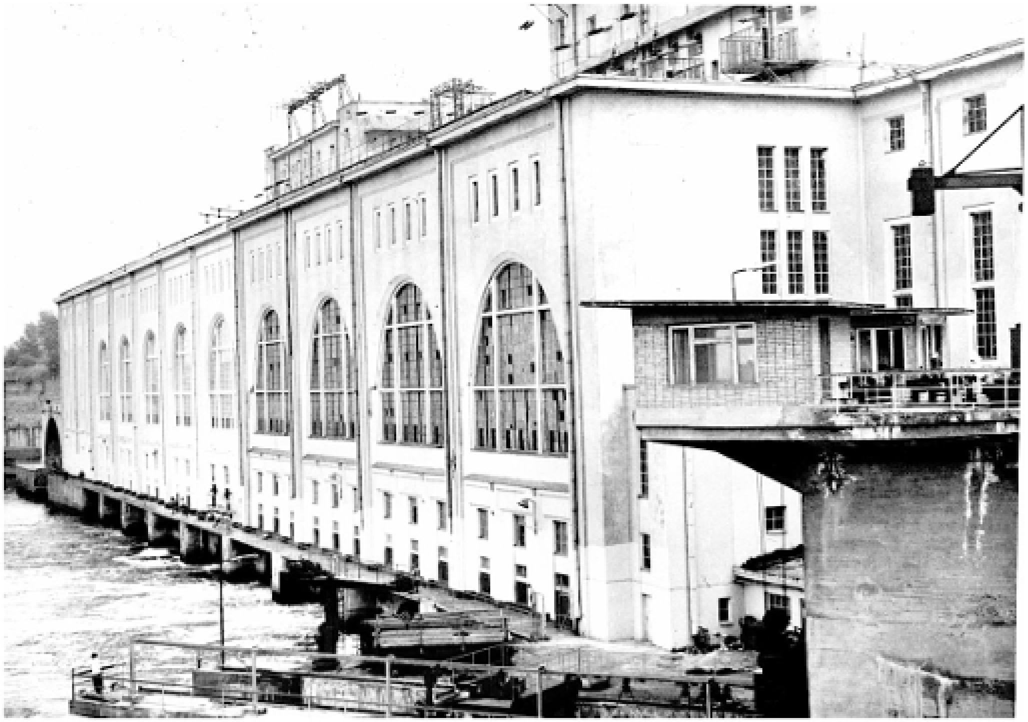
As late as the second decade of the 20th Century, the Russian Empire did not have widespread use of electricity. Even its major cities used little electricity, and city street

202 Lenin's quote on electrification was so extensively used in Soviet propaganda that it eventually became an object of ridicule and concealed criticism of the USSR among some Soviet citizens, such as "Soviet power is Communism minus electricity" and "Electricity is Communism minus Soviet power", treating Lenin's saying as a mathematical equation.

lighting remained fueled by coal gas, kerosene, or both. There was little support for electrification among the general population and apparently considerable fear of accidental electrocution. Religious leaders tended to oppose electricity, such as when a Russian Orthodox bishop at Samara tried to block the creation of a hydroelectric plant on the Volga River. Private companies built some thermal power plants, which used fuels like coal, peat, and fuel to generate electricity. This electricity was mostly used to power some factories, mining operations, and workshops and to run trams in some cities.

The Russian Empire also used hydropower to a minor extent to generate electricity. A private company built the empire's first hydropower plant in 1887 in the Caucasus Mountains, to power a mining operation. Thereafter, only a few, mostly small hydropower plants were built by private companies. By 1913, hydropower provided only 2.1% of Russia's electricity. Total Russian electricity generation that year was only 1.95 GWh, or about 16.7% of the USA's 11.56 GWh for 1912 (I have not found a figure for 1913). Russia electricity generation increased little in the following years due to World War I, while in comparison US electricity generation more than doubled by 1917, to 25.44 GWh.

In 1917, a revolution toppled the Russian Empire, with the country temporarily run by a Provisional Government that attempted some reforms and modernization. One project was a large hydropower plant on the Volkhov River, intended to provide electricity to the capital, Petrograd (formerly Sankt-Peterburg ["St. Petersburg"], later renamed Leningrad by the Soviets). However, work stopped later in 1917 due to ongoing Russian economic collapse. In late 1917, another revolution saw the Soviets come to power. They restarted the building of this plant in 1918, only to halt construction in 1919 in order to concentrate resources to fight the Russian Civil War. Nevertheless, this plant was the beginning of Soviet hydropower.



Volkhovskaya GES (See map below for its location)

In 1921, the Soviets subsumed the construction of the hydropower plant on the Volkhov River into the GOELRO plan, as the Volkhovskaya GES. It was a high-priority project for the electrification of the country, with up to 15,000 workers toiling on the project. Being the first hydropower plant built by the Soviets, it served as a learning process for the construction of other plants. Soviet industry could not yet build advanced electrical equipment, so four hydraulic turbines (also known as hydro turbines or hydropower turbines), a number of high-voltage transformers, and other equipment was imported from Sweden. Electric lines were strung overland from the plant to Leningrad, as Petrograd was renamed after Lenin's death in 1924. The plant was also named in honor of him, becoming Volkhovskaya GES named for V.I. Lenin. It went into operation in late 1926.

During World War II, the Germans cut off the overload routes to Leningrad in September 1941, severing the plant's electrical connection to the city. In October, a German offensive driving east across the Volkhov River threatened possible capture of the plant, causing the Soviets to evacuate its turbines and other equipment. The plant did not fall to the Germans, who were then driven back west across the Volkhov during the Soviet winter counteroffensive. With the plant now safe, the Soviets began restoring its equipment starting in February 1942. The first two turbines resumed operation in May. With land communications to Leningrad cut off, the Soviets laid an underwater electric cable to Leningrad across Lake Ladoga. This restored the plant's power to the city in September 1942 and allowed Leningrad to put a number of factories back into operation and to increase tram traffic. Restoration of the plant continued throughout the war, with work being completed in 1945.

When the Soviets took over the country, they saw mass electrification as a key way to modernize the land, to industrialize, and to improve people's lives. The Russian Civil War had adversely affected the few existing power stations, so the Soviets started almost from scratch. In 1920, while the country was still just the Russian SFSR, the Soviets created the State Commission for the Electrification of Russia or GOELRO (for ***Go****sudarstvennaya Komissiya po* ***El****ektrifikatsii* ***Ro****ssii*), which that year developed a plan for electrification of various cities and rural areas. The Soviet government approved implementation of the plan in late 1921.

The GOELRO plan called for the constructions of 30 power plants in the Russian SFSR. One important aspect of the plan was that 20 thermal power plants would be located near fuel sources like coal, petroleum, shale oil, and peat deposits, so that they could be supplied with fuel without have to transport it long distances. The plan also called for the development of 10 hydropower plants, involving damming of rivers to create reservoirs that would provide water pressure for electric turbines.

Russian and Soviet Electricity Generation (in gigawatt hours, GWh)

Year	Total Electricity Generation	Hydropower Electricity Generation	Hydropower, % of Total
1913 (Russian Empire)	1.945	0.040	2.1%
1921 (Russian SFSR)	0.520	0.010	1.9%
1923 (USSR)	1.146	0.020	1.7%
1925 (USSR)	2.925	0.040	1.4%
1927 (USSR)	4.205	0.286	6.8%
1929 (USSR)	6.224	0.462	7.4%
1931 (USSR)	10.687	0.592	5.5%
1933 (USSR)	16.357	1.250	7.6%
1935 (USSR)	26.288	3.676	14.0%
1937 (USSR)	36.173	4.184	11.6%
1939 (USSR)	43.203	4.705	10.9%
1940 (USSR)	48.309	5.113	10.6%
1941 (USSR)	46.671	?	?
1942 (USSR)	29.068	?	?
1943 (USSR)	32.288	?	?

1944 (USSR)	39.214	?	?
1945 (USSR)	43.257	4.841	11.2%
1946 (USSR)	48.571	6.046	12.4%

Sources: All but 1942-1944 are from James Harvey Bater; thesis, "The Soviet Hydroelectricity Industry"; 1965. Years 1942–1944 are from *Narodnoe Khozyaystvo SSSR v Velikoy Otechestvennoy Voyne 1941–1945 gg.* (*People's Economy of the USSR in the Great Patriotic War 1941–1945*); 1959. Also used is *Energetika i Energetiki v gody Velikoy Otechestvennoy Voyny 1941–1945* (*Energy and Electricity during the Great Patriotic War 1941–1945*); Executive Committee, CIS Electric Power Council; 2015. Also consulted is Joël Darmstadter; *Energy in the World Economy*; 1971. Some sources give 1940 total generation as 48.6 GWh or 48.0 GWh. Darmstadter most agrees with Bater for pre-war total generation but has significant differences for pre-war hydropower generation.

The plan called for its electrification goals to be achieved in 10 to 15 years, with a total capacity of 8.8 GWh. Foreign equipment and expertise were required in the early years, which had to be paid for in foreign currency. (The USSR was cut off from foreign loans or credit after the Soviets refused to honor the debts incurred by the Russian Empire.) Foreign currency was raised by selling the few things the USSR produced that other countries wanted: mostly materials like oil, gasoline, grain, and lumber. Grain was sold even during a major Soviet famine.

The Russian Empire had used wind power, but not to generate electricity. Instead, it had many thousands of windmills, most of which were used to grind grain. The Soviets, on the other hand, were interested in wind-generated electricity almost from the start of their rule. In 1918, they began researching the principles of wind turbines, initially based on analysis of how windmills functioned. This work was done at the Central Aero-Hydrodynamic Institute (TsAGI, for ***Ts****entralnyy* ***A****ero****g****idrodinamicheskiy* ***I****nstitut*), which became an immensely important Soviet scientific organization involved with aerodynamic research for aviation as well as wind turbines and with hydrodynamic research for ships, naval aircraft (particularly flying boats), and water turbines. By 1925, a wind turbine theory had been developed at TsAGI, followed by a 30 KW wind turbine. In the 1920s, these turbines were used to supply off-grid electric power at remote places in the USSR that had dependable wind but were too expensive to connect to the grid. For example, many were installed in the Buryat-Mongolian Autonomous Soviet Socialist Republic (now Buryatia in the Russian Federation), a very distant, low-population region of the Russian SFSR just north of Mongolia.

GOELRO was a success, with the USSR seeing significant increases in electric supply in the mid-to-late 1920s. The plan was revised over time, such as incorporating the lessons of building hydropower plants based on the construction of the first one, Volkhovskaya GES. Of the 10 planned hydropower plants, six were canceled and replaced by newly-planned hydropower plants at other locations.

One point of debate for hydropower was whether to build many small hydropower plants or just a few massive ones. In most cases, the Soviet chose to build massive hydropower plants. Perhaps the Soviets' love of gigantic construction projects played a role, but there was also a practical reason for big hydropower plants: the large reservoirs compensated for season fluctuations in rivers' water levels and allowed the hydropower plants to function throughout the year[203].

By 1931, two more hydropower plants were in operation by 1931, with the remaining seven still under construction. However, many more hydropower plants were also planned and went into construction in the 1930s, as part of the series of Soviet five-year-plans.

The growing success of GOELRO by the late 1920s provided some inspiration for the first Soviet five-year plan of economic development. This began in 1928 and envisaged massive industrialization and increased electrification of the USSR. By 1931, Soviet electricity generation capacity had reached 10.7 GWh, exceeding GOELRO's goal of 8.8 GWh. By 1935 the USSR was third in the world for total electricity generation, behind only the USA and Germany. By 1940, the Soviets had 48.3 GWh of electricity generation capacity, in just nine years increasing 1931's capacity by well over four times.

Electricity generator plants by large cites were "thermal electric stations" (TETs) that not provided electricity but usually also heating for the city. These plants used steam-driven generators that reused the spent steam to provide hot water and steam heat via pipelines to office buildings, factories, and apartment buildings.

One goal of Soviet electrification was for electric streetlights to replace the older coal gas and kerosene street lamps. This was accomplished gradually as the electricity industry was built up. For example, the last of the old-style street lamps in Moskva were replaced with electric streetlights in 1932. Interestingly, the city still required the equivalent of lamp lighters for the electric streetlights. People would have to walk the streets each dusk to manually turn on the lights one-by-one, and again each morning to turn them off. It was only in 1941 that Moskva

203 Jared James Dye; thesis, "From Leader to Laggard: The Development of Wind Power in Russia"; 2017; https://etd.ohiolink.edu/apexprod/rws_etd/send_file/send?accession=osu1492725236380155

obtained a centralized system for turning the lights on and off all at once. Almost ironically, a few months after the system was installed, Germany invaded the USSR and Moskva's streetlights were subjected to a mandatory, complete blackout. The blackout was only lifted on 30 April 1945, just days before Germany surrendered.

Soviet 100-KW wind turbine at Yalta[204]

Wind generation of electricity also greatly expanded in the 1930s. TsAGI had developed a 100 KW wind turbine that could be connected to the power grid. The first one was erected on a 30-meter (98-foot) tower in the Crimea at Yalta in 1931. It was the largest wind power installation in the world at the time. The Soviets went on to install "dozens" of these turbines in the southern regions of the USSR[205]. In 1938, the Soviet began construction of a 5 MW wind farm in the Crimea, which by itself would have required 50 of these turbines[206].

The Soviets also developed a flywheel in an evacuated casing to store kinetic energy from the wind. During low-wind periods when a wind turbine could no operated, energy from the flywheel was used to generate electricity. It is unclear, however, if flywheels were ever extensively deployed or if they remained an experimental technology at the time.

204 https://bldgblog.com/2008/12/the-inhabitable-wind-turbine/

205 Jared James Dye; thesis, "From Leader to Laggard: The Development of Wind Power in Russia"; 2017; https://etd.ohiolink.edu/apexprod/rws_etd/send_file/send?accession=osu1492725236380155

206 During the German occupation of Crimea in World War II, I have no mention of the Germans using any of these wind turbines. Likely, the Soviets evacuated or destroyed these turbines as they retreated.

Despite the deployment of many wind turbines, wind power supplied only a minuscule amount of electricity for the Soviets. I estimate it was much less than 0.1% of Soviet total electricity generation, based on a wild guess that it was likely less than 20 MWh.

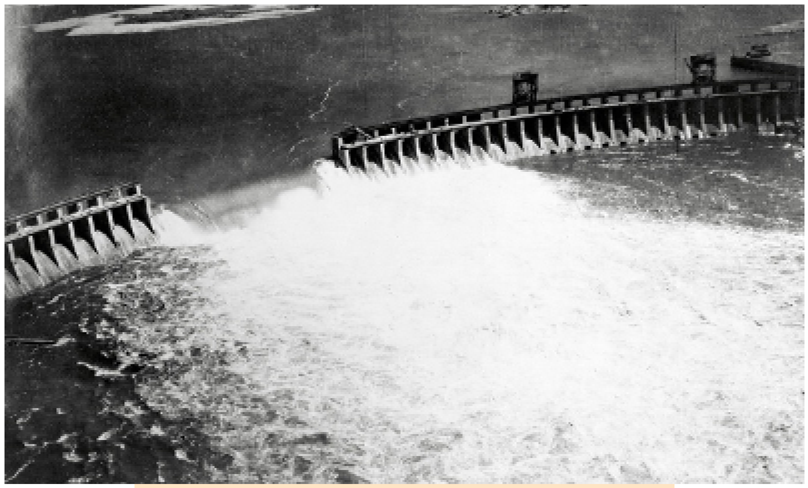
Water power, however, was easier to harness at scale. The preeminent Soviet hydropower project of the 1920s–1930s was the building of a massive dam, huge reservoir, and capacious hydroelectric plant on the Dnepr River in central Ukraine. The power plant would supply electricity to cities, mines, and industrial facilities throughout the region. The location of the dam was chosen so that it would flood an almost 100-km (60 mile) stretch of rapids in the river. Ship locks were also to be built to allow large, sea-going ships to sail from the Black Sea to Kiev. Previously, only smaller river boats could make the journey to Kiev.

Location of DneproGES in the Ukrainian SSR and approximate extent of the reservoir

Note: Crimea was part of the Russian SFSR at this time. It was later transferred to the Ukrainian SSR (1954). After the dissolution of the USSR (1991), the Russian SFSR became the Russian Federation and the Ukrainian SSR became Ukraine. Russian military forces later took Crimea from Ukraine (2014).

The Soviets did not have the engineering experience or the industrial ability to build and equip a huge hydropower plant, so experts and turbines from the USA were brought in, together with other equipment from Germany and Czechoslovakia. American engineers, technicians, and managers directed the project on-site on a daily basis for years. Soviet engineers and technicians assisted, learning how to handle such a project, gaining knowledge and experience they would then use in building large hydropower projects on the Volga River.

The first generator was installed in May 1932, and the power plant began supplying electricity in October of that year. This was the operational start of the Dneprovskaya Hydroelectric Station named for V.I. Lenin, aka DneproGES. The capacity of the plant was incrementally increased until it reached full generation ability in 1939, making it the third largest hydroelectric plant in the world at that time. It was the largest hydroelectric plant in Europe until larger plants on the Volga River were built.



DneproGES breached, 18 August 1941

After the Germans invaded the Soviet Union in June 1941, DneproGES soon became a casualty of war. In early August, the Germans had encircled and destroyed a large Soviet force west of the Dnepr River in central Ukraine. The Soviets realized that they could not halt the Germans west of the Dnepr, so they began building a defense line on the east bank of the river. On 18 August, to deny the dam and power plant to the Germans, Soviet engineers set off 20 tons of demolitions that breached the dam and destroyed the generators. This unleashed a massive flood that drowned perhaps 20,000–30,000 Soviets, mostly civilians but also some soldiers attempting to retreat across the river. The German military claimed 1,500 German soldiers approaching the river were also lost.

During the German occupation of Ukraine, a massive lack of electricity hampered German plans to exploit Ukrainian resources. Rebuilding the Dnepr dam and restoring the hydropower station became a key German project. Work started well before May 1942, when the German high command decided to also rebuild some Ukrainian industries, which would also require Dnepr electricity. The project was overseen by Organization Todt. Experts brought in from German companies managed about 1,600 Ukrainian civilian workers and 2,500 Soviet POWs to repair the breach and install generators[207]. Electricity generation began on 31 December 1942[208]. By April 1943, the plant was supplying 96% of the electricity in its region and 78% of that in the Donbass. The availability of this power sped up the draining of the flooded Donbass mines.

207 Kim Christian Priemel; "Occupying Ukraine: Great Expectations, Failed Opportunities, and the Spoils of War, 1941–1943"; *Central European History* Vol. 48 No. 1; 2015; http://www.jstor.org/stable/43965115.

208 Some Russian- and Ukrainian-language sources possibly using Soviet-era information claim the Germans resumed electricity generation at DneproGES in mid-1942. Priemel (see previous footnote) using German wartime records claims 31 December 1942.

> In the autumn of 1943, with a Soviet offensive approaching the river, the Germans destroyed the dam and power plant. They had intended massive damage using 300 tons of explosives, but the demolition was not complete. Soviet scouts and engineers managed to disconnect some of the wires leading to the detonators. The Soviets in turn in January 1944 began restoring the dam and power plant, removing 66 tons of explosives as part of the effort. Improved American generators were imported for the plant, with the first one becoming operational in 1947. The plant was full restored in 1950.

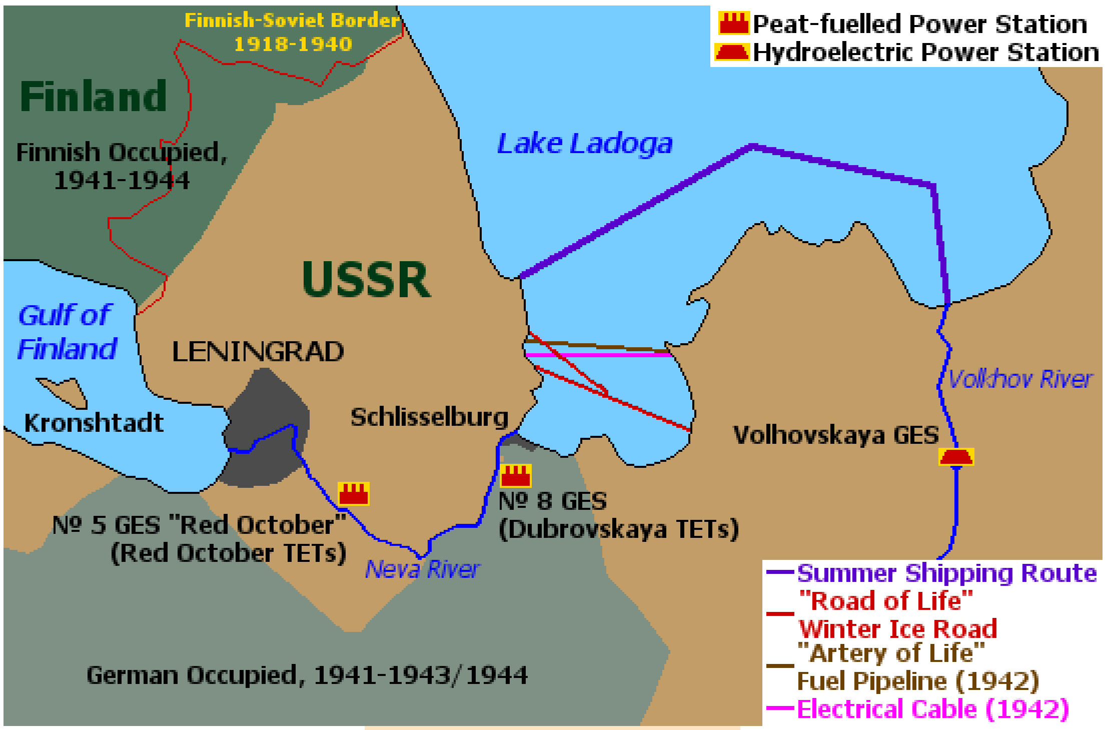
In the 1930s, many hydropower stations were built using the forced labor of GULag inmates. DneproGES was not, almost certainly because of the on-site presence of American engineers and managers supervising the project. They might have refused to work with forced laborers and likely would have been appalled by how GULag prisoners were treated. This could have resulted in unwanted international attention. Instead, Soviet citizens were hired as wage laborers. They lived on the site in rather poor housing conditions at first, which improved over time.

Hydropower projects without a foreign presence, however, greatly used GULag slave labor. For example, the "Big Volga" hydroelectric plan called for the construction of reservoirs and power plants along the Volga River. The scale of effort can be seen by the fact that 97,000 GULag prisoners were involved in building just two of the plants: the Uglich plant near Yaroslavl and the Rybinsk plant north of Moskva. More prisoners were used at the other Volga projects.

When the war started on 22 June 1941, electricity generation quickly became a major concern for the Soviets. By the end of that month, the Soviets had ordered crash construction projects to finish electricity plants under construction. They feared the Germans would attack their electricity plants by sabotage and bombing. Unknown to the Soviets, attacking these power plants was not in Germany's plans for 1941. The Germans expected the USSR to collapse with German forces capturing much of the western part of the country. German special operations efforts were far less in scope than what the Soviets feared they would be, and, in 1941, mainly concentrated on military objectives near the front lines. The Luftwaffe was used extensively as a tactical air force in support of ground operations. Some strategic bombing operations were occasionally launched against Soviet cities and facilities including factories and power plants. Other than two medium-sized night strikes against Moskva in July, the remaining strategic air operations were sporadic night raids against facilities using 12 or fewer bombers, little more than nuisance raids. Even the Moskva strikes were not sustained in strength or duration to cause serious, lasting damage.

The Soviets quickly adopted a scorched earth policy to try to prevent the Germans from capturing almost anything they could use for their war effort or economy. Facilities of all sorts in the path of the invaders were evacuated. This included generators, turbines, and electrical equipment from power plants and electrical substations. What could not be evacuated was damaged or destroyed whenever possible. The Germans did manage to capture important equipment and resources, but after the initial weeks of the invasion they were able to seize far fewer things of value.

In August 1941, it became clearer to the Soviet high command that the Red Army was not yet able to halt the invaders and further territory would be lost. The Soviets accordingly ordered further crash construction projects to build or finish power plants in the Volga River region, Central Asia, the Urals, and western Siberia, all places where the Soviet were evacuating their factories. Many of these plants received generators, transformers, and other electrical equipment evacuated from the western USSR.



Leningrad area, 1941–1944

Notes: Schlisselburg was liberated from German occupation in 1943. It was renamed Petrokrepost ("Peter's Fortress") in 1944, as "Schlisselburg" was too Germanic a name. It resumed its Schlisselburg name in 1992, following the collapse of the USSR in 1991.

There was a workers' settlement next to № 8 GES, which in 1953 became the town of Kirovsk.

What is labeled Finland on the map was part of Finland until 1940. At the end of the Winter War of 1939–1940, a large part of southeastern Finland was ceded to the USSR, including all Finnish territory shown on the map. In 1941, Finland attacked the USSR following the German invasion and regained its former territory, considering it part of Finland again. Finally, in 1944, Finland was defeated and lost this territory again.

In September 1941, the Germans cut Leningrad's overland communications to the rest of USSR, starting a long siege of the city. Leningrad was the birthplace of the Soviets' rise to power, was the USSR's second largest city, was a major naval center, and had significant industry that had not been evacuated. The Soviets were determined to hold the city if at all possible. However, the city immediately had an electricity shortage, as one major thermal power plant, № 8 GES, fell to the enemy and one hydropower plant was shut down and its equipment evacuated in case the Germans moved to take it. The rest of the story on № 8 GES is told below.

