THE NATURAL GAS INDUSTRY
OF THE USSR

by

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of
GEOGRAPHY

We accept this thesis as conforming to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA
April, 1965
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Department of Geography

The University of British Columbia, Vancouver 8, Canada

Date May 4, 1965
The last few years have witnessed momentous decisions in Soviet fuel policy. After long neglect, a sudden and all-out priority was given to the production of petroleum and natural gas, and the creation of a massive petrochemical industry was ordered. The official support and the economically more rational climate of the post-Stalin decade proved a tremendous boon to the gas, oil and petrochemical industries. In composition the fuel structure of the USSR is fast approaching that of the United States, and the petrochemical build-up—though younger—is also vigorous. The new fuel policy has already put its mark on the map of the country, but the full impact is yet to come. The Soviet energy picture, therefore, is in a state of flux and furious development, and the same goes for the chemical industry. The new fuels have not yet had time to create a crystallized and mature geographic pattern, as in the United States, but such a pattern is in emergence and can now be examined. This paper deals with the position of natural gas in the new Soviet fuel geography and, in addition, considers its contribution to the emerging petrochemical industry of the USSR.

Since the early fifties the natural gas industry, which was completely undeveloped throughout the Stalin era, experienced a growth, the rate of which exceeded all other branches of the fuel industry of the USSR. Contributing less than one-forth of the fuel mix as late as 1955, its share has grown to an eighth in 1963 and is close to a sixth today. The Soviet Union is thought to have far greater resources of gas than any
other country in the world but its fully proved reserves are still only a quarter of those of the United States.

Over eighty percent of production today comes from only three regions, all in European Russia, yet the areal discordance between production centers and the major consuming areas is quite considerable. With one or two exceptions, the industrial centers of the country have no output on their own and generally are located far from supplying fields. This areal discordance and, consequently, the large-scale transport of natural gas over great distances are increasing, as the immense reserves, believed to exist south and east of the Urals, are proved and brought into production.

The amount consumed, the share of gas in the fuel mix, and the sectorial distribution of consumption differ greatly in each economic region. However, the share of industry (the generation of electricity included) everywhere predominates, and far more heavily than in the United States. Variations in the amount consumed and the manner of utilization lend a distinctness of character to the gas industry in each Soviet region. Nevertheless, similarities in certain areas are great enough to permit regional groupings.

The essay consists of two main parts: a general and a regional. In Part I the evolution of Soviet fuel policy, the production of, and markets for, natural gas, the characteristics of Soviet reserves and, finally, the Russian pipeline network are considered. Part II examines the principal regions where gas is produced and is utilized, attempts an integrated treat-
ment of the role of gas in the regional economy, and analyses interregional variations. Because the research done so far on that very young industry usually treats it on a national plane, the analysis of regional profile, attempted in Part II, is considered to be the major contribution of this paper.
I wish to express my gratitude to Dr. D. J. Hooson and Dr. J. D. Chapman for their advice and criticism in the writing and organization of this thesis. I am also indebted to Dr. W. M. Armstrong, Dean of Metallurgy, and Dr. H. M. McIlroy, Department of Mechanical Engineering, for their help in some of the technical questions involved. Special thanks are due to Dr. Robert Campbell of Indiana University who made a chapter of his forthcoming book on the economics of Soviet oil and gas available to me. Finally, I am grateful to my wife, Jennie, who drew most of my maps and assisted me throughout the work.
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</tr>
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<td>16 &amp; 50</td>
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<td>Map 3</td>
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<td>Map 11</td>
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<td>Map 13</td>
<td>The North Caucasus</td>
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</tbody>
</table>
There is extensive and apparently reliable statistical data available on the Soviet fuel industries, and over the last decade the problem of a rational fuel mix has also been examined by a small number of Soviet scholars. The natural gas industry, however, is so young that most worthwhile information on it is restricted to the 1960's. Today one finds a relative abundance of material on dry natural gas, but sources are still extremely scanty on oil-well gases, natural gas liquids and their use as petrochemical feedstocks. Owing to the very youth of the industry, Russian terminology is sometimes inconsistent, especially concerning natural gas liquids and petrochemicals. This makes interpretation and comparisons occasionally very difficult.

Soviet writers generally emphasize production over consumption in their works, and statistical data is lacking on many aspects of consumption which a student of the Soviet fuel industries would be interested to know. What exists on the utilization of natural gas is found almost exclusively on an all-Union basis, and the regional pattern of consumption is extremely difficult to get. For this reason, the material lends itself more easily to an economic than a geographic analysis. Recently Soviet economists have shown considerable sophistication in their treatment of the economic effects of alternative uses for gas, but little has been done yet to examine the regional profile of the gas industry in detail.
The irrationality of Soviet internal boundaries presents the greatest difficulty to the latter. The boundaries of major economic regions frequently break up economically homogeneous and tightly-knit areas. Considerable juggling and transforming of data are frequently required in order to arrive at reasonably accurate figures for more meaningful regions.

In the writing of this thesis extensive use had to be made of technical materials. These included the chief gas and oil journals of the USSR and the United States, chemical periodicals and publications. Much valuable information was gained, mainly for the regional section, from economic and geographic publications and from newspaper articles.
PART I

GENERAL SECTION
Chapter I

THE EVOLUTION OF SOVIET FUEL POLICY
Despite her less developed economy and smaller absolute production of energy, on the eve of the First World War, Tsarist Russia could in some ways boast a more "modern" fuel mix than the United States. While in the latter country coal accounted for 80 per cent of all energy production and oil and gas merely 8 per cent, in Russia the share of coal stood at about 50 per cent and that of oil about 30 per cent. Both nations were already moving away from wood at a swift pace, though in Russia it still supplied close to a fifth of all energy, a share twice as large as in the United States. Following the recovery from the ravages of war, revolution and civil strife, the semi-capitalistic New Economic Policy further stimulated the utilization of more effective fuels. In 1928, the share of oil again reached close to one-third, and the production of natural gas also started. Before 1900, perhaps the greater portion of Russia's oil was exported and did not enter into the domestic fuel mix. By the last decade of Tsarist rule, however, only a small share of the output went abroad: 8 per cent in 1908 and about a tenth in 1913. Most of the output, therefore, was consumed at home.

1 Sam H. Schurr and Bruce C. Netschert: *Energy in the American Economy*. John Hopkins Press, Baltimore, 1960, p. 497 Table II.
2 For sources, see Table I.
## 3.

### Table I

**Fuel Production in Russia and the USSR**

*(all fuels are converted to "nominal fuel": 1 ton = 7000 Calories)*

<table>
<thead>
<tr>
<th>Year</th>
<th>All fuels</th>
<th>Coal</th>
<th>Oil</th>
<th>Natural gas (including oil well gases)</th>
<th>Peat</th>
<th>Shale</th>
<th>Wood</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Million tons</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1913(within present boundaries)</td>
<td>48.2</td>
<td>23.1</td>
<td>14.7</td>
<td>---</td>
<td>0.7</td>
<td>---</td>
<td>9.7</td>
</tr>
<tr>
<td>1913(within inter-war boundaries)</td>
<td>45.9</td>
<td>23.1</td>
<td>13.2</td>
<td>---</td>
<td>0.7</td>
<td>---</td>
<td>8.9</td>
</tr>
<tr>
<td>1940</td>
<td>237.7</td>
<td>140.5</td>
<td>44.5</td>
<td>4.4</td>
<td>13.6</td>
<td>0.6</td>
<td>34.1</td>
</tr>
<tr>
<td>1945</td>
<td>185.0</td>
<td>115.0</td>
<td>27.8</td>
<td>4.2</td>
<td>9.2</td>
<td>0.4</td>
<td>28.4</td>
</tr>
<tr>
<td>1950</td>
<td>311.2</td>
<td>205.7</td>
<td>54.2</td>
<td>7.3</td>
<td>14.8</td>
<td>1.3</td>
<td>27.9</td>
</tr>
<tr>
<td>1955</td>
<td>479.9</td>
<td>310.8</td>
<td>101.2</td>
<td>11.4</td>
<td>20.8</td>
<td>3.3</td>
<td>32.4</td>
</tr>
<tr>
<td>1958</td>
<td>616.4</td>
<td>362.1</td>
<td>161.9</td>
<td>33.9</td>
<td>21.1</td>
<td>4.5</td>
<td>32.9</td>
</tr>
<tr>
<td>1960</td>
<td>692.8</td>
<td>373.1</td>
<td>211.4</td>
<td>54.4</td>
<td>20.4</td>
<td>4.8</td>
<td>28.7</td>
</tr>
<tr>
<td>1963</td>
<td>845.3</td>
<td>388.5</td>
<td>294.7</td>
<td>105.1</td>
<td>21.8</td>
<td>6.5</td>
<td>28.7</td>
</tr>
</tbody>
</table>

**Percent of total**

<table>
<thead>
<tr>
<th>Year</th>
<th>All fuels</th>
<th>Coal</th>
<th>Oil</th>
<th>Natural gas (including oil well gases)</th>
<th>Peat</th>
<th>Shale</th>
<th>Wood</th>
</tr>
</thead>
<tbody>
<tr>
<td>1913(within present boundaries)</td>
<td>100</td>
<td>48</td>
<td>30.5</td>
<td>---</td>
<td>1.4</td>
<td>---</td>
<td>20.1</td>
</tr>
<tr>
<td>1913(within inter-war boundaries)</td>
<td>100</td>
<td>50.3</td>
<td>28.8</td>
<td>---</td>
<td>1.5</td>
<td>---</td>
<td>19.4</td>
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<tr>
<td>1928(inter-war boundaries)</td>
<td>100</td>
<td>52.0</td>
<td>30.8</td>
<td>0.6</td>
<td>4.1</td>
<td>---</td>
<td>12.5</td>
</tr>
<tr>
<td>1940</td>
<td>100</td>
<td>59.1</td>
<td>18.7</td>
<td>1.9</td>
<td>5.7</td>
<td>0.3</td>
<td>14.3</td>
</tr>
<tr>
<td>1950</td>
<td>100</td>
<td>66.1</td>
<td>17.4</td>
<td>2.3</td>
<td>4.8</td>
<td>0.4</td>
<td>9.0</td>
</tr>
<tr>
<td>1955</td>
<td>100</td>
<td>64.8</td>
<td>21.1</td>
<td>2.4</td>
<td>4.3</td>
<td>0.7</td>
<td>6.7</td>
</tr>
<tr>
<td>1958</td>
<td>100</td>
<td>58.8</td>
<td>26.3</td>
<td>5.5</td>
<td>3.4</td>
<td>0.7</td>
<td>5.3</td>
</tr>
<tr>
<td>1960</td>
<td>100</td>
<td>53.9</td>
<td>30.5</td>
<td>7.9</td>
<td>2.9</td>
<td>0.7</td>
<td>4.1</td>
</tr>
<tr>
<td>1963</td>
<td>100</td>
<td>46.0</td>
<td>34.9</td>
<td>12.4</td>
<td>2.5</td>
<td>0.8</td>
<td>3.4</td>
</tr>
</tbody>
</table>


It is, of course, possible that the quickening pace of industrial development and a sharp increase in fuel consumption—still very low in absolute terms—would have raised somewhat the share of coal, relative to petroleum and gas, in the nation's energy supply. Indeed, the output of oil had reached a peak in the first five years of the century, which it did not reach again until 1927. But the growth of coal production was rapid and, in addition, unbroken until the Revolution.

Yet, the rapid growth of the oil industry and the high share of liquid fuels in the nation's energy supply was just too striking to be dismissed as a flash-in-the-pan development. It seems that Russia began its belated Industrial Revolution with an already "modern" fuel mix, which—other things remaining equal—would persist. It was a fuel structure which the United States would reach—though on an enormously greater absolute scale—only in the late 1920's and Western Europe only in the last decade.

This surprisingly modern early energy structure of Russia did not continue unbroken. The Stalin era was an unquestionable set-back for liquid and gaseous as compared to solid fuels. Although output of petroleum and natural gas was gradually rising, the growth of production was much slower than in the case of coal, shale and peat. As a result, in the

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4 Narodnoye Khozyaystvo SSSR v 1958 godu, p. 201 and 208.
fuel mix of the USSR, the share of oil and gas comprised less
than a fifth of the total in 1950— an all-time low even if one
includes the years of the Civil War. Especially after 1935,
Stalin also forced the production of low quality "local fuels"—
lignites, peat and shale— in areas far from major coal basins,
and even in regions where the presence of oil and/or gas was
already known. The output of very expensive, low quality
lignites from the Uralian, Central Asian and, especially, Moscow
Basins soared, while throughout the 1950's the mining of shale
continued in the Syzran (Volga) and Stavropol' (North Caucasus)
regions. The combined share of local fuels rose in relative
importance, and in 1950 constituted a seventh of the nation's
energy balance. Yet these fuels— notably peat— appear to
have been subsidized.

This outdated fuel mix was not due to ignorance about
the potentialities of the country's petroleum and gas reserves.
Although there was pessimism in certain quarters, many leading
geologists exhibited an early awareness about the riches of
the Soviet sedimentary basins. Excellent geological and gravi-
metric studies identified the subterranean structures of most
of European Russia, Middle Asia, even part of Western Siberia,

5. S. Lisichkin & L. Tomashpol'sky: "Nekotorye metodologi-
cheskiye voprosy toplivno-energeticheskikh balansov, "Voprosy
Ekonomiki, 1962, No. 11, pp. 48-49.
Dept. of Commerce, Washington, 1962, p. 82, Table III; p. 85,
Table VII and p. 33.
7. Ibid., pp. 43-45.
and the probable existence and approximate whereabouts of huge oil and gas deposits were generally known by the mid-thirties. Yet this did not lead to quick seismic mapping and vigorous exploratory drilling for lack of official support. Only the terrible lessons of World War II quickened, finally, the pace of prospecting, though even in the mid-fifties the amount of drilling was small by American standards.

This trend was contrary to that which was followed by the United States from the early twenties onward, and some fifteen years later, at a slower pace, even by the world at large. The development of Soviet energy production between 1928 and 1955 resembled not the contemporary trend in the United States, but that prevailing between 1880 and the end of the First World War (see Appendix, Table I). Soviet fuel policies were based on non-economic considerations—on political and ideological beliefs, such as regional autarky and the forced development of ferrous metallurgy, and reflect the bureaucratic blunders frequent in an over-centralized economy.

The failure to base fuel policy on genuinely economic grounds and thus favour the growth of the petroleum and gas industries was dearly paid for. Even if firewood is excluded, in 1955 the average calorific content of a kilogram of fuel produced in the USSR was only 5608 Cal. (less than the world average in 1913), while the world average in 1953 was 7520

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Cal. From 1913 to 1955, Russia experienced merely 6 per cent (from 1928 to 1955 only 1 per cent) increase in the calorific content per kg. of fuel produced. The increase for the world as a whole was almost 30 per cent. Over the same period, the weight of fuel equivalent per 100 kwh in the United States declined by 35 kg. in Russia by only 10 kg. The average number of kilograms required to produce 1000 kwh of electricity in the USSR was much more in excess of that required in the United States in the year 1953 than it was in 1913. The outdated fuel structure also led to injurious effects upon productivity in fuel extraction and refining. Output of raw mineral fuels per extraction worker did not even double between 1928 and 1950, and output of refined products-- coke, petroleum products etc.-- per refining worker actually declined. It has also burdened the Soviet economy with excessive transport and handling costs and deprived it of a wide range of by-products.

**EFFECT OF THE NEW FUEL POLICY ON THE**

**NATURAL GAS INDUSTRY**

Only after Stalin's death could the question of fuel priorities be subjected to serious critical examination. The obsolete nature of the country's energy structure quickly became evident and the wider use of liquid and gaseous fuels

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10 D. M. Shimkin: *op. cit.*, Table I, p. 80.
was strongly urged. The new, post-Stalin climate, with its increasing degree of economic rationality, provided a powerful stimulus for the growth of the natural gas industry. Output increased ten fold between 1955 and 1963, from less than 9 billion cubic meters to over 90 billion, and is expected to reach 128 billion by the end of 1965. As Table II indicates, the production of free gases has been increasing considerably faster than that of oil-well gases, while the volume of those manufactured from coal and shale has remained stationary and of negligible importance. Natural gas is taking a progressively greater share in the fuel mix of the USSR, accounting for over 12 per cent in 1963, a figure which is to rise to 17 per cent by the end of 1965. Oil and gas jointly already supply more than half of all fuel requirement and their share will continue to rise in the future. The Soviet Union is striving to achieve an energy-balance resembling that of the United States. In all probability, given a dozen years, the shares of the three main fossil fuels will match closely in the two countries. The present chemical drive—another move in the direction of greater rationality in the Soviet economy—is also intimately connected with the development of oil and

11 A. Probst: op. cit., Voprosy Ekonomiki, No. 1, 1956, p. 27.
TABLE II
Production of Gas in the USSR (million cu. meters)

<table>
<thead>
<tr>
<th>YEAR</th>
<th>FROM GAS WELLS</th>
<th>FROM OIL WELLS</th>
<th>MANUFACTURED</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>3997.4</td>
<td>1763.5</td>
<td>419.6</td>
<td>6180.5</td>
</tr>
<tr>
<td>1955</td>
<td>5897.6</td>
<td>3083.3</td>
<td>1375.2</td>
<td>10356.1</td>
</tr>
<tr>
<td>1956</td>
<td>8408.1</td>
<td>3661.8</td>
<td>1613.0</td>
<td>13682.9</td>
</tr>
<tr>
<td>1957</td>
<td>14256.0</td>
<td>4327.1</td>
<td>1646.5</td>
<td>20229.6</td>
</tr>
<tr>
<td>1958</td>
<td>22674.9</td>
<td>5409.7</td>
<td>1807.5</td>
<td>29992.1</td>
</tr>
<tr>
<td>1959</td>
<td>28858.5</td>
<td>6532.5</td>
<td>1876.4</td>
<td>37267.4</td>
</tr>
<tr>
<td>1960</td>
<td>37596.9</td>
<td>7706.3</td>
<td>1910.9</td>
<td>47214.1</td>
</tr>
<tr>
<td>1961</td>
<td>50383.5</td>
<td>8597.8</td>
<td>1916.1</td>
<td>60897.4</td>
</tr>
<tr>
<td>1962</td>
<td>63511.4</td>
<td>10013.5</td>
<td>1718.7</td>
<td>75243.6</td>
</tr>
<tr>
<td>1963</td>
<td>77678.6</td>
<td>12145.7</td>
<td>1627.0</td>
<td>91451.3</td>
</tr>
</tbody>
</table>


gas extraction and refining, since petroleum and natural gas are the most important as well as the cheapest raw materials for the chemical industry. In most areas, natural gas also provides the least expensive energy for that fuel and power-intensive activity. The neglect of these fuels during the Stalin era proved exceedingly harmful to the development of the chemical industry, which was practically non-existent despite the strong tradition of Russian chemistry. What little existed was based on coal and-- to a large extent-- even on vegetable raw materials, wood and animal fat. Costs were extremely high and operations backward. The present crash program to develop
10. a large-scale petrochemical industry, reduce the share of coal and eliminate the reliance on plant and animal sources, would not be possible without the change in the fuel policy which took place in the second half of the last decade.

THE NEW FUEL POLICY IN WORLD PERSPECTIVE

It is important not to regard the Soviet fuel and chemical revolutions only in their narrow national context or as merely a crucial step in the economic race with the United States. These revolutions are not peculiar to the two great superpowers alone, and the Soviet policy change is best seen against an international background.

Appendix, Table II shows a rapid rise in the share of liquid and gaseous fuels all over the world. The case of Western Europe is particularly illuminating, for here energy consumption has long reached a high level, the chemical industry was well developed and the economy was essentially coal-based. In most countries, however, coal reached a peak by 1930, and from that time oil consumption has been increasing at a much faster rate. This is not true of Germany, dedicated to the principle of economic autarky and after 1945 prostrate in defeat. The trend, however, was strong in coal-hungry countries such as Sweden, Holland, France and Italy, and clearly evident even in coal-rich Great Britain by 1950.

Since 1950, this trend became a revolution. The share of liquid fuels in the energy mix of Western Europe as a whole has now reached one-third, and, in Italy and Sweden has well
surpassed the share of oil in the United States. Coupled with it came the phenomenal upsurge of petrochemical industry even in such a traditional citadel of coke chemistry as the Ruhr. In 1961-62, over half of all organic chemical production in West Germany came from petroleum, in Great Britain nearly two-thirds.

The fuel and chemical revolutions in Western Europe were almost exclusively based on imported crude, and—due to small reserves—natural gas as yet has played a very minor role. This situation, however, is about to change as the presence of huge gas deposits around and under the North Sea are becoming evident. Although it is unlikely that Western Europe could ever rival the Soviet Union in natural gas output, a marked increase in the consumption of that fuel seems certain. In any case, it is clear that with her new fuel policy and petrochemical drive, the Soviet Union is not treading any novel or extraordinary path peculiar to her and the United States only, but has simply joined in a world-wide trend, followed even by such European countries which have no oil, little gas, and are rich in coal.

12.

REGIONAL DISTRIBUTION OF NATURAL GAS PRODUCTION

Table III, Maps 1, 2 and 3 supply data about the output of natural gas in the chief regions of the USSR. At present, production is sharply concentrated in three areas—the Ukraine, the North Caucasus and the Volga—which together accounted for over 80% of all output in 1962 (about 61.4 billion cubic meters out of a total of 73.5 billion). All three regions are situated in European Russia which—together with the Transcaucasus—consumed 97 per cent of all gas at the above date. As Map 3 shows, the Central Asian republics and Kazakhstan still produce much less than their vast reserves would warrant, while production has not yet begun in Western Siberia. At the same time, the shares of the Ukraine, the North Caucasus and most of the Volga are higher in production than in reserves. (For a detailed analysis of reserves, see Chapter III). The last years of the current Seven Year Plan call for a sharp increase in output in Central Asia. From a mere two billion cubic meters in 1962, it is to rise to 19 billion by the end of 1965, 17 billion of this from the Uzbek Republic.

Over the last decade important changes have taken place in the gas industry of the Ukraine and the North Caucasus. Until the early fifties, most of the Ukrainian output came from the old Carpathian fields, and though small in absolute volume, production from these deposits represented over a

\[16\]

Derived from production data and the distribution of pipeline network in 1962.
### Table III
Regional Breakdown of Natural Gas Production
(billion cubic meters)

<table>
<thead>
<tr>
<th>REGIONS</th>
<th>1958 Free Oil Well gases</th>
<th>1962 Free Oil Well gases</th>
<th>1965 (plan) Free Gases gases (except for total USSR)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USSR</td>
<td>22.67</td>
<td>5.40</td>
<td>63.5</td>
</tr>
<tr>
<td>RSFSR</td>
<td>10.16</td>
<td>3.58</td>
<td>31.5</td>
</tr>
<tr>
<td>Volga-Urals</td>
<td>4.22</td>
<td>3.00a</td>
<td>9.9</td>
</tr>
<tr>
<td>Kuybyshev Ob.</td>
<td>0.65</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>Orenburg Ob.</td>
<td>1.57</td>
<td>5.2</td>
<td></td>
</tr>
<tr>
<td>Saratov Ob.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bashkir ASSR</td>
<td>2.00</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>Volgograd Ob.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Astrakhan Ob.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&amp; Kalmyk ASSR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Caucasus</td>
<td>4.93</td>
<td>0.47a</td>
<td>20.8</td>
</tr>
<tr>
<td>Krasnodar Kray</td>
<td>0.53</td>
<td>9.4</td>
<td></td>
</tr>
<tr>
<td>Stavropol' Kray</td>
<td>4.30</td>
<td>11.3</td>
<td></td>
</tr>
<tr>
<td>Chechen-Ing.ASSR</td>
<td>0.09</td>
<td>n.a</td>
<td></td>
</tr>
<tr>
<td>Dagestan ASSR</td>
<td>0.01</td>
<td>n.a</td>
<td></td>
</tr>
<tr>
<td>Komi ASSR</td>
<td>1.03</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>West Siberia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>East Siberia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sakhalin Ob.</td>
<td>0.10</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Ukrainian SSR</td>
<td>9.10</td>
<td>0.398</td>
<td>25.3</td>
</tr>
<tr>
<td>West Ukraine</td>
<td>4.95c</td>
<td>0.398</td>
<td>7.9c</td>
</tr>
<tr>
<td>East Ukraine</td>
<td>5.05c</td>
<td>17.45c</td>
<td></td>
</tr>
<tr>
<td>Azerbaydzhan SSR</td>
<td>3.33</td>
<td>1.115</td>
<td>4.6</td>
</tr>
<tr>
<td>Central Asia</td>
<td>0.08</td>
<td>0.271</td>
<td>2.0</td>
</tr>
<tr>
<td>Uzbek SSR</td>
<td>0.08</td>
<td>0.045</td>
<td>1.9</td>
</tr>
<tr>
<td>Turkmen SSR</td>
<td>0.08</td>
<td>0.224</td>
<td>0.238</td>
</tr>
<tr>
<td>Kirgiz SSR</td>
<td>0.002</td>
<td>0.1</td>
<td>0.018</td>
</tr>
<tr>
<td>Kazakh SSR</td>
<td>0.042</td>
<td>0.046</td>
<td>0.06</td>
</tr>
</tbody>
</table>
quarter of the total for the whole USSR in 1950 and over a third if oil-well gases are excluded. By 1958, however, the chief center of production in the Ukraine has shifted to the newly discovered huge Shebelinka field in Kharkov Oblast'. In that year, Shebelinka already accounted for 55 per cent of the

Notes for Table III:

a) Approximate. Calculated by assuming the same gas-oil ratio for the North Caucasus as in Azerbaydzhan, where oil-fields are in similar depth and have been exploited for about the same length of time. Data for the Volga Region was obtained by subtracting production in the North Caucasus from the total for the RSFSR and assigning 110,000 cubic meters for the other (very minor) regions in 1958 and 410,000 cubic meters in 1962. For data on oil production in the North Caucasus, see footnote 6, p. 162 (Chapter VII).

b) Includes oil-well gases.

c) Approximate. Calculated by taking the mid-value between the 1961 and 1963 production at Shebelinka, then subtracting it from total Ukrainian production to obtain output in the Western Ukraine. 1965 production was calculated by assuming the same relationship between the output of the two Ukrainian regions that existed in 1963.

d) Ranges are due to discrepancy among sources.

e) These plans were formulated in 1959 and it is now clear that they will be far from realized.

RESERVES AND PRODUCTION OF NATURAL GAS IN THE EUROPEAN USSR

Oil well gases are excluded from production data.
The full extent of these reserves is not yet known.
output of the Ukraine, while by 1963, its share was nearly 70%. In the North Caucasus, the large scale production of natural gas began in 1953 from the large North Stavropol' field, Krasnodar Kray remaining unimportant until the present decade. Due to the development of several deposits in the Kuban, however, output in Krasnodar and Stavropol' Kray is about equal today.

As explained in more detail in Chapter III, the present rate of production is severely taxing the resources in many regions of European Russia, such as the Volga, the Transcaucasus and the Ukraine. At the same time, the large reserves of Central Asia and the Lower Ob Valley are used very inadequately or not at all today. As output from the old fields cannot substantially be increased any further, and new discoveries in here are less likely than south and east of the Urals, a gradual shift in production centers could be expected in the future.
Chapter II

MARKETS FOR NATURAL GAS
Since 1955, natural gas is playing a progressively greater role in the Soviet economy. It is consumed by a variety of users and its share in the fuel mix of the USSR increases steadily. To analyze its various uses, an understanding of its terminology and basic categories is necessary.

Natural gas may be derived from distinct gas deposits as well as from oil fields, where the gas forms a cap overlying the crude. Both categories are included in the term 'natural gas' (prirodnyy gaz in Russian), although in Russian literature the term can also be restricted to mean free gas only, to distinguish it from oil-well gas which has a separate name, popytnyy. In its broadest meaning, however, natural gas also includes natural gas liquids—liquid petroleum gases (LPG's), natural gasoline, and condensates—progressively heavier hydrocarbons, which are generally separated from methane the chief component of natural gas, in gas-processing plants.

In trying to analyze the use of gas in the Soviet economy, one is hindered by the inconsistencies in Soviet data. It is not always clear in Soviet literature which categories are included in the term 'natural (prirodnyy) gas'. Production figures generally include output of oil-well gases (this fact is nearly always indicated), and it is easy to see when they do not. Output data refers to gas before it is processed; natural gas liquids, therefore, are not treated as additional output. Manufactured gases are clearly separated in production statistics that refer to natural (prirodnyy) gas. On the other hand, consumption figures for various sectors of the economy,
especially when they are given in percentages, are frequently ambiguous, for it is often hard to determine which categories of gas are included in the data.

Table IV shows the consumption of natural gas by sectors of economy in the USSR and the United States. Several sources provide data on Soviet gas consumption, all showing disagreements. Two have been selected below, the second (Bokserman) giving the breakdown only in percentages. Novikov expressly, and Bokserman, probably, include manufactured gases in the figures, but since these gases represent less than two per cent of Soviet gas output, their inclusion does not greatly affect the allocation pattern. The US total refers to processed gas from which natural gas liquids have been extracted. These liquids, however, seem to be included in the Soviet figures. It cannot be determined what conversion is used between wet natural gas and natural gas liquids, and here 100 per cent is simply taken as total output before processing.