Dubrovskaya TETs (№ 8 GES named for S.M. Kirov) near Leningrad

In June 1931, construction began on this 200-MW power plant. The plant would greatly increase the supply of electricity to Leningrad, which was supplied with only 140 MWs in 1929. The plant, the Dubrovskaya TETs, was a pet project of S.M. Kirov, a top Party leader in the Leningrad region and a strong supporter of Stalin's industrialization drive. The plant was sited near a peat deposit on the Neva River, about 55 km (34 miles) east of Leningrad. The peat would supply fuel for the power plant. The plant officially opened in March 1933 when its first 50-MW steam turbine generator became operational, with the second 50-MW turbine following in November. In March 1934, the plant was renamed the № 8 GES named for S.M. Kirov. In December 1936 a third 50-MW generator came on line, and the fourth and final one became operational in 1938. However it seems that further work was necessary (possibly construction of additional boiler capacity to provide more steam for the turbines), as another source notes the plant did not achieve its full 200-MW capacity until 1940. The plant was a source of heating as well as electricity. However, Leningrad was much too far away to benefit from its heating ability, which was instead used locally.

The outbreak of war on 22 June 1941 immediately affected the plant. The workers set up air defenses and instituted a blackout to make it difficult for enemy bombers to find it at night. The workers also organized into People's Militia units to defend the plant. Enemy air power did not bomb the plant. Instead, the danger came over land when the German Army Group North broke through the Soviet front lines and advanced into the Leningrad region. The Red Army stopped the Germans outside of Leningrad itself but could not halt them from advancing along the Neva River to the shores of Lake Ladoga. Leningrad was thus cut off by land from the rest of the USSR, and № 8 GES was captured by the Germans, taking down one of Leningrad's major sources of electricity. Before the plant was captured, Soviet power engineers managed to evacuate one turbine and one boiler to the east. The plant remained close to the active battle zone and was quite near the Soviets' Neva Spot bridgehead, from which the Red Army launched several courageous but failed attempts to break the German encirclement.

In January 1943, Soviet forces from the east managed to take a small corridor along the shores of Lake Ladoga, creating a tenuous land connection to Leningrad. The next month in February, they managed to seize the area containing № 8 GES. The Germans severely damaged the plant's building and remaining equipment before withdrawing. The front lines remained quite near the plant. The Soviets accordingly did not attempt to restore the plant in 1943. In January 1944, the Soviets finally pushed the Germans out of the Leningrad region, and in June 1944, they started to restore the plant. Generation of electricity began in March 1946. The plant reached 100-MW capacity in 1947 and 200-MW capacity in 1950. The plant underwent later expansions and name changes, and it switched from using peat to natural gas. The plant is still in operation today and is still also a thermal plant supplying heating mainly to what has become the nearby town of Kirovsk, named for S.M. Kirov.

Before the end of September 1941, Leningrad was left with only one large, peat-fueled power plant (№ 5 GES) next to a peat extraction operation, and several small, coal-fueled power plants. Soon, Leningrad's stockpiles of coal was exhausted, leaving just the peat plant operational. Leningrad's electricity was greatly rationed, with only hospitals, crucial military facilities, and a few critical industries needed for the defense of the city being powered. The rest of the story on № 5 GES is told below.

№ 5 GES “Red October” in 1930 (formerly Red October TETs)
(See map above for its location.)

A Belgian company began construction of an electricity generating station, the Utkina Plant, just before the start of World War I. The plant was intended to supply electricity to Sankt-Peterburg, the capital of the Russian Empire. Sources disagree on how it would be fueled, with one claiming “English coal and fuel oil” while others claiming peat. Perhaps the fact that it was built near a peat-producing location is a clue. The war, however, prevented the plant from being completed.

After the Russian Civil War, with the Soviets in control of the country, they included the completion of this plant, now called Red October TETs, in their GOELRO plan. Like many GOELRO plants, Red October TETs would burn peat to boil water and use the resulting steam to generate electricity in turbines. In October 1922 the first turbine became operational. The rest of the plant was completed by 1926, and its generation capacity was expanded in 1929–1930. Sometime in the 1920s the plant was renamed № 5 GES “Red October”. It was one of several plants supplying the city, now called Leningrad, with electricity.

In 1941 during the war, the Germans besieged Leningrad, cutting off all overland communications with the city. They also captured № 8 GES, Leningrad’s largest source of electricity, and caused Volkhovskaya GES, Leningrad’s second largest source of electricity, to go off line. Red October became Leningrad’s only significant remaining power plant, while a few small, coal-fired plants supplied the city with only a fraction of Red October’s output. The city had to severely ration electricity, with only hospitals, crucial military needs, and critically-needed factories receiving power. In January 1941, Leningrad’s stockpiles of coal ran out, and Red October became the city’s sole source of electricity.

Being located near its source of peat, Red October at least would not run out of fuel. Except, it did. It had no reserve stockpiles of milled peat and depended on newly milled peat being delivered daily. The winter of 1941/1942 was extremely cold, and one night in February the water froze in the idled steam locomotives that hauled peat to the plant during the day. With no fuel, the plant shut down, the plant's boiler then froze, and Leningrad was without any electricity at all. During the next day, the Soviets managed to get one locomotive operating and hauling peat and also managed to thaw out the plant's boiler. The plant resumed operation.

In late March 1942 an improved boiler was put into operation, which allowed electricity generation to be increased. Freight trams could now be put into operation in Leningrad, followed by limited-service passenger trams in April. The besieging Germans were well aware of the importance of the plant to Leningrad. They frequently shelled it with artillery but failed to disable it[209]. Red October remained Leningrad's only significant source of electricity until September 1942, when the Soviet laid an underwater electric cable across Lake Ladoga, increasing the supply of electricity to the city. Factories were able increase their output.

The Germans failed to knock out the USSR in 1941 but survived the subsequent Soviet winter counteroffensive. When good weather returned, the Germans went on the offensive again. For much of 1942, the Germans hoped to capture the oilfields and refineries in the North Caucasus and Transcaucasus regions, as well as the cities of Leningrad and Stalingrad. Once again the Luftwaffe was used mainly as a tactical air force in support of ground operations, with only occasional night strategic raids on Soviet facilities. German special forces were used to try to stir up rebellion in restive Soviet ethnic groups near the front lines and in hopes of seizing oil facilities at Groznyy if German regular forces were about to capture this oil center. Only when these hopes were dashed did the Germans start bombing Soviet infrastructure. Groznyy's oil infrastructure was struck in October 1942. Other tasks, mainly reacting to Soviets and Allied offensives, then occupied the Luftwaffe until spring 1943. In June 1943, the Luftwaffe launched a series of strategic bombing raids on three Soviet cities containing factories and refineries. No power plants were targeted, however. Afterwards, the Luftwaffe supported the failed German offensive at Kursk in July and then for the rest of the war supported German ground forces against a steady drumbeat of Soviet offensives.

Other than partially restoring the Volkhovskaya GES hydropower plant to supply electricity to besieged Leningrad, the Soviet electricity effort in 1942 was to build electric generation capacity mainly in Central Asia, the Urals, and Siberia, while evacuating generators and other electrical equipment out of the path of the German 1942 offensive. 1942 was the nadir of Soviet electricity generation, being only about 60% that of 1940.

209 The plant was beyond direct observation range of artillery spotters in the German front lines. Had they been able to observe the plant, they would have been able to improve the accuracy of the artillery fire. This might have been enough to put the plant out of operation, making life in Leningrad even more harsh.

The Germans planned to use territory they occupied in the USSR to supply food and various raw materials for the German economy, such as oil and manganese ore. Soviet centers with resources centers in sufficient supply in Germany, such as iron ore and coal, were to be left in ruins. The German occupation forces needed electricity to efficiently exploit Soviet resources as well as for other tasks, but the Soviet destruction of their power plants hindered the German efforts. The Germans thus had to rebuilt many power plants. They also had to bring in, at a fair expense, coal from Germany to fuel some of the plants, until they finally decided to restore some coal production at the captured Donbass coal center.

Things turned badly against the Germans in 1943. The Soviet won the Battle of Stalingrad and began to drive back the Germans. They then won the Battle of Kursk and began a series of offensives that liberated occupied Soviet lands and ultimately drove into Germany, capturing Berlin. As the Germans retreated, they destroyed electrical infrastructure. On the order of 60 power plants were badly damaged or destroyed by the Germans. For the rest of the war, the Soviets worked to restore these power plants and also continued to build new electricity generation capacity in the never-occupied regions of the country.

Once the Germans were losing the war, some in the German high command wanted to attack Soviet power plants, in the hopes of greatly disrupting the Soviet economy and war effort. In 1943, a Luftwaffe plan called for attacking Soviet hydropower plants at reservoirs in the Moskva and central Volga regions, together with strikes on electrical substations and power lines. The Germans believed that if two-thirds of the hydro turbines at the plants were destroyed, the Soviet defense industry would lose about 75% of its electricity. However, German analysis of the Soviet electricity system seems to me to have been seriously flawed. Hydropower generated only on the order of 10% of Soviet electricity. (It was 10.6% in 1940. I have not found wartime percentages.) There's no reason to believe that Soviet defense industry was so dependent just on hydroelectric power, when about 90% of Soviet electricity came from thermal plants.

Nonetheless, knocking out these hydropower plants would have caused the Soviets serious difficulties, albeit not as catastrophic as the Germans believed. The Soviets would have had to ration electricity strictly. Almost certainly, the civilian economy would lose more of its access to electricity, so that the key defense industries could still function. Also, the Soviets could not easily replace destroyed hydro turbines. All their large turbines had been imported, from Sweden and, mostly, the USA. Soviet industry was not yet capable of manufacturing large turbines like these. American Lend-Lease could have sent replacements (as indeed it did for the Dnepr hydropower plant late in the war), but this would have taken time. Even damaging a hydro turbine might have been enough to knock it out for a considerable period. Allegedly, the Soviets only had one factory with the capability of repairing hydro turbines, and it was located in besieged Leningrad.

Soviet electricity was also likely vulnerable in ways the Germans may not have realized. The Soviet electric grid almost certainly had little excess generation capacity. Further, since the USSR was a huge country, the various regions on the Soviet power grid were likely not robustly interconnected, due to the expense of doing this. Thus, if a region's plants and grid suffered serious bombing, it is likely that there was little electricity to send from other regions and few connections to get it there. In other words, the Soviet situation was likely the opposite of what the US military believed was the case for Germany: robust inter-regional connections and excess electricity generation capacity of up to 20%[210]. These factors dissuaded the US from launching a serious, sustained bombing campaign against German electricity infrastructure.

The German plan envisioned the use of special floating bombs to destroy the hydro turbines. These were to be dropped in the reservoirs near the plants and would float into the turbine's water intakes, exploding in the turbines. These bombs, however, had a number of technical issues that delayed their deployment. This kept postponing the operation until it became impractical. Soviets offensives pushed the Germans back, out of medium bomber range of the reservoirs, while Soviet and Allied air operations seriously weakened the Luftwaffe. The Germans were mostly forced to concentrate on defensive fighter forces at the expense of offensive bomber forces.

This was not the end of Germany's interest in bombing Soviet power plants. To strike them, they planned to use an improvised, but possibly highly-effective secret weapon: the Mistel composite bomber.

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210 Germany actually developed an electricity shortage at times during the war, but the US was not aware of this.

One version of the German Mistel composite bomber

The Germans developed the *Mistel* ("Mistletoe") by attaching a single-engine fighter to a multi-engine bomber modified to become in effect a huge flying bomb. The bomber did not have a crew, defensive armament, or any gear unnecessary for its use as a flying bomb. It retained its engines, fuel tanks, and controls, and it was packed full of explosives, up to 1,800 kg (3,960 lbs). Many were configured as shaped-charge bombs, with a modified nose replacing the bomber's regular nose.

The fighter was structurally attached to the bomber with explosive bolts and had a fly-by-wire system connecting the fighter's cockpit to the bomber. The fighter pilot flew the composite aircraft to within a couple of miles (3–4 km) the target using the bomber's fuel, aimed the bomber in a shallow dive, detached the fighter, and flew back to base using the fighter's fuel. The flying bomb was equipped with an autopilot that kept it on course towards the target.

Submodels of the Me 109 or Fw 190 were used for the fighter, and submodels of the Ju 88 were used as the flying bomb. Design projects envisaged using other fighters and bombers for future versions of the Mistel, including the Me 262 and He 162 jet fighters, the Ju 287 jet bomber (which was only in prototype stage), and the Arado E.377 jet-powered glide bomb (under-development), which the fighter pilot could guide to its target via a control cable.

While the Mistel did not compare well to an Allied heavy bomber, for the late-war Germans with their growing resource problems, it provided them with what was in effect a long-range fighter-bomber with a powerful punch. The shaped charge explosion could penetrate up to 50 cm (19.5 inches) of warship armor (some sources say 70 cm) and to blast through about 18 m (60 feet) of reinforced concrete. Since the aircraft flew to the target using the bomber's fuel, the entire fuel of the fighter was available for a one-way flight back to base. With an Fw 190G fighter equipped with two drop tanks, the fighter could fly about 930 miles (1,500 km), sufficient in 1944 to return to eastern Germany and in 1945 to return to the Courland Peninsula, a part of Latvia still held by the Germans. By 1945, the Germans were also prepared to have the pilots ditch their fighters and try to return home on foot if, on the return flight, poor flying conditions or enemy opposition resulted in too much fuel being consumed to reach an airfield.

As the Germans developed the Mistel bomber, interest grew in using it against Soviet power plants. If the bomber hit the plant right, the powerful jet from the shaped-charge explosion would have been very destructive. In early 1945, plans were underway to assemble a force of about 100 Mistels to attack both thermal and hydropower plants in the Moskva and central Volga regions. The Mistels would fly at night, to avoid Soviet day fighters. Since the target regions were out of range of German medium bombers, it is possible the attacks would have caught Soviet air defenses by surprise. The attacks thus might have succeeded, disrupting some electricity generation and industrial production. Coming so late in the war, however, it is difficult to see how this would have altered the war's outcome at all.

In any event, events in the war precluded the attacks from being made, even though neither the western Allies nor the Soviets seemed to have been aware of the German plan. Allied bombing hampered the assembly of the force and destroyed some Mistels. Devastating Soviet offensives in Poland and eastern Germany as well as Allied offensives in the west induced the Germans to expend Mistels in attacking bridges near the front, in hopes of slowing the enemy advances. With the German ground forces now collapsing, however, nothing could stop the total defeat of Nazi Germany.

By the end of 1945, with the war over and the Soviets concentrating their efforts on rebuilding the country, Soviet electricity generation reached 90% of the 1940 level and soon surpassed 100% in 1946. A lot of this generation capacity came from power plants that were never captured by the Germans or were newly completed during the war. Many plants destroyed by the Germans were only fully restored years after the war ended.

Soviet Electricity Usage, 1940–1945 (in gigawatt hours, GWh)

Category	**1940**	**1942**	**1943**	**1944**	**1945**
GWh Electricity Generated	48.309	29.068	32.288	39.214	43.257
Electricity Usage:					
GWh used by Industry	32.093	19.953	22.343	26.619	28.377
Industry %	66.4%	68.6%	69.2%	67.9%	65.6%
GWh used by Power Plants	2.559	1.723	1.950	2.423	2.656
Power Plants %	5.3%	5.9%	6.0%	6.2%	6.1%
GWh used by Agriculture	0.538	0.232	0.254	0.300	0.398
Agriculture %	1.1%	0.8%	0.8%	0.8%	0.9%
GWh used by Rest of the Economy	9.69	5.24	5.43	6.84	8.19
Rest of the Economy %	20.1%	18.0%	16.8%	17.4%	18.9%

GWh lost to Network Losses	3.43	1.92	2.31	3.03	3.63
Network Losses %	7.1%	6.6%	7.2%	7.7%	8.4%

Source: Narodnoe Khozyaystvo SSSR v Velikoy Otechestvennoy Voyne 1941–1945 gg. (*People's Economy of the USSR in the Great Patriotic War 1941–1945*); a 1959 formerly-secret statistical compilation by the Soviet government. The Power Plants rows represent electricity consumed by the power plants themselves. Network Losses are unavoidable losses of electricity as it is distributed over a network of electrical lines and transformers (much of it by the Joule Effect, heating that occurs when an electric current flows through a resistance). For comparison, network losses in the USA in the 2010 averaged about 5% to 6% of generated electricity.

9 Human and Animal Power

Notes: This section contains an overview of Soviet labor, including civilian workers and forced laborers. Only the highlights are covered on this complex, immense subject.

The Russian phrase "*professionalnykh soyuzov*" (sometimes abbreviated as "*profsoyuzy*") is typically translated into English as "trade unions", but I use "labor unions" since it corresponds best with American usage. By the way, "*professionalnyk*" does look like the English word "professional" and can mean that, but it can also mean "vocational" and "occupational".

I used terms like "free citizens" and "free workers" to mean people who are not prisoners. Free workers thus means people in the Soviet work force who were not prisoners and not subject to forced labor. These people earned wages, so their labor was not free.

9.A Overview

Old and New: A Soviet horse-drawn vehicle advancing beside Soviet tanks

The 1920s-1940s Soviets extensively used human and animal power. Agriculture used both in abundance, even despite major efforts to mechanized agriculture in the 1930s. Animal power, usually horses but sometimes oxen, were used to haul loads wherever motor vehicles were not present. Regional use of animals included camels as pack animals in Soviet Central Asia, reindeer as pack animals and sled pullers in the northern parts of the USSR, and dogs as sled pullers also in the northern parts of the USSR.

The Soviets only seriously built up automotive and tractor industries in the 1930s. Even though production concentrated far more on trucks and tractors than passenger cars, by the start of the war in 1941 there simply were not enough trucks or tractors for agriculture, the cities, or the military. Horses pulling carts, wagons, and artillery pieces were still used extensively. The table below shows the USSR in comparison to two of the leading capitalist industrial countries, the USA and the United Kingdom. In the US and UK, free markets allowed ordinary citizens to purchase what they wanted most, which as the table obviously shows was passenger cars. In the USSR, a centrally-planned command economy delivered what the government and Party leaders wanted, which clearly wasn't passenger cars.

Stock of Horses and Motor Vehicles 1939

Country	Horses	Passenger Cars	Trucks	Tractors
USA	10,815,000	26,201,000	4,414,000	1,567,430
United Kingdom	987,000	2,132,000	492,000	52,000
Germany	3,000,000	1,535,431	450,641	n/a
USSR	20,200,000	125,000	766,880	438,000

Note: The USSR is estimated to have had about 34 million horses in 1929, falling to about 20 million by 1939 due to the effects of mechanization, famine, and peasant farmers slaughtering livestock when forced into collective agriculture.

After the war began in June 1941, the USSR quickly lost many thousands of trucks and tractors. Human and animal power had to substitute. Horses towed many of the lighter artillery pieces for the Red Army rifle forces. With the loss of many tanks, horsed cavalry for a while became the largest component of Soviet mobile forces. From one-horse carts to multi-horse wagons, horses hauled supplies to the troops wherever trucks were not available. At the start of the war, Soviet horse stocks were about 20 million horses. However, the war quickly took a great toll of Soviet horses. The Soviets lost about 11 million horses, due to Red Army reverses and loss of territory. Throughout the war, the Soviets had to manage a horse shortage as best they could.

11.7+7.7+3.6+2.5+2.3

Soviet Work Force, millions

	1940	1941	1942	1943	1944	1945
Total Work Force	87.2	73.4	55.1	57.5	67.4	76.0
...in Military Services	5.0	7.1	11.3	11.9	12.2	12.1

...Total Civilian Work Force	82.2	66.2	43.8	45.5	55.3	63.9
…...in Agriculture	49.3	36.9	24.3	25.5	31.3	36.1
...Civilian Non-Agricultural Work Force	32.9	29.3	19.5	20.0	24.0	27.8
...in Industry	13.9	12.8	8.8	9.1	10.3	11.7
...in Civilian Services	9.1	7.7	4.8	5.1	6.5	7.7
...in Transport/Communications	4.0	3.5	2.4	2.4	3.0	3.6
...in Trade and Catering	3.3	2.8	1.7	1.7	2.1	2.5
...in Construction	2.6	2.5	1.8	1.7	2.1	2.3

Source: Derived from Mark Harrison; "Soviet Production and Employment in World War II: A 1993 Update"; *Soviet Industrialisation Project Series*, No. 35; 1993. I have added "Total Civilian Work Force" (being Total Work Force excluding Military Service) and "Civilian Non-Agricultural Work Force" (being Total Work Force excluding Military Service and Agriculture) to show these important categories and allow comparisons with other sources.

These are Harrison's estimates based on studies of the Soviet economy. GULag forced-labor prisoners are apparently included in the totals, although this is difficult to ascertain as Harrison does not go into detail on it. It is also unclear to what extent Harrison captures the employment of women and child once the war began. He only alludes once to "compulsory mobilization of previously non-employed civilians", which presumably includes women but perhaps not children.

The large increases in the civilian work force in 1944–1945 almost certainly is mostly due to people in liberated Soviet territory rejoining the Soviet work force.

Despite these potential problems, Harrison estimates covers the wartime years. No other sources I've found do far do this, except for 1945.

To check the accuracy of Harrison's estimates, I have compared the figures with Fitzpatrick who has some figures for 1940 and 1945 based on Soviet sources. For the civilian non-agricultural work force in 1940, Harrison has 32.9 million while Fitzpatrick has 33.9 million. For the civilian non-agricultural work force in 1945, Harrison has 27.8 million while Fitzpatrick has 28.6 million. Based on these two data points, Harrison's estimates appears to be short about 0.8–1.0 million workers and appear good enough to see the broad picture of the wartime work force.

Human labor in the USSR, particularly under Stalin, developed into a peculiar, tiered system. The top tier consisted of tens of millions of civilian (non-prisoner) workers, the proletariat. The bottom tier consisted of convicts and political prisoners in forced-labor prisons. Under Stalin, prisoner labor evolved into the GULag system of camps and colonies. The prisoners at GULag camps essentially were slave laborers who either worked or starved.

Only Nazi Germany during the war would build a slave labor system than rivaled and then surpassed that of the USSR. During the war, a third, middle tier of labor developed, consisting of millions of forced laborers, who were classified as prisoners but not were not convicts nor in the GULag.

9.B Civilian Labor

The Bolshevik Party's ideology placed the Party as the "vanguard of the proletariat", leading the workers first into revolution to overthrow their oppressors and then in the building of a socialist state. After the revolution, the Bolsheviks set up their Soviet state and became the Communist Party. In November 1917, the Soviets issued a Decree on Workers' Control, putting the workers in charge of all industrial, commercial, and agricultural enterprises, removing the former owners and managers from any role in the enterprises. They soon began confiscating, without compensation to the owners, all major industries and businesses, establishing state control over the economy and trumpeting the triumph of the proletariat over their bourgeois exploiters.

Nonetheless, the Soviets themselves soon encountered labor unrest. Mostly, only politically-radicalized workers, a minority of all workers, were firmly on their side. Most workers were mainly interested in their own welfare and not in Communist ideology. With all major enterprises now owned by the Soviet state, the Communists, the self-proclaimed protectors of the proletariat, found it politically embarrassing when workers went on strike over labor conditions. They responded by centralizing Soviet power over the workers, removing non-Communist workers from positions of control in enterprises, and turning labor unions into Communist-controlled organizations that supported government policy and refused to allow strikes. Rather than representing the workers, one of the main tasks of labor unions was to indoctrinate the workers with political education that supported Party policies and government regulations.

Sidetrip: Strikes, Labor Disputes, and Teykovo

According to Marxism-Leninism, strikes were a product of class conflict between the exploiting capitalists and the exploited proletariat. Thus, strikes were not supposed to occur in the socialist USSR. The Soviets themselves of course exploited their workers, who protested in various ways. To avoid even using the work "strike" or the notion of collective action by workers, the Soviets tried to categorize labor unrest as only "labor disputes", and only between individuals and their places of employment.

Strikes, however, did occasionally happen in the USSR, even during Stalin's brutal rule. When the level of worker mistreatment grew unbearable, workers would go on strike without the authorization of their Soviet-controlled labor unions. For example, a number of miners' strikes occurred in 1930 because of conditions in the mines during the First Five-Year Plan's drive to significantly increase output.

The Teykovo strike was the largest collective action by workers during Stalin's rule. 16,000 cotton workers at Teykovo, a town about 240 km (150 miles) west-northwest of Moskva, went on strike in April 1932 over reductions to the daily bread rations for not only the workers themselves but also for their families. Almost all of the workers joined the strike, except for members of the Communist Party, the Komsomol (Communist Youth League), and a few others. The Soviets responded by branding the strikers as counterrevolutionaries and brought in the secret police, who attempted to arrest the strike's leaders. As it became clear the Soviets were uninterested in granting any real concessions and were going to resort to repression and violence, the strike fizzled out. The Soviets would go on to retaliate against the strike leaders and "class-alien" strikers (people with class origins outside the proletariat), primarily by subjecting them to varying degrees of internal exile in the USSR. The Soviets also enacted strict laws on "theft of socialist property" and against work "absenteeism" as methods to deter future strikes.