Only certain categories of consumption can be compared in the two countries. In particular, it is not possible to determine accurately what portion of the total is used as petrochemical raw material (since U.S. statistics treat natural gas liquids separately, by far the greatest part of gas-derived raw materials are, in any case, excluded from the U.S. data given below).

I am indebted to Dr. Robert W. Campbell of Indiana University for calling my attention to the above problem.
### Table IV

**Consumption of Natural Gas by Sectors of Economy**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bill. Per cu.m.</td>
<td>Bill. Per cu.m.</td>
<td>Bill. Per cu.m.</td>
</tr>
<tr>
<td>Household &amp; municipal</td>
<td>7.4 12.2</td>
<td>7.5 10.0</td>
<td>132.1 33.4</td>
</tr>
<tr>
<td>Chemical ind.</td>
<td>2.2 3.6</td>
<td>Industry (except power stations) 46.0 61.2</td>
<td>Carbon black 3.8 1.0</td>
</tr>
<tr>
<td>Energy needs of industry</td>
<td>32.9 54.0</td>
<td>Of which:</td>
<td>Field use 56.5 14.3</td>
</tr>
<tr>
<td>(except power stations)</td>
<td></td>
<td>a) chemical 4.7 6.2</td>
<td></td>
</tr>
<tr>
<td>Of which:</td>
<td></td>
<td>b) oil &amp; gas 6.6 8.8</td>
<td></td>
</tr>
<tr>
<td>a) metallurgy</td>
<td>7.3 12.0</td>
<td>c) metallurgy 11.0 14.7</td>
<td>Oil refining 22.2 5.6</td>
</tr>
<tr>
<td>b) cement</td>
<td>3.8 6.3</td>
<td>d) building material 8.4 11.2</td>
<td>Iron &amp; steel 10.0 2.5</td>
</tr>
<tr>
<td>c) machine bldg. &amp; metal work.</td>
<td>5.2 8.5</td>
<td>e) machine bldg. &amp; metal work 7.8 10.4</td>
<td>Portland cement 15.8 1.45</td>
</tr>
<tr>
<td>d) other branches</td>
<td>16.6 27.2</td>
<td>f) food 2.9 3.9</td>
<td></td>
</tr>
<tr>
<td>Electric stations</td>
<td>16.4 26.9</td>
<td>g) other branches 4.5 6.0</td>
<td></td>
</tr>
<tr>
<td>Pipeline need &amp; losses plus export</td>
<td>2.0 3.3</td>
<td>Transport 1.3 1.7</td>
<td>Pipeline fuel 13.5 3.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agriculture 0.7 0.1</td>
<td>All other fuel 111.6 28.1</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>60.9 100.0</td>
<td>76.0 100.0</td>
<td>392.7 100.0</td>
</tr>
</tbody>
</table>

* Used, apparently, only as raw material.

** Used as fuel and raw material.

*** Approximate: Included in "All other fuel". Should not be included in total.
As is evident from the table, the pattern of gas consumption in the USSR differs significantly from that found in the United States. In the latter country, household and municipal users take a full third of the total gas supply, while thermal electric stations burn only one-seventh. In Russia the opposite is true. Power stations represent the largest single consumer group, using well over a quarter of all gas, while the household and municipal sectors consume only a tenth. The industrial sector (including the generation of electricity) completely dominates consumption in the Soviet Union, accounting for 88 percent of the total, against 63 percent in the United States. The following section of this paper examines the role of gas in three important branches of industry then briefly treats its use by the household and municipal sectors.

INDUSTRIAL USES OF NATURAL GAS

Gas in industry is consumed in two ways: as fuel and as raw material in the manufacturing of petrochemical products. By far the greater portion of gas is used as fuel. Even the petrochemical industry burns perhaps the larger part of the

Note to Table IV: The differences between the data for the USSR are not due merely to the difference in years. Both authors give breakdown for 1960 with appreciable variation.

amount consumed to produce thermal energy. The various cat-
gories of gas, however, are utilized in different ways. Dry
natural gas—composed mainly of methane, a paraffin, expensive
to crack—is less significant as a petrochemical feedstock
and is used overwhelmingly to produce heat. A large portion
of natural gas liquids, on the other hand, is consumed as raw
material.

Although dry natural gas is used principally for one
purpose, the production of thermal energy, it has many advan-
tages over other fuels. It requires little processing from
the producer and imposes no handling or storage problems on
the consumer. It is clean and easy to control during combus-
tion, leaves no waste materials, and has been generally cheaper
than other fuels. Due to its special qualities, in most metal
industries it can improve the quality—and therefore the
value—of the product at no greater cost. It is no wonder
that since the war gas had made such rapid inroads in most
industries in North America and is now doing the same in the
USSR and Western Europe.

As industrial fuel, gas is utilized in two ways: under
boilers and in ovens (furnaces). Thermal power plants, the
chemical, leather, textile and food industries burn gas
chiefly under boilers to produce steam, while the metallur-
gical, building materials and engineering industries burn it
in furnaces.
THE USE OF GAS IN ELECTRIC STATIONS

In fuel-power plants thermal energy is utilized to produce electricity. Heat is supplied to a "working fluid" (steam or various gases) which drives the turbine by expanding. Almost all thermal electricity today is generated by steam produced in boilers, which can be heated by any fuel from peat to natural gas. Table IV shows the heavy consumption of gas by electric stations both in the United States and the USSR. Though accounting for a lower share of total consumption than their counterparts in the Soviet Union, US power plants burned 56 billion cubic meters (1965 billion cubic feet) in 1962, while Russian plants burned 20 billion cubic meters.

In recent years the gas turbine has become fully competitive with the steam turbine in thermal power plants and further improvement in its position can be expected. Gas turbines require no boiler and those which operate on an open cycle—discharging the exhaust gases into the atmosphere—need no condensers or cooling apparatus either. This significantly reduces construction and maintenance costs and for the open cycle plants completely eliminates the need for water. Such plants are ideal in a desert environment and a number of them are under construction in Soviet Central Asia.


See sources for Table IV.
The relatively low price - especially during the summer period - is no doubt the chief reason for such massive use. Nevertheless, the special features of natural gas produce still additional benefits. Since no handling, pulverization or drying of fuel is necessary as is the case with coal, lignite or peat, labour costs in gas-fired plants may be as much as 20 per cent lower than in coal or peat-fired stations of comparable capacity. Because of better flame control, natural gas further improves the operation of the already highly efficient boiler. Boiler efficiency, defined as the ratio of the heat absorbed by the water to the heat content of the fuel, can reach 92 per cent when gas is burned but at most 85 per cent if coal is used.

The majority of thermal stations, both in the United States and the Soviet Union, purchase natural gas on an interruptible basis. The extreme versatility of modern steam plants enables them to burn practically any fuel with little change in their efficiency. To keep pipelines functioning as near full capacity as possible during the summer months, natural gas is made available to electric plants in this period at very low prices. Sales are interrupted once colder weather provides more lucrative markets for the gas. These inter-

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ruptible sales are generally at prices below the production and transport cost of the fuel, yet, because they are in large volumes and go far towards evening out seasonal fluctuations in demand, they are profitable for the gas industry and, naturally, for the power plants. According to the new price system (effective since 1964) the USSR State Production Committee for Natural Gas, for instance, sells gas to power stations two rubles below the price level, during the summer period.

In several regions of the USSR, however, many thermal electric stations burn or will burn natural gas all year around. Switching to other fuels in winter is often not possible economically at a number of plants in the Moscow Region, the Baltic, the Urals, Middle Asia, the Caucasus and Moldavia. The use of natural gas as boiler fuel has increased greatly in absolute terms, and the share of that consumption was between 27 and 28 per cent from 1959 to the end of 1962. However, there is now considerable criticism against the indiscriminate use of that quality fuel under boilers in certain areas, notably the Ukraine and the Volga. Because of its special characteristics, its use in furnaces and as chemical

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raw material could result in greater gains to the economy. Therefore, a relative decrease in the gas consumption by thermal stations is likely in the future and a number of plants, running on gas, may be switched to other fuels at least for the winter period. The wider extension of interruptible sales, however, is continued to be urged, and the rising demand for electricity will result in an absolute increase in the use of natural gas by power plants.

THE USE OF NATURAL GAS IN THE IRON AND STEEL INDUSTRY

The metallurgical industries consume gas chiefly in furnaces, where its special features yield great benefits. A pure flame, the absence of harmful products, an even distribution of temperature and easy regulating of combustion are highly desirable and often imperative in modern furnaces designed for good quality metals.

In the last decade, the iron and steel industry has become the second largest industrial consumer of natural gas in the Soviet Union and the third largest in the United States.

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In both countries, gas now holds second place in the fuel requirement of ferrous metallurgy, being exceeded only by coal. Natural gas is consumed in the production of steel as well as pig iron, but the role and significance of its utilization differ considerably in their processes.

Iron making is essentially a process of reduction: iron oxide (the ore) is reduced by carbon monoxide produced during the slow burning of a fuel. Very high temperatures and rate of heat transfer is necessary for such an operation. For this reason, the blast furnace in which coke is intermingled and is in direct contact with the ore - thus permitting a high rate of heat transfer - has retained its supremacy in the production of pig iron.

Natural gas (or oil), therefore, will not oust coal as the principal fuel in the smelting of iron ore, especially since coke production from poorer quality coals is now feasible. However, the injection of gas into the furnace - particularly if enriched with oxygen - can reduce greatly the amount of coke needed for the process, and a coke consumption rate of 0.3 ton per ton of pig iron is now anticipated. Table III in the Appendix illustrates the advantages gained by gas-injection.

Over half of all blast furnaces in the Soviet Union used natural gas in 1963 and smelted 60 per cent of all Soviet

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pig iron. This share is soon to rise sharply as pipelines reach all the major Ural mills. Ten of the largest works in the Ukraine have experienced a 10 to 20 per cent reduction in coke consumption since they began to blast with gas, even though they still do not take full advantage of the new techniques.

If it gains widespread acceptance, the new process of pre-reduction of ore will further increase the consumption of natural gas in pig iron production. The rotary kilns, in which the ore is partially reduced before being loaded into the blast furnace, are fired either by liquid or gaseous fuels. Since rotary furnaces are relatively easy and inexpensive to construct, and as they can save much coke for the blast furnace, a wide application of the technique in the future may be expected.

In contrast to pig iron production, where coal is still king, steel-making is now the domain of gas and oil. Since 1910, most of the world's steel is made in open-hearth furnaces (85 per cent of the total output in both the Soviet Union and the United States today), although new methods are beginning

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to challenge this monopoly. In the open-hearth furnace the metallic charge (scrap and pig iron) is purified through the process of oxidization by a flame blown directly onto it. Because flame control with solid fuels is poor and labour costs high, gaseous and liquid fuels have nearly completely replaced coal in the steel-making process. Although natural gas and fuel oil furnish slightly different flames but this produces no appreciable difference in the working of the open-hearth furnace or the quality of the steel produced, and may be used interchangeably as economy dictates. Most companies in the U.S.A. now utilize both fuels in their furnaces, purchasing gas cheaply on an interruptible basis during the summer period of low demand for natural gas and switch to oil during the winter months. In a few instances, blending is practised. On the whole, however, natural gas provides a higher percentage of total calories than fuel oil.

In the USSR, the relative significance of natural gas in open-hearth furnaces may soon become even greater. The great bulk of Soviet oil is highly sulfurous, and of all impurities, sulfur is the most harmful to both pig iron and steel. The high quality Caucasian oil has been in great demand in the metallurgical centers of the Eastern Ukraine and the Urals. But it is relatively scarce as well as expensive. At present, the majority of open-hearth furnaces still operate on a mixture of coke-oven and blast-furnace gases, which have

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\[\text{American Iron and Steel Institute: Report of Technical Committee on Open-Hearth and Basic Oxygen Steel Making. 1964, passim.}\]
low heat value. Considerable attention is therefore paid to
the more intensive utilization of natural gas in open-hearth
furnaces throughout the USSR.

The open-hearth operation, however, is no longer the
most efficient process of steel-making, and not many open-
hearth furnaces will be built from now on. The future is
for the oxygen converter, which requires no fuel. The tech-
nological development, therefore, seems to bode ill for
natural gas in the steel-making process. One must remember,
however, that due to sheer inertia and high capital investment
open-hearth furnaces will continue to provide the dominant
share of steel output over the next decade or two. Moreover,
the possibility of using external heat in oxygen converters
which would combine the best features of both the open-hearth
and the converter process, cannot be ruled out, and indeed was
already suggested. Finally, if for technological reasons,
natural gas will be unable to gain a market in the newest
steel mills and eventually lose some of it in the old ones,

12 V.F. Andreyev et al: Ekonomika Chernoy Metallurgii
13 See for instance: V.B. Karbivnichiy-Kuznetsov:
"Uluchsheniye Ispol'zovaniya Prirodnoogo Gaza pri Otoplenii
Martenovskikh Pechey, "Ispol'zovaniye Gaza v Promyshlennosti,
14 U.N. Economic Commission for Europe: Comparison of
15 Ibid., p. 82.
it may find compensation in its increasing application for the production of pig iron. Both blast furnaces and pre-reducing vessels utilize it to an increasing degree. Because blast furnaces are immensely expensive, iron works hope to meet increasing demand by technological improvement rather than new construction.

**NATURAL GAS IN THE CHEMICAL INDUSTRY**

The chemical industry utilizes natural gas both as fuel and as raw material. It also makes use of the sulfur, often found in natural gas, constituting a harmful impurity which must be extracted. As fuel, gas is used chiefly under boilers to produce steam and may be replaced by any fuel as economy dictates. Most branches of the chemical industry require a great deal of thermal energy which - together with electricity - may constitute half the total cost of a particular product. Since natural gas has been generally cheaper than other fuels, in those countries where it is available in large amounts, it serves as the most important producer of thermal energy for the chemical industry. As fuel, its role is simple and, because it is burned chiefly under boilers, is similar to that played in the production of electricity. More interesting, and in many respects more important, is its role as a chemical raw material, especially since once it is used as a chemical feedstock, it almost invariably provides the necessary thermal energy also.
Natural Gas as Raw Material

The utilization of natural gas and natural gas liquids as chemical raw materials cannot be understood without some knowledge of technology, all the more so since they can be readily replaced by refinery products, derived from crude oil. Natural gas, as well as crude oil, is a mixture of hydrocarbon molecules and, in addition, frequently contain impurities. A hydrocarbon molecule is made up of carbon and hydrogen atoms in various arrangements. By far the most important is the open chain series known as paraffins which, together with some impurities, compose natural gas, liquid petroleum gases, as well as the largest fraction of most petroleum, condensates and natural gasoline. The paraffin series consists of methane (CH$_4$), ethane (C$_2$H$_6$), propane (C$_3$H$_8$), butane (C$_4$H$_{10}$) and pentane plus (C$_5$H$_{12}$ to C$_8$H$_{18}$).

Natural gas is "dry", when composed overwhelmingly of methane, and "wet", when propane, butane, pentane, make up a large percentage. When the gas is processed, the propane, butane, pentane and, to some extent, ethane fractions are extracted from the gas and liquefied. Liquefied petroleum gases, especially propane and butane, are the most important raw materials for the manufacturing of organic petrochemicals. (The term "petrochemical" refers to chemical elements and compounds produced from oil and natural gas hydrocarbons and sold for chemical uses. Organic chemicals generally contain carbon molecules while inorganics do not. Organic petrochemicals serve as chief raw materials for the synthetic industries,
while inorganic petrochemicals are used mainly as fertilizers.)

The production of petrochemicals involve a large number of complicated processes, which in essence change and rearrange the hydrocarbon molecules, combine them with other elements and each other. Paraffins, the most important hydrocarbon feedstocks, however, are by nature unreactive and do not combine with other elements. To make them reactive therefore, they are made to lose some hydrogen atoms: ethane thus turns into ethylene, propane into propylene, butane into butylene, and so on. Such hydrocarbon molecules are called olefins and are very reactive. Methane, the simplest hydrocarbon and the main constituent of natural gas contains only one carbon atom and does not, therefore, have an olefin. Two methane molecules, however, as well as the other paraffins, may be turned into acetylene (H=C≡C-H), which is extremely reactive on account of the triple bond. But this process requires higher temperatures and energy inputs than the forming of olefins.

Olefins are the chief basic chemicals used in organic synthesis. Their major source is LPG's (from wet natural gas)

\[ \text{For example:} \]

\[
\begin{align*}
\text{ethane} & : \quad \begin{array}{c}
H \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H}
\end{array} \\
\text{C} & \quad \begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H}
\end{array} \\
\text{C} & \quad \begin{array}{c}
\text{C} \\
\text{H} \\
\text{H} \\
\text{H}
\end{array} \\
\text{H} & \quad \begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H}
\end{array}
\end{align*}
\]

\[
\begin{align*}
\text{ethylene} & : \quad \begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H}
\end{array} \\
\text{C} & \quad \begin{array}{c}
\text{C}
\end{array} \\
\text{C} & \quad \begin{array}{c}
\text{H}
\end{array} \\
\text{C} & \quad \begin{array}{c}
\text{H}
\end{array} \\
\text{H} & \quad \begin{array}{c}
\text{H}
\end{array}
\end{align*}
\]

\[
\begin{align*}
\text{propane} & : \quad \begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H}
\end{array} \\
\text{C} & \quad \begin{array}{c}
\text{C}
\end{array} \\
\text{C} & \quad \begin{array}{c}
\text{C}
\end{array} \\
\text{H} & \quad \begin{array}{c}
\text{H}
\end{array}
\end{align*}
\]

\[
\begin{align*}
\text{propylene} & : \quad \begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H}
\end{array} \\
\text{C} & \quad \begin{array}{c}
\text{C}
\end{array} \\
\text{C} & \quad \begin{array}{c}
\text{C}
\end{array}
\end{align*}
\]

Ethylene is also made from propane by the more drastic (but cheaper) method of knocking off one C and four H atoms.
and petroleum feedstocks. In the United States, for instance, half of all ethylene is derived from wet natural gas and some 45 per cent from (oil) refinery gases. In Europe, most ethylene as well as propylene and butylene, is produced from oil. Thus, wet natural gas has to compete with petroleum in the production of these basic chemicals and local conditions determine which source is used. Dry natural gas cannot be utilized economically for this purpose because the required feedstocks, ethane, propane, butane, are present in very low concentration.

Because methane has no olefins, it is less useful in organic synthesis than the above fractions, although a few highly important organic chemicals (e.g. methyl alcohol and formaldehyde) are made from it on a large scale. It is, however, a basic feedstock for the production of inorganics, such as ammonia, urea and other nitric fertilizers. Methane can also be cracked to form acetylene which vies with ethylene as a versatile raw material for a host of organic petrochemicals. Because its greater investment, fuel and electricity requirements, however, acetylene always found it hard to compete with ethylene. In 1961, the United States produced over five and a half billion pounds of ethylene (the most important olefin) against some 200 million pounds of acetylene derived from natural gas. (Only about a quarter of all acetylene is derived from hydrocarbon sources; almost all of it

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from methane the rest is made from coal via calcium carbide.)

The disadvantageous position of acetylene, versus ethylene is the chief reason for the relatively meager use of dry natural gas for organic synthesis.

However, in certain regions acetylene - and therefore dry natural gas - may become competitive for the production of synthetic materials. By using the partial combustion process (reaction of methane with oxygen), the manufacturing of acetylene is combined with that of synthesis gas (CO₂H₂), the chief raw material for both ammonia and methyl alcohol. It is easy to see that acetylene production by the above method appears attractive enough where ammonia or methyl alcohol can also be profitably marketed. During the manufacturing of one ton of acetylene, ten to eleven thousand cubic meters of synthetic gas is also obtained, enough to make 4.2 tons of ammonia or 3.4 tons of methyl alcohol. To obtain a unit amount of ammonia plus acetylene by this process requires only a little more natural gas - used both as raw material and fuel - than by the methane-steam process (also via synthesis gas), which is the cheapest way to produce ammonia alone. Acetylene by the electric or thermal cracking of methane is more expensive, but may prove economic in areas which do not have

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17 The Oil and Gas Journal, Jan. 13, 1964, p. 47.
19 Vysstavka Dostizheniy Narodnogo Khozyaystva SSSR, Nov., 1963, p. 10
access to cheap LPG's or refinery gases but possess dry natural
gas and low-cost power - either from gas or other sources.

The production of LPG's and indeed of all liquid gases
in the USSR is still very undeveloped. Russian data and ter-
minology is often confusing on that subject. The term
"szhizhennye gazy" is sometimes being used to refer to liquified
propane and butane, sometimes to all natural gas liquids and
sometimes to all liquid gas including refinery liquid gases as
well. Be this as it may, in 1962, total production of
"szhizhennye gazy" in the USSR amounted to less than 1 per
cent of liquid gases produced by gas-processing plants in the
United States. (Output in the Soviet Union was 1.3 million
tons against nearly 39.5 million tons in the U.S. In the latter
country, an additional 13.3 million tons of liquified gas was
produced in petroleum refineries, while in the Soviet Union
refineries produced only about 160,000 tons.) In 1963 the
Soviet plan called for 1.8 million tons from both sources.

Oil-well gases represent the most valuable source of
natural gas liquids, but the utilization of these gases in
the USSR is proceeding very inadequately. Despite constant
complaints, only some 60 per cent of associated gases, re-
leased during petroleum production, is utilized today, the
rest is flared or vented. And only two-fifths of the portion

"Gazovaya promyshlennost' - moshchnaya basa razvitiya
Bolshoy Khimii," Gazovaya Promyshlennost', No. 1, 1964, p. 28;
D.A. Tsvetkov: "Ispol'zovaniye szhizhennykh gazov v narodnom
Khozyaystve SSSR," Gazovoye Delo, No. 11, 1963, p. 42; L.P. Gas,
April, No. 4, 1963, p. 36; Butane-Propane News, No. 10, 1962,
p. 53. Production by refineries in the USSR was obtained by
subtracting production by gas-processing plants
given in G.P. from total figure, given in G.D.
not wasted — some 4 billion cubic meters in 1963 — is processed, the greater part is burned as fuel. An acute shortage of gas processing plants holds up the development of the LPG industry. At the beginning of 1964, the USSR had, at most, a dozen such plants and some of them still work far below full capacity. The Seven Year Plan had forecast the construction of 20 gas-processing works, but it is now certain that this objective will not be reached for another few years.

One important consequence of this shortage is that the budding petrochemical industry in the USSR is largely deprived of the most convenient and perhaps the cheapest raw materials for organic synthesis. This is all the more true since the larger portion of liquid gases is not used as chemical feedstock but as fuel. (Propane and butane are very important in rural households while heavier hydrocarbons readily serve as motor fuel).

In trying to divine the role that natural gas will play in the development of Soviet petrochemical industry, one must remember that wet oil-well gases — the main source of LPG's — represent less than 20 per cent of the total natural gas output.

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of the USSR. (Though their share could be raised to 30 percent if all amounts released were utilized.) Table V presents the chemical composition of Soviet gases, both free and associated. It can be observed that most of Russia's free gases are very dry. Methane is preponderant even in the condensate deposits, and besides methane many of them contain only ethane in appreciable quantities. Associated (oil well) gases are rich in the ethane to pentane fractions, although those of Azerbaydzhan are surprisingly "dry" considering that they are derived from oil wells. Only in the Middle Volga, however, are "wet" gases produced in really significant quantities, while again it is only in the Volga Region and in Krasnodar Kray that gases from gas wells contain more than a negligible amount of heavier paraffin fractions. It is, therefore, easy to understand why Soviet planners attach so great importance to acetylene, especially when combined with the manufacturing of ammonia, urea, and other nitric fertilizers. The principal Soviet agricultural regions possess rich resources of natural gas, or have long-distance pipelines passing through them. At the same time, these same regions are in dire need of nitric fertilizers, the manufacturing of which can profitably be combined with that of acetylene as outlined above.

Since LPG production is increasing rather slowly due to the lack of gas-processing plants, and since they would have to be shipped to most regions by rail, in many areas the new organic petrochemical plants seem to be better based on dry natural gas (via acetylene) than on "imported" LPG's (via
### Table V
Average Chemical Composition of Gases in the Major Soviet Deposits

<table>
<thead>
<tr>
<th>Deposits</th>
<th>Composition of gas (percent of total volume)</th>
<th>CH$_4$</th>
<th>C$_2$H$_6$</th>
<th>C$_3$H$_8$</th>
<th>C$<em>4$H$</em>{10}$</th>
<th>C$<em>5$H$</em>{12}$</th>
<th>CO$_2$</th>
<th>H$_2$S</th>
<th>Ng+ rare elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stavropol' Kray</td>
<td></td>
<td>98.6</td>
<td>0.40</td>
<td>0.14</td>
<td>0.06</td>
<td>--</td>
<td>0.10</td>
<td>--</td>
<td>0.70</td>
</tr>
<tr>
<td>Krasnodar Kray</td>
<td></td>
<td>92.9</td>
<td>6.00</td>
<td>0.50</td>
<td>--</td>
<td>0.50</td>
<td>0.01</td>
<td>--</td>
<td>0.09</td>
</tr>
<tr>
<td>Western Ukraine</td>
<td></td>
<td>98.5</td>
<td>0.25</td>
<td>0.20</td>
<td>0.15</td>
<td>--</td>
<td>0.10</td>
<td>--</td>
<td>0.80</td>
</tr>
<tr>
<td>Saratov Oblast'</td>
<td></td>
<td>92.2</td>
<td>2.60</td>
<td>1.10</td>
<td>0.40</td>
<td>0.05</td>
<td>0.28</td>
<td>--</td>
<td>3.37</td>
</tr>
<tr>
<td>Volgograd Oblast'</td>
<td></td>
<td>96.7</td>
<td>0.96</td>
<td>1.19</td>
<td>0.09</td>
<td>0.11</td>
<td>0.25</td>
<td>--</td>
<td>1.70</td>
</tr>
<tr>
<td>Kuybyshev Oblast'</td>
<td></td>
<td>75.3</td>
<td>6.20</td>
<td>1.94</td>
<td>0.90</td>
<td>0.80</td>
<td>0.58</td>
<td>0.37</td>
<td>13.96</td>
</tr>
<tr>
<td>Orenburg Oblast'</td>
<td></td>
<td>75.6</td>
<td>6.00</td>
<td>1.70</td>
<td>0.52</td>
<td>1.10</td>
<td>0.28</td>
<td>0.28</td>
<td>16.50</td>
</tr>
<tr>
<td>Gazli</td>
<td></td>
<td>98.1</td>
<td>1.60</td>
<td>0.03</td>
<td>--</td>
<td>0.05</td>
<td>0.12</td>
<td>--</td>
<td>0.10</td>
</tr>
<tr>
<td>Shebelinka</td>
<td></td>
<td>92.9</td>
<td>4.5</td>
<td>0.8</td>
<td>0.6</td>
<td>0.6</td>
<td>0.1</td>
<td>--</td>
<td>0.5</td>
</tr>
<tr>
<td>Stepnoye (Saratov Oblast')</td>
<td></td>
<td>95.1</td>
<td>2.3</td>
<td>0.7</td>
<td>0.4</td>
<td>0.8</td>
<td>0.2</td>
<td>--</td>
<td>0.5</td>
</tr>
<tr>
<td>Kanevskoye (Krasnodar Kray)</td>
<td></td>
<td>88.8</td>
<td>4.8</td>
<td>1.4</td>
<td>0.5</td>
<td>1.8</td>
<td>0.2</td>
<td>--</td>
<td>2.5</td>
</tr>
<tr>
<td>Russkiy Khutor</td>
<td></td>
<td>69.1</td>
<td>11.3</td>
<td>3.3</td>
<td>1.7</td>
<td>8.6</td>
<td>2.7</td>
<td>--</td>
<td>3.3</td>
</tr>
<tr>
<td>Karadag (Azerbaijanzhan)</td>
<td></td>
<td>93.4</td>
<td>2.2</td>
<td>1.4</td>
<td>1.1</td>
<td>1.2</td>
<td>0.5</td>
<td>--</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**From Oil Wells**

<table>
<thead>
<tr>
<th>Deposits</th>
<th>Composition of gas (percent of total volume)</th>
<th>CH$_4$</th>
<th>C$_2$H$_6$</th>
<th>C$_3$H$_8$</th>
<th>C$<em>4$H$</em>{10}$</th>
<th>C$<em>5$H$</em>{12}$</th>
<th>CO$_2$</th>
<th>H$_2$S</th>
<th>Ng+ rare elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azerbaydzhan</td>
<td></td>
<td>91.8</td>
<td>4.49</td>
<td>1.62</td>
<td>1.08</td>
<td>0.81</td>
<td>0.20</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Tatar ASSR</td>
<td></td>
<td>48.0</td>
<td>16.5</td>
<td>16.1</td>
<td>7.30</td>
<td>2.90</td>
<td>--</td>
<td>--</td>
<td>9.10</td>
</tr>
<tr>
<td>Bashkirt ASSR</td>
<td></td>
<td>41.0</td>
<td>19.7</td>
<td>17.0</td>
<td>7.30</td>
<td>3.20</td>
<td>0.20</td>
<td>--</td>
<td>11.60</td>
</tr>
<tr>
<td>Kuybyshev Oblast'</td>
<td></td>
<td>68.5</td>
<td>12.5</td>
<td>5.5</td>
<td>4.00</td>
<td>2.50</td>
<td>1.50</td>
<td>3.00</td>
<td>1.50</td>
</tr>
<tr>
<td>Krasnodar Kray</td>
<td></td>
<td>65.5</td>
<td>10.3</td>
<td>9.4</td>
<td>6.80</td>
<td>6.50</td>
<td>1.00</td>
<td>--</td>
<td>0.50</td>
</tr>
<tr>
<td>Western Ukraine</td>
<td></td>
<td>30-45</td>
<td>51-76</td>
<td>not given</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

olefins). Parts of the Ukraine and of the North Caucasus, the whole of Middle Asia, the Central Region could fall into that category. In regions such as East Siberia, which boast extremely cheap energy, acetylene production from methane could become economic even by the electric cracking process.