Whether it was the workers running the enterprises or the Soviets themselves, almost none of these people had any managerial experience. The result was that most enterprises were run poorly and inefficiently. The Soviets ended up bringing back former many "bourgeois" managers to run the factories more efficiently, while watching them for counter-revolution and sabotage.

Another trouble for the Soviets is that they wanted to get more labor out of their workers without paying for it. In 1919, during the Russian Civil War, the Soviets devised a way to do this. It consisted of workers putting in a voluntary day of labor without pay on some of their days off. Soviet propaganda claimed this started in the railroad sector. The railroads were in so dire straits in 1919 that railroad workers on their own initiative began doing unpaid labor after their shifts and on days off. At least some of this did occur, but in actuality, voluntary days of labor under the Soviets had occurred earlier. The Soviets seized upon the railroad origin story to promote the practice and quickly spread it across the Soviet economy.

This work was supposed to be voluntary. In the early days, many did genuinely volunteer, especially the politically-motivated supporters of the Soviet regime. However, it is very likely that the Soviets also used social pressure to induce some, perhaps many, to volunteer against their inclinations. This volunteer work became know as *Subbotnik*, named after the Russian word for Saturday, when the work was often done, and also as *Voskresnik*, after the Russian word for Sunday, another day sometimes used for voluntary work. *Subbotnik* and *Voskresnik* also became known as “holidays of liberated labor”, taken from a speech by Lenin. (For convenience, I just call the practice *Subbotnik*, regardless of what day it occurred on. Indeed, changes to the Soviet work week would mostly divorce *Subbotnik* and *Voskresnik* from Saturday and Sunday for over a decade. *Subbotnik*, *Subbotniki*, *Voskresnik* and *Voskresniki* also meant the person or people doing the work.)

Detail of a Soviet poster commemorating Lenin on *Subbotnik*, 1 May 1920

Subbotnik spread quickly after its introduction in 1919. The next May Day, 1 May 1920, was officially declared the All-Russia Subbotnik May Day. Lenin himself participated in it, and Soviet legend had him moving logs for four hours that day. After Lenin’s death in 1924, his birthday, 22 April, became the All-Union Leninist Communist Subbotnik, where Communist Party members and Komsomol were expected to volunteer for prepare for the upcoming May Day.

The Soviets multiple crises during the Russian Civil War, so obtaining unpaid, voluntary labor could be justified as necessary. However, Subbotnik became standard practices in the USSR throughout its existence and, at least during Stalin’s rule, became mandatory to all practical effect. The frequency of Subbotnik ranged from only a few days per year to almost weekly. While in theory workers were volunteers, they faced huge social pressure to participate and condemnation or dismissal if they refused. Managers eventually would often just put Subbotnik on the work schedule without asking for volunteers. Subbotnik became mandatory for workers in Soviet trade unions. The Soviet-controlled union leaders of the unions agreed to Subbotnik, and "proletarian trade union discipline" meant this agreement was the will of the workers[211].

Labor conditions were somewhat chaotic and unstable in the early USSR, due to the physical and economic devastation caused by World War I (1914–1918) and the Russian Civil War (1918–1922). War Communism had helped the Soviets win the civil war, as it essentially allowed them to take whatever they needed often with nominal or even no compensation. This, however, left the economy in a state of collapse by 1920–1921. The New Economic Policy (NEP), implemented over 1921–1922, allowed for a limited return of capitalism, private enterprises, and free markets, all under varying degrees of state control. By 1924, the economy was recovering, although unemployment was an issue, leaving about a million workers without jobs. The state provided some unemployment benefits and organized labor exchanges to match unemployed workers with jobs.

The NEP was successful, and its effects spilled over into the state-controlled parts of the economy. By 1928, it is estimated that urban and industrial workers' real wages had significantly risen compared to real wages in the pre-war Russian Empire[212]. The standard of living for agricultural workers also rose, since many peasant farmers could now earn a profit from selling their agricultural output in free markets.

The NEP ended in 1928 as Stalin increasingly exerted dictatorial control over the USSR and began to collectivize agriculture and industrialize. Stalin's ambitious industrialization program created very many jobs, and by 1930 the USSR was having labor shortages. Soviet propaganda proclaimed the USSR had full employment. The Soviets ended unemployment benefits and closed the labor exchanges. In reality, various forms of unemployment continued to exist, but, as long as person was willing to work, some job was available. Often, the long-term jobless consisted of professional criminals and beggars.

By now, workers did have somewhat better conditions than they had under the previous Russian Empire. There were plentiful jobs, which not only earned them wages but granted them housing and some social benefits. Workers had the right to change jobs. In various fields, to encourage people to work diligently, wages often made up only 80% of total possible monetary remuneration, with another 20% available in bonuses for meeting goals. Some industries instead paid using a piecework system, although piecework laborers could

211 Frederick I. Kaplan; "The Origin and Function of the Subbotniks and Voskresniks"; *Jahrbücher für Geschichte Osteuropas* Vol. 13 No. 1; 1965; http://www.jstor.org/stable/41042470

212 Robert C. Allen and Ekaterina Khaustova; "Russian Real Wages Before and After 1917: in Global Perspective"; 2017; https://nyuad.nyu.edu/content/dam/nyuad/academics/divisions/social-science/working-papers/2017/0003.pdf

not be paid less than a Soviet-decreed minimum wage. In some enterprises, in-kind goods made up part of workers' compensation. In-kind pay could be products the enterprise was making that workers needed themselves, or it could be kerosene, which many workers used at home as a fuel for cooking and sometimes for heating and lighting.

The USSR established many awards and prizes that encouraged work. These awards were open to any citizen, but some were very exclusive, essentially winnable only by the Soviet intelligentsia like scientists and other highly-educated or highly-talented people. Others could actually be won by anyone who made a valuable contribution to the economy or culture.

Sidetrip: Soviet Awards and Honor Related to Labor in Some Form

Note: The date is the year the award was established. In several cases, the award was first bestowed only in the following year.

Order of the Red Banner of Labor (post 1943 version)

1920: The **Order of the Red Banner of Labor** (*Orden Trudovogo Krasnogo Znameni*) was established in the Russian SFSR for outstanding service in economic production, science, labor activities, and various civil and social activities. At the time, the Russian SFSR was the Soviet state. When the USSR was formed, the Russian SFSR became one of several union-republics. In the 1920s (most sources give 1928 but some 1925), an Order of the Red Banner of Labor was created at the

USSR level. This elite prize was open to anyone who qualified, including common workers, but was awarded only to a few people. (The Order of the Red Banner of Labor was the civilian version of the military Order of the Red Banner, which was the first Soviet military decoration, established in 1918.)

1925: The **Lenin Prize** (*Leninskaya Premiya*) was a Soviet equivalent to the Nobel Prizes. It was awarded for accomplishments relating to science, architecture, the arts, literature, and technology. Given its award categories, it was essentially restricted to the Soviet intelligentsia. It was often known as the V.I. Lenin Prize. In the 1930s, as Stalin gradually downplayed veneration of Lenin in favor of a cult of personality celebrating Stalin himself, the Lenin Prize ceased to be awarded from 1935. Awards resumed soon after Stalin's death. (The Lenin Peace Prize was a later, different prize, reserved for foreigners. The Order of Lenin was also separate award and not work-related.)

1927: **Hero of Labor** (*Geroy Truda*) was a title awarded for people of outstanding merit in economic production, science, government service, or public service. Before 1927, Heroes of Labor titles had been given out by various Soviet regional and local organizations; the Soviet government institutionalized it for the entire country in 1927. It was open to everyone but was an elite award with only a few people winning it. From 1938, the title was supplanted by the Hero of Socialists Labor title.

Order of the "Badge of Honor"

1935: The **Order of the "Badge of Honor"** (*Orden «Znak Pochota»*) was established for outstanding achievements in economic production, scientific research, various social and cultural activities, and other things. This award was open to any citizen, with over 1.5 million people winning it.

1938: The **Medal "For Valorous Labor"** (*Medal «Za Trudovoe Doblest»*) was an award for heroic contributions to labor, manufacturing, science, and culture. It was open to everyone, and almost two million people won it during the award's history. The name of the medal is sometimes translated as the "Medal for Labor of Valor".

1938: The **Medal "For Distinguished Labor"** (*Medal «Za Trudovoe Otlichie»*) was an award for outstanding contributions to labor, manufacturing, science, and culture. It was the junior medal to the more-prestigious Medal "For Valorous Labor". It was open to everyone, and just over two million people won it during the award's history.

Hero of Socialist Labor

1938: **Hero of Socialist Labor** (*Geroy Sotsialisticheskogo Truda*) was a title awarded for exceptional achievements in the Soviet economy and for culture. It was open to everyone but was an elite award with only about 21,000 people ever winning it. The first winner was Stalin himself in 1939 for his "exceptional services in organizing the Bolshevik Party, creating the Soviet state, building a socialist society in the USSR and strengthening friendship between the peoples of the Soviet Union". The next winners were in 1940–1941, before the war began, and were all weapon designers.

1939: The **Stalin Prize** (*Stalinskie Premii*), originally called the **Prize in the name of Stalin** (*Premii imeni Stalina*) effectively became the top Soviet prize for scientists, artists, inventors, military leaders, and (from 1940) writers. In theory, the Lenin Prize might have been considered more prestigious, but Stalin's USSR simply stopped issuing Lenin Prizes in 1935.

Depending upon the accomplishment, a Stalin Prize came with a monetary award of 25,000–100,00 rubles. (The decree that established the prize specified a range of 50,000–300,000 rubles, but this was quickly reduced to 25,000–100,00 rubles[213].)

213 Alex Inkeles; "Social Stratification and Mobility in the Soviet Union: 1940-1950"; *American Sociological Review*, Vol. 15, No. 4; 1950; https://doi.org/10.2307/2087305

> After the war, an International Stalin Prize “for Strengthening Peace among Nations” was added. In the 1950s during the de-Stalinization of the USSR after the death of Stalin, the Stalin Prize was discontinued and the Lenin Prize was awarded again, while the International Stalin Prize was renamed the International Lenin Prize. In 1966, a USSR State Prize was established, which was equivalent to the former Stalin Prize. The Soviets also went to the Orwellian extent of renaming at least some earlier-awarded Stalin Prizes as State Prizes in some reference works.

After a convoluted process during 1929–1931 that I won’t go into, many workers ended up with a 6-day work week, having one day per week off and working 7-hour shifts the other days. Workers in dangerous occupations had 6-hour shifts. This 6-day/week work calendar was used in parallel with the 7-day/week Gregorian calendar that the Soviets used for all other purposes. In 1936, the 7-hour work day was included in the USSR’s new constitution as a worker’s right.

The work calendar was partly a propaganda move, as in many capitalist countries at that time many workers had one day in seven off and worked 8-hour or longer shifts on work days. The atheistic Communist Party also liked the work calendar because they believed would help weaken religious belief. Many Soviet workers were religious but did not have any right to have their day off on their religion’s traditional day of worship. With the work calendar, one day off in six guaranteed that most of the time workers’ days off would not match up with their traditional days of worship.

Despite the seeming care the USSR bestowed on it workers, the system was rigged so that the state benefited from workers’ labor more than the workers did. Many jobs were poorly paid, working conditions were often arduous and unsafe (especially in factories), and Soviet labor unions were controlled by state and Party to prevent strikes and keep the workers working. While many workers accepted this, especially Communist Party members, Komsomol members, and other politically-motivated ones, many more workers were apathetic or resentful. Stalin’s emphasis on building heavy industry also meant that there were few consumer goods available for purchase. Had there been, more workers would have been motivated to work harder to raise their earning and acquire these goods[214].

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214 Andrei Sokolov; “Forced Labor in Soviet Industry: The End of the 1930s to the Mid-1950s (An Overview)”; (Chapter 2 of Paul R. Gregory and V. V. Lazarev, editors; *The Economics of Forced Labor: The Soviet Gulag*; 2003). Unlike the rest of the book, Chapter 2 is not about the GULag but the non-prison Soviet work force. The “Forced Labor” aspect in the chapter’s title comes from the many coercive measures Stalin’s USSR took to rescind workers’ rights and to bind workers to their jobs even against their wills. However, Sokolov also points out that the USSR at times did implement rewards to try to motivate workers to be

Absenteeism, high labor turnover, drunkenness, indiscipline, and indifference to quality work were work force problems the Soviets faced in various forms almost throughout the USSR's existence. The compensation system of 80% wages and 20% bonuses (covered above) attempted to motivate workers, with limited success. To deter absenteeism, workers who were absent without justification for three days in a month could be dismissed from employment, which also meant they lost their work-related housing. However, since the USSR definitely had a labor shortage and supposedly had no unemployment, a dismissed worker could obtain another job elsewhere, although the new job could be worse than the old one.

The USSR had a planned economy, and the five-year plans set ambitious goals. This assumed a stable and reliable work force. However, as long as workers had the right to quit and seek new jobs, industrial workers frequently left unsatisfactory, often unsafe jobs in search of better ones. Disliked industrial enterprises found it hard to retain worker and to recruit new ones, making it difficult to meet the plans' goals.

The USSR mostly reacted to these labor problems in characteristic Stalinist way: the workers were blamed for the problem and coercion was used to make them work. Communist ideology elevated the proletariat as the "ruling class" under socialism and communism, having replaced the bourgeoisie as the ruling class during capitalism. Rather than face the real problems of working conditions, Soviet leaders decided that the proletariat had become impudent in their presumed rights and needed discipline. At the Soviets' most brutal levels, workers could be executed or sent to the GULag. However, at all levels, workers experienced a steady erosion of labor rights and working conditions from 1928 throughout 1940, the last full year of peace. Occasionally, incentives were introduced to encourage workers to be more productive, but coercion dominated.

1928+ Subbotnik: Stalin's USSR extensively used and promoted the existing practice of Subbotnik, workers doing a day of "voluntary" unpaid labor on some of their days off. Even during the war with Germany, when working shifts were extended in hours and the work week was extended, Subbotnik remained a feature of Soviet work. During the war, trying to avoid Subbotnik could result in a worker being accused of being unpatriotic, a dangerous position to be in.

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more productive.

2+2=5, Soviet Poster, 1931

"Arithmetic of ongoing industrial-financial plan: 2+2 plus enthusiasm of workers = 5"

1928+ Propaganda: Soviet domestic propaganda relentlessly called on Soviet workers to produce more, in order to build the Soviet socialist state. For example, the first Five Year Plan of 1928–1932 gained the slogan 2+2=5, when the Soviets claimed that 50% of the plan had been realized in the first two years. Propaganda then pushed for the other 50% to be realized in the next two years, in hopes of meeting the goal a full year ahead of schedule. (The Soviets went on to proclaim that the plan had been fulfilled in just four years and three months. In actuality, even by the end of the fifth full year, many of its goals had not been met. However, industrial and resource output did increase substantially.)

1928+ Dangerous Working Conditions: Organizations faced enormous pressure to meet and exceed the ambitious goals of the five-year plans, as did individuals to meet and exceed their work quotas. This resulted, among many things, in shortcuts being taken. Health and safety precautions were often neglected and rules about them ignored. Often, quantity of work was rewarded while quality was neglected, especially if quality meant taking taking longer to make a product or build a facility. Factories were often built to low standards, with equipment often breaking down. Workplaces often became dangerous, with many accidents occurring. Industrial waste was often dumped untreated into the nearby environment, polluting not just the factory itself and its vicinity but also the air and water resources of the city the factory was located in.

For an example, the Soviet chemical warfare industry was a highly-secret effort to produce offensive chemical warfare agents for the Soviet military and security forces. The industry was rapidly built up in the 1930s and had many accidents that caused death, disablement, and serious health issues among its workers. Safety rules were often ignored. Protective safety equipment for handling toxic and corrosive chemicals was sometimes in very short supply or lacking altogether. Since work quotas had to be filled, workers would handle extremely dangerous chemicals using porous cloth gloves and common tools like shovels. Ventilation systems were often poorly designed and sometimes did not function at all, even in factories making mustard gas. Manufactured mustard gas would be transported through standard plumbing pipes, which corroded due to the hot gas and leaked, exposing workers to the chemical. Toxic liquid waste would be dumped into rivers that downstream cities used for drinking water. A factory making highly toxic chemicals in Moskva experienced so many major liquid leaks that the Soviets relocated it away from the city to prevent the city's water from being poisoned. Other toxic waste was often just buried, sometimes in ordinary metal barrels that would eventually leak, in the grounds around the factories (which typically were in cities) or at unmarked locations in nearby parks or forests. Waste containing arsenic and other highly toxic chemicals from the chemical warfare factory at Dzerzhinsk was buried around the plant and leaked into the city's water, making Dzerzhinsk one of the most polluted cities in the world.

1928+ Wrecking: Industrial accidents were inevitable in the rush to industrialize the USSR. This was clear as early as 1928 when many accidents and fires were occurring at industrial enterprises. The Soviet response, as was so often the case, was to blame the victims. The Soviets had been concerned about their enemies trying to sabotage their efforts almost from the very start of Soviet power, so victims could easily be recast as saboteurs. The Soviet legal system and the secret police punished real and imaged economic sabotage. Under Stalin, legal charges of "wrecking" became a response to accidents and a way to intimidate the work force. Not only were ordinary wage workers targeted, but also managers, technicians, professionals, engineers, and many others. The Shakhty show trial of 1928 was the first to target professional workers in a highly-public way, with all sorts of professionals thereafter being vulnerable to arbitrary arrest, imprisonment with hard labor, and execution.

1928+ Pressure on Women to Work: The Soviets had proclaimed the equality of men and women after taking power. They enacted laws towards this end, including outlawing marital rape and allowing women to initiate divorces and to have abortions. (Women had already received the right to vote and hold public office in 1917 in Russia before the Soviets came to power.) However, the Soviets also saw equal rights as a way to increase women's participation in the work force and thus as source of labor for the state. At first this was slow to happen, especially since the devastation caused by World War I and the Russian Civil

War limited employment opportunities. Women were 23% of the work force in 1924 and just 24% of the work force in 1928, despite Soviet propaganda urging women to become wage workers. Under Stalin's five-year plans, women's work force participation greatly increased, reaching 39% of the work force in 1940. Many women wanted to work and have careers, but the Party and state deployed propaganda and pressure to increase female work force participation.

Although the Soviets had declared women's equality and passed laws on it, they did little to alter traditional cultural views on the place of women in society. Most men in the USSR continued to expect women to be primarily responsible to take care of the home and children. Working women thus had a heavy burden of a full-time job, housework, and child-rearing. Many leaders in the Communist Party obviously held these attitudes. Despite the presence of accomplished women revolutionaries before the Communists came to power and dedicated women Party and Komsomol members afterwards, the Party and Soviet government leadership was dominated by men. They almost always promoted other men to leadership positions, aside from a very small number of women in mostly-token upper leadership posts. This was true in the Central Committee and Politburo, the highest bodies of the Communist Party and also in the Council of People's Commissars, the highest executive body of the Soviet state. It was also true at the very top. Stalin's inner circle of advisors and cronies, for example, was almost exclusively male from the 1920s to his death in the 1950s.

Some Soviet policies actually reinforced traditional roles of women as mothers and child-raisers. In 1936, the Soviet made abortion illegal (see 1936 below for more details). In 1944, the USSR established several awards for women with large families. For these awards, the children could be natural or adopted:

- **Mother-Heroine** (*Mat-Geroinya*) was the highest award. It was a title for mothers with 10 (or more) children. The title came with some benefits such as state payment of utilities, state provision of food and some other goods, and increased retirement benefits. The award existed from 1944 until the dissolution of the USSR in 1991, with about 430,000 women being awarded this title.
- The **Order of "Maternal Glory"** (*Orden «Materinskaya Slava»*) was the second highest award. It had three classes: I degree for mothers with nine children (being awarded about 750,000 times), II degree for eight children (awarded about 1,500,000 times), and III degree for seven children (awarded about 2,800,000 times). The award existed from 1944 until the dissolution of the USSR in 1991.

- The **Maternal Medal** (*Medal Materinstva*) was the lowest award. It had two classes: I degree for mothers with six children and II degree for five. The award existed from 1944 until the dissolution of the USSR in 1991, being awarded about 13,200,000 times.

By 1944, the USSR had suffered tens of millions of deaths due to the direct and indirect effects of the war, so the awards were attempt to rebuild the Soviet population. However, the awards were maintained throughout the existence of the USSR, likely at least in part because in the 1960s the Soviet birth rate dramatically decreased. Further, although in 1955 the Soviets rescinded the 1936 law that made abortion illegal, Soviet policy still discouraged abortion. The emphasis on large families, discouragement of abortion, pressure for women to become workers, and traditional expectations that women and not men take care of home and children all put a heavy burden on Soviet women.

1928-1933 and afterwards, Shocks of Industrialization and Collectivization of Agriculture: Stalin's drive to build up Soviet heavy industry unleashed a wave of inflation in the USSR, particularly during the first five-year. Soviet urban and factory workers were unable to strike or negotiate better wages, as their labor unions negotiated for them, but the unions were controlled by the Soviets, not the workers. Workers' standards of living of living fell, reaching a low point around 1932–1933[215].

Stalin's collectivization of agriculture was especially brutal and also reduced the rural standard of living about the same time. However, collectivization of agriculture also released many rural inhabitants to go work at factories in the cities and towns. Since the rural standard of living was much lower than that of urban areas, these people did gain a better standard of living.

Soviet Rural and Urban Population, 1926 vs. 1939, millions of people

Year	Total Population	Rural	Urban
1926	147.0	120.7 (82%)	26.3 (18%)
1939	170.5	114.6 (67%)	55.9 (33%)

Source: Sheila Fitzpatrick; "War and Society in Soviet Context: Soviet Labor before, during, and after World War II"; International Labor and Working-Class History, No. 35; 1989; http://www.jstor.org/stable/27671803

1939 numbers do not include any territory annexed into the USSR that year.

215 Robert C. Allen; "The Standard of Living in the Soviet Union, 1928-1940"; *The Journal of Economic History*, Vol. 58 No. 4; 1998; http://www.jstor.org/stable/2566851

It is estimated that about 18 million peasants migrated from the countryside into cities and towns from 1926 to 1939, become urban workers, particularly unskilled factory workers.

Overall standards of living subsequently recovered after 1933 and reached new heights until starting to fall again in the late 1930s, when the USSR began converting its economy for extensive military production.

Inflation continued throughout the 1930s, but the Soviets began raising wages in late 1930s. However, the overall impact on this is difficult to assess. The USSR had a system of "open" and "closed" shops in which the Soviet ruble had different purchasing power. Anyone could purchase goods, food, or services at open shops, which used one set of prices. Closed shops were only available to a restricted set of people and used prices based on the wages of those people. Factory workers, for example, could purchase meals at their factories' canteens, which were closed to other people. These meals were often cheap but also were low quality, often featuring watery cabbage soup. High level government workers could purchase good-quality three-course meals at closed restaurants. Although these meals cost more than those at canteens, these government workers made much higher wages and at times seem to have paid a lower percentage of their incomes on these meals than factory workers did.

1929+ Socialist Competition: In 1929, "socialist competition" (*sotsialisticheskoe sorevnovanie*) began, with Soviet propaganda heavily promoting it[216]. Socialist competition consisted of competitions between organizations or individuals to over-fulfill their production quotas. The winners were publicly celebrated and awarded. Individuals who over-fulfilled their quotas were celebrated as "shock workers". "Storming", a period of heavy exertion during a shift to dramatically increase output, was also praised.

The Soviets claimed socialist competition was voluntary. Technically, it was, but it soon became almost impossible for workers to refuse to volunteer. Party and government officials, managers of enterprises, leaders of labor union, and the security services used social pressure, coercion, and the threat of going to the GULag for wrecking to require people to participate. This in turn often led to organizations and individuals gaming the system (such as hoarding resources at the expense of others who needed them) and outright cheating (such as double accounting of output). As the extent of cheating became clear, the Soviets began to denounce "false shock workers", workers who went over quota through personal or organizational cheating.

216 In Communist ideology, "capitalist competition" was a social evil, destructive force rewarding the predatory capitalistic few at the expense of the proletariat and common people. The Soviets soon realized that the "competition" in socialist competition was inviting negative analogies with capitalist competition in media outside the USSR. They abbreviated ***sots**ialisticheskoe* ***sorevnovanie*** as *sotssorevnovanie* and insisted that be translated as "socialists emulation".

At some point before World War II, storming went from praiseworthy to reprehensible. Storming's concentration on quantity over quality was actually ill-suited for many economic activities, especially manufactured goods. For example, hastily-made trucks, aircraft, or tanks that soon broke down in the field or even arrived inoperable from the factory were of little use to the recipients until costly repairs were made. There were many reasons for the low quality of Soviet manufacturing other than storming, but storming exacerbated the problem. Further, storming was often outright destructive, as production equipment used in storming would often be overworked and under-maintained until it prematurely wore out, again requiring expensive repairs or outright replacement. Storming also could needlessly waste materials. For example, an oil refinery storming output often suffered a higher rate of industrial accidents, with refined fuel being lost in the accidents.

Storming, however, did not always end once the Soviets soured on it. Instead, enterprises would secretly resort to storming when needed to increase production quickly or for prestige purposes. This even happened during the war years. For example, after the Ufa refinery greatly increased its output, the Soviets celebrated its success. It soon became evident that there were problems at Ufa, and it turned out the refinery was storming, overusing its equipment, and experiencing many accidents and loss of oil products. A "special commissar" from the oil industry was sent there to make things right.