It seems, therefore, that both wet and dry gases will prove essential as raw materials to the developing petrochemical industry of the USSR. Due to forces of location, dry natural gas in the Soviet Union seems to be in an economically more favourable position vis a vis other hydrocarbon sources than it is in the United States. The two kinds of gases, however, have advantages in very different regions due to the influence of technology and transport. As fuels, their cheapness and great convenience guarantees their intensive utilization in that energy-hungry industry.

HOUSEHOLD AND MUNICIPAL CONSUMPTION

The most striking difference between the consumption of natural gas in the USSR and the United States appears in the household and municipal sectors. The small share of one-tenth versus one-third is still more apparent when one considers the fact that the Soviet figure seems to include bottled propane and butane delivered mainly to rural and small town households. Consumption of bottled gas in US statistics is treated separately from that of natural gas, but over 40 per cent of

the very considerable propane-butane production (176 million tons in 1962) is consumed by the domestic sector.

At the beginning of 1963, a full 30 percent of all living quarters in the USSR (1,637,800 out of a total of 5,398,500) received gas not through pipelines but in cylinders. Assuming five people per household, natural gas—bottled gas included—was available to only 12 percent of the Soviet population. According to the target of the Seven Year Plan, which may not be reached, only a quarter of the Soviet population was hoped to be supplied by the end of 1965. The general neglect of the residential sector and the relative importance of bottled gas are reflected by the fact that the length of the Soviet distribution lines is much smaller than that of the transmission network (17,600 km. vs. 25,300 in 1962), while in the United States, the length of the distribution system is more than twice that of the transmission lines (427,600 miles vs. 200,200 miles in the same year).

It is fair to point out, however, that the share of household and municipal sectors in the consumption of natural gas is somewhat understated. The majority of Soviet thermal stations, and nearly all of them in large urban centers, are

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so-called thermal electric centers (TETs) which produce not only electricity but also by-product heat for households and factories. Pages 103-104, Chapter V, shows their importance in the Central Region and the City of Moscow. This practice, called toplifikatsiya, undoubtedly raises the share of the domestic sector in the consumption of natural gas to some degree. Two further qualifications, however, must be made. First, this practice also raises the share of the industrial sector. Since much of the steam required in industry is also provided or planned to be provided by TETs's, the increase in the share of certain industrial sectors may be even greater. Secondly, much natural gas in the U.S. homes is utilized via electricity, much more than in Soviet households. If indirect uses of gas, such as toplifikatsiya, are allowed for in the case of the USSR, indirect uses through electricity should also be considered for the United States.

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Chapter III

RESERVES
Hydrocarbon reserves are notoriously difficult to estimate; they can be proved only by the drilling of wells. Natural gas reserves can be reliably appraised even from one well, provided that it had produced enough to make a measurable decline in the reservoir pressure. This latter, however, is a crucial limitation for it restricts trustworthy estimates to developed areas and essentially to producing fields. In addition, the "proved reserves" concept, used by the gas industry, limits reserves to those recoverable under present operating practices. Thus, in the last analysis, it is a function of production. Its role is crucial for the immediate future and distribution of the industry but is obviously inadequate for any long-term forecast.

Any other estimates, however, are uncertain. They are usually based on geological studies of sedimentary basins and on past and present production of known petroliferous provinces. Especially difficult is the evaluation of gas reserves contained in petroleum reservoirs: these are generally calculated from gas-oil ratios applied to crude-oil estimates.

Soviet categories of reserves are only partly comparable to those used in the United States or Canada. The main categories used by the Soviet oil and gas industries are A, B, C₁ and C₂, to which two extremely uncertain further divisions

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are sometimes added. Category A roughly corresponds to US "proved recoverable reserves", though Soviet recovery expectations are set higher than the American, while Category B stands for reserves which are fully surveyed as to quantity though incompletely as to quality, recoverability and exact distribution of productive strata. In published statistics A and B are usually combined under the term "industrial reserves". They are used in comparisons with US "proved reserves" estimates both in Soviet sources and in this paper, though it is clear that vis à vis the American classification the Soviet figures are somewhat inflated.

Category C₁ generally includes new fields covered only by reconnaissance prospecting or such horizons in older deposits. A, B and C₁ combined and called "balance reserves" embrace all fields discovered to date and approximate US estimates of the reserves of known reservoirs. Category C₂ represents estimates of future discoveries upon favourable geological and geo-physical evidences in already surveyed petro-liferous areas. Though uncertain, they must be distinguished from "predicted" or "ultimate reserves", which are calculated only from the extent of sedimentary basins, most of which are yet untouched. Slightly over three-quarters of all natural gas known today in the USSR is found in distinct gas deposits, while the rest is contained in oil reservoirs, as a gas-cap overlying the crude.

4 Ibid (Bokserman): p. 27
At the beginning of 1963, total industrial reserves of natural gas in the USSR amounted to nearly two trillion (2,000,000,000,000) cubic meters, or well over twice the proved reserves of Canada and close to a quarter of that of the United States. Unlike coal, where nine-tenths of the reserves are located east of the Urals, the distribution of natural gas is more favourable. More than two-thirds of proved reserves and close to a third of all potential ones are found in European Russia, where -- if the Urals are included -- four-fifths of all fuel and energy consumption is concentrated. Maps 1, 2 and 3 and Table VI show the detailed distribution of industrial reserves (Category A & B), and of reserves in Category C₁ and C₂.

It is worth noticing that nearly nine-tenths of all natural gas known today is found in only four areas: the North Caucasus, the Ukraine, Uzbekistan and the Volga. Three giant fields alone -- Gazli, Shebelinka and North-Stavropol' -- account for nearly half of all gas discovered to date. The large extent of sedimentary basins in Siberia, where the presence of gas has already been proved, however, also deserves notice. With the continuing attention given to the development of the southern part of Siberia, the discovery and exploitation of large fields could be expected. In addition, Western Siberia is in a better geographic position to provide

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5 Ibid., p. 17 and 28.
6 Ibid., p. 24 and 28.
7 Yu. I. Bokserman; op. cit., p. 27
Table VI

Reserves of Natural Gas

<table>
<thead>
<tr>
<th>REGIONS</th>
<th>(A + B) bill.</th>
<th>per cent</th>
<th>(A + B + C₁) bill.</th>
<th>per cent</th>
<th>(A + B + C₁ + C₂) bill.</th>
<th>per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>USSR</td>
<td>1942.1</td>
<td>100.0</td>
<td>2786.5</td>
<td>100.0</td>
<td>6091.3</td>
<td>100.0</td>
</tr>
<tr>
<td>RSFSR</td>
<td>930.1</td>
<td>46.0</td>
<td>1315.4</td>
<td>46.4</td>
<td>2002.6</td>
<td>33.0</td>
</tr>
<tr>
<td>Volga-Urals</td>
<td>217.3</td>
<td>11.2</td>
<td>279.6</td>
<td>10.0</td>
<td>732.8</td>
<td>12.1</td>
</tr>
<tr>
<td>Kuybyshev Ob.</td>
<td>4.9</td>
<td>---</td>
<td>8.3</td>
<td>---</td>
<td>35.6</td>
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</tr>
<tr>
<td>Orenburg Ob.</td>
<td>19.1</td>
<td>---</td>
<td>26.7</td>
<td>---</td>
<td>187.8</td>
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</tr>
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<td>70.4</td>
<td>---</td>
<td>88.2</td>
<td>---</td>
<td>138.7</td>
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</tr>
<tr>
<td>Bashkir ASSR</td>
<td>1.9</td>
<td>---</td>
<td>13.2</td>
<td>---</td>
<td>69.1</td>
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<tr>
<td>Volgograd Ob.</td>
<td>105.1</td>
<td>---</td>
<td>114.9</td>
<td>---</td>
<td>211.4</td>
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</tr>
<tr>
<td>Astrakhan Ob. &amp; Kalmyk ASSR</td>
<td>15.7</td>
<td>---</td>
<td>27.9</td>
<td>---</td>
<td>90.2</td>
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</tr>
<tr>
<td>North Caucasus</td>
<td>634.8</td>
<td>32.7</td>
<td>842.7</td>
<td>29.9</td>
<td>1072.3</td>
<td>17.8</td>
</tr>
<tr>
<td>Krasnodar Kray</td>
<td>376.1</td>
<td>---</td>
<td>508.2</td>
<td>---</td>
<td>548.2</td>
<td>---</td>
</tr>
<tr>
<td>Stavropol' Kray</td>
<td>252.2</td>
<td>---</td>
<td>323.8</td>
<td>---</td>
<td>505.8</td>
<td>---</td>
</tr>
<tr>
<td>Chechen-Ing.ASSR</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>11.4</td>
<td>---</td>
</tr>
<tr>
<td>Dagestan ASSR</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
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<tr>
<td>Rostov Oblast</td>
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<td>---</td>
<td>5.2</td>
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<tr>
<td>K.-Balkar &amp; S.-Ocetin ASSR's</td>
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<td>---</td>
<td>---</td>
<td>---</td>
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<tr>
<td>Komi ASSR</td>
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<td>16.5</td>
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<td>17.5</td>
<td>.15</td>
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<tr>
<td>West Siberia</td>
<td>49.3</td>
<td>2.5</td>
<td>130.1</td>
<td>4.5</td>
<td>130.1</td>
<td>2.1</td>
</tr>
<tr>
<td>East Siberia</td>
<td>18.5</td>
<td>1.0</td>
<td>46.5</td>
<td>1.5</td>
<td>46.7</td>
<td>.75</td>
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<tr>
<td>Sakhalin Ob.</td>
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<td></td>
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<tr>
<td>Ukrainian SSR</td>
<td>373.4</td>
<td>19.2</td>
<td>529.9</td>
<td>20.0</td>
<td>689.0</td>
<td>11.3</td>
</tr>
<tr>
<td>West Ukraine</td>
<td>---</td>
<td>---</td>
<td>179.9</td>
<td>6.5</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>East Ukraine</td>
<td>---</td>
<td>---</td>
<td>350.0</td>
<td>12.5</td>
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<tr>
<td>Azerbaydzhan SSR</td>
<td>37.2</td>
<td>1.9</td>
<td>57.4</td>
<td>2.0</td>
<td>101.3</td>
<td>1.6</td>
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<td>Central Asia</td>
<td>594.4</td>
<td>30.6</td>
<td>866.2</td>
<td>30.9</td>
<td>3262.1</td>
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<td>Ukrainian SSR</td>
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<td>26.5</td>
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<td>22.6</td>
<td>969.6</td>
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<td>Turkmen SSR</td>
<td>71.2</td>
<td>3.7</td>
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<td>7.8</td>
<td>2246.9</td>
<td>37.0</td>
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<tr>
<td>Kirgiz SSR</td>
<td>4.2</td>
<td>---</td>
<td>9.9</td>
<td>---</td>
<td>39.0</td>
<td>---</td>
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<tr>
<td>Tadzhik SSR</td>
<td>1.4</td>
<td>---</td>
<td>4.1</td>
<td>---</td>
<td>6.6</td>
<td>---</td>
</tr>
<tr>
<td>Kazakh SSR</td>
<td>6.0</td>
<td>.3</td>
<td>17.6</td>
<td>0.7</td>
<td>36.4</td>
<td>.6</td>
</tr>
</tbody>
</table>

Source: Yu.I. Bokserman: op. cit., Table 15, p. 22-24 and Table 18, p. 28.
Oil well gases are excluded from production data.
The full extent of these reserves is not yet known.
gas for the Urals than Central Asia and should eventually vie with the latter as the chief supplier of that industrial region.

It is evident from the maps (Maps 1, 2 & 3) and Table VI that the two richest provinces at present are the North Caucasus and Middle Asia, each accounting for some thirty per cent of the total industrial as well as balance reserves. Next in line come the Ukraine and the Volga-Ural, accounting respectively for a fifth and a tenth of all gas discovered to date in the Soviet Union.

The North Caucasian petroliferous area consists of the Azovo-Kuban downwarp, the Stavropol' anticline and the depression of the Terek Valley which merges into the Caspian Lowland. The deposits are found in Cretaceous layers, but both the deeper-lying Jurassic and the closer Tertiary beds show great promise. Most of the proved reserves are concentrated in Krasnodar Kray, especially in its north-western part, and in the Stavropol' Platform, occupying the western portion of Stavropol' Kray. Very little gas has yet been discovered in the Terek Valley, but the area is thought to have great potentials.

Girdling the shores of the Caspian Sea is a huge area of recent deposition extending on the east to the foothills of the Tienshan. It is underlain by Mesozoic formations with a number of folds and uplifts on whose flanks very promising

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8 Ibid., p. 28 - 31.
petroliferous structures occur. This may prove to be the potentially richest province for natural gas in the Soviet Union. Small amounts of oil and gas have been produced on the shores of the Caspian and in the Fergana Basin but reserves -- especially of gas -- were insignificant. Then, with the upsurge of prospecting in the mid-fifties, came the discovery of the Bukhara deposits, near the place where the Zeravshan River peters out in the sand of the southern Kyzyl Kum. The Bukhara area now contains over half a billion cubic meters of industrial reserves and an additional 170 billion in Category C₁. This is not far from the known reserves of Alberta. One field alone, Gazli, accounts for over 450 billion cubic meters in Categories A, B and C₁, that is, half as much as the gigantic Hugoton in the Texas Panhandle. The two large Mubarek deposits southeast of Gazli, contain 30 billion cubic meters each in the A, B and C₁ categories.

The presence of gas in Middle Asia has now been proved in numerous places to justify hopes of other similar finds. The Kara Kum Platform and the adjoining Prekopet Dag Depression

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to the south are especially attracting attention. In early 1964 a very promising strike was made at Darvazy, in the center of the Turkmen SSR, and the field is now thought to contain some 50 billion cubic meters. Especially large deposits are suspected in the Cretaceous and Jurassic beds on the southern flank of the Platform but remoteness and difficult physical conditions hinder exploration. Because of the metamorphism of the Paleozoic beds, tests below 2000 - 4700 meters appear unwarranted in Middle Asia. This helps to reduce costs, but may limit somewhat the potentialities of the region. Prospects for gas reserves are very good also in the Caspian Lowland, where as yet only the small Emba region is explored. Practically the entire Lowland is dotted with underground salt domes analogous in structure to those of the Gulf Coast in Louisiana and Texas. These, however, often lie at great depths and have hardly been studied.

The Ukrainian deposits are located in two distinct petroliferous areas, separated by the crystalline rocks of the Podolian Massif. The West Ukrainian fields are much older.

Together with minor oil deposits, they are found in the former Habsburg province of Galicia. Many of them were known even before World War I, although only some of the oil fields were producing. Reserves of gas are not very large and they have been exploited longer than most Soviet deposits. The combined balance reserves (A, B and C₁) of some dozen fields, found in Jurassic and Upper Tertiary beds, are appraised as 180 billion cubic meters. Hemmed in between the Carpathians and the Podolian Block, this petroliferous province extends, however, all the way to the Black Sea and the Balkan Mountains, covering also half of Rumania. The presence of gas has already been proved in the Crimea, north of the Yaila Range, and geologists consider the whole of Moldavia a promising area. In addition, the shallow sea of Azov and the Bay of Odessa may become scenes of prospecting in the future.

The East-Ukrainian gas province is a long, fairly narrow syncline, wedged between the Podolian and Voronezh Massifs. Despite its excellent location, it was not carefully prospected until the mid-fifties. Small amounts of gas have been found in Mesozoic and Late Paleozoic formations at over a dozen places.


and one giant field at Shebelinka, near the city of Kharkov. It is the second largest deposit in the Soviet Union with balance reserves of 350 billion cubic meters; its propitious location, high field pressure and richness have made it the most productive field in the country. The possibilities of this East-Ukrainian downwarp are by no means exhausted. Recently a high-pressure well was blown in Donets Oblast and geological exploration indicates that the gas-bearing strata may extend as far east as the Don Bend, joining the region to the Volga Basin.

The Volga and Pechora provinces are now considered to be one enormous petroliferous area, stretching from the Caspian to the Kara Sea between the Urals and the Russian Platform. Its northern part is little known yet, but the Volga Basin is now well explored. The region is famous mainly for its oil deposits, yet its gas reserves are also quite considerable. Distinction must be made between the northern part of the region, comprised of Kuybyshev and Orenburg Oblasts and the Tatar and Bashkir Autonomous Republics, and its southern portion, made up of Saratov and Volgograd Oblasts. In the former area most of the gases are auxiliary gases associated with oil wells, while in the latter they are mainly free gases. The gas-oil ratio in the Middle Volga is fairly low—only 40-50 cubic meters per ton of oil compared to 100 cubic meters for

the USSR average or 340 cubic meters for the United States; nevertheless, the total amount of oil-well gases represents a very large resource. The presence of free gases in the Lower Volga area were known even before the Revolution, and the deposits of Saratov are some of the oldest exploited in the USSR. Yet, here too, large-scale prospecting began only in the 1950's. Although most of the fields are of modest size, three of them boast considerable reserves, between 20 and 30 billion cubic meters each.

In contrast to the majority of Soviet gas deposits which are located in Cretaceous and Jurassic beds, those of the Volga Basin are found in Paleozoic formations, often in the deep-lying Devonian, which also produces most of Russia's oil. They are associated with numerous uplifts paralleling the Urals and the Caspian -- Emba Depression. The Pechora area, which is but a northward extension of the Volga-Ural petroliferous province, is still very inadequately prospected, though it is one of the few areas where gas deposits were known to exist even before the Revolution. Proved reserves do not exceed 20 billion

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cubic meters and there is little hope of augmenting them until
more complete geological and gravimetric studies have been car-
rried out.

Like the Middle Volga, the Transcaucasus, too, is famous
more for its petroleum than natural gas. Here, too, much gas
is found in oil wells and their industrial use first began in
that region. There are two condensate gas fields -- Karadag
and Zyrya, with combined industrial reserves of 20 billion cubic
meters. They both lie in Upper Tertiary beds at the base of
the Apsheron Peninsula. The Lower Tertiary and the still
untouched Mesozoic layers hold great promise both for oil and
natural gas, but their great depth (3-5000 meters) makes
special drilling techniques necessary. Only the eastern
Transcaucasus is petroliferous. Armenia contains no sedimentary
basins and their extent in the Georgian Republic is minuscule.

As can be seen from Map 3, substantial reserves of
natural gas have already been proved in Siberia and the Far
East. All but two of these deposits are located in the Cre-
taceous beds of the West Siberian Lowland, a huge petroliferous
province which rivals the Volga-Pechora in size, extending
along the Arctic to include the Khatanga Basin in the Taymyr
Peninsula and into Kazakhstan to embrace the Turgay Lowland.

21 Ibid., p. 28; A. F. Anufriyev: Energeticheskiye Resursy
Komi ASSR; Akademiya Nauk SSSR, Moskva, 1963, p. 15.
To date, over 20 fields have been discovered in this area but few of them are explored carefully enough to be included in the category of industrial reserves. Most of these deposits are found along the Lower Ob. With few exceptions, they are small and expensive to exploit due to complicated geological structures although two fields, the Punga and the Taz, boast with estimated reserves of 100 billion cubic meters each. Their propitious locations -- one near the Urals, the other near Noril'sk -- will assure them an important role in the future.

By reckoning of many Soviet geologists, this huge Trans-Ural area is fabulously endowed and may contain a third of all ultimate gas and oil reserves. In the opinion of some western geologists, however, the relative shallowness of the basin and the metamorphosis of Paleozoic basement rocks may restrict its yield. Prospecting in this area is difficult and slow. The severe climate, impassable swamps, and lack of transport facilities create major problems. Practically all equipment and provision have to be flown in, including the clumsy drilling rigs weighing often more than four thousand pounds. Special types of twin-turbine helicopters are employed to move the rigs over hundreds of miles, and wherever possible extensive use is

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made of the rivers.

The great shield area of north-central Siberia holds little prospect for natural gas. However, it contains a few sedimentary basins which must be considered. Three of them, the Tunguska, Lena and Kolyma-Indigirka are too shallow to show much promise, although their areal extent is quite large. Two others, however, are of greater value. In the small Vilyuy syncline basin, which adjoins the Lena, a rich deposit was opened some years ago at Tas-Tumus. Though this gas will materially affect the economy of Yakutia, its remoteness from all centers of production renders it insignificant in the national picture. Much better located is the long Angara-Lena downwarp, squeezed between the Central Siberian Massif and the Baykal Mountains. The basin is somewhat shallow, but a very good oil well was blown here recently from the Cambrian. It proves that this formation -- together with other Lower Paleozoic beds -- cannot be ruled out as petroleum possibilities, although it produces very little elsewhere. Very little gas has been discovered yet, but such finds could be highly significant to the rapidly growing industrial belt between the Kuzbass and Lake Baykal. Very recently, appreciable reserves of natural gas have been discovered on the northern part of Sakhalin, estimated to be in the neighbourhood of 50 billion cubic meters. The geological formations hold promise for an

26 Oil and Gas Journal, June 8, 1964, p. 112.
additional 50 billion. Their relative proximity to Komsomol'sk and Khabarovsk, which lack cheap sources of energy, will render them highly important already in the current decade.

At present rate of production, total industrial reserves (A + B) are sufficient to last for nearly a quarter of a century. A twenty-year supply is considered the usual safety limit, both in the Soviet Union and the United States. One finds, however, great differences among the individual regions. While the enormous Uzbek deposits can last over a century at the present rate of production and over 80 years even at the planned 1965 level, the reserves of the North Caucasus are sufficient for less than two decades and those of the Ukraine for less than a dozen years. The deposits of the Volga and of Azerbaidzhan are taxed the most: their life expectancy is only 10 years and 8 years respectively.

The large extent of promising petroliferous areas, therefore, gains great importance, and the present distribution of reserves may change significantly in the near future. Soviet geologists put the maximum extent of hopeful sedimentary basins, including offshore areas, as near 12 million square kilometers (four and a half million square miles) - a territory twice the size of similar areas in the United States, Alaska included. The more promising area, however, is perhaps


closer to three million square miles. The great variety and number of stratigraphic and structural anomalies bode well for future discoveries and there is every reason for the optimism of Soviet geologists.

The present pattern, however, is likely to change. As shown earlier, over half of all reserves today are located in the North Caucasus and the Ukraine, although the combined extent of petroliferous territory in these two regions form but 4 per cent of the enormous tract of sedimentary areas considered promising for gas finds. In addition, these regions produce some three-quarters of all free gases extracted in the USSR, which places a great strain on their deposits. It is obvious that if output is to increase as planned -- to over 300 billion cubic meters by 1970 and circa 700 billion by 1980 -- many new fields will have to be opened in hitherto little prospected areas. Lately authoritative articles in the Soviet

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These figures include oil-well gases utilized in the course of petroleum extraction. However, associated gases today compose but 15 per cent of Soviet natural gas production and 25 per cent of the total gas withdrawal (total withdrawal figures include gas flared, vented or recycled). In the more mature gas industry of the United States, oil-well gases make up 30 per cent of the total withdrawal and much of it is recycled. It seems reasonable to assume, therefore, that the proportion of associated gases in the total utilized output natural gas in the Soviet Union will not be above this figure.


Yu. I. Bokserman: *op. cit.*, p. 22-24 (Table 15), p. 29 (Table 19) and p. 5 (Table 2); Theodore Shabad, *op. cit.*, p. 59.
press have been criticising the low level of exploration in promising regions of Middle Asia and West Siberia; more intensive prospecting work in these provinces could, therefore, be expected in the future. The former region in particular is called upon to supply over 40 billion cubic meters of gas to other parts of the country by 1970 and over a hundred billion, ten years later -- a plan that requires a drastic increase of reserves. The successes already achieved on the West Siberian Depression and the region's proximity to the Urals should act as powerful incentives for future prospecting in this area also.

Discoveries in other regions are unlikely to affect appreciably the geographic pattern of gas-reserves. As mentioned before, some finds are likely in the southern part of the Angara-Lena Downwarp, but chiefly as a result of a search for oil, since in energy-saturated Central Siberia, the urgency for natural gas is not really present. The other areas in Siberia are too remote from population concentration and too harsh climatically for intensive prospecting. The much better located Caspian Lowland will play a significant role only after an important improvement in drilling technology and a reduction in the present cost of deep drilling. The petroliferous formations here lie at great depth. However, the much publicized ultra-deep exploratory well near Arasor, begun in 1961, apparently could not reach the desired depth of 7000 meters, which bodes ill for successful prospecting in this area.

32 Robert E. King: op. cit., p. 1341.
Although the marked concentration of gas reserves is likely to change as exploration spreads into new areas, the general westerly orientation will remain. One may confidently assume that for the next 20 years, perhaps even longer, at least nine-tenths of all Soviet gas will be obtained in an area covering a third of the U.S.S.R. Very nearly a sector of a giant circle, this area is bounded by the Soviet border from L'vov to the Pamir and by two straight lines converging on Noril'sk. While the older basins in the densely populated southwestern section will continue to represent an important share of the total, the West Siberian Depression and Central Asia will probably succeed to the dominant position by 1975. This expected change in the geographic distribution of natural gas may be compared to that which overtook the oil industry in the 1950's. In contrast to petroleum, however, which greatly improved its position by the massive shift from the Caucasus to the Middle Volga, a similar move to Central Asia and north-west Siberia will create problems for the gas industry. As European Russia and the Urals will surely remain the chief consumers of natural gas, the long-distance transport of this fuel on an ever larger scale will be necessary.
Chapter IV

TRANSPORT
In the modern industrial age, when large quantities of energy have to move over long distances, low cost, flexibility and ease of transportation acquire great importance and can decisively set for a while the energy pattern of regions or even whole countries. Long distance transport is at once a monument to the achievement of modern technology—efficient, reliable and increasingly economical—and an example of that sovereign influence that transport can hold upon a fuel which is dependent on one unique mode of conveyance. While solid and liquid fuels are able to take advantage of a variety of transport media, natural gas—like electricity—is to some extent handicapped by rigidity in its mode of conveyance. As yet its only commercially practiced mode of transportation is by pipeline. Shipment of frozen gas by methane tankers—while technically solved—seems to be profitable if very large quantities can be delivered, but only where transport by pipeline must be ruled out. Thus, while energy-hungry continents may embark on large-scale ocean shipment of frozen gas, cabotage—marine shipment between ports of the same country—will not be practiced in the near future. In the land-locked Soviet Union such practice would be especially difficult.

Large-scale natural gas production therefore, is unthinkable without a developed pipeline system, and pipeline transport possesses a number of unique characteristics not

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A. M. Leeston, op. cit., p. 256.
shared by any other transport media. It does not involve return freight and there are no intermissions in delivery. This continuous, one way movement facilitates automation and leads to great economies of labour, but it also demands uninterrupted absorption at the end of the line. Pipeline companies or trusts must resort to a number of techniques to counteract the seasonal and diurnal fluctuations in consumption. Interruptible sales are made during periods of weak demand to power stations and, occasionally, to certain industries, which replace gas with other fuels during peak seasons, freeing gas for more lucrative uses. Manufactured gases and-- in the future-- frozen methane may be utilized for short-time peaking, and to an ever increasing extent underground storage is employed to rectify the severe discrepancy between high winter and low summer consumption.

The transport of natural gas requires massive capital outlay. Since large-capacity trunklines must have large diameters, minimum wall thickness and high tencil strength, the pipes must be produced of special steel. As the moving gas loses pressure, the drop must be made good by periodic compression. Modern, efficient trunklines have compressor stations on every 60 to 100 miles and in the Soviet Union they constitute about half the total capital costs of the transmission network.

Natural gas is expensive to transport. General comparisons of transport costs for energy in different forms, however, can be quite misleading due to a number of variables that depend on local circumstances. Transport of energy in various forms, among many other things, involves different proportions of fixed and variable costs, handling and storage charges, etc., all of which vary differently from place to place.

It is not surprising, therefore, that J. Davis in Canada and V. K. Savelev in the U.S.S.R. have arrived at different conclusions about the relationship of various forms of energy transport. According to Davis, natural gas (converted to coal equivalent.) is about half as expensive to transport by a 34 inch diameter pipeline as bituminous coal by rail. Savelev claims that hard coal--transported by electrified railway--is cheaper, although brown coal and lignite are more expensive. Savelev's figures are given below, together with Robert Campbell's corrections (third column) for operating costs.