1931+ Pay for Piecework: The Soviets gave official preference to compensation by piecework rather than by wages and bonuses. The goal was to encourage workers to become more productive, since higher output resulted in higher pay. By 1933 or 1934, 70% of the labor performed in large industrial plants was compensated by piecework[217], compared to 57.5% in 1928[215].

Piecework pay was on a so-called progressive scale, with each occupation category having its own customized scale. Each occupation had a pay rate, with 100% pay only attainable by achieving 150% or more of the work quota. Lower output resulted in lesser pay. Failure to reach 100% of quota resulted in a minimum wage, from about 15–45% of full pay. This system was designed to motivate workers to fulfill at least 100% of quota, as the minimum rate was very difficult to purchase enough food for a family. (Failure to achieve 100% quota frequently enough could also result in disciplinary measures, criminal penalties, or imprisonment in the GULag.)

217 Vladimir Gsovski; Elements of Soviet Labor Law: Penalties Facing Russian Workers on the Job; Bulletin of the United States Bureau of Labor Statistics, No. 1026; 1951.

Selected Piecework Pay Rates, December 1936

Occupation	Pay Rate for under 100% of Quota	Pay Rate for 100–119% of Quota	Pay Rate for 120–149% of Quota	Pay Rate for 150% of Quota or more
Ore mining	14.8%	44.4%	81.8%	100%
Engineering	15.4%	40.3%	71.5%	100%
Chemical	16.7%	50.5%	79.9%	100%
Cotton	44.9%	90.8%	98.1%	100%
Timber	33.5%	68.7%	94.0%	100%
Paper	31.6%	74.2%	93.2%	100%

Source: Robert C. Allen; "The Standard of Living in the Soviet Union, 1928-1940"; *The Journal of Economic History*, Vol. 58 No. 4; 1998.

In the spring of 1937 for most industries, the Soviets raised the amount of output needed to achieve 100% quota by 13–40%. This allowed the Soviets to increase labor output without increasing pay.

Some managers at various enterprises well knew that the progressive piecework system resulted in relatively low pay for many workers. They tried to manipulate the system to increase pay in various ways, but this brought down the wrath of the Soviets. Tellingly, it was N.M. Shvernik, the head of the All-Union Central Council of Trade Unions, that publicly denounced this practice, saying "We must fight against the attempts utilize the progressive piecework system for a mechanical increase of wages, unconnected with an increase in the productivity of labor". Yes, the head of the Soviet labor union movement was against better pay for workers. With perhaps more that a little irony involved, Shvernik later won the Hero of Socialist Labor award.

The progressive piecework system made life difficult for average workers in another way. Each enterprise was allocated an annual fixed sum for compensation, mostly or completely based on the assumption that every worker would make 100% of quota. This meant that the higher pay for workers who made 120% or 150% of quota ended up reducing the pay of the other workers[215].

1932+ Easier Dismissal for Absenteeism: Previously, workers could be dismissed from their jobs for three unjustified absences in a month. In 1932, this was reduced to just one unjustified absence. However, in practice many managers at enterprises would ignore this policy unless they actually wanted to get rid of a worker. Many enterprises in the 1930s often had high labor turnover and a great need to higher new workers, so managers were reluctant to fire an acceptable existing worker just for an absence. Absenteeism thus remained a problems in many places throughout the Soviet economy. However, in the mid-to-late 1930s labor laws were tightened and violations criminalized, while at the same time the Great Purge 1938 cowed workers and managers alike into much greater obedience.

1932+ Internal Passports: With work conditions deteriorating in many places, the workers' right to change jobs became a problem. Workers would quit over-demanding or unsafe jobs to take better jobs elsewhere. Although the USSR should have responded by incurring the extra expenses or delays to improve working conditions, these considerations were trumped by the goal of fulfilling the five-year plans. In 1932 the Soviets decreed that internal passports would be introduced in parts of the USSR. The passports were intended to make it harder for workers to change jobs, as well as for other purposes such as preventing peasants to escape collectivization of agriculture by fleeing to cities and towns. (Most peasants were not issued passports but needed one to be legally living in a city or town.)

Sidetrip: Internal Passports

Internal passports were not a Soviet invention, and indeed their adoption repudiated a Soviet propaganda claim of the superiority of socialism.

The Russian Empire first issued internal passports during the reign of Pyotr I ("Peter the Great"), for taxation purposes and to control the movement of his subjects. Commoners were issued internal passports but not the aristocracy. A growing number of commoners were fleeing to other parts of Russia rather than be subjected to some of Pyotr's policies. For example, an attempt to build a Russian settlement and naval base in newly-captured land by the Sea of Azov involved conscripting thousands of commoners, with their families, to go live and work there. Conditions at settlement were harsh, with high rates of disease and death. Escapees spread the truth about the settlement throughout Russia, resulting in many commoners trying to escape conscription by hiding, fleeing, or bribing officials. Many more who were conscripted deserted during or after the journey to the settlement.

By the 19th Century, the Russian Empire was using police-registered residency permits along with internal passports to try to prevent unauthorized migration within the empire. While people could travel on trips, they could not stay away from their registered residence for more than six months. Police and other officials would check people's documents to ensure compliance. This state of affairs was used in anti-empire propaganda by the Bolsheviks (the future Communists). For example, Lenin in 1903 demanded "complete freedom of movement and trade for the people" and "to destroy the passports". For peasant farmers, he claimed the passports were a form of oppression and serfdom. These words were aimed to increase unrest among the peasants, since many were still paying off loans their ancestors incurred from the 1861 liberation of the serfs.

Internal passports were officially abolished in 1917 before the Bolsheviks took over. However, since the passports were often the only means of personal identification available to most Russian citizens, they unofficially remained in use, even after Bolsheviks took over and created the Soviet state. In 1923 the Soviets introduced voluntary personal identity cards as a way to finally retire the passports. As late as 1930, the Soviets were praising their lack of internal passports. For example, the *Malaya Sovetskay Entsiklopediya* (*Small Soviet Encyclopedia*) of that year stated that an internal passport system was incompatible with the Soviet system and was a tool of bourgeois police states to control and tax their people. Two years later, the Soviets began their own internal passport system.

1935+ Abolition of Ration Cards: Soviet urban and industrial workers had received ration cards, which allowed them to buy about a third of the food they needed at a very low price. In 1935, the ration cards were abolished, forcing the workers to buy all their food at the standard prices. This in effect was a pay cut without having to reduce the amount of pay workers received.

1935+ Stakhanovite Movement: On 31 August 1935, coal miner A.G. Stakhanov was credited with mining 102 tons of coal in less than six hours, 14 times his quota. Propaganda promoted his accomplishment, and organizations across the country responded by creating their own "Stakhanovites" (*Stakhanovetsy*, singular *Stakhanovets*), particularly in the manufacturing, resource-extraction, and agricultural sectors. In late 1935, the Soviets held their 1st All-Union Stakhanovite Conference, followed by the Communist Party deciding to institute formal Stakhanovite competitions in 1936. Stakhanovite status was a step above being a shock worker, and the shock worker title faded into near-irrelevance.

Enterprises were under great pressure to have their own Stakhanovites, and managers in turn brought pressure to bear on their workers to become Stakhanovites. The Stakhanovite movement even spread to the GULag, where the best food rations were reserved for those who achieved Stakhanovite levels of production (150% of the quota).

Sidetrip: The Stakhanovite Movement and Cheating

A Stakhanovite medal
CCCP, Stakhanovtsu Zolotoplatinovoy Promyshlennosti
(USSR, Stakhanovite of the Gold-Plantinum Industry)

Given the Soviet emphasis on Stakhanovites and socialist competition, organizations were under great pressure to have some Stakhanovites in their work forces. As usual in the Soviet system when unrealistic goals were expected to be fulfilled routinely, organizations often cheated. Creative accounting could turn, for example, five workers who achieved 110% of quota into one 150% Stakhanovite and four 100% workers. (Since over-fulfilling quotas typically were only rewarded at the 120% (shock worker) and 150% (Stakhanovite) levels, 110% workers were no better than 100% workers.)

Stakhanovites sometimes could be secretly given assistants to help with the work, often were given the newest or best-maintained tools, and could be given the best work conditions. In the GULag, pre-selected Stakhanovite wood cutters were created by allowing selected workers to cut only the best, most valuable trees (which counted more towards quota), rather than clear-cutting all the trees on a site as was required for the other wood cutters.

After the death of Stalin, the new Soviet leadership de-Stalinized the country. The Stakhanovite movement was denounced as a Stalinist propaganda deception and disbanded. It was replaced by “brigades of socialist labor”, and the shock worker title was brought back into prominence.

1936: "He who does not work, neither shall he eat": This was a long-standing element of the Soviet state: someone who refuses to work is not entitled to receive food. The first Soviet constitution, issued in 1918, had declared that work was a duty of all citizens and that "He shall not eat who does not work". In 1936, the Soviets introduced a new constitution for their state with this principle again enshrined in it:

> ARTICLE 12. In the U.S.S.R. work is a duty and a matter of honor for every able-bodied citizen, in accordance with the principle: "He who does not work, neither shall he eat."

Outside of some people living traditional lifestyles in remote regions, almost every Soviet citizen knew this phrase by heart. It was applied especially cruelly in the GULag, where food rations were scaled how much work a prisoner did. For most workers, the rations were inadequate unless they could perform 125% or more of their daily work quotas.

1936+ Abortion Made Illegal: Soviet policies had caused millions of needless civilian deaths in the 1920s–1930s, particularly from famines, the "liquidation" of class enemies like kulaks (better-off peasants who supposedly were victimizing the poorer peasants), and Stalin's Great Purge. By the mid-1930s, the Soviet birth rate was also dramatically falling, from over 40 children per thousand people in the 1920s to 29.78 per thousand in 1935[218]. To try to maintain population growth, the Soviets made abortion illegal for all reasons except health concerns. They also instituted benefits for women who had large families, although housing and provisions remained inadequate. The Soviets at the same time continued to pressure women to enter the work force. All this deteriorated women's living conditions. Further, the abortion law was difficult to enforce, so many women resorted to illegal abortions, often with poor health consequences.

1936–1938 The Great Purge: In 1936, Stalin unleashed the NKVD in a growing campaign of political repression across the entire USSR. This became known as the Great Purge (later, also the Great Terror, invoking the example of the Reign of Terror from the French Revolution) in the West. The Great Purge was not directly about work conditions, but these were affected as many thousands of workers were arrested for wrecking, economic sabotage, anti-Soviet agitation, and so on. Punishment could be extra-judicial execution by the NKVD or imprisonment in the GULag for three to ten years. Many workers feared being denounced to the NKVD by their co-workers or managers for being outspoken about poor, unfair, or arbitrary work conditions.

218 https://www.statista.com/statistics/1038013/crude-birth-rate-russia-1840-2020/

The Great Purge might have lessened labor unrest, but it came at cost. Workers and managers became very cautious in their jobs, attempting to fulfill their quotas by any means without doing anything that might attract unwanted attention. This was likely an important factor in the "economic fever" or sickness of the late 1930s, an economic slowdown. (Historians and economists are still debating the factors the contributed to the economic slowdown.)

1937–1938 Wage Increases but with Automatic Pay Deductions: Persistent inflation was eroding the purchasing power of workers. In 1937, the Soviets raised the wages of low-paid workers, establishing a minimum wage (for 100% of work quota) of 110–115 rubles per month. In 1938, they increased wages for many workers, not just the low-paid ones.

However, about at the same time as the wage increases, the Soviets also instituted an involuntary, automatic deduction for "motorization of the Red Army" from the wages of workers. Thus, the Soviets were paying workers more but were taking back some of the increase.

1938+ Stricter Working Conditions: Many workers were dissatisfied with their working conditions and pay, resulting in indifference towards work. The Soviets responding by increasing penalties for things like tardiness, leaving work before the end of the shift, loitering on the job, and taking overly-long lunch breaks. Anyone in violation were to be issued a warning or demoted. Multiple violations would lead to dismissal.

These policies were refined in 1939. A worker who was tardy for 20 minutes or less was not to be dismissed but was to suffer a milder punishment. However, a worker who was tardy for more than 20 minutes was to be immediately dismissed. Managers who did not apply the penalties themselves could be dismissed or prosecuted for violating the law.

The law on tardiness and the like was somewhat ambiguous, which occasionally caused issues in the Soviet justice system. Many people were charged with sleeping on the job, for example, but was this being absent from work? Some courts decided this way, but the issue was that the worker was actually present at work, just sleeping instead of working. Other courts decided it was a form of loitering, which was lesser offense, and this interpretation eventually became the accepted interpretation. (It is unclear based on sources I've for this if people earlier convicted of absenteeism for sleeping on the job had their cases reviewed.)

In 1941, the Soviets decreed that workers who were intoxicated while at work were guilty of absenteeism, not loitering. Although sources do not go into this, it seems likely that drunkenness at work was a more frequent problem than workers sleeping on the job. Thus, absenteeism with its harsher penalty was chosen to deter this behavior.

1938+ Longer Contracts and Work Books: Most workers were employed at enterprises and institutions under multi-year labor contracts. In 1938, the Soviets increased the length of these contracts to five years, which made it harder for workers to change jobs.

The Soviets also introduced mandatory work books (sometimes called labor books in English). The cadre departments (the Soviet equivalent of a personnel department, with political indoctrination added in) of enterprises and institutions were required to maintain a work book for each worker. A book recorded all job changes, promotions, demotions, warnings, pay history, and punishments for the worker. A worker's performance was to be evaluated based on the work book and not subjectively based on other factors.

The Soviets had actually tried using work books earlier in the 1930s, but with little success[219]. There was tremendous passive resistance to them in the work place. Managers also often ignored them as much as possible, as they were frequently desperate for workers and were willing to ignore some problems in workers' work histories in order to retain workers or to hire new ones. By 1938, the Soviet work force had been thoroughly intimidated by the Great Purge, so work books were reintroduced and their use enforced by the authority of the state.

1940+ Lengthening of the Work Day and Work Week: On 26 June 1940, the Soviets increased the work day from seven hours to eight for factory and office workers, although workers in dangerous occupations still kept their 6-hour work days. The Soviets also abandoned their 6-day work week of five days of labor with one day off. They reverted to the traditional 7-day week, with six days of labor and one day off. Thus, many workers went from working 35 hours per week to 48.

The law also introduced criminal penalties for things like tardiness, laziness, and poor discipline, which previously had just been subject to non-criminal disciplinary measures or dismissal. An unauthorized tardiness of 20 minutes or more was punished at the enterprise by placing a worker on probation for six months, during which the worker's pay was reduced by 25%. Further violations while on probation could be punished by criminal penalties.

In August, criminal penalties were added for more workplace infractions including hooliganism, intoxication, and petty theft.

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219 Hugo S. Cunningham; "Stalinist Laws to Tighten "Labor Discipline," 1938-1940"; 1999; https://libcom.org/files/The%20Soviet%20Wages%20System.pdf

Substantial numbers of workers fell afoul of the labor laws. In 1940, the last full year of peace before the war, about 2.1 million workers went to court charged with labor offenses. About 1.8 million were sentenced to six months of corrective labor without reduction in normal work hours and were reduced to one-quarter pay. About 0.3 million were sent to prison[214].

Since Nazi Germany had just forced France to surrender and Britain to withdraw its forces from continental Europe, the threat of a German invasion of the USSR had significantly increased. It thus made sense to boost production by increasing the work week. However, the Soviet government simply decreed the increase to an eight-hour day despite a seven-hour day being part of the Soviet constitution:

> ARTICLE 119. Citizens of the U.S.S.R. have the right to rest and leisure. The right to rest and leisure is ensured by the reduction of the working day to seven hours for the overwhelming majority of the workers, the institution of annual vacations with full pay for workers and employees and the provision of a wide network of sanatoria, rest homes and clubs for the accommodation of the working people.

The proper procedure would have been for the Presidium (the highest day-today executive body of the USSR) to propose to amend the constitution on this. The Supreme Soviet of the USSR would then do this with a single two-thirds majority vote. Since the Communist Party complete controlled the Supreme Soviet, there was no chance it would not amend the constitution if Stalin wanted it to. The Supreme Soviet met twice a year for two days each, but a special session of the Supreme Soviet could easily have been called. Instead, the Presidium simply proclaimed the eight-hour day on 26 June, to take effect immediately, and the Supreme Soviet in its regular August meeting ratified the change without amending the constitution[220].

However, the Soviets were not interested in enforcing constitutionality. Instead, they deliberately blurred the distinction between constitutional right, government laws, and managerial policies, so that they could simply decree changes in working conditions as they wished. This made it more difficult for workers to challenge changes.

The Soviets were also well aware that lengthening the work day and work week would invite unfavorable international attention. Since they controlled the labor unions, they ordered the unions to have their members publicly celebrate the laws as necessary reforms to make life better. Communist Party propaganda then proclaimed:

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220 Vladimir Gsovski; Elements of Soviet Labor Law: Penalties Facing Russian Workers on the Job; Bulletin of the United States Bureau of Labor Statistics, No. 1026; 1951.

To the petit-bourgeois mentality, these laws might suggest that Comrade Stalin was anti-labor. Nothing could be further from the truth. The difference between the Soviet Union and capitalist societies is that Soviet workers are building their own future, while Western workers are exploited for the advantage of greedy capitalists. As testimony from trade unions reveals, Soviet workers themselves were fed up at the frustration of their efforts by slackers, parasites, and self-seekers. They were grateful for this evidence that the Soviet Government took their concerns seriously.[219]

The longer work day and work week did mean that workers would be paid more. Also, the Soviets further increased workers' wages. They also increased the difference in pay between unskilled labor in general versus that of skilled labor in important industries like defense and oil production. These skilled workers now made twice as much as unskilled workers.

Food purchases consumed over half an average worker's pay. To help relieve this, many workers were also allowed allowed to farm small garden plots. One million workers began farming these plots in their spare time, not only growing crops but also raising livestock. (Agricultural workers at collective and state farms had earlier received the right to farm their own household plots, so this in effect extended the system to industrial workers. Output from these plots could be privately sold as well as used personally.)

1940+ Quitting and Changing Jobs Made Harder: Most workers no longer were able to voluntarily quit their jobs during the term of their five-year labor contracts. They could request authorization to quit, but managers were under no obligation to grant the requests. This effectively bound workers to the enterprises they worked at. Workers who quit without authorization could be imprisoned, for two to four months for many workers but for up to eight years for workers in defense industries.

1940+ Involuntary Transfer of Skilled Labor: On 19 October 1940, the Soviets allowed department heads to transfer some technicians and skilled laborers between enterprises, without their consent. This allowed them, for example, to simply transfer oil industry engineers throughout the country as the oil industry needed. Workers who refused to transfer were in violation of the law and could be punished as if they quit without authorization (see previous paragraph).

1940+ Restrictions on Vocational Graduates: The USSR had vocational schools that trained teenage youths to become factory workers. Graduates of these schools were obligated to work for a term of several years at an appropriate enterprise. In October, the USSR reorganized its vocational education system, lengthened the term of obligatory work to four years, and forbade graduates to voluntarily quit during their terms. Students at vocational schools also became subject to criminal penalties for disciplinary violations and unauthorized absences.

The Soviets also began conscripting youths aged 14–17 into vocational schools, as part of a Labor Reserves system. This allows the Soviets to train future workers based on the anticipated needs set by the economic central planners. During peacetime, these people were exempt from military conscription while at school and during their subsequent four-year obligatory labor service. At first, only boys were subject to labor conscription, but later girls were conscripted as well.

Vse dlya pobedy! Frontu ot zhenshchin SSSR
Everything for victory! To the front from the women of the USSR
Soviet Great Patriotic War poster

Women often appeared in Soviet propaganda posters urging workers to make maximum efforts to supply the Red Army with tanks, aircraft, weapons, and ammunition. This is likely because so many women went to work in defense industries during the war, as millions of men went into the Red Army to fight the enemy. Women comprised about 56% of the Soviet work force in 1945.

(Hundreds of thousands of women also went into the Red Army; some in combat roles like snipers or fighter pilots, and most in support roles like military medicine, communications, and military traffic directors.)

The Soviet population was profoundly affected once the war broke out on 22 June 1941. Millions of men were withdrawn from economic or agricultural work to serve in the military services, on the order of 20 million being called up throughout the entire war. Millions in territories occupied by the enemy were lost to the Soviet economy, even though the Soviets evacuated on the order of 10 million people out of the path of the enemy in 1941 alone, with several millions more fleeing east on their own initiatives. More millions were lost through death caused directly or indirectly by war.

The German invasion thrust the USSR into an existential battle for survival. This placed many new, heavier burdens on the Soviet work force. Workers' shifts were lengthened; officially to 11 hours, per a Soviet edict on 26 June 1941 that allowed management to impose a mandatory 3 hours of overtime per day, but in practice at least for some industries like the oil industry daily shifts of 12–14 hours became common. Some heavy-labor, dangerous occupations like mining seem to have had their shifts increased from 6 hours to 10 hours, but longer shifts also occurred. Weekend work became mandatory and all vacations were canceled. Days off were infrequently and sometimes subject to Subbotnik, unpaid, "voluntary" days of labor.

The composition of the work force also dramatically changed. Millions of men went into the Red Army to fight the enemy. Some crucial industries like oil production or defense exempted many men from serving in the military. However, these men were encouraged to volunteer for military service, and many did so. Experienced male workers were replaced by the elderly, teenagers, and, especially, women. Most of these new workers had no experience in their new jobs and had to learn as they worked. This was dangerous. Many industrial facilities were under immense pressure to increase production as much as possible, and this together with the use of thousands of initially-unskilled women and adolescents resulted in many industrial accidents. The oil industry, for example, needed to extract and refine vast amounts of oil to supply fuel for the Red Army. With its many inexperienced new workers in 1941, industrial accidents at oil industry facilities were sometimes double or triple the facility's' peacetime rate.

Soviet Non-Agricultural Work Force, Selected Years, millions of people

Year	Total Work Force	Male	Female
1928	11.4	8.6 (76%)	2.6 (24%)
1935	25.9	18.0 (67%)	7.9 (33%)
1940	33.9	20.7 (61%)	13.2 (39%)

1945	28.6	12.7 (44%)	15.9 (56%)

Source: Sheila Fitzpatrick; "War and Society in Soviet Context: Soviet Labor before, during, and after World War II"; *International Labor and Working-Class History*, No. 35; 1989; http://www.jstor.org/stable/27671803

1940 figures include the population of the territories annexed into the USSR in 1939–1940.

The dramatic increase in female employment during the war included about 3 million women who had not previously been wage workers.

The age component of the Soviet work force changed significantly during the war, with more youth and elderly being employed. In 1939, 6% of the work force was 18 years or younger; by 1942 it was 15%. Some of the increase came from former students: 500,000 from the senior classes in Soviet high schools were ordered to stop their education and join the work force in the second half of 1941.

In 1939, 9% of the work force was 50 years or older; by 1942 it was 12%. This included a number of retired workers who return to work, often to the same industry or even enterprise that they had worked for. The retirees often were not as physically fit as younger workers but were often very welcome because they had work experience.

The German invasion prompted the Soviets to evacuate important factories and other facilities to the east. Several waves of evacuations occurred in 1941 in response to German offensives, and a lesser amount of evacuations occurred in the summer of 1942 due to that year's German offensives. Millions of workers and their families were also evacuated, and millions more spontaneously fled east to escape the enemy. This caused chaotic labor conditions for the evacuated factories, which the Soviets worked to set up and get back into production as quick as possible. Few if any major factories managed to retain all their pre-evacuation work forces. Some factories ended up with only about 6–8% of their pre-evacuation workers. Many had about 25–40%. The Soviets made up for these shortages of workers by extensively recruiting new workers in the areas the factories were sent to. Evacuated factories thus often had two mass waves of inexperienced workers joining them: the first early in the war when factory workers mobilized in the military were replaced by new workers, and again in late 1941–early 1942 after the factory had been evacuated to its new location.

Conditions at the site receiving the evacuated factories could be quite rudimentary at first, as the top priorities were getting the factories back into production as fast as possible and rapidly increasing production. At some locations, the workers and their families lived poorly-built dormitories at the factories due to lack of local housing, working, eating, and sleeping there. Some of these facilities were poorly heated, lacked proper beds, lacked enough mattresses and blankets (which were rarely cleaned), lacked hot water or sometimes even drinking water. Sanitary facilities could be inadequate, and medical care grossly substandard. At least at one factory, conditions were so bad that typhus broke out in early 1942[221].

Young children were often used as workers in the factories, even if this was not an official policy. At least in some cases, it seems that children of newly-evacuated workers were kept near their parents at the factories for lack of schools or other places to keep them. Since they were present in the factories and consuming resources, they had to earn their keep there, too.

Factory workers were supposed to receive adequate, albeit not generous food rations, especially in defense industries. However, the rations were not adjusted for the longer, wartime work shifts, which often involved calorie-burning heavy manual labor. In 1942, food rations were particularly tight due to the loss of farmland in 1941. Some workers suffered debilitating exhaustion and even starvation.

Despite the industrial workforce dropping by several millions from 1940 to 1943, industrial production of military equipment was soaring in 1943. This was achieved by greatly increasing the work load on the remaining workers and converting vast amounts of non-military production to military production. In the crisis years of 1941–1942, industries mostly concentrated on producing existing weapon models even if better designs were available, to avoid production interruptions that retooling the factories would incur.

Throughout the war, the designs for military equipment were simplified as much as possible, resulting in equipment that was easier, quicker, and less resource-intensive to make. This was much more important that it might sound. For example, the USSR had two different 76.2mm divisional guns in 1941, the F-22-USV (aka 76-mm Divisional Gun Model 1939) that required 1,300 "machine hours" to manufacture, and the ZiS-3 (aka 76-mm Divisional Gun Model 1942) at 1,029 machine hours. In 1942, the F-22-USV was phased out in favor of the ZiS-3. But, this was just the start. During the war, the ZiS-3's design was often revised to make it even easier to manufacture. A ZiS-3 required only 909 machine hours in 1943 and just 475 in 1944, 46% of the time required in 1941.

Soviet collective and state farms also helped with war production, beyond just providing agricultural output. Many of the larger farms had repair shops, powered stationary tools,

221 Martin Kragh; "Soviet Labour Law during the Second World War"; *War in History*, Vol. 18, No. 4; 2011; http://www.jstor.org/stable/26098287

and other facilities that could be used to make goods and supplies for the Soviet military. It is unclear how significant this production was, but the Soviet agricultural work force was always larger than the rest of the civilian work force combined, so even a little production per worker could have yielded worthwhile results.

Soviet domestic propaganda portrayed the war as a patriotic fight for the homeland against foreign invaders, rarely invoking Communist ideology or international socialism that had been prevalent in prewar propaganda. Workers were exhorted to work to the utmost to support the Red Army and help defeat the enemy. The Stakhanovite Movement of supposedly high-output workers created a new, higher category of Stakhanovite workers, the Two-Hundreders. These were workers produced 200% or more of their work quotas during work shifts. The top peacetime category had been Stakhanovites who produced 150% or more of their work quotas during work shifts.

During the war, workers in defense industries and various other workers who services were crucial to the war effort were placed under military discipline, where penalties for violation of the rules were more draconian than those in the harsh civilian labor laws of 1940. Defense workers were put under military discipline in December 1941, and offenses not longer were tried in judicial system but by military judges. Absenteeism and extreme cases of idleness at work were treated as desertion “from the labor front” and were punishable with 5–8 sentences in the GULag. Workers guilty of negligence that led to major accidents could be executed. Almost 600,000 defense workers were punished under military discipline in 1942–1944.

In the spring of 1943, railroad workers were subjected to military discipline. The railroad workers’ superiors were allowed to arrests their workers for violations at their own discretion. A worker given a punishment could appeal to the next higher superior, whose decision was final. No court appeals through the Soviet judicial system were permitted. Similar military discipline was imposed on maritime workers, inland waterways workers, workers on other transportation lines; various workers in the Civil Air Fleet, various communications workers (postal, telegraph, and radio), and workers at state electric power plants.

As you may have noticed, very many transportation workers came under military discipline. These workers were often involved in transporting troops, weapons, and supplies to and even within the battle zone. The Soviets believed civilian penalties were not sufficient to deter dereliction of duty during dangerous circumstance, which could then deprive the troops in the field of the reinforcements and supplies they needed. The danger to transportation workers was real. For example, during the Battle of Stalingrad, German air power targeted trains and river boats on the Volga River that were supporting the Red Army in the city. About 50,000 transport workers were punished under military discipline in 1943–1944.

Paramilitary forces and workers in protective service were also subject to military discipline: guards of facilities, civilian air defense personnel, and firefighter for defense industries.

By the end of 1944, the Soviets had cleared almost all Soviet territory of the enemy and were clearly on the verge of decisive victory over Germany. The numbers of workers being punished under military discipline greatly fell. Although the sources I've seen do not go into details, I speculate that only the most serious work violations were referred to military discipline, with the pre-war system resuming for other violations.

In 1943–1945, a new labor issue arose as the Red Army liberated Soviet territory that the Axis had occupied: evacuated workers in the east returning to their former homes. Formally, workers were not allowed to quit their jobs, nor were they supposed to travel with NKVD authorization. Nonetheless, an estimated one million or more evacuated workers evacuated to Siberia found ways on their own initiatives to leave their jobs and return west. This was up to about two-thirds of all workers that had been evacuated to Siberia. Likely many workers sent to the Urals also returned west on their own. It it unclear how factories in the east made up for these labor losses. One way almost certainly was to do without: efficient design had greatly reduced the amount of time to build various weapons by 1944, so full production could be maintained with few workers. Another way was to transfer more workers out of agriculture into industry.

This might explain why the Soviets frequently began rebuilding destroyed and damaging industrial sites soon after liberating them: workers would be returning there anyway, so this was a way to use their labor. Some of these site managed to enter production before the end of the war, but others would only go on line after the war.

In December 1944, the Soviets also proclaimed an amnesty to defense workers who had abandoned their jobs without authorization. There would be no punishment if they returned to work. There were about 200,000 of these labor deserters, who had been sentenced to long terms of imprisonment *in absentia*. Many of these workers were teenagers who had been sent to work. Many of them had found the work overwhelming, with its long hours and heavy manual labor. Others had left to care for sick or elderly parents or to farm the household plot so their families could get enough food. Being teenagers, the threat of severe punish did not deter them as much as it did adults, and the *in absentia* sentences just mostly made them all the more determined to avoid Soviet authorities at all costs. The amnesty was thus a way to get mostly-young people back into the work force. Unfortunately, my sources do not say what happened next, but given how Stalinism worked, it seems likely that at least some who did return were eventually punished in some form.

9.C Labor Service

The Russians and Soviets at times resorted to labor service or labor conscription, requiring various groups of citizens to perform mandatory labor for the government. This was not forced labor, and the laborers were not prisoners or convicts. Many countries did (and some still do) have forms of labor conscription, for emergencies or as a form of national service. For example, France as of 2021 has both types, the Sanitary State of Emergency (*Etat d'urgence sanitaire*) for epidemics and the Universal National Service (*Service national universel*), currently a small pilot program but intended for citizens aged 16–25 to have a month of compulsory service at civilian and military facilities.

Sidetrip: Germany's Reich Labor Service

Nazi Germany during the 1930s to the end of the war had mass labor conscription, the Reich Labor Service (***R****eichs****a****rbeits****d****ienst*, RAD). Young men aged 18–25 were conscripted into the RAD, and in practice served six months in the RAD before their conscription into the German armed forces. There was a separate RAD branch for young women, but it was voluntary until 1939. The RAD was not just for labor service but was also intended to indoctrinate its members "in the spirit of National Socialism".

The RAD was not part of the German armed forces but during World War II assisted military forces in the field with labor for hauling supplies and for tasks like road, railroad, and airfield construction and maintenance. The RAD also helped to build fortifications (often in conjunction with the Organization Todt paramilitary construction force), laid minefields, and staffed homeland antiaircraft units. Some RAD units were armed and in emergencies on the Eastern Front served as infantry. Their military use grew in 1944–1945 as the German armed forces decline in strength, with some RAD members fighting against the British on the Western Front during the Allies' Market-Garden operation. From March 1945, RAD members were used to form five German Army divisions: four numbered RAD infantry divisions plus a fifth mountain division most of RAD members. Weapons and equipment were in short supply, and the unit thus were rather weak. Four divisions nonetheless took the field, although one was still in training when the war ended.

The Russian Empire had excluded most of its male Muslim population from military service. (All females in the empire were excluded from military service at this time.) These Muslims lived in the Caucasus and Central Asia and mostly had been been conquered by Russia in the 19th Century. They were excluded from service because the Russian government believed their overall loyalty to Russia was questionable or non-existent. In 1916 during World War I, however, the Imperial Russian Army needed more manpower. These Muslims were still not wanted as soldiers, but the government decided they could be drafted to replace the Army's rear-area laborers, who could in turn then serve in the front lines. The Russian Empire instituted labor conscription for these Muslims in 1916. While some Muslims submitted to conscription, other Muslims protested, rioted, and then revolted, requiring Russia to send in 30,000 troops to suppress the rebellion.

The Soviets rose to power in late 1917. Lenin, now the leader of both Party and state, had earlier repeatedly warned that the bourgeoisie (the property-owning classes, essentially all middle- and upper-class citizens, plus the clergy and various former Tsarist officials) and "loafers" would be required to do forced labor. In 1918, the Soviet instituted labor service for the members of the bourgeoisie. For any such person already in employment, the service was in addition to their regular job. The intention of this service was for revenge against the bourgeoisie for their alleged crimes against the proletariat and peasantry and to reeducate them through work[225]. This service applied to both men and women, of all ages from teens to old age. The bourgeoisie primarily lived in cities and towns and were required to clean buildings and public spaces, unload freight, chop firewood, shovel snow, and so on. Many were watched by armed guards to ensure they did their assigned work, so this could be considered a form of forced labor rather than actual labor service.

However, also in 1918 the Soviets adopted a constitution and then introduced an extensive labor code for their state. Work was declared to be the responsibility of every citizen, and the constitution explicitly adopted the motto, "He shall not eat who does not work". (Women at home taking care of their households were equated as workers, albeit unpaid ones.) Among its many provisions, the labor law made all citizens subject to compulsory labor service. In 1920, the Soviets issued a new decree on compulsory labor service, with avoiding labor service being a criminal offense. For civilians in employment, labor service was in addition to their regular jobs. The decree also allowed member of the Red Army and Red Navy to be used for labor duties for the civilian economy, although remaining under the control of the Soviet military. These soldiers and sailor were organized in “labor armies”, into which civilians could also be conscripted. These labor armies are covered below[222].

One reason for the 1920 decree was that the Soviet economy was collapsing due to the destruction of the Russian Civil War and due to War Communism, the draconian Soviet policies that supported the war effort at the expense of the economy. Labor service was a way to keep the economy running. Over the course of 1920, the Soviets won the civil war, and labor service became one of the means to start rebuilding the economy. In 1922, War Communism was abandoned and the New Economic Policy was adopted, which through its allowance of limited capitalism and free markets accelerated economic recovery. General labor service was discontinued at this this time, although work as a duty of all citizens remained enshrined in the constitution. The Soviet state could still require compulsory labor service during times of emergencies.

The most serious emergency the USSR faced began in June 1941, when Germany invaded the Soviet. In August 1942, when the German summer offensive was threatening Soviet oil and fuel production, the Soviets instituted labor conscription for civilians, consisting of work for up to 11 hours per day for up to two months per year. This officially applied to male civilians aged 16 to 55 and female civilians aged 16 to 45. Required labor included military defense work, construction, peat mining, fire fighting, and so on. Although labor service had a minimum age of 16, in reality younger adolescents and children often also worked. Per one account (L.V. Kopinkina; “Torfyanaya Otrasl SSSR v gody Velikoy Otechestvennoy Voyny” [“Turf Industry of the USSR during the Great Patriotic War”; 2012[223]], translated from the Russian:

> Schoolchildren also helped to dry the peat. They worked as tractor drivers, machinists and assistants to steam locomotive drivers, water jets, quarry workers, plumbers, uprooted forest, dug ditches, moved fragments of temporary railway tracks, turned peat over for drying. Hard work “on peat” became part of the military experience of the generation of war children. It is difficult to understand what percentage of the production volume was occupied by child and adolescent labor, but there is no doubt that it was. Thus, the selfless labor feat of workers associated with the extraction of peat helped the country's industry and energy sector to withstand the difficult years of the Great Patriotic War.

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222 1918 labor service: https://www.prlib.ru/en/history/618951
1918 constitution: https://www.marxists.org/history/ussr/government/constitution/1918/index.htm
1918 labor code: https://www.prlib.ru/en/history/619798
1920 decree: https://www.prlib.ru/en/history/618990

223 https://cyberleninka.ru/article/n/torfyanaya-otrasl-v-gody-velikoy-otechestvennoy-voyny-k-70-letiyu-velikoy-pobedy/viewer

By no means all civilians were conscripted for labor service, but millions were. In 1943, about 7.3 million were drafted as labor conscripts, including 1.3 million for industry and construction, 3.8 million for agriculture, and 1.3 million for lumbering operations. Additional labor came from the Labor Reserves of the vocational school system, with about 2.5 million teenagers working in the system during the war[224].

9.D Forced Labor of Prisoners: The GULag and GUPVI

In 1918, soon after the foundation of the Soviet state, the Soviets were imprisoning political opponents and class enemies in camps where they were forced to do manual labor, such as logging. Forced labor was by no means a Soviet innovation in what had been the lands of the tsars.

The earlier Russian states had used slavery for centuries, with both individuals and the state itself owning slaves. In the 18th Century, the Russian Empire ended slavery but did not free the slaves. Instead, they became unfree serfs, joining the already-existing agricultural serfs. Many Russian serfs in practice were little better than slaves with far fewer rights than serfs in western Europe during the Middle Ages. In the 19th Century, the Russian Empire ended serfdom but continued to use forced labor. The Russians used Siberia and other remote parts of the country as a place of exile and forced labor for various criminals, revolutionaries, and political dissidents. People were sentenced to *katorga*, forced hard labor in remote camps.

> *Katorga* was an old Russian word derived from the Greek work *katergon*, a galley rowed by slaves. In Russian, *katorga* came to mean forced labor of prisoners. The Russians also used "*katorzhnyye raboty*", roughly meaning convict workers, for criminals sentenced to hard labor.

Many katorga camps were involved in extracting raw materials, such as coal mining, metal mining, salt works, and lumbering. Other work included making things (what was called other "factory" work) such as woodworking, distilling, metal working, and wooden boat building. Still other tasks for the forced laborers included construction of buildings, roads, and bridges in remote areas.

The camps were places of confinement but not quite walled prisons, and often the forced laborers were shackled together. One practice was to shackle ten men together in a chain gang and enjoin "mutual responsibility" on them. If any man escaped, the remaining ones would be punished. Nonetheless, people occasionally did escaped the camps and managed

224 Source: Sheila Fitzpatrick; "War and Society in Soviet Context: Soviet Labor before, during, and after World War II"; *International Labor and Working-Class History*, No. 35; 1989; http://www.jstor.org/stable/27671803

the journey through wilderness to return to their homes in western Russia. Their stories about their treatment helped to build the fearsome reputations of places like Siberia and Sakhalin Island among the inhabitants of Russia. At the height of the katorga system, the Russian Empire was sentencing about 20,000–30,000 people per year to forced labor. Besides being a punishment, katorga was a way to settle Siberia and extract its natural resources. Many katorga prisoners remained in Siberia as settlements, and the Russian authorities would occasionally issue mass amnesties converting katorga convicts into settlers.

The Russian also allowed private enterprises in Siberia to contract to use katorga labor. Overall, this usually did not work out well. Most private enterprises did not like to use katorga labor, as the prisoners often did not want to work, tried to escape, or got drunk. Morale of the free (non-prisoner) wage workers at these enterprises dropped when the prisoners were there. Many of the few enterprises that were eager to use katorga labor did so because they mistreated and cheated the prisoners. It is estimated that prisoners made up 2% or less of the labor at private enterprises in Siberia.

Katorga labor could be harsh but by the late 19th Century was often little different than the manual labor of wage workers. For example, free and katorga coal miners could work at the same mine under the same conditions, the only major difference being the katorga workers were under guard. Russian katorga was often inefficient. Men in poor health would be sentenced to katorga but were physically unable to work, in essence reducing them to the status of regular prisoners. Also, it often happened that a portion of people sentenced to katorga did little or no labor, as there often wasn't enough work for all those sentenced. Sometimes the prisoners would be shackled and left to wander outdoors due to lack of work.

Finally, the use of shackles was often discontinued, since in many cases it interfered with the prisoners' ability to work[225]. However, shackles were used at various times and places even in the 20th Century, especially when prisoners worked outdoors, where the chance of escape was greater. In 1915–1916 during World War I, katorga and exile essentially ended in the Russian Empire, with the exiles being released so that they could join the Russian military and help fight the war. Instead of forced labor of Russian prisoners, the state now used the labor of the many prisoners of war they had taken from the Central Powers, particularly Austria-Hungary.

225 Elzbieta Kaczynska; "Forced Labour in Russia and the Soviet Union. Continuity or Change?"; *IAHCCJ Bulletin*, No. 16; 1992; http://www.jstor.org/stable/43658105

Sidetrip: Katorga and the Amur Wheel Road

The main route of the Trans-Siberian Railroad, built 1891–1904, bypassed much of the Amur region in the Russian Far East, taking a much shorter route through Manchuria, then part of the Chinese Empire, to the Russian port of Vladivostok on the Pacific Ocean. This left the Amur Region without a good transportation system, but repeated appeals to the Tsar's government eventually secured funds to build a horse-drawn cart road of about 2,000 km (1,200 miles) in the region. This was the origin of the "Wheel", the Amur Wheel Road (usually translated into English as the Amur Car Road). The road was for the transportation of goods, people, and the mail throughout the main settlements in the region, which were on or near the Amur River.

Work began in 1898, and the road was primarily built using katorga forced labor. Most workers at first were criminals brought in from elsewhere. From 1905, more political prisoners were sent to work on the Wheel, enough so that the authorities took to shackling one political prisoner together with nine criminals in the chain gangs. Later, prisoners from local Amur prisons were also used on the project. Finally, the use of paid civilian labor was authorized, but it seems few civilians other than some migrant peasants were induced to join the work force. Perhaps the heavy labor and the reputation of the lawlessness of work on the Wheel made joining this work force unappealing. Soldiers from local Imperial Russian Army units were sometimes ordered to work on the road.

The Amur Wheel Road may have been the single largest katorga project of the Russian Empire, reaching a maximum of about 1,250 forced laborers in 1907. Many more people than this worked on the Wheel during its construction, as the work force had a high mortality rate. The project ran year-round, even in the depths of the Siberian winters. The winter work force was several hundreds of prisoners, less than the summer one, and concentrated on doing whatever preparatory work was possible for the upcoming summer work season. The work force of forced laborers had a high annual turnover, due not only to deaths but also because many prisoners completed their sentences. Each year, hundreds of more prisoners had to be sent to the Wheel to replenish the work force.

The road was built for two-way traffic, being 4–5 meters wide (13–16 feet). The Wheel was a dirt road, with wooden bridges crossing streams and small rivers and ferry crossings at larger rivers. Although the road was dirt, it was built with an improved roadbed, digging deep into the ground to remove stumps, roots, and stones. Drainage ditches were dug on both sides of the road to divert rainwater and melt water. The work was arduous, supposedly from dawn to dusk every day, and involved clearing the path of the road through the swamps and forested wilderness between Amur settlements and through mountainous regions. Most places had no existing facilities of any kind. To build a stretch of the Wheel, workers would first have to build crude huts to live in, then sometimes full katorga encampment, and finally the road, repeating the process for each stretch. Living conditions were primitive. Medical care was minimal, so that lack of effective treatment for accidents and disease contributed to the high death rate.

During construction of the road, war broke out in Asia between Russia and Japan, the Russo-Japanese War of 1904–1905. The road was far from Manchuria where most of the fighting occurred, but it was nonetheless affected. During the conflict, the authorities ordered the road to be built quickly as a temporary road, in order to open communications in the Amur Region. Likely all this work had to be redone after the war ended to rebuild it as a permanent road. In 1905, the Japanese captured the Russian island of Sakhalin, and Russian forced laborers evacuated from the island were sent to work on the Wheel.

The road was completed in 1910. However, parts of the road would soon become of secondary importance. The Russian defeat in the Russo-Japanese War raised fears that the part of the Trans-Siberian Railroad running through Manchuria was vulnerable to capture by the Japanese in a future war. The Russians accordingly built a bypass, the Amur branch, entirely in Russian territory through the Amur region to Vladivostok in 1906—1916. The Russian post of course used the railroad instead of the cart road, and as did the Amur region's more-valuable goods and passengers who could afford the fares. The Wheel was used less in the areas where the Amur branch ran, although it remained important in areas not along the rail line.

You may not have heard of the Wheel, but elements of the story may sound familiar: forced labor in a remote area, poor living and medical conditions, and a high death rate. These are all characteristics of the Soviet GULag. In some ways, it was the Russian Empire's katorga scaled up immensely to tens of thousands on a project and millions in the camps.

The revolutionary Bolsheviks during the era of the Russian Empire denounced forced labor as a repressive means to control the people and as against the basic dignity of human beings[225]. However, the Bolsheviks even then were not completely against forced labor. They proclaimed that when they came to power they would force loafers to work (as a matter of justice, to reeducate them to be productive for the common good) and especially the bourgeoisie to work (as matter of revenge for their exploitation of the proletariat). The Bolsheviks came to power in 1917, established their Soviet state, and soon required the bourgeoisie to labor regardless of their wishes. Some of the work was not particularly arduous but was humbling, such as the Soviets requiring middle-class women who had never before held jobs, to publicly clean buildings and streets. This initial trickle of forced labor would eventually swell into a mighty flood across the Soviet state.

During World War I, the Russian Empire developed a massive black market, due to shortages caused by the war and by poor government policies. Widespread corruption of government official and the Russian police exacerbated the situation. These problems continued in the Soviet state, also due to shortages and poor policies. In 1918, the Soviets decreed forced labor as a punishment for bribery and speculation. They also established the Cheka, the Soviets' first secret police force, to fight not only counter-revolutionary actions by the regime's opponents but also excessive profiteering, speculation, and corruption. The Soviets intended the Cheka to be a fearsome instrument to terrorize the population into obedience, and the Chekists fanatically lived up to the expectations entrusted to them. The Cheka was allowed extra-judicial powers to punish whomever they arrested as they saw best, including capital punishment without review by or appeal to the judicial system. One common Cheka punishment was imprisonment in forced labor camps.

Some of these camps originated after March 1918, when the Treaty of Brest-Litovsk established peace between the Soviet state and the Central Powers of World War I. The many Central Powers' prisoners of war held by the Soviets were released, and the Cheka took over many of the POW camps to imprison the class enemies of the Soviet state as well as others the Cheka arrested for political and economic crimes. Lenin had already warned the Russian population that he would require the bourgeoisie and "loafers" to work, so it was a short step from this to coercing at least some of the camp prisoners to do forced labor.

Domestic resistance to the Soviets turned into the Russian Civil War in 1918, with the Soviets at times fighting for survival. They imprisoned hundreds of thousands of people, including not only what Lenin called "idlers, parasites, and hysterics" but also political prisoners. In May 1919 the Soviet government institutionalized and expanded the use of forced labor.

Various Soviet organizations other than the Cheka got into the forced-labor game and ran their own camps. From 1919, forced labor of prisoners was common, with lumbering being a common task, since the prisoners only needed hand tools. The Soviets justified the purpose of these camps as “re-education through labor”, but the economy benefits of forced labor were far more important for the Soviet state than rehabilitation.

Forced labor was a somewhat controversial measure, since before coming to power the Bolsheviks had denounced forced labor as a crime of capitalism. However, the Soviets easily squared this circle through ideological arguments: Compulsory labor under capitalism was the reverse of compulsory labor under the dictatorship of the proletariat. The first was “the enslavement of the working class” by outside forces exploiting the proletariat; the second was “the self-organization of the working class” for their own benefit[226]. “Self-organization” actually meant forced labor was decreed by the Communist Party and implemented by the Soviet government, rather than through any voluntarily initiatives of the workers themselves, but this was no problem. The Communists were the “vanguard of the proletariat” and hence their decisions were the will of the proletariat.

The Soviets won the civil war in 1920 and mopped up holdouts in 1920–1921. Prisoners were increasing released from the camps. Forced labor became, for a time, insignificant to the Soviet economy, although some camps remained in the existence, such as the Northern Special Purpose Camps (*Severnye Lagerya Osobogo Naznacheniya*, SLON), informally called “Elephant” because the Russian abbreviation, SLON, was also the Russian word for elephant (*slon*).

Even after the civil war, the Soviets continued to arrest people for their political beliefs and incarcerate them as political prisoners. In 1923, the Soviets converted a former Russian Orthodox monastery, which was on the isolated Solovetskie Islands in the White Sea, into a prison for both political and criminal prisoners. They named it the Solovki Special Purposes Camp (*Solovetskiy Lager Osobogo Naznacheniya*, also abbreviated SLON like the Northern Special Purpose Camps and again informally called “Elephant” because of its abbreviation). It assimilated the other SLON’s forced-labor camps throughout the region, with these prisoners being sent to the islands. However, a swelling camp population soon reversed the flow: Solovki established branch camps in various places throughout the northwestern region of the USSR. Forced labor was on the rise again in the USSR.

SLON was run by the OGPU, the secret-police successor to the Cheka. In the mid-1920s, the OGPU was operating at least 7–8 camps and political prisons at:

226 Paraphrased from various writings of Nikolay Bukharin, a top Bolshevik/Communist.

- The Solovetskie Islands in the White Sea. This was the SLON forced labor camp and was guarded by the OGPU's Separate Solovetskiy Regiment, later redesignated the OGPU 4th Rifle Regiment[227].
- The Upper Urals Prison near Chelyabinsk in the Urals, guarded by an OGPU contingent, possibly a rifle battalion. This was a special, high-security "political isolator" prison where non-Communist socialists (Mensheviks and Social Revolutionaries), anarchists, and possibly other radical political prisoners were sent. The purpose of this prison was to prevent these ideologically-dangerous prisoners from radicalizing the rest of the political prisoner population.
- Tula, where a facility (camp or political prison) was guarded by the OGPU 1st Tula Rifle Regiment.
- Suzdal, where a facility was guarded by the OGPU 6th Rifle Regiment[228].
- Nizhniy Novgorod, where a facility was guarded by the OGPU 5th Nizhniy Novgorod Rifle Regiment.
- Yaroslavl, where a facility was guarded by the OGPU 8th Yaroslavl Rifle Regiment.
- Vyatka, where a facility was guarded by the OGPU 15th Vyatka Rifle Regiment. (The Vyatka Corrective Labor Camp only opened in 1938, but this does not preclude some other secret police facility being there earlier.)
- Voronezh, possibly. I have not yet found a source that states an OGPU facility was at Voronezh at this time. However, the OPGU 4th Voronezh Rifle Regiment was stationed there. Based on the stationing of the other OGPU rifle regiments in places outside of Moskva, this strongly suggests it was guarding an OGPU facility.