(Since Savelev does not include any capital charge, which is extremely important in the case of transport by pipeline, Professor Campbell corrects the operating costs with an arbitrary interest rate of 10%).

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Table VII

Cost of Transporting Various Fuels over a Distance of 1000 km. (per ton of nominal fuel)

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Capital Costs (rubles)</th>
<th>Operating Costs without interest (rubles)</th>
<th>Operating Costs with interest at 10% (kopeks per ton/km)</th>
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<tbody>
<tr>
<td>Crude oil by pipeline</td>
<td>35</td>
<td>4.0</td>
<td>.75</td>
</tr>
<tr>
<td>720 mm</td>
<td>35</td>
<td>4.0</td>
<td>.75</td>
</tr>
<tr>
<td>630 mm</td>
<td>46</td>
<td>5.4</td>
<td>1.0</td>
</tr>
<tr>
<td>Coal by electrified railroads of Class I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7,000 Cal/ton</td>
<td>81</td>
<td>13.3</td>
<td>2.1</td>
</tr>
<tr>
<td>5,000 Cal/ton</td>
<td>113</td>
<td>18.6</td>
<td>3.0</td>
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<tr>
<td>3,000 Cal/ton</td>
<td>189</td>
<td>31.0</td>
<td>5.0</td>
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<tr>
<td>Natural gas pipeline of 1020 mm diameter</td>
<td>136</td>
<td>16.2</td>
<td>3.0</td>
</tr>
<tr>
<td>Electric power transmission</td>
<td>200</td>
<td>13.7</td>
<td>3.4</td>
</tr>
</tbody>
</table>


The Soviet pipeline network for natural gas is as new as the industry itself. Although there were small local networks for coal-derived town gas even before the Revolution, the first two lines of any importance which carried natural gas were built only in the 1940's. They ran from Buguruslan to Kuybyshev and Saratov to Moscow. Completed in 1946, the latter had a diameter of 300 mm (12 inches). Construction proceeded
very slowly at first. Ten years later the length of pipelines for natural gas still totaled but 5000 km. Since that time, however, growth has been more rapid. The length of transmission lines has reached 28.5 thousand km in 1963 (over 26000 km of them carried natural gas), and further 8 to 9 thousand is scheduled for completion by the end of 1965.

The greatest difference between the Soviet and U.S. network is the radically different relationship between the length of transmission and distributing lines. In 1962, the Soviet network had 25,300 km of transmission lines against 17,600 km of distribution lines, a ratio of nearly 3 to 2, while in the U.S. the length of transmission lines reached 200,200 miles, but that of distributing lines 427,600 miles, a ratio of less than one to two.

Comparing the transmission network of the two countries, one finds a significant difference in the share of large diameter pipelines. At the beginning of 1963, nearly half (48%) of all Soviet trunklines had diameters of 28 to 42 inches, while in the United States only a fifth (27%) of them had diameters of 25 to 30 inches. The length of Soviet network in the

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28 to 42 inch category was greater than the length of U.S. network in the 30 inch and over category. We must remember, however, that of pipelines between 25 and 30 inch diameters alone, the United States had over 82 thousand km, more than three times as long as the entire Soviet network.

The Soviet natural gas industry is perhaps even more dependent on long distance transport than that of the United States, and this dependency is destined to increase once the Central Asian and West Siberian fields reach their full production capacities. It is worth noticing that in the United States the abundance of natural gas (and of oil) in the South-West successfully attracted industry. Texas, Oklahoma, Arkansas and Louisiana account for almost half of the nation's industrial consumption of natural gas. Such shift of industry to the gas (and oil) producing areas is proceeding very slowly in the USSR. Probably less than a fifth of the output of the North Caucasus is consumed in the region and local use in the Western Ukraine is negligible. Similarly, some three-quarters of the Uzbek production is destined to go to the Urals, and Central Asia cannot hope to receive much more than a quarter. Under such circumstances, the proximate location of the North Caucasian

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and Shebelinka deposits to the highly industrialized and densely populated Donets-Dnieper area is very propitious indeed. Utilization of gases in the Volga region is also proceeding very slowly. The wasteful flaring of oil-well gases in that area can be explained by the fact that these wet-gases, containing a high proportion of heavier hydrocarbons, cannot be transported without previous treatment. Their flaring is proof of the lack of sufficient industrial capacity on the Volga.

This situation is unlikely to improve greatly in the near future except, perhaps, in the Volga area. The long distance pipelines, must, therefore, be considered the lifeblood of the industry perhaps even more than in the United States. Map 5 shows the principal trunklines, existing, projected, and under construction, and indicates their diameters. Their convergence on Moscow from all directions is noteworthy, and the three parallel lines between Moscow and the North Caucasus clearly show which region is the chief supplier of the Soviet capital. A 32-inch pipeline necklace now surrounds the city joining the converging supply lines. Three long tentacles extend to the Baltic; two from the Western Ukraine (its eastern branch to Leningrad not yet completed), and one from the North Caucasus which branches off to the above city from Serpukhov, north-west of Moscow. Shebelinka supplies the eastern and southern parts of the Ukraine, the Soviet capital and -- in the future -- the Baltic as well. The Ordzhonikidze-Tbilisi pipeline, vaulting the Great Caucasus along the old Georgian military highway, links the Transcaucasian network to that of
MAJOR GAS PIPELINES of the USSR

Diameter of pipelines:
- 40 inches
- 28 Inches
- 20 inches or less
- existing
- under construction
- proposed

△ major producing fields
▽ minor producing fields
△ speculative field
the rest of the country. The pride of the USSR, however, is the giant 42-inch Bukhara-Ural trunkline, which is currently being doubled. Along its nearly 2000 km course, it bores through sandy deserts, barren limestone plateaus and the maze of irrigation ditches of the Amu Darya delta. If the large-scale discoveries hoped for in Central Asia materialize, a super gas-main from this area to the Moscow region may also come into being within the next decade.

As yet almost the entire pipeline network is confined to European Russia. Middle Asia has but a single line— from Bukhara to Tashkent— and a modest building program plans to extend it to the northern foothills of the Tien-Shan, to the Fergana Valley and to Karaganda within the present decade. Inside two years, the Urals are to be supplied from three directions: from Bukhara, from the Lower Ob and from the Volga. At Sverdlovsk, the giant Bukhara-Ural trunkline will meet another 40-inch pipeline now advancing from the Lower Ob. A much smaller one already supplies Magnitogorsk from Bashkiria, and another one from the Volga (Orenburg Oblast) will join the twin giants from Uzbekistan.

Apart from the slowly advancing Berezovo-Serov-Sverdlovsk line, properly belonging to the Ural network, Siberia cannot yet boast a single gas pipeline. A few are planned, however, and on two of them preliminary work has already begun. The

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first of these will connect the Taas-Tumus and Bestyak deposits with the capital of Yakutia and should alleviate somewhat the hardship of existence in the backward, hopelessly isolated region near the cold pole of the earth. The second will join Northern Sakhalin with the Far Eastern industrial center of Komsomolsk and will run parallel to the existing oil line across the Tartar Strait. The other two pipelines are more distant projects. One would deliver gas from the large field at the Taz estuary to Norilsk and thus put an end to the fuel problems of this amazing Arctic city. The longest and most important line, however, would run from Okhteure, in the middle of the West Siberian wilderness, to the Kuznetsk Basin.

It must be noticed that of these four pipelines only the last one will be of national importance. If built, it would greatly reduce the cost of pig iron and steel in the third metallurgical center of the country and aid in the creation of a sizable chemical industry. The other lines will be merely of local significance, hardly affecting the economy outside their immediate areas. The supplying of other cities of Southern Siberia from the Yakutian and present West Siberian deposits does not appear likely in spite of certain proposals. However, in case of successful strikes nearer the southern belt of population concentration, the construction of gas-mains to supply the Siberian cities will be highly probable.

If the hopes in highly promising Central Asia and north-

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For sources about the Soviet pipeline network, see page 247. (Sources for Map 5)

*Preliminary construction work is reported on this pipeline.
Table VIII
Transport Costs of Natural Gas over Full Length of Certain Major Pipelines (in rubles per 1000 cu. m.)

<table>
<thead>
<tr>
<th>Pipeline</th>
<th>Diameter</th>
<th>Length (km)</th>
<th>1959</th>
<th>1960</th>
<th>1961</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stavropol' - Moscow</td>
<td>720 mm</td>
<td>1296.0</td>
<td>3.35</td>
<td>3.01</td>
<td>2.08</td>
</tr>
<tr>
<td></td>
<td>800 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saratov-Moscow</td>
<td>300 mm</td>
<td>840.0</td>
<td>5.22</td>
<td>5.35</td>
<td>5.56</td>
</tr>
<tr>
<td>Dashava-Minsk</td>
<td>700 mm</td>
<td>656.0</td>
<td>--</td>
<td>--</td>
<td>2.63</td>
</tr>
<tr>
<td>Serpukhov-Leningrad</td>
<td>700 mm</td>
<td>803.0</td>
<td>--</td>
<td>3.63</td>
<td>2.30</td>
</tr>
<tr>
<td>Shebelinka-Belgorod-Bryansk</td>
<td>700 mm, 300 mm</td>
<td>541.0</td>
<td>0.42</td>
<td>0.92</td>
<td>0.99</td>
</tr>
<tr>
<td>Shebelinka-Dniepropetrovsk</td>
<td>700 mm</td>
<td>195.0</td>
<td>0.31</td>
<td>0.42</td>
<td>0.45</td>
</tr>
<tr>
<td>Dashava-Kiev-Bryansk</td>
<td>700 mm</td>
<td>900.0</td>
<td>2.66</td>
<td>2.57</td>
<td>2.06</td>
</tr>
<tr>
<td>Stavropol' - Gorkiy</td>
<td>800 mm</td>
<td>601.0</td>
<td>--</td>
<td>--</td>
<td>1.92</td>
</tr>
<tr>
<td>Stavropol' - Groznyy</td>
<td>700 mm</td>
<td>446.0</td>
<td>--</td>
<td>--</td>
<td>1.47</td>
</tr>
<tr>
<td>Rostov-Taganrog-Slavysansk</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.71</td>
</tr>
<tr>
<td>Karadag-Akstafa-Tbilisi-Yerevan</td>
<td>700 mm</td>
<td>611.0</td>
<td>--</td>
<td>3.55</td>
<td>3.06</td>
</tr>
<tr>
<td>Dzharkak-Bukhara-Tashkent</td>
<td>720 mm</td>
<td>756.0</td>
<td>--</td>
<td>--</td>
<td>3.76</td>
</tr>
<tr>
<td>Average for USSR</td>
<td>--</td>
<td>--</td>
<td>2.23</td>
<td>2.21</td>
<td>2.07</td>
</tr>
</tbody>
</table>

* One branch varying diameter along its length
** Approximately

west Siberia materialize, however, the most important flow of natural gas in the future will be westward and northward, to Soviet Europe and the Urals. The relatively well prospected and areally small European gas regions cannot for long satisfy the rapidly growing demand. As with coal and electricity, the eastern territories will have to step into the breach.

The various Soviet trunklines operate on very different levels of efficiency and vary greatly in their diameters and lengths. Transport costs over them from field to market, therefore, appear highly dissimilar as Table VIII plainly shows. It is more than twice as expensive, for instance, to ship gas to Moscow from Saratov than from Stavropol', although the latter city is twice as far away. The chief reason for such anomalies lies in the advantage of using large-diameter pipelines (Appendix, Table IV), and here the strenuous efforts to increase the length of such lines have clearly paid off.

Many of the Soviet pipelines, however, are still rather inefficiently operated. The 28.5 thousand km long Soviet network had only 42 compressor stations with an aggregate capacity of less than 1.3 million horsepower in January 1963. Distances between stations, therefore, are sometimes too large, and the pipelines operate with relatively low pressures and high resistance coefficients which impair their carrying capacities.

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Due to the low level of automation, labour productivity over the Soviet lines is extremely poor. In spite of gradual improvement, the number of persons operating the major pipelines seems to exceed 50 per 100 km even today. By comparison, the entire TransCanada is run by 102 workers, that is 2.8 per 100 km. This difference is in fact so large that there may be an additional factor present, making the data non-comparable. The Soviet petroleum industry, for instance, is very much over-staffed partly in order to train personnel. A similar situation may exist here.

The cost structure of transportation of natural gas in the USSR does not differ markedly from that in the United States. As in the latter country, the amortization of facilities constitutes the largest share and may reach 70 per cent. The incomplete mechanization in the Soviet Union, however, produces one significant difference: a very high share for labour expenditure (wages and salaries) -- a cost item which is small in North America. (See Appendix, Table V.)

Since every pipeline represents a fixed, invariable carrying capacity on which capital charges lie heavy, periodic

---


drops in demand mean underutilization and huge losses. Seasonal imbalances over the Soviet network are quite considerable despite the very high share of industrial consumption of natural gas which always fluctuates less than residential consumption. Table IX shows the variation between the volume of transported gas in January and June of 1961 and 1962 over eight major pipelines in the USSR.

Between 1959 and 1963, the major lines delivered, in toto, 12 to 16 per cent more gas to consumers during the first and fourth quarters than during the warmer half of the year. In none of these years was the actual difference very far from a tenth of the total output of non-associated gases (e.g. 4.17 billion cubic meters in 1963; 6.2 billion in 1962).

The problem of seasonality is particularly acute in the big cities where the large and highly variable domestic market accentuates the fluctuation. Moscow, for instance, consumes 23 per cent and Leningrad 11 per cent more natural gas during the six winter months than during the summer half of the year. And much of that summer consumption represents interruptible sales to electric stations in these cities, which use gas from March to September in order to reduce the imbalance in demand.