SLON grew into its own, mostly-self contained resource-extraction and industrial area. It engaged in logging, sawmill operations, fishing, hunting, road and railroad construction and operation, peat mining, farming, brick making, and so on. The camp met its needs as much as possible from its own production and sent its surplus, particularly logs and lumber, to the general Soviet economy[229]. Since the political prisoners came from all walks of life, the camp

227 Based on other regiments guarding OGPU facilities, this regiment might have been designated the OGPU 4th Solovetskiy Rifle Regiment, but I have not yet confirmed this.

228 Based on other regiments guarding OGPU facilities, this regiment might have been designated the OGPU 6th Suzdal Rifle Regiment, but I have not yet confirmed this.

229 For a time, the camp even exported some of its products to other countries. However, prisoners who managed to escape both the camp and the USSR revealed what was going on, and the Soviets faced some international censure for using what amounted to slave labor. To avoid further censure, the Soviets later ensured that forced-labor products would remain in the

used their wide range of skills, such as to help provide medical care. The camp was not completely self-sufficient and needed some food and other resources from the Soviet economy. Overall, though, the camp was a net gain for the Soviet economy. The Soviets particularly liked the fact that the prisoners were not paid for their labor, as cost of paying wage workers was viewed as a financial burden to the state.

Prisoners arriving at the Solovki Special Purposes Camp in 1927 or 1928

Conditions for the political prisoners initially were benign, including keeping them separate from the criminal prisoners. However, over time Solovki became notorious for its brutal treatment of political prisoners, including torture and extra-judicial executions, as well as for harsh forced-labor conditions. Prisoners who escaped both the camp and the country published books on their treatment in 1926-31[230], bringing unwelcome international attention to the Soviet treatment of prisoners, which the Soviets denied and countered with propaganda and deception. For example, when British dignitaries toured the northwestern USSR in 1931 in part to check on Soviet claims that forced labor was not being using in the timber industry, the Soviets simply moved the forced-labor timber operations to remote areas[231]. After the British visitors left, the prisoners were moved back, and operations resumed as before.

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domestic economy.

230 *Examples:*

S.A. Malsagoff; *An Island Hell: A Soviet Prison in the Far North*; 1926.

J.D. Bessonov; *My Twenty-six Prisons and My Escape from Solovetsk*; 1928.

I.M. Zaitsev; *Solovki*; 1931.

In the late 1920s, Stalin achieved dictatorial control over the USSR and in 1928 began extremely ambitious projects to industrialize the country and collectivize its agriculture. The Soviets were interested in numerous construction and resource-extraction projects that turned out to be too expensive to undertake, primarily because of the cost of paying the thousands of workers needed. Other projects were in remote, low-population regions of the USSR where there were simply not enough workers to make the project possible. The unappealing nature of these places also meant wage workers elsewhere in the country would not voluntarily move there.

Solovki provided the answer to these issues: use the forced labor of prisoners. Alexandr Solzhenitsyn, author of *The Gulag Archipelago*, would call the Solovki Special Purposes Camp the "mother of the GULag", because it set the example for Soviet forced-labor camps[232]. In 1929, the Soviets began setting up these camps throughout the country. In 1930, a special government body was organized to administer the camps; its abbreviation was GULag, for ***G****lavnoe* ***U****pravlenie* ***Lag****erey*, Main Administration of Camps. The full name of the GULag was actually longer and changed over time, as the following Sidetrip shows.

What's in a Name: The GULag

The GULag often had its official name changed during its existence, but except for a brief initial period as ULag it was always abbreviated as GULag or Gulag:

April 1930: Ulag.
The Directorate of Corrective-Labor Camps.
U*pravlenie Ispravitelno-Trudovykh* ***Lag****erey* (*ULag*).

October 1930: GULag.
The Main Directorate of Corrective-Labor Camps.
Glavnoe ***U****pravlenie Ispravitelno-Trudovykh* ***Lag****erey*).

July 1934: GULag.
The Main Directorate of Forced-Labor Camps and Labor Settlements.
Glavnoe ***U****pravlenie Ispravitelno-Trudovykh* ***Lag****erey* i *Trudovykh Poseleniy*.

231 Paul R. Gregory, V.V. Lazarev, editors; *The Economics of Forced Labor: The Soviet Gulag*; 2003. See in particular Christopher Joyce;"The Gulag in Karelia, 1929 to 1941" (Chapter 9).

232 SLON remained outside the GULag at first. In 1930, it had 70,000 prisoners, but this dropped to 15,000 the next year as many were transferred to the GULag to help built the White Sea-Baltic Canal. In 1933 SLON was officially closed down, but all this meant is that the name was dropped. Its facilities, staff, and prisoners

October 1934: GULag.
The Main Directorate of Camps, Labor Settlements, and Places of Detention.
Glavnoe U*pravlenie* ***Lag****erey i Trudposeleniy i Mest Zaklyucheniya*.

Between October 1934 and February 1941, the GULag had its official name changed two more times, but I have not yet discovered what these were.

February 1941: GULag
The Main Directorate of Forced-Labor Camps and Colonies.
Glavnoe U*pravlenie Ispravitelno-Trudovykh* ***Lag****erey* i *Koloniy*.
Note: The GULag retained this official name until after Stalin's death in the 1950s, after which the Soviet leadership began the processes of reducing and closing the GULag.

Initially, the Soviets termed the camps "forced-labor camps", but this term had embarrassing connotations of coercion and slave labor. They switched to "corrective-labor camps" (***I****spravitelno-****T****rudovye* ***L****agerya*, ITL), on the pretense that the prisoners were criminals being rehabilitated into productive citizens through labor. The name change was purely cosmetic, and the camp inmates were still essentially slave laborers. Since throughout Stalin's rule the camps always contained many innocent people, the rehabilitation pretense was a cruel joke. Eventually, a common joke told privately among some Soviet citizens went along these lines:

> A convoy of new prisoners arrives at a camp. One, Ivan Ivanovich, is assigned a barracks full of camp veterans.
>
> Camp veteran: "How long are you in for?"
>
> Ivan Ivanovich: "Five years."
>
> Camp veteran: "What did you do?"
>
> Ivan Ivanovich: "Nothing!"
>
> All the veterans roar with laughter.
>
> Camp veteran: "Come on; we all here know how things work. 'Nothing' only gets three years. Tell us, what did you really do?"

The camp inmates often worked and lived under appalling and deadly conditions as shown in the writings of Aleksandr Solzhenitsyn, Julius Margolin, and others. Of all the means the GULag used to coerce labor from the prisoners, its foremost principle was "He who does not work, neither shall he eat". Despite its phrasing, this applied to women as well as men, and there were many thousands of women in the camps. A prisoner's food rations were based on how much work the prisoner accomplished, with all but the most productive prisoners rarely getting enough to eat.

The cost of the camps to the USSR was low because the prisoners would not be paid wages and would make as much as they could for their own use and for the use of the camp administrators and guards. They even grew some of their own food, although many camps were located in cold or arid climates that greatly limited their agricultural output. Outside of arid regions, many camps were located in or near forests, and the prisoners often built these camps themselves, with all the wooden structures required to house, feed, and confine them.

The vast majority of the work on the construction projects using GULag prisoners was done with manual labor, sometimes with just hand tools and wheelbarrows. For example, the White Sea-Baltic Canal was mostly dug by hand by GULag prisoners. This saved even more money on these projects, as they needed few or no pieces of motorized construction equipment, which in the late 1920s–early 1930s had to be purchased from foreign companies.

As with Solovki, prisoners were extensively used based on their civilian skills. Accounts and other literate, numerate prisoners were used to keep the camps' books. Imprisoned doctors and other medical staff ran the camp infirmaries. Prisoner barracks had attendants chosen from less-fit prisoners. Camp commandants, some of whom were just semi-literate, would have prisoner assistants who could read, write, handle paperwork, and run tasks. These assistants sometimes were lawyers, college professors, or other highly-educated people. Prisoner mechanics would work in the camps' repair shops or, if present, machine shops. Each camp organized its prisoners into multiple work brigades, and each brigade had a prisoner brigade leader, a straw boss responsible for getting the brigade's work done. All this might sound efficient, but the GULag greatly wasted the skills of its prisoners. There were rarely enough skilled positions to use all the skilled prisoners in a camp, and everyone else who wasn't ill or disabled did hard manual labor.

Many camps in remote areas had nearby settlements of free citizens. Camp guards, free administrators, and their families would live in these settlements. Over time, these settlements tended to grow. When prisoners served their full terms, they would be released. Some would be given railroad tickets or funds purchase tickets so they could return to their former places of residence in the USSR. However, some were released without tickets or funds, and they had to stay in the settlement area until they earned enough money to buy their own tickets. This could take many years, and some simply gave up trying to save money, becoming permanent residents of the settlements. Other prisoners upon release were forbidden to leave the area and perforce became permanent residents. All these former prisoners formed a pool of labor at the settlements. Often, they became employed in the camps themselves, sometimes in their former jobs if it had involved a skilled position rather than manual labor. They typically worked like the prisoners and alongside them, only they were allowed to leave the camp at the end of their shifts. Some former prisoners even became camp guards.

The White Sea-Baltic Canal project

Left: Prisoners working on the canal in 1932.
Right: 1931 poster exhorting the workers to work with the message, “Canal-Armyist! The heat of your work will melt your prison term”. Canal workers who survived the work had their GULag sentences reduced. “Canal-Armyist” was meant in part to equate canal work with military service, as the lowest rank in the Red Army was called “Red-Armyist”, the equivalent of a private.

The White Sea Canal was the first massive construction project in the USSR to use GULag forced labor.

Sidetrip: The White Sea Canal and the GULag

The White Sea Canal, officially the Stalin White Sea-Baltic Canal (*Belomorsko-Baltiyskiy Kanal imeni Stalina*, abbreviated BBK or *Belomorkanal*) was a premiere project for the northwestern USSR area. A canal from the Baltic Sea to the White Sea had been proposed numerous times in the Russian Empire but was never built, because of its high cost. It remained too expensive for the Soviets, too, until they decided to use forced labor of prisoners. A GULag organization called the

White Sea-Baltic Corrective-Labor Camp (*Belomorsko-Baltiyskiy Ispravitelno-Trudovoy Lager*, abbreviated *Belbaltlag*) was created to administer the project and its huge numbers of prisoners. Belbaltlag was not a single camp up a whole series of them across the northwestern USSR from the Leningrad area to the White Sea.

Forced labor reduced the cost by about two thirds. Since the GULag did not contain enough skilled workers and technicians for canal work, the canal planners in official documents recommended that skilled workers be arrested and assigned to work on the project. It is unknown how many, if any, innocent people were ensnared in the GULag because of this.

While the BBK was called a canal, it was really a shipping channel, as most of its route was along existing rivers and lakes, which were to be dug deeper to allow passage of cargo vessels as well as warships up to the size of a destroyer. The waterway was built in 1931–33 with a work force of over 100,000 prisoners from the GULag. The workers had to be replaced frequently because of the high death rate, with an official toll of 12,000 deaths and credible estimates of 25,000[233]. The USSR greatly publicized the project as a triumph of both socialism and Stalin's first five-year plan. The fact that prisoners were used to build the canal was not hidden but, instead, propagandized as reformative labor, turning criminals into productive members of the USSR through hard labor. What was hidden was the prisoners' harsh treatment and high death rate[234].

233 Paul R. Gregory, V. V. Lazarev, editors; *The Economics of Forced Labor: The Soviet GULag*; 2003. Specifically see Mikhail Morukov; "The White Sea-Baltic Canal"; (Chapter 8). Morukov mentions the cut in the workers' rations but does not explicitly make the connection between that event and the Soviet famine of 1932–1933.

234 The Soviets had a book written about the construction of the canal, *The White Sea-Baltic Canal in the Name of Stalin: The History of its Construction 1931–1934* (Maksim Gorkiy, editor; 1934). Gorkiy himself, a socialist, had at times supported the Soviets but at other times opposed their repressive policies. He went into voluntary foreign exile from the USSR for years until lured back by Stalin. Gorkiy became one of Stalin's most publicly celebrated writers. The Soviets then renamed the city of Nizhniy Novgorod, Gorkiy's birthplace, to Gorkiy in his memory. On his return, the city of Nizhniy Novgorod was renamed Gorkiy in his honor. (It resumed its old, historic name after the dissolution of the USSR.)
Gorkiy and a "writers' brigade" of over 100 writers, under the close supervision of the secret police, assembled material about the canal and wrote the book. It was a propaganda piece, extolling the forced labor as "successful rehabilitation of the former enemies of proletariat". Writers' interviews with the canal workers were highly controlled by the secret police, who only allowed access to criminal prisoners. They feared that political prisoners might tell the truth about conditions at the canal even despite threats of punishment or execution. Nonetheless, it seems very likely that many of the writers had some idea that conditions at the canal were brutal. They produced the propaganda piece through some combination of loyalty to the state and fear of being punished. Gorkiy himself claimed the canal was built "without a single death", very likely knowing this to be a lie. However, Gorkiy by the second half of 1934 had become critical of the Soviets, who then placed him under house arrest until his death in 1936.

The high death rate among the canal workers was due to overwork, with 16-hour days of manual labor being typical, along with poor housing and hygiene, inadequate medical care, and poor food rations. Things worsened after 1931, as the Soviet famine of 1932-33 caused the prisoners' food rations to be cut, with significant decreases of almost all food types. This weakened the prisoners, who were then more prone to die of disease or in accidents.

During the project, political goals ended up overriding the economic goals of the canal. The canal was supposed to be finished in just two years, a very tight schedule, and was to be built cheaply, by forced labor mostly by hand with shovels, wheelbarrows, and the like. Only the minimum amount of expensive construction machinery was to be used. After construction started, it soon became evident that the plan was unrealistic for the northern part of the canal. Either the schedule had to be extended to allow the prisoners more time to dig the canal mostly by hand, or expensive construction machinery, including imported machinery, would have to be brought in. Neither option was acceptable to the Soviets.

Since the Soviet state was little concerned about the human cost of forced labor, it might seem that extending the time to build the canal by forced labor was a practical solution. However, the canal was bound up with the USSR's first five-year plan, which was greatly publicized and promoted as being on track to finish ahead of time. Rather than extending the canal's schedule, work was rushed to finish it in just 20 months, four months ahead of the original schedule. To achieve this, the Soviets decided to dig the northern part of the canal to only 67% of the depth originally planned. This did allow the canal to be completed on its accelerated schedule, but the canal ended up with a much lower shipping capacity than originally planned. Military benefits were also reduced. The northern part was too shallow to be traversed by modern Soviet destroyers. (The few shallower-draft destroyers the Soviets inherited from the World War I-era Imperial Russian Navy could traverse the entire canal, but these had only limited naval value.)

While regular barges could use the southern part of the canal, only small, low-capacity barges could use the northern part, and building these barges became another forced-labor task for Belbaltlag's prisoners. The Soviet Union thus realized far less benefit from the canal than it could have, and the canal quickly faded from Soviet propaganda. (The canal was eventually reworked and modernized in the 1960s and again in the 1970s, greatly increasing its capacity.)

Belbaltlag was not disbanded following the opening of the canal in 1934. Instead, it remained in existence as the entity controlling the GULag camps of the northwestern USSR, which moved on to other activities such as lumbering.

Almost from the start, the Soviet leadership regarded the construction of the White Sea Canal as a success because of its costs savings. They were soon using GULag forced labor for other large construction projects, such as Dalstroy (the State Trust for Road and Industrial Construction in the Upper Kolyma Area), which was organized in 1931 in Siberia, and the I.V. Stalin Moskva-Volga Canal. This canal project used up to about 200,000 prisoners at a time from 1932-1937 to build an 80-mile (128-km) canal from the upper Volga near Dubna to Moskva. The purpose of the canal was to supply the growing capital city with more drinking water and also to create a shorter, deeper shipping route to the city than the existing Moskva River. Like the White Sea Canal, the Moskva Canal had a massive death toll, with an official tally of 22,842 deaths in Dmitlag, the prison camp housing the workers. However, the actual death toll was likely higher, as it seems the 22,000 figure may only have recorded deaths at the camp itself. Certainly, many more workers died on the construction site, from accidents and other causes, including on-the-spot executions by the secret police.

The GULag was actually a dual forced-labor system. Besides the camps, there were the corrective labor colonies (***I****spravitelno-****T****rudovye* ***K****olonii*, ITK). (The colonies were initially called settlements, a term I ignore for simplicity.) People sentenced to terms of less than three years went to the colonies rather than the camps. While the camps were all-union (run by the Soviet government), the colonies at first were run by the individual union-republics themselves (Russian SFSR, Ukrainian SSR, etc.). In 1934, the USSR formed the all-union NKVD with the GULag, the secret police, other security and intelligence services, and many other directorates and departments. At this time, the colonies were removed from the union-republics and subordinated to the GULag.

While the camps were self-contained systems with little contact with the rest of the USSR, many colonies were much more integrated with the rest of the Soviet economy. There were three grades of colonies:

- Factory-Plant and Agricultural Corrective Labor Colonies were the best ones to be in, for lesser criminals and some political prisoners. These were typically associated with state farms, factories, and other places of work throughout the USSR and in essence contracted out their inmates to work for the farms, factories, and other enterprises. Others had their own industrial, agricultural, or lumbering activities. The treatment of prisoners was usually much better than at the camps, especially when the prisoners were working alongside non-prisoner workers.

- Corrective Labor Colonies of Mass Work were for "class enemies" and dangerous criminals. They were located in remote regions and were subject to stricter discipline.
- Penal Corrective Labor Colonies were for disobedient prisoners from the other grades of colonies. Prisoners who were systemically disobedient to colony authorities or who were determined to avoid working as much as possible were sent to the penal colonies for punishment. These colonies were isolated from other facilities and enforced heavy labor and very strict discipline.

About the same time that the Soviets were turning to forced labor, Stalin's first purge of professional workers occurred. This process started with the Shakhty show trial of 1928. 53 engineers and managers were tried for conspiring to sabotage the coal industry at the town of Shakhty, supposedly on the behest of the former owners of the coal mines. Five were executed, four were acquitted, four more received suspended sentences, and the rest went to prison. The charges were false but were used by Stalin to discredit moderates in the Communist Party leadership, who wanted industrialization to proceed at a slower, more rational pace. The three moderates in the Politburo were all soon demoted or expelled from the Party and later were accused of major crimes. One (M.P. Tomskiy) committed suicide to avoid being arrested by the NKVD, and two (N.I. Bukharin and A.I. Rykov) were arrested, tried for treason, and executed.

The Shakhty Trial was soon followed up by the Industrial Party show trial in 1930, in which several Soviet scientists and economics were accused of plotting a coup. All were sent to prison. A wave of arrests and trials for wrecking followed, being a purge of Soviet industry that foreshadowed the Great Purge later in the 1930s. The show trials were meant to signal Stalin's will rather than a standard way to purge professionals. The vast majority of professionals who went into the GULag were arrested and sentenced through normal Soviet means, such as by the regular police and the courts or by the secret police using extra-judicial methods. Some professionals did hard labor in the camps, a waste of their skills. However, the USSR was not completely wasteful of these people. A number of imprisoned scientists, engineers, and technicians were sent to special design bureaus or special technical bureaus organized by the NKVD. These were combined prisons and research-and-development centers, where the prisoners worked on technical projects of interest to the

USSR, such as aircraft or weapon design. The prisoners informally and ironically called such a bureau a "*sharashka*" (also "*sharaga*"), ultimately derived from Soviet criminal slang for a gang of criminals.

Although sharashka prisoners were not subject to hard manual labor, they worked extremely long hours, such as 16 hours per day, and were under immense pressure to produce results. To terrorize the prisoners into working hard, the NKVD used threats of sending sharashka workers to the GULag labor camps and of outright execution. Some prisoners had first been sent to camps before being transferred to a sharashka and knew about the camps' hard labor, inadequate food, and appalling conditions, so the threat of going to the camps was very effective.

A sharashka needed a sufficient number of engineers and technicians to be able to function effectively. At times, the NKVD simply arrested professionals with the needed skills, sentenced them for some arbitrary crime they did not commit, and sent them to the sharashkas. However, sharashkas were usually located near or in cities with a civilian work force containing a wide mix of skills. Accordingly, the NKVD simply hired non-prisoner engineers and technicians to work with the prisoners at some sharashkas. The non-prisoner workers were subject to most of the working conditions at the sharashkas, including the long work day. However, they were free to go home at the end of their shifts, a situation that caused some resentment and tension between the sharashka prisoners and the free workers.

Only some highly-educated prisoners went into sharashkas, those with particular technical skills the USSR did not want to waste. All the others went into the GULag in general. By one measure, in 1939 the GULag had a higher share of people with university degrees than did the USSR in general: the 1939 Soviet census showed that about 1% of the Soviet population had university degrees, while about 2% of the GULag's prisoner population had university degrees. Since the vast majority of these prisoners were performing manual labor, this represents a huge waste of talent and state spending on education.

Worse, many of these people were not allowed to return home once their sentences were done. People sent to the GULag camps convicted of counter-revolutionary activities were classified as "enemies of the people". Since Stalin's Great Purge sent many highly-educated people to the GULag for imaginary political crimes, about 15% of the enemies of the people had university degrees. Until 1959, enemies of the people upon their release from the GULag received special internal passports that prevented them from living in many Soviet cities. Many of these people ended up simply residing and working in the villages and towns that grew up near many camps. All this meant the USSR under Stalin had an unintended policy of settling highly-educated people in remote areas. As of 2021, areas within about 30 km (roughly 20 miles) of a sample of 79 former GULag camps show greater-than-expected economic development and higher-education attainment, believed to be the lasting effect of preventing enemies of the people from returning home[235]. While this situation certainly benefited these remote areas, it is likely that these people would have benefited the overall Soviet economy even more had they been allowed to return home.

In the 1930s, the USSR increasingly used GULag prisoners to build roads and railroads throughout the USSR. The Soviets preferred GULag labor for this even in settled areas with plenty of non-prison workers present, for the usual reasons: The prisoners did not have to be paid, and hand tools could be used as much as possible to avoid using expensive motorized equipment. Prisoners working in the field on road and railroad projects where not guarded by the GULag camp guards. Instead, NKVD "Convoy Troops", a branch of the mobile, armed NKVD Internal Troops who were charged with protecting Soviet land and inland water communications, guarded the prisoners. In 1939–1941, the USSR annexed large tracts of land in eastern Europe, and many prisoners and convoy troops were sent into the region to build and improve roads and railroads, as well as converting various rail lines from standard gauge to Soviet-regulation broad gauge.

Life in the GULag camps was very hard for most prisoners. They often only had substandard food, housing, and medical care. Although the medical staff often were full qualified doctors (albeit also usually prisoners), the infirmaries were unsanitary and necessary medical provisions of all types were in short supply or totally lacking. Some "medicines" were concocted from local plants and had dubious medical value. Clothing, blankets, and the like were poor quality. Prisoners were issued boots made from recycled tractor tires. Coats were not waterproof. Only one coat per year would be issued to a prisoner, often a worn out coat from a former prisoner. If the coat fell apart or was stolen, the prisoner would not receive another one. Prisoners thus guarded their coats zealously and constantly mended them with whatever materials they could scrounge. The GULag only issued on pair of socks to a prisoner per year. If a prisoner managed to secure a second pair, they would be confiscated if found during the frequent barracks inspections.

Food rations were designed to encourage the prisoners to work hard. There were four levels for non-invalid prisoners not being punished, based on how much of their work quotas they achieved in the previous day:

235 Gerhard Toews and Pierre-Louis Vézina; "Enemies of the People"; 2021; https://voxeu.org/article/enemies-people

- The best rations were "Stakhanovite" rations, for prisoners who achieved 150% of quota or more. These were able to fully maintain a prisoner engaged in heavy manual labor at full strength.
- The second-best rations were for prisoners who achieved 125% of quota (but less than 150%). Prisoners considered these just-sufficient-enough to maintain their strength and health.
- The third-level rations were for prisoners who achieved 100% of quota (but less than 125%). These were not adequate to maintain strength and health. Prisoners on a steady diet of these rations either needed to find other food off the books or work harder to achieve a better-level ration. Otherwise, they would gradually lose strength until they were unable to meet 100% of quota.
- The lowest level was for prisoners who achieved at least 70% of quota (but less than 100%). These rations were quite inadequate, and prisoners would rapidly lose strength if they could not get better food.

Prisoners who failed to achieve at least 70% of quota were punished. They were locked up together in a punishment cell and fed less food than the 70% level. Prisoners who refused to work or failed to perform any work at all would not be fed. The Soviet saying "He who does not work, neither shall he eat" was constantly quoted in the GULag.

Sick or hurt prisoners could be medically exempted from hard work on a day-by-day basis or sent to the infirmary for a longer stay. However, a camp's medical staff was strictly limited to how many prisoners they could disqualify from work. Since the staff would be punished for disqualifying too many prisoners, they were careful to keep within the limits. In most camps, there was no effort made to ensure the sickest prisoners were disqualified. Instead, it was mostly on a first-come, first-serve basis in the early morning before the work day began, with work exemptions ending as soon as the limit was reached. This meant many sick prisoners were kept at hard labor.

Many prisoners experienced declining health until they got so weak they could perform only extremely light labor or even none at all. The medical staff could declare such a prisoner to be an invalid. Invalids did a little light work inside the camp, such as carrying messages or assisting the medical staff in the infirmary. They were fed a minimal ration that essentially was barely adequate to maintain them in their weakened state. Many invalids died of their conditions unless they were luck enough to survive to the end of their sentences. Very many invalids were diagnosed with alimentary dystrophy, which meant they were suffering the effects of starvation. Most of these could have been saved with rest and adequate food, but that was not the GULag's way of handling things. "Alimentary dystrophy" was a convenient medical term that allowed the Soviets to disguise the fact in their records that they were starving many of their prisoners.

Internationally, the Soviets did not hide the fact that they were using "corrective" labor, supposedly turning criminals into good citizens. However, the vast scale of the GULag, its brutality, and its high death rate were kept secret, to avoid international outcry over what the USSR was doing. The death rate per hundred prisoners in the (peacetime) GULag for 1934–1940 was about four to six times higher than the death rate per hundred citizens for the entire USSR. However, this GULag death figure does not include GULag deaths in 1933, during the Soviet famine of 1932–1933, a time when the death rate in the GULag were particularly high due to starvation and exhaustion.

Overall, the GULag camps were somewhat similar to the German wartime forced-labor camps, which also had brutal conditions, inadequate food, and a high death rate. However, the camps were not like the German wartime extermination camps, where the Nazis engaged in mass murder of people they deemed inferior. The Soviets were certainly capable of mass murder, and, for example, killed about 22,000 Polish prisoners in 1940. The Soviets even did once have the near-equivalent of a death camp, although it was not part of the GULag. In 1937–1939, the site of the now-closed SLON camp on the Solovetskie Islands was reopened as the Solovetskie Special-Purposes Prison [*Solovetskaya Tyurma Osobogo Naznacheniya*], informally called "Groan" because its Russian abbreviation, STON, was also the Russian word for groan (*ston*). This prison was run directly by the secret police, who used it almost like a death camp, part of a massive plan to defeat "the whole gang of anti-Soviet elements in the most merciless way"[236]. Many prisoners at STON ended up being executed by the secret police, although most were first transferred to nearby Soviet Karelia on the mainland for actual execution, since it was easier to hide mass graves in the Karelian forests than on the small Solovetskie Islands. STON closed in 1939.

As bleak as life in the camps actually was, there were ways the prisoners could make life a bit easier on themselves. Most prisoners were allowed to correspond with their unimprisoned relatives elsewhere in the USSR (although their letters were examined), and they asked to be sent food, clothing, and other necessities. Many relatives in turn sent packages with food and items, as much as they could spare. The GULag not only allowed this but was instrumental in ensuring the packages were distributed to the prisoners. As

236 per NKVD Order № 00447.

long as no contraband like weapons was sent, the GULag allows the prisoners to keep the clothing and other items; they did not count towards the GULag-issued items. Although not presented as such, this package system in effect was a voluntary tax paid by Soviet citizens to support the prisoners in the GULag.

The dark side to the packages was that the GULag took no responsibility for the contents of the packages after delivery. The GULag contained many *urki*, consisting of hardened professional criminals as well as ordinary prisoners driven to a state of permanent cruelty by their experiences, the "wild ones". The *urki* preyed on all prisoners who could not protect themselves and would steal anything they wanted from the other prisoners. For many prisoners, food had to eaten quickly or hidden thoroughly to prevent the *urki* from getting it. Clothing, particularly warm winter coats and hats, was frequently stolen at the first chance or extorted from the weaker prisoners. Prisoners who complained to the camp guards that their items had been stolen were simply told that what happens between prisoners was no concern of the guards. Sometimes, some guards collaborated with the professional criminals to rob the prisoners, receiving a cut of the take as payoff for not intervening. Some guards would detain new prisoners or prisoners in transit between camps with the professional criminals, so that the prisoners would be robbed.

Another way to make life easier was to obtain food from unauthorized means. Prisoners sent to work outside the camp, such as for lumbering, would search for wild food whenever they could get away with it, including semi-edible grasses and especially berries when in season. Camps located in areas that could grow food had their own farms, which produced some of the food for the camp. Even rather northerly camps could at least grow potatoes and often raise pigs. Prisoners sent to work the fields would eat the food raw when the guards were not watching or would try to smuggle it back into their barracks. Since farm food was property of the camp, the guards would try to prevent this or sometimes be given a cut of the take to look the other way. Prisoners sent to unload train cars of grain or other food deliveries would try to steal some of the food. Sometimes the guards themselves would steal some of the food, to secure a bit more sustenance for their families.

The camps themselves had quotas to fulfill for their various operations, in addition to the individual work quotas given to the prisoners. It could be very bad and even dangerous if a camp missed its quotas, as the camp commandant and other non-prisoner administration staff could be disciplined, dismissed, or even accused of the crime of wrecking. The result was that the camp administration did everything in its power to meet camp quotas, mainly by squeezing more work out of the prisoners. Prisoners' already-long day shifts could be indefinitely extended until the quota was met. The camps had occasional days off from work, at times about one day in every ten, but the days off would be canceled if the camp was behind on its quotas.

As the Soviets tried to wring more work out of the civilian economy, the GULag adapted these measures to its own operations. A form of socialist competition occurred between the camps, such as differing camps with lumbering operations competing to see who could over-fulfill their quotas the most. In theory, this competition was voluntary, at the discretion of the camp commandants, but in practice few if any failed to volunteer, for fear of the consequences to their careers. The prisoners of course had no choice in whether to participate in these competitions.

The Stakhanovite movement also spread to the GULag from its origins in the civilian economy in 1935. Its main feature in the camps was to award the best food rations to workers who achieved Stakhanovite levels of production (150% of their quotas). As in the civilian economy, many camps gamed the system to be able to show they had Stakhanovite workers.

From its inception, the GULag had no lack of prisoners. The ending of the New Economic Policy in 1928 followed by massive industrialization and collectivization of agriculture meant a constant stream of prisoners flowed into the camps. "NEPmen" who had profited under the limited capitalism allowed by the NEP became prisoners, lawyers who defended the NEPmen in court, and many people who resisted collective agriculture or industrialization all were imprisoned. Class enemies (presumed to be anti-Soviet even if they committed no crime) were sent to the camps, including kulaks (well-off peasants) and clergy. Political dissidents and former members of banned political parties (all parties except the Communists) went to the camps. Stalin's ascension to power resulted in new groups that went into the GULag, including Trotskiyites (supporters of Lev Trotskiy, Stalin's purged and exile rival for power) and wreckers. As always, the USSR had numerous professional criminals who were sent to the camps when caught.

In 1935, a previously untouched group of people became liable for forced labor: youthful offenders. In early 1918, the Soviets had removed juvenile offenders under the age of 18 from prosecution in the justice system or from incarceration in penal institutions. Instead, special commissions consisting of a judge, a teacher, and physician examined these offenders for their "social neglect", personality, and medical condition. These traits were supposed to guide the commissions to decide on the "medical-pedagogical" treatments for these offenders. (A later law allowed the commissions to transfer youth who were not responding to treatment to the Soviet courts for punishment, but commissions rarely invoked this law[237].)

This system seems to have worked until about 1928–1930, when the USSR began its massive drives to industrialize and to collectivize agriculture. Juvenile delinquency rates then began to increase substantially, with 1934's rate being 185% that of the already-rising 1931 rate. Almost certainly the disruption of family life caused by industrialization and collectivization was a huge factor in the rising rates, but as always Stalin's USSR blamed its victims rather than reforming itself. In 1935 the Soviets abolished the commissions and made juvenile offenders aged 12–18 subject to the Soviet courts and to criminal prosecution. They were liable to all degrees of punishment, including the death penalty. The justice system did not use the standard adult courts to handle juvenile cases but instead used special branch courts or selected judges. Work camps were set up for youths sentenced to corrective labor, administer by the People's Commissariat of Justice rather than the GULag. However, in practice, some juveniles as young as 16 went through the adult courts and ended being sent to the GULag. Minors in the GULag were particularly brutalized by the *urki* and frequently became *urki* themselves.

The Soviets also blamed the parents and other adults for most juvenile delinquency and tried them accordingly. Parents judged guilty of neglect were subject to fines. Any adult found guilty of contributing to the delinquency of a minor faced a five-year sentence of forced labor in the GULag.

Starting in 1936, Stalin unleashed the Great Purge across the USSR. All sorts of people were denounced and imprisoned as spies, wreckers, anti-Soviet agitators, and so on. The goal was to rid the USSR "once and for all of the entire gang of anti-Soviet elements who undermine the foundations of the Soviet State" (per N.I. Ezhov, the People's Commissar in charge of the NKVD. Almost no part of the USSR was spared, with the NKVD's secret policy purging civil society, economic enterprises, government bodies, the military, the Communist Party, and, eventually, even the secret police themselves. Millions or people, most of whom had not really committed a serious crime, went into the GULag. People went into the GULag for making jokes about their jobs or the USSR that resulted in charges of anti-Soviet activity. Completely innocent people went to the camps for no reason other than the secret police had quotas on how many people they had to arrest, and the NKVD always met its quotas. (Some NKVD officers eager for promotion petitioned to have their quotas increased.) People who

237 Nathan Berman; "Juvenile Delinquency, the Family, and the Court in the Soviet Union"; *American Journal of Sociology*, Vol. 42 No. 5; 1937; http://www.jstor.org/stable/2767762

were arrested were often put under great pressure or tortured to supply names of other people to arrest, resulting in the innocent causing more innocent to be arrested. The Great Purge was greatly scaled back in 1938 but never really ended until the Germans invaded the USSR in 1941.

In addition to these people, Stalin had come to seriously mistrust any and all ethnic groups that had members both in the USSR and in nearby countries, the so-called "nationalities of foreign governments". Among the persecuted groups were Soviet Chinese, Estonians, Finns, Germans, Greeks, Koreans, Latvians, Poles, and Romanians. Some of these groups, particularly the Poles, had been persecuted before, but the Great Purge savaged them. However, relatively few went into the GULag. At least 335,000 member of these groups were arrested and sentenced, but on the order of 250,000 were executed[238].

There were likely many reasons why Stalin had the GULag built up to an immense size, although his actual thoughts will never be known with certainty. Likely his personality defects played important roles, such as possible paranoia about being surrounded by enemies, revenge against Old Bolsheviks who respected him less than Lenin and other Bolshevik leaders, and a desire to terrorize the Soviet population into unquestioning obedience to his wishes. However, it also seems clear he regarded slave labor as a convenient and cheap way to build the Soviet economy. Many raw materials were in remote, inhospitable regions where free civilians did not wish to go, so GULag labor was used to extract them. By about 1940, the GULag (and thus the NKVD) was producing about three-quarters of USSR's tin, about 60% of its gold, almost half of its nickel, and about a quarter of its lumber, plus many other resources.

The NKVD had established sharashkas or sharagas of skilled workers, as covered above. During the Great Purge, there were so many prisoners with professional skills that the NKVD through the GULag greatly extended its economic influence over the Soviet economy. Many sharashkas were formed. Some occupations, particularly aircraft design, had many of its top designers tied up in the GULag, usually in sharashkas, at some point, including:

- A.A. Arkhangelskiy (Ar-2 dive bomber) was arrested and sent to Tupolev's sharaga, although he was never convicted of the spurious crime he was charged with.
- R.L. Bartini (Stal-7 twin-engine experimental aircraft, which led to the Er-2 and Er-4 medium bombers) was arrested and sent to a sharashka.

238 Werth Nicolas; "The NKVD Mass Secret National Operations (August 1937–November 1938)"; *Mass Violence & Résistance*, [online]; 2010; https://www.sciencespo.fr/mass-violence-war-massacre-resistance/en/document/nkvd-mass-secret-national-operations-august-1937-november-1938.html

- D.P. Grigorovich (R-1 recon plane and I-5 fighter, both co-designed with N.N. Polikarpov) was arrested and sent to a sharashka.
- K.A. Kalinin (K-5 airliner) was arrested and executed. He was not sent to a sharashka but nonetheless worked on an experimental design of a delta-wing aircraft while awaiting trial.
- S.P. Korolyov (aircraft and rocket designer, future chief designer of the Soviet space program) was sent to the GULag camps and forced to mined gold in Siberia before being assigned to a sharashka.
- V.M. Myasishchev (various models of the Pe-2 twin-engine aircraft) was arrested and sent to a sharashka.
- V.M. Petlyakov (Pe-2 attack bomber) was arrested and sent to a sharashka.
- N.N. Polikarpov (I-15 and I-16 fighters) was arrested and sent to a sharashka.
- A.N. Tupolev (TB-1 and TB-3 heavy bombers, Tu-2 attack bomber) was arrested and sent to a sharashka.

At one point, the NKVD even had a secret sharashka researching offensive biological warfare agents, in competition with the Red Army's secret biological warfare program. Saner heads eventually prevailed, and the NKVD biological warfare effort was transferred to the Red Army.

With its labor camps, labor colonies, and sharashkas, by the late 1930s the NKVD had considerable influence over the Soviet economy. It was roughly analogous to the influence SS had over the German economy during the late war years. The rise of the NKVD's economic power, however, was offset by a decline in the growth rate of the non-prison Soviet economy. The purges sent millions to the GULag, but poorly-fed slave laborers using hand tools was not a particularly efficient or productive means to grow the economy. The purge also terrorized the many millions of free (non-prison) workers into being cautious and trying to meet their work quotas no matter what, taking a lot of dynamism out of the Soviet economy.

The sharashkas were not particularly efficient at cutting-edge research and development. Soviet aircraft design shows this. Fighter technology was changing extremely rapidly in the second half of the 1930s. During the Great Purge, however, Soviet fighter development stalled, likely because so many designers were in sharashkas unable to do their best work, while the free designers were too afraid to take chances at innovation, lest failure caused them to be imprisoned. While other countries in 1936–1938 were developing a new generation of advanced fighters, the Soviets were only making minor improvements to their existing fighters. Near the end of the 1930s, the Soviets finally woke up to the fact that German and British fighters were now substantially better than Soviet fighters. They instituted crash projects to try to catch up. By the time of the German invasion of 1941, a new generation of Soviet fighters was entering service, but these were roughly equivalent of the 1939 generation of foreign fighters and not their 1941 ones. Most tellingly, all the new fighters, the LaGG-1, LaGG-3, MiG-1, MiG-3, and Yak-1, came from free aircraft designers, not those in sharashkas.

In August 1939, the USSR signed a non-aggression pact with Nazi Germany. The treaty had a secret agreement that split eastern Europe between the two countries. In 1939–1940, the USSR took its share by occupying and annexing the following territories into the Soviet Union:

1939: Eastern Poland.

1940: Estonian, Latvia, Lithuania, and part of Romania (Bessarabia and Northern Bukovina).

All these territories were purged of hundreds of thousands of so-called class enemies, including the middle class, clergy, business owners, politicians, professionals, and so on. Some were executed, many were sent into internal exile elsewhere in the USSR, and many went into the GULag. According to Soviet records, which might not be accurate, just over 200,000 of these people received sentences for political and anti-Soviet crimes. Other sources suggest the total was much higher.

Eastern Poland was a special case. Not only were the class enemies persecuted but on the order of 300,000 Polish soldiers were taken prisoner. Soviet-based sources claim many common soldiers were released and only about 130,000 ended up in Soviet POW camps, but I have not seen this confirmed in the few Polish-language or English-language sources I have examined. In 1940, Stalin at first approved a proposal to execute all Polish POWs, but this was later reduced to mostly just executing Polish officers plus other Polish nationalists and educated people who might lead a future resistance to Soviet rule. About 22,000 were executed. Most of the other POWs went into the GULag.

As soon as Germany invaded Poland on 1 September 1939, many Polish citizens in western Poland fled east to escape the invaders. When the USSR entered eastern Poland later in September, the region thus had hundreds of thousands of refugees. Since they were not inhabitants of eastern Poland, they did not automatically become Soviet citizens when the USSR annexed the region. The Soviets brought pressure to have these people declare themselves Soviet citizens. Very many, probably most, did not agree to this, as they hoped to return home to western Poland if and when Germany was defeated. The Soviets dealt with this resistance by sending these people into the GULag. To justify their occupation of eastern Poland, the Soviets claimed that the Polish state had collapsed and ceased to exist, ignoring the fact that the Polish government had actually gone into exile in Britain. On the pretext that the Polish state ceased to exist, the Soviets then refused to recognize the refugee's Polish identity documents as valid. It was a crime for foreigner to be in the USSR without proper papers, which then gave the Soviets the legal pretext to send the refugees to the GULag, with sentences of five years of forced labor.

The German invasion of June 1941 profoundly affected the GULag, like it did with the rest of the USSR. Soon, the GULag was ordered to do much more, to support the war effort, while the resources it received from the Soviet economy were cut. Although the GULag tried to be as self-sufficient as possible, it did require various manufactured goods made by the non-prison economy, such as vehicles, communications gear, electrical equipment, fuel, and so on. All these preferentially went to the Red Army and defense industries, leaving the GULag most to get by as best it could. The camps tried to maintain existing equipment as best they could or substitute less-effective alternatives. At the same time, the Soviets demanded the GULag increase its production of raw materials and manufactured products to help with the war effort, typically without providing the GULag with more supplies to achieve this goal. The GULag responded by increasing the work loads of its prisoners.

Like the rest of the USSR, the GULag was unprepared for the Axis invasion. It had a number of camps in the western USSR that ended up in the battle zone, as well as numerous constructions projects with prisoners building roads and railroads there. Some of these construction sites were overrun by the rapidly-advancing Germans in the opening weeks of the war. The convoys troops would fight the Germans, and at times the prisoners would grab weapons and fight the enemy as well. However, the Soviets were afraid that GULag prisoners might prefer to defect to the enemy if possible, so they moved all GULag camps and construction crews out of the battle zone. With the trains and trucks having to support the war effort, most of the prisoners were marched by foot to safer locations, on treks that could take weeks.

Sidetrip: Julius Margolin and the Wartime GULag

Julius Margolin wrote about his experiences in Stalin's wartime GULag, in two books. They have been published together in English in 2020 as *Journey into the Land of the Zeks and Back*, actually comprising his *Journey to the Land of the Zek* and his *The Road to the West*. "Zeks" was the informal name for prisoners of the GULag.

Julius Margolin was a Jewish citizen of Poland and resident of the British mandate of Palestine, where he and his family lived in worked in what would become Israel. Margolin has the tremendous misfortune to be on a working trip to Poland in the summer of 1939. Germany invaded Poland in September 1939, and Margolin was one of many thousands who fled to eastern Poland to escape the Nazis. He was unable to escape in Romania, being turned back twice on the border by Romanian border guards who refused to allow Jews to enter Romania. On one of these occasions, a Polish Army officer helped the Romanians to identify Margolin as Jewish. Margolin was stuck in eastern Poland when the Soviets occupied it, and he was one of many thousands there sent to the GULag in 1940, essentially for wanting to return home and thus refusing to accept Soviet citizenship. He was appalled at the immense size and monstrous cruelty of the GULag, which he, like most people outside the USSR, did not existed in such a form.

Margolin served a five year sentence in the forced-labor camps, was released in 1945, and soon was allowed to be repatriated to Poland, now controlled by Polish Communists. From there, he managed to leave the country for France and then sailed by ship back home to Palestine. He wrote about his experiences in the 1940s, exposing and denouncing Stalin's monstrous system. I highly recommend *Journey into the Land of the Zeks and Back* if you are interested in a first-hand account of what the GULag was like during World War II. The book's introduction is essentially a synopsis of Margolin's two books with a bit of context and analysis. I recommend you read Margolin's work first to get the full impact. (If you only want a summary, then read the introduction instead.)

Margolin had no access to Soviet documents or other information about the GULag, so his writing comes from his own experiences and what he was told by the other prisoners and the camps' administrators. Nonetheless, he does an amazing job in covering the GULag. Margolin was a highly educated man (with a Ph.D. in philosophy), highly literate, and able to speak Russian, Polish, German, Hebrew, and other languages. He was thus able to observe and remember very many things about the GULag, almost like a sociologist researching a foreign land.

I've only noticed two issues in his work: 1) He states that GULag prisoners were not sent to fight in the Red Army during the war. This is not correct, as many were released to serve in the Red Army. Margolin would have known about this from the other prisoners had it occurred at his camp, so possibly none were released from that camp. (The camp had very many of what the Soviets called "Westerners", people who like Margolin were sent to the GULag for being in eastern Poland and refusing to accept Soviet citizenship. Possibly camps like this were treated differently than camps containing only Soviet citizens.) 2) He claimed the GULag contained about 10 million prisoners. Once-secret NKVD records suggest the NKVD had about 2 million prisoners in 1940–1941. Margolin's figure very likely came from what the prisoners and camp administrators themselves believed was the size of GULag. 10 million is consistent with what the NKVD itself was telling the upper reaches of the Soviet government at the time, as covered below.

The food situation in the GULag was always poor, and it grew much worse soon after the war began. The many camps in remote regions with harsh climates meant that the GULag could not grow enough food for itself. However, the Germans in 1941 occupied Ukraine, a crucial food-producing region of the USSR. Food quickly went into short supply, and the Soviets rationed it based on military priorities. The Red Army, which was vital in the defense of the country, got top priority[239], followed by civilian workers in defense industries. Other workers got less, as did civilians not in the labor force. The prisoners of the GULag had the least priority. Since even Red Army soldiers struggled to get enough food as late as 1944–1945[240], the situation in the GULag was dire. Prisoners' food rations were cut several times in 1941–1942. Since all but the 125% of quota and 150% of quota rations were already inadequate, this tipped hundreds of thousands of prisoners into malnutrition and starvation. Malnourished prisoners quickly weakened and became mostly or completely unable to work. The winter of 1941/42 saw mass starvation, resulting in about one quarter of the

239 At least officially. Top Communist Party and Soviet government officials got fully adequate, sometime lavish rations, particularly the inner circle of Stalin and his top advisers and cronies.

240 Even as late as 1945, hungry Soviet soldiers extensively looted farms of food as they advanced into Germany and Poland. For a good account of this, see Antony Beevor; *Berlin: The Downfall 1945*; 2002.

GULag's prisoners dying in 1942, mostly of starvation or of being overworked while severely malnourished. The winter of 1942/43 was little better, resulting in about one fifth of prisoners dying in 1943. The mortality rate decreased significantly thereafter; about 10% for 1944 and 5% for 1945, still rather high rates when you realize the GULag contained few elderly people.

Like the rest of the Soviet economy, the GULag converted its manufacturing abilities to military production as much as it could. It made weapons, ammunition, uniforms, and various supplies. Skilled workers and technicians in the GULag were transferred to special labor colonies which helped to make tanks and aircraft. (They were likely contracted out at workers to non-prison tank and aircraft factories.)

As soon as the autumn of 1941, the Soviets realized the GULag had serious problems. They began releasing hundreds of thousands of young women and unproductive, invalid workers from the GULag. However, the remaining prisoners were made to work harder, so the ranks of the invalids were constantly being replenished due to starvation and overwork.

Starting at least in 1942, military-capable prisoners were given the choice of serving in the Red Army. Well over a million had their sentences suspended and were released from the camps for military service. Depending upon how well they served, their GULag sentences could be reduced or negated. Deaths, releases of the unfit, and releases for military service greatly reduced the prisoner population of the camps, from perhaps about 1.5 million in 1941 to a bit more than 650,000 in 1944.

Internal NKVD records indicate that about 620,000 prisoners died in the GULag in 1942–1943, almost 40% of the total of about 1,610,000 deaths through the GULag's entire existence (1930–1956). Around this time, the prisoners left in the GULag began to joke and hope that the end of the GULag was in sight, given how the prisoner population was dwindling. However, 1943 soon saw the start of new masses of prisoners flowing into the camps. The Soviets were now winning the war, pushing the Germans back and liberating swathes of Soviet territory that had been occupied by the enemy. Many Soviet citizens in the occupied territories had collaborated with the Germans, some willingly and others not. The Soviets regarded these collaborators as traitors and sent many of them to the GULag. They even brought back the use of the phrase "*katorzhnyye raboty*" (convict forced labor) for these prisoners, who were treated more harshly than others.

In 1943, the Soviets started deporting "collaborationist" Soviet ethnic groups into internal exile in the USSR. Members of these groups had collaborate with the Germans, and the

Soviets collectively punished the entire group. Kalmyks were deported in 1943, followed in 1944 by Chechens, Crimean Tatars, Ingush, and others. While these groups did not go into the GULag as a whole, anyone who tried to stay in the homelands or fled from their place of exile were sentenced to hard labor in the GULag. They too were *katorzhnyye raboty* and subjected to severe treatment.

In 1944–1945, three new sources of Soviet citizens also began going to the GULag: military collaborators, Soviet prisoners of war liberated from German POW camps, and Soviet citizens who worked in Germany as slave laborers. Over a million Soviet citizens had assisted the German military, some as auxiliary helpers and some as armed security and military forces. Many who survived to the end of the war tried to escape returning to the USSR, but most were returned. Soviet citizens. Military collaborators in territories occupied by the western Allies were often turned over to the Soviets by the Allied forces. The Soviets of course regarded these people as traitors and severely punished many of them. Many higher officers were executed, and very many were sent to the GULag camps, often with a double punishment of a first 10-year sentence to be automatically followed by a second, 5-year sentence.

Soviet soldiers taken prisoner by the Germans during the war were also under serious suspicion of being traitors. Many western histories claim that essentially all the ex-POWs went into the GULag, but this is not correct. All except the sickest or most disabled were initial sent to internment camps (not GULag labor camps) run by the NKVD security forces. The NKVD processed these people, releasing some while send other on into the GULag. Presumably many ex-POWs who had voluntarily surrendered to the Germans were regarded as traitors and punished, while those who had surrendered on the orders of Red Army generals (like in the Kiev Pocket in 1941) were not classed as traitors. However, the sources I've seen on this do not go into enough detail to be sure on this point.

As early as the autumn of 1941, the Germans were sending Soviet citizens in the German occupied region of the USSR to Germany as workers. At first, thousands of civilians, particularly from Ukraine, volunteered to go work in Germany. These were people who had been severely mistreated by the Soviets in the 1920s–1930s and saw the Germans as liberators. However, by the spring of 1942 the well of volunteers had dried up. Soviet civilians in Germany from the start were treated extremely poorly, essentially as forced labors with few rights. Some of these Soviets managed to escape Germany and return home, where they told their stories of mistreatment. Also by this time, the Soviet civilians in the occupied regions were thoroughly disillusioned with Germany due to the inhumane policies of the German occupation. The Germans responded to the lack of volunteers by deporting Soviet civilians to Germany, where their status deteriorated into outright slave laborers. In 1945, the Soviets liberated these people as they overran the eastern half of Germany. However, the Soviets regarded all these people as suspect. Anyone who volunteered of course was regarded as a traitor. However, they feared that even people who had been forced go work in Germany might have developed anti-Soviet attitudes after seeing how much better living conditions were in Germany as compared to the USSR. The NKVD security forces processed these people similar to the ex-POWs, releasing some and sending others to the GULag.

At least some of the prisoners sent to the camps as wartime traitors were housed in special barracks apart from the other prisoners and were treated more harshly. I speculate that part of the reason they were kept in separate barracks was to guard them specially. Since many of the people had combat experience, the GULag authorities might have regarded them as more likely to mount a revolt than the other prisoners.

As the Soviets won the war in 1943–1945, they took many Axis soldiers, mostly Germans, as prisoners of war. The Soviets were incensed by the vast number of war crimes committed by the Axis, by the brutal German occupation policies in the USSR, and by the vast destruction the Germans inflicted as they retreated. Axis POWs were forced to work to rebuild the USSR, even after the war ended. The Soviets consider this labor as part of the reparations the Axis owed the USSR due to the war. (Ethnic German civilians from Germany and eastern European countries were also forcible deported to the USSR to work as forced laborers, as covered below.)

Technically, Axis POWs were under the NKVD's GUPVI (***G****lavnoe* ***Up****ravlenie po Delam* ***V****oennoplennykh i* ***I****nternirovannykh*, the Main Administration for Affairs of Prisoners of War and Internees) and not the NKVD's GULag. However, this mattered little in practice. GUPVI was run by personnel from the GULag and its camps were like GULag camps with excessive forced manual labor, inadequate food, and high death rates. At times, both GUPVI and GULag prisoners worked together on the same projects. In these cases, its seem both types of prisoners were housed at GULag camps, likely with the Axis POWs in separate, better-guarded barracks.

The number of German POWs held by the Soviets and the number of these POWs who died during forced labor is still subject to considerable controversy. There was on the order of 3 million German POWs in the USSR and several hundred thousand deaths. Besides the Germans, about 2 million other Axis POWs were forced laborers in the USSR, including many Hungarians, Italians, Japanese[241], and Romanians, with several hundreds of thousands dying. However, the Japanese were treated much better than the Germans or other Axis nationalities, since Japan had not invaded the USSR nor had taken part in the brutal Axis occupation of Soviet territory. Most POWs were repatriated by 1950. POWs convicted of war crimes remained longer, with the last leaving in 1956.

The decisive victory of the USSR over Germany gave hope to many Soviet citizens that the Soviet Union would liberalize its repressive policies in the immediate post-war period. This was not to be. Instead, Stalin not only wanted to rebuild the USSR as rapidly as possible, he was also planning to spread Communism and Soviet influence throughout the world. He knew his former allies would be opposed to this, perhaps militarily, so he kept building up Soviet heavy industry and investing in new weapons of all types. In pursuit of these goals, by the early 1950s, the GULag grew even larger that it had been ever before, reaching and staying at about 2.5 million prisoners. However, the death dramatically decreases from 1949 on, indicating that conditions in the camps were not as inhumane as before.

Stalin died in 1953 and almost immediately the new Soviet authorities began releasing hundreds of thousands of people from the GULag. In 1953, an amnesty released non-political prisoners and some political prisoners, those with sentences of less than five years. In 1954–1956, the Soviets released the longer-term political prisoners or sent them to the forced-labor colonies. Many camps closed, while others were converted to regular prisons. The colonies, however, continued to exist. The GULag was officially disbanded in 1960, with the colonies in operation as a different organization under the MVD, the successor to the NKVD. Forced labor remained a punishment in the USSR, although it was not as inhumane as under Stalin. The USSR continued to punish political opponents and dissidents, including with imprisonment. During the era of attempted reforms in the 1980s, the USSR finally closed the last of its forced-labor colonies.

By the Numbers: GULag Population and Death Toll

The number of prisoners sent to the GULag camps and colonies, and the number of deaths there, are still somewhat open questions. Secret NKVD records on this became available after the collapse of the USSR, but it is unclear how accurate these records actually are. Sometimes, the GULag did not report the actual prisoner population of the camps but the maximum prisoner capacity of the

241 Most Japanese soldiers captured by the Soviets considered themselves internees and not POWs, since they had been taken prisoner after Japan had surrendered. The Soviets seem not to have made a distinction.

camps. It is believed in these cases the actual prisoner population was about 85% of the maximum.

Worse, there is considerably discrepancies in reported prisoner population figures. Internal NKVD records state the GULag camps and colonies had a total of about 1.20 million prisoners on 31 December 1936. However, the NKVD claimed a total of 2.75 million GULag prisoners for the Soviet census of 6 January 1937, and it is unbelievable that the prisoner population more than doubled in about a week. One, or perhaps both, of these figures is likely incorrect.

This pattern of discrepancies crops up repeatedly. Beriya, the head of the NKVD, at the end of 1938 told the Politburo the GULag had almost 7 million prisoners, but internal NKVD records show 1.9 million prisoners. In 1952, an official MVD report to Stalin stated the GULag had 12 million prisoners, but internal MVD records show 2.5 million prisoners. (The MVD was the post-war name of the NKVD and was still under Beriya.) Was the NKVD/MVD consistently overstating the GULag population to the highest levels of the Soviet government and Party? This could have braggadocio or empire-building on the part of Beriya, but it would have been very dangerous for him if the numbers turned out to be very wrong. Were the internal NKVD records known to be inaccurate, with the NKVD adjusting them for external use? GULag camps were in remote areas and often lacked literate or numerate administration staff, so errors were likely. Many historians accept without much evidence that the internal NKVD records were likely more accurate, but that is not very reassuring.

Interesting, Julius Margolin in *Journey to the Land of Zeks and Back* claims the GULag population was about 10 million prisoners circa 1940–1941. Margolin was a Polish citizen and resident of British Palestine who had the misfortune to be in eastern Poland when the Soviets occupied it in 1939. The Soviets sent Margolin to various GULag camps in 1940–1945. He survived, managed to leave the USSR, and soon wrote about his experienced. Margolin would have had no way to know the total prisoner population of the GULag, so his 10 million claim likely came from what the prisoners and the camp administration believed to the population. Note that 10 million for 1940–1945 is quite consistent with Beriya's claims of 7 million for 1938 and 12 million for 1952. All told, the actual population of the GULag should be regarded as an open question.

The prisoner death records in particular are known to be inadequate. The GULag often released prisoners who had fatal illnesses or were in the terminal phase of starvation. Almost all of these people would have died in a short time, but their deaths were not attributed to the GULag. Also, at least in some camps at some times, it seems that only prisoners who died on the camp groups themselves were recorded. The deaths of prisoners who died while doing forced labor outside the camps were not attributed to the GULag. This likely happened, for example, during the construction of the Moskva Canal, which had an official death tally of 22,842 deaths in Dmitlag, the prison camp housing the workers. However, the actual death toll was likely higher, as it seems the 22,000 figure may only have recorded deaths at the camp itself. Some other camps likely operated similarly.

All that said, the following tables show the population of the GULag and its death toll based on the internal NKVD/MVD records.

GULag Prisoner Population, Selected Years

Figures are from internal NKVD/MVD records on the GULag and list the number of prisoners as of 1 January of each listed year.

Year	In Camps	In Colonies	Total	Notes
1935	725,483	240,259	965,742	
1936	839,406	457,088	1,296,494	The Great Purge starts in 1936.
1937	820,881	375,488	1,196,369	
1938	996,367	885,203	1,881,570	
1939	1,317,195	355,243	1,672,438	Although the Great Purge is now over, the population of the camps continues to grow significantly
1940	1,344,408	315,584	1,659,992	
1941	1,500,524	429,205	1,929,729	This is the highest population of the GULag before the start of the Great Patriotic War.
1942	1,415,596	361,447	1,777,043	
1943	983,974	500,208	1,484,182	Significant numbers of collaborators from liberated Soviet territories begin going to the GULag.
1944	663,594	516,225	1,179,819	
1945	715,505	745,171	1,460,676	The Great Patriotic War ends this year and is followed by a short war with Japan.

1946	746,871	956,224	1,703,095	1946 is the first full year of peace. The GULag population begins significant growth again.
1948	1,108,057	1,091,478	2,199,535	
1950	1,416,300	1,145,051	2,561,351	This is the highest population of the GULag throughout its history.
1952	1,711,202	793,312	2,504,514	
1953	1,727,970	740,554	2,468,524	Stalin dies in 1953 and soon the Soviets start releasing significant numbers of prisoners from the GULag.

GULag Death Rate, Selected Years

Figures are from internal NKVD/MVD records on the GULag. The figures include the GULag camps and colonies as well as Soviet prisons unless otherwise indicated.

Year	Deaths	Death Rate	Notes
1930	7,980	4.2%	Figures only include the camps, not the colonies or prisons.
1931	7,283	2.9%	Figures only include the camps, not the colonies or prisons.
1932	13,197	4.8%	Figures only include the camps, not the colonies or prisons.
1933	67,297	15.3%	Figures only include the camps, not the colonies or prisons. The rate is high due to the Soviet famine of 1932–1933.
1934	25,187	4.3%	Figures only include the camps, not the colonies or prisons.
1935	31,636	2.8%	
1936	24,993	2.1%	
1937	31,056	2.4%	
1938	108,654	5.4%	
1939	44,750	3.1%	
1940	41,275	2.7%	
1941	115,484	6.1%	The Great Patriotic War begins this year.
1942	352,560	24.9%	The year with the highest death rate in the GULag.

1943	267,826	22.4%	The year with the second highest death rate in the GULag.
1944	114,481	9.2%	
1945	81,917	6.0%	The war ends this year.
1946	30,715	2.2 %	
1948	50,659	2.3%	
1950	24,511	1.0%	The GULag’s death rate never goes above 1% from this year.
1952	20,643	0.8%	
1954	8,358	0.7%	
1956	3,164	0.4%	
Total	1,606,748	8.9%	

9.E The Labor Army and Other Forced Labor

“Devastation and the Labor Army.”
Propaganda poster; Nikolai Kochergin; 1920

In 1920, the Soviets were winning the Russian Civil War, but the economy was collapsing. They began converting some of their armies and other military units that were no longer needed for combat into "labor armies", sometimes with conscripted civilian laborers. These labor armies greatly ranged size, from 15,000 to 250,000 soldier-workers and civilians. Their work involved the confiscation of "surplus" food from the peasantry, delivery of fuel and food to the cities, logging, coal and peat mining, petroleum extraction, and railroad and bridge reconstruction. These labor armies technically were not considered forced labor but a form of labor service. However, many of the peasants who had been drafted into the Red Army were very unwilling soldiers and labor army workers, and some of the civilians conscripted into the labor armies may have been unwilling, too. The labor armies thus had some aspect of forced labor about them.

Part of the rational for having labor armies was the ability to convert them back to military armies if needed for combat again. As military threats subsided, the Soviets disbanded these labor armies, starting in December 1920 and ending in February 1922.

Also during the Russian Civil War, the Soviets required forced labor from the prisoners of war they captured.

During the Great Patriotic War, the Soviets required forced labor from Soviet citizens considered to be potentially disloyal, and from members of or Soviet ethnic groups collectively considered to be disloyal. These workers were informally called the "Labor Army" in imitation of the civil-war-era labor armies.

Sidetrip: Internal Exile and Special Settlements

The 1920s–1940s USSR used internal exile as a punishment and deterrent, often for minor political offenses of common civilians and for political opposition to Stalin of some important Party leaders. For example, Lev Trotskiy was first sent into internal exile for being a major rival to Stalin over control of the Party after Lenin's death in the 1920s. At the time, Stalin insufficiently powerful just to have the very popular Trotskiy imprisoned or executed. (Trotskiy was later sent into foreign exile and then assassinated on Stalin's orders.) For another example, the workers who ended up leading the Teykovo strike of 1932 were sent into internal exile. People sent on internal exile were prohibited from leaving their place of exile, which could be a region, city, or town.

The USSR under Stalin also went through waves of forcing selected groups of Soviet citizens or entire Soviet ethnic groups to resettle from their homelands to other places in the USSR, which they were then prohibited from leaving. People who avoid resettlement or left the resettlement area were sent to the GULag camps when caught. The Soviets had several terms for this resettlement, including special settlements, exile settlements, special resettlement, and administrative exile. Today, the forced resettlement of ethnic groups is called a form of ethnic cleansing.

Internal exile and forced resettlement were administered by the NKVD. Force resettlement of ethnic groups was usually particularly brutal, with everyone in the group being rounded up with minimal time to prepare to move. Only some personal items could be taken. No exceptions were allowed for pregnant women, ill persons, or the extreme elderly. Transport typically was by rail in unheated cattle cars with inadequate sanitation, inadequate food, and no medical care. The forced settlers were often just left in remote regions of Siberia or the Kazakh SSR with no preparations made to house, feed, or care for them. Many died on the trip to the resettlement area or in the first year after resettlement. Death rates of a quarter or more of the settlers were common.

Resettlement at first did not involve forced labor. However, members of many ethnic groups resettled in 1939–1944 subsequently became forced laborers during the Great Patriotic War.

The wartime Soviet government never officially called the forced labor of these people the Labor Army. Officially, the workers were in various labor battalions or detachments, labor columns, and labor collectives, all under NKVD guard. Soviet citizens forcibly conscripted into the Labor Army were no longer considered free citizens, although they were not convicted prisoners like those in the GULag. Mistrusted citizens of several ethnic backgrounds were sent to the Labor Army as shown below.

Ethnic Composition of Soviet Citizens in the "Labor Army"

Initial	**Ethnic Group**
Groups sharing ethnicity with an Axis country	Finnish, German, Hungarian, Italian
Groups in territory recently incorporated in the USSR	Estonian, Latvian, Lithuanian, Romanian
Any Time	**Ethnic Groups**
Individuals believed likely to betray the state	Any ethnicity (Russians and Ukrainians dominated simply due to the size of the ethnic groups, but these groups themselves were not considered disloyal)

Later in War	Ethnic Groups
Individuals likely to have collaborated with the enemy	Any ethnicity (Belarusians and Ukrainians dominated simply due to the fact that the Germans occupied all of the Belorussian and Ukrainian SSRs)
Groups sharing ethnicity with groups in Japanese occupied territory	Koreans
Groups with members known to have collaborated with the enemy	Bashkirs, Chechens, Crimean Tatars, Ingush, Kalmyks, others
Later in War; Reason	**Ethnic Groups**
Soviet soldiers taken prisoner by the Axis and suspected of disloyalty*	Any ethnicity
Soviet citizens forced to work for the Germans as slave laborers*	Any ethnicity

> * These soldiers and citizens were processed by the NKVD on their return to Soviet authority. Besides being sent to the Labor Army, they could be sent instead to the GULag or released to return home, based on how guilty or innocent the NKVD believed them to be.

The USSR had many citizens with ethnic German ancestry (many of whom spoke German), a legacy of Tsarina Ekaterina II encouraging Germans to settle in 18th Century Russia. When Germany invaded, the Soviets feared their ethnic Germans would collaborate with the invaders, so they deported them east from Ukraine and the Volga River valley to the Urals, Central Asia, and Siberia. Starting in September 1941, the Soviets then conscripted German males aged 15–55 and German females aged 16–45 but without young children into the Labor Army. These people were forced to work at mining, oil drilling, peat extraction, logging, construction, and other manual labor activities. Work conditions were often very hard, frequently the same as in the GULag. Indeed, many were sent to work at GULag camps, although they were supposed to be housed separately from the prisoners (but this did not always happen). Many died of overwork and disease.

Other Soviet ethnic minorities and other Soviet citizens were also sent to the Labor Army, although in most places ethnic Germans remained the majority of forced laborers. Some sources imply the Labor Army was disbanded at the end of the war in 1945. In actually, some forced laborers began to be released in 1944, when the USSR was clearly winning the war, while others were demobilized in 1945–1947. However, many Soviets citizens actually entered the Labor Army in 1945, consisting of Soviet soldiers who had been Axis prisoners of war and of Soviet citizens forced to work as slave laborers in Germany. The labor detachment and columns were all disbanded in 1947. However, special labor settlements of ethnic Germans remained working until 1955 and at least partly were involved in building secret facilities and close cities for the Soviet nuclear industry.

During the war with the USSR, the Germans began forcibly deporting Soviet citizens to do forced labor in Germany, where they became poorly-treated slave laborers. The Soviets over the course of 1943–1944 decided that some ethnic Germans in turn would be deported to the USSR and forced to do labor to help rebuild the USSR. This policy was always presented as a labor component to the reparations Germany owed the USSR for the war. However, there likely was another intention as well, revenge for Germany's use of Soviet citizens as forced laborers.

This Soviet policy was particularly cruel in that it applied to ethnic Germans in general, not just the ethnic German citizens of Germany. There were many ethnic Germans, the *Volksdeutsche*, living in many eastern European countries. Many *Volksdeutsche* were proud of their German heritage, and some actively helped Nazi Germany, even to the extent of willingly fighting for Germany. However, other *Volksdeutsche* were indifferent or hostile to the Nazis. The Soviets would treat them all alike. In late 1944 and in 1945, about 270,000 people, supposedly ethnic Germans, were sent to the USSR. The Soviets advanced deep into eastern Europe before they captured significant territory in Germany itself, so the eastern European *Volksdeutsche* were the first to be deported to the USSR. It is certain that the Soviets departed people that were not ethnic Germans, as it was sometimes difficult to ascertain ethnicity. Poland provided a particularly tricky case. Large parts of western Poland had come parts of Germany when the Polish state was recreated after World War I. Although the region had an ethnic-Polish majority, there were many ethnic Germans also living there. Many remained and perforce became Polish citizens. Some of them could speak Polish as well as German, just like some ethnic Poles who lived in the region could speak German as well as Polish. Germany occupied western Poland in 1939 and annexed a large part of it into Germany, expelling many ethnic Poles there in order to resettle *Volksdeutsche* in their places. (Many of these *Volksdeutsche* came from regions annexed into the USSR in 1939–1940.) Besides speaking German, some of these *Volksdeutsche* could also speak the language of the country they came from, such as Romanian. When the Soviets entered this region, sorting out ethnic Germans from other ethnic groups was a huge task, and not one that the Soviets charged with deporting ethnic Germans to the USSR were particularly good at. Of the 270,000 "Germans" deported to the USSR, about 20,000 were subsequently sent back as being “Polish citizens”, presumably being ethnic Poles rather than ethnic Germans. It seems likely that others who were not ethnic Germans but could not convincingly demonstrate it were kept as forced laborers in the USSR.

Most of these forced laborers worked in heavy industry in the Donets Basin and in the Urals. They were kept in the equivalent of prison camps. Some were women and older men who could not perform heavy manual labor, and the Soviets began to repatriate these people starting in 1945. However, about a quarter of these workers died from the harsh work conditions. Almost all survivors were repatriated by 1950. Even calling it “repatriated” is a bit misleading. Many of the *Volksdeutsche* who were deported to the USSR could not return to their home countries. Eastern European countries like Czechoslovakia and Yugoslavia expelled almost all all their ethnic German citizens after the war and refused to take back these *Volksdeutsche* returnees. Instead, they had no place to go except to Germany, where they had to start their lives all over again in a new country.

9.F Soviet Labor Productivity

Soviet Labor Productivity (baseline year is 1940 at 100)

Years	Industry	Construction	Transportation
1940	100	100	100
1941	110	100	98
1942	130	91	79
1943	139	96	74
1944	142	95	67
1945	114	89	68

Source: Narodnoe Khozyaystvo SSSR v Velikoy Otechestvennoy Voyne 1941–1945 gg. (*People’s Economy of the USSR in the Great Patriotic War 1941–1945*); a 1959 formerly-secret statistical compilation by the Soviet government. The Industry column excludes any industrial activities at Soviet collective and state farms.

Industrial labor productivity soared during the war because the workforce was required to work mandatory overtime hours and was not allowed to take voluntary time off.

10 Concluding Remarks

A typical Western view of the USSR during World War II is that it fought the war using quantity over quality. The Red Army was huge and bumbling, especially in 1941–1942, but even by the end of the war soldier-for-soldier the armies of Germany and the western Allies fought better. Soviet industry supplied the Red Army with poorly-made weapons, especially in 1941–1942, but even by the end of the war their engines wore out quicker and their aircraft and tanks were manufactured more poorly than those of Germany and the western Allies. The Soviets won the war by repeatedly throwing hordes of men, tanks, and aircraft into battle, taking heavy casualties but wearing down the German forces to the point of collapse. This view is a bit stereotyped, but it is mostly accurate.

This work on Soviet energy shows a different side of the USSR: skilled workers, technicians, and engineers repeatedly overcoming great challenges to supply the USSR with the energy and fuel it needed to win the war. Allied aid did greatly help with Soviet energy, particularly by sending the oil industry vitally-needed equipment and by sending about half the aviation gasoline (including light gasoline fractions) the Soviet military needed. However, this aid only enhanced the efforts of the Soviet energy industries.

The Soviet coal industry lost about half its coal production capacity when the Donbass was lost in 1941. It spent the rest of the war building up production at other coal basins and successfully supplying Soviet defense industries with the coal they needed to make steel and weapons. The oil industry took a big hit to oil production and refining capacity during the German 1942 summer offensive, but the Soviets denied the Germans from capturing any intact oil fields or refineries. Oil equipment evacuated out of the path of the enemy was quickly put back into operation at locations farther east. The natural gas industry was in its infancy at the start of the war. It not only began its growth to became a major energy source and exporter, it also provided gas to some industrial cities, allowing then to reduce their coal usage. The electricity generation industry underwent a construction boom that help power the factories. Despite suffering major capacities losses in 1941–1942, it had regained 100% of its 1940 level in 1946, well before the coal and oil industries had recovered. All told, these Soviet industries overcame major challenges and provided the energy, fuel, and power to help the Soviets win the war.

However, the Soviets' treatment of their work force and, indeed, their entire population was inhumane and wasteful, not only during the war but also throughout Stalin's entire tenure as dictator (1928–1953). In the 1930s, literally millions of Soviet citizens died due badly implemented policies (especially from famine due to collectivization of agriculture and the destruction of the kulak class of better-off peasants), arbitrary executions by the secret police, exhaustion and starvation in the GULag, and unnecessary accidents in the mad rush to industrialize at any human cost. Forced labor in the GULag's camps and colonies was very inefficient. Free workers were subject to ever-growing policies that removed their rights and tried to force them to work harder, which disillusioned and demotivated many workers. The Great Purge terrorized common and professional workers alike, removing some of the dynamism from the economy. As covered above, for one example, the effects of the purge caused the USSR to miss an entire generation of fighter aircraft. The Soviets then instituted crash development project for fighters, resulting in problem-plagued new fighters that were still about two years behind German fighters in 1941.

The Soviets and their apologists contend that what the USSR did was necessary to industrialize rapidly and prepare for the coming war. I contend the Soviets likely would have been even better prepared and militarily stronger had the USSR treated its people and workers better. Industrialization might have proceeded slower at first, but in return Soviet industry could have avoided much of the many destructive accidents and low-quality manufacturing that characterized it. With good results compounding over time, the economy likely would have grown faster in the late 1930s, instead of it historical "catching a fever" with lesser rates of growth. The USSR thus could have had millions more workers and soldiers available when Germany invaded. Better-treated workers likely would have been more productive, and the economy would have been more productive without the masses of GULag slave laborers. Weapons would have been better designed, better made, and available in greater quantity. The war could have ended earlier in Soviet victory, with much less loss of life and destruction.

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