At present, the USSR has very limited underground storage facilities for natural gas, and construction is proceeding

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18 Yu. I. Bokserman: op. cit., p. 277-78
Table IX

Seasonal Fluctuation over Major Soviet Gas Pipelines

<table>
<thead>
<tr>
<th></th>
<th>Transport of gas: million cu. meters</th>
<th>Coefficient of fluctuation</th>
<th>Transport of gas: million cu. meters</th>
<th>Coefficient of fluctuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stavropol'-Moscow (double line)</td>
<td>1009 781</td>
<td>1.29</td>
<td>1493 918</td>
<td>1.63</td>
</tr>
<tr>
<td>Krasnodar-Kray-Serpukhov</td>
<td>446 341</td>
<td>1.31</td>
<td>654 567</td>
<td>1.15</td>
</tr>
<tr>
<td>Shebelinka-Belgorod-Bryansk</td>
<td>526 435</td>
<td>1.21</td>
<td>697 502</td>
<td>1.39</td>
</tr>
<tr>
<td>Dashava-Kiev-Bryansk</td>
<td>211 182</td>
<td>1.16</td>
<td>272 181</td>
<td>1.50</td>
</tr>
<tr>
<td>Stavropol'-Groznuy</td>
<td>134 62</td>
<td>2.16</td>
<td>177 177</td>
<td>1.00</td>
</tr>
<tr>
<td>Dashava-Minsk</td>
<td>91 84</td>
<td>1.08</td>
<td>176 168</td>
<td>1.05</td>
</tr>
<tr>
<td>Krasnodar-Tbilisi-Yerevan</td>
<td>79 66</td>
<td>1.20</td>
<td>106 97</td>
<td>1.09</td>
</tr>
<tr>
<td>Saratov-Moscow</td>
<td>55 48</td>
<td>1.15</td>
<td>53 49</td>
<td>1.08</td>
</tr>
</tbody>
</table>

rather slowly. Two large reservoirs with a combined capacity of one billion cubic meters were completed near Moscow during 1963 and more modest ones are being prepared near Leningrad and Ryazan. Only part of the volume stored up in any reservoir can be used, however, since one-third to one-half of all the gas must be permanently kept there to maintain pressure. Only the Central Region and the Leningrad area seem to have such reservoirs in operation, though construction has begun on others near Kiev, Tashkent and the Urals. Total active capacity, therefore, appears to be between two and three billion cubic meters, or less than a thirtieth of the annual production of the USSR. In the United States, active capacity exceeds 100 billion cubic meters, or a quarter of yearly production.

Because the number of old depleted wells in the Soviet Union is limited, porous aquiferous formations will play the leading role in gas storage, but will also increase costs. Considering that the net cost of extraction plus transport ranges between two to six rubles per 1000 cubic meters, the relative cost of storage--in existing as well as projected reservoirs--is fairly high, running--according to the most favourable estimates--from one half to two rubles per 1000 cubic meters.

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23 V. S. Chernovol, op. cit., p. 40.
There is a fair amount of discussion in Soviet sources about underground storage in the USSR and it appears that the problems are many.

Liquefied petroleum gases and other gas liquids in the Soviet Union are transported almost exclusively by rail, whereas in the United States truck and pipeline transport overtook the entire industry in the last decade. In the USSR, pipeline transport of natural gas liquids is limited to a few very short lines, almost entirely in the Volga region, supplying petrochemical works from gas-benzine factories. Their number is most certainly under a dozen. Truck transport is restricted to the distribution of cylinders for households within a limited radius. Most LPG, as well as natural gasoline, moves by rail tank-car, sometimes over a great distance, the longest large-scale shipment being the supplying of Murmansk from Bashkiria 3300 km away.

As with pipeline transport of dry gases, shipments of NGL's (natural gas liquids) today are confined almost entirely to European Russia and the Urals. Between 1963 and 1966, however, several populated points in the Virgin Land Kray hope to receive liquefied gas and natural gasoline. On a small scale, it is

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24 Oil and Gas Journal, March 16, 1964, p. 111.
already being utilized in tractors and other agricultural machinery. A small amount of these gases is also consumed in rural Middle Asia. The Virgin Lands are, and will be, supplied mainly from the Middle Volga, Central Asia from the Cheleken peninsula. The great Bukhara deposits contain very dry gases, which do not lend themselves to liquefaction. Their role in supplying these areas with natural gas liquids, therefore, will be negligible.

The geographic significance of long-distance gas transport may be compared to that of high voltage transmission of electricity. Although the former represents movement of energy in an original state, while the latter implies transformation, the similarities are unmistakable. In the USSR, the ultimate aim in both cases is the tapping of distant energy reserves for the energy-hungry cities of the Urals and European Russia. At present, 85 per cent of all natural gas is produced in the Ukraine, the North Caucasus and the Volga, in well-populated regions, with long established or developing industry. Yet the bulk of the gas leaves these areas to be consumed in the Central Region, Leningrad and the Baltic, hundreds of miles away. As Chapter I showed, however, Central Asia and the West Siberian Depression will almost certainly succeed to a dominant


position in reserves sometime during the 1970's. At the same
time, the very high rate of production will considerably deplete
the Ukrainian and Caucasian deposits: the two eastern regions,
therefore, will surely catch up and may even overtake, in output.
As with electricity, where both in potentials and soon in pro-
duction, remote easterly regions hold sway, so it will be with
gas.

If anything, however, large-scale shipments of gas to
European Russia will be an even more extreme case, reflected
in the geographic pattern. The proposed high-voltage link be-
tween Siberia and the Urals will neither originate in, nor pass
through, economically unresponsive territories. It will begin
in the fast-developing Kuznets-Angara region and follow the
grain of Soviet economic activity through the true "Heartland"
of the USSR, to use David Hooson's phrase. Similarly, en
route to major centers of people and industry, the pipelines
of European Russia span established, populated areas, distrib-
uting fuel all along the way.

It is otherwise with pipelines tapping the infant, but
apparently fabulous gas-regions of the East. In our lifetime,
neither the swampy wilderness of north-west Siberia, nor the
deserts and barren plateaus of Middle Asia will be anything
but economic vacuums. On their way to the major consuming
centers of Soviet Europe, these trunklines will have to pass

David J. M. Hooson: *A New Soviet Heartland?* Van
through similar country or at best through very sparsely peopled, unindustrialized areas of the Virgin Lands and Lower Volga Valley. These lines, therefore, as the already existing Bukhara-Ural unquestionably is, will be but giant siphons which will pump energy out of otherwise useless wastelands to the industrial hearts of the country. They will not be meant to, or be able to, fill the economic hollows, decreed to be more or less permanent by nature.
PART II

REGIONAL SECTION
Fuel consumption in the U.S.S.R. is highly concentrated. Three regions, in roughly equal proportion, account for half of all non-renewable energy consumption in the country. These are: the Center (including the Gor'kiy complex and the Central Chernozem area), the Urals, and the Donets-Pridnieper-Rostov region. Five other regions have shares greater than 5 percent: the Northwest, the Volga, the rest of the Ukraine (with Moldavia), and the two regions in Southern Siberia and Northern Kazakhstan. It can be observed from Map 6 that all but two of these regions are found in European Russia and that more than three-fourths of all fuel is utilized west of Chelyabinsk, between the 60°N parallel and the Caucasus range.

Yet it is the supreme fact of Soviet economic geography that only three regions in this area have a sufficient local power base, and in two of these - the Volga and the North Caucasus - by far the greater part of the rich fuel resources have been discovered only recently. Until after the Second World War -

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1 "Statisticheskiye Materialy": Vestnik Statistiki, No.5, 1962, p. 91. Some estimating was necessary since my regions do not exactly correspond to the official Soviet economic regions. The Rostov Oblast was detached from the North Caucasus and added to the Donets-Pridnieper region, while the Northwest (Leningrad Region) in this study excludes all lands east of Vologda and north of Lake Onega. Southern Kazakhstan was added to Central Asia and two regions, not existing in Soviet classification, were defined in the North Kazakhstan -- South Siberian belt west of Lake Baykal. The procedures of calculating, or adjusting, fuel consumption in these regions are explained in the appropriate chapters.
aside from the remote and frozen Pechora province - only the Eastern Ukraine could be considered affluent in energy in the whole of European Russia. At the end of the 1920's, the declining oil wells of the North Caucasus still supplied a tenth of all fuel, but by 1940 this share has fallen to 2\% percent. The Volga contributed a mere 1 percent even at the latter date. It has only been in the last decade that the latter region attained true prominence and the North Caucasus acquired a new vital role in the national energy supply.

Except in the Donets Basin, modern industry in Russia has grown up on distant supplies of coal and on such expensive low-quality fuels as ashy lignite, peat and shale. Coal import from Cardiff and Newcastle to St. Petersburg may be substituted by "imports" from the Donets and the Pechora during Soviet times, but the essential dependence of much of European Russia on far-away sources of power has remained. The Urals, too, industrial giant of Soviet power, was built up very largely on coal brought in from 1500 miles, and in absolute terms its energy import still increases every year.

The present shift in the fuel mix does not change that imbalance in Soviet industrial geography; most of Soviet Europe

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2 These figures were calculated from D. Shimkin: The Soviet Mineral-Fuel Industries, Table 5, p. 31 and Table VI, p. 85; 1940 figures were checked against Table XIV, p. 90. Figures for total fuel production were taken from: Narodnoye Khozyaystvo 1958 g, p. 200 (for 1940) and J.P. Cole and F.C. German: A Geography of the U.S.S.R, Table 22a, p. 111 (for year 1920).
is still a deficit area and the supply of energy to parasitic regions, often over long distances, is more than ever a necessity. The use of mobile hydrocarbon fuels however, has considerably lightened that tremendous burden on the economy, made possible a greater diversification in power consumption, and furnished the chemical industry with inexpensive raw materials.

In this section, the role played by natural gas in each region is examined in detail. The contribution of gas to the regional fuel mix, the pattern of its consumption, and the benefits derived from its utilization are analyzed in the individual context of each territorial division.

The economic regions are grouped into three categories: consuming areas, producing areas and regions with both characteristics. Strictly consuming regions are the Center, the Leningrad Region, the Baltic and the Urals. They are traditionally poor in energy and have to depend on "imported" fuels. Provinces of consumption as well as production are the Greater Ukraine, the Volga and the Transcaucasus. While benefiting greatly from this new source of energy, they all have rich, though more expensive, supplies of other fuels and-- with the exception of the Transcaucasus-- are able to export a substantial part of their natural gas output to other areas. Essentially producing regions-- "exporting" most of their output-- are the North Caucasus and Central Asia (Uzbekistan and Turkmenia). Siberia, including Northern Kazakhstan, is treated in a separate chapter. Here-- excepting the Lower Ob Valley, tied completely to the Uralian economy-- the natural gas industry is
entirely undeveloped or is in an extremely rudimentary stage. Its future significance can be assessed only tentatively.
Chapter V

CONSUMING REGIONS
94.

THE CENTRAL REGION

The Central Region occupies the middle of the East European Plain. Its strategic position, the presence of the capital and largest metropolis and the radiating railways have given the region a commanding position in Soviet Europe. Though its boundaries are very uncertain and underwent frequent administrative changes, no other economic area in the U.S.S.R. has such a prominent core. In this analysis, the Center includes the Gorkiy Oblast, belonging officially to another division, and the Central Chernozem region, which is often made into a separate economic unit.

This is a large region, three times the size of Great Britain, and it accounts for over 17 percent of the country's population, 16 percent of its fuel consumption and perhaps a fifth of its industrial capacity. Within this region, however, one can witness a sharp concentration of economic activity. Three-fifths of the Center's population, most of its cities and almost all its manufacturing, is found in a relatively small quadrangular area, less than a quarter of the total, with

THE ENERGY SUPPLY of the CENTRAL REG.
Kalinin, Rybinsk, Gorkiy and Tula as its corners. And it is in this core area that probably 80 percent of all fuel consumed in the Central Region is utilized. Outside this industrial core, only one single complex is destined to use large quantities of fuel in the near future, Lipetsk, where a very large integrated iron and steel work is now nearing completion. Attention, therefore, will be focused primarily on this inner industrial center described above.

Excepting the Urals, the Center is the oldest industrial region in Russia. In addition, it contains the largest conurbation in the country, the seat of the government and a disproportionately high share of scientific and cultural institutions - all of which were important even during the time when St. Petersburg served as the capital of the Russian Empire. The development of manufacturing was based entirely on the advantages of location that had already given the region prominence in political development and trade. The Center has never been able to supply more than half of its energy needs even by the strenuous and very costly exploitation of its local resources. Generally, the share of "imported" fuels far exceeded that of the locally produced ones in the region's energy mix and was espec-

These figures were calculated or estimated on the basis of data supplied by Narodnoye Khozyaystvo RSFSR v 1962 g, p. 8 and p. 12 and Akademiya Nauk, Institut Geografii: Tsentral'nyy Rayon, Gosisdat, Moskva 1962.

ially dominant in the fuel supply of the Moscow industrial core.

In every respect, therefore, the Central Region appears to be an area where the utilization of clean and mobile hydrocarbon fuels could produce especially great benefits. Although natural gas has entered the Soviet fuel-mix only recently, it is notable that its first contribution (aside from field uses of oil-well gases) was made in the Central Region. The first gas-pipeline built in the USSR (excepting a short one in the Middle Volga) was constructed from Saratov to Moscow (1949). The second, too, though it reached Kiev first, was quickly pushed on to the capital (Dashava-Kiev-Moscow). Since that time, the above region has continued to receive the lion's share of pipe-line construction, until today it is supplied through five

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4 In 1908, for instance, three-quarters of all fuel consumed in the vicinity of Moscow was brought in from distant regions (Akademiya Nauk: Tsentral'nyy Rayon, p. 95). Even during the Five Year Plans, despite feverish exploitation of Moscow lignite and peat, the increase in fuel output could not keep up with industrial growth (Tsentral'nyy Rayon, p. 166) and local fuels seem to have furnished only about a fifth of the energy consumed in the industrial core and perhaps double that share in the entire Center. (Since only some % percent of fuel produced in 1938 was exported and the amount in inventory in the thirties is not likely to have been great, total production for the USSR as a whole can be roughly equated with total consumption. The share of the Center in total fuel consumption could not have been smaller during the thirties and early fifties than in 1960, and it was probably larger. Most fuel produced in the Central Region must have been consumed locally, since Moscow coal and peat are not transportable. Assuming these, above figures have been calculated from: "Statisticheskiye Materialy," Vestnik Statistiki, No. 5, 1962, p. 91 (share of various regions in total fuel consumption); D. Shimkin: op. cit., Table 5, p. 31 (share of various regions in total fuel production in 1928, 1940 and 1955) and Narodnoye Khozyaystvo v 1962 g, p. 152 (total fuel production in 1940).
trunklines, with two more projected, linked by a large capacity pipeline ring just inside the boundary of Moscow Oblast. (See Map 5) Consumption has been increasing by leaps and bounds: it was 4 billion cubic meters in 1958, about 8.4 billion in 1960, and between 25 and 30 billion in 1962-63. In 1962, the city of Moscow alone used as much natural gas as the whole Central Region two years earlier (8.4 billion cubic meters), and by the end of 1965, the capital is to receive some 12½ - 13 billion cubic meters, the equivalent of 15 million tons of hard coal.

It can be seen, therefore, that the capital is much more heavily supplied than the Central Region as a whole. By 1961, natural gas accounted for half of Moscow's fuel balance, a fraction which is to grow to nearly nine-tenths by the end of the Seven Years Plan (1965). In the Region as a whole, however,

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5 These figures were calculated from shares of total fuel consumption with the conversion factor: 1 ton of nominal fuel (7000 Cal) = 1.21 thousand cu. m. of gas. Data taken J.P. Cole and F.C. German: op. cit., p. 160 - (for year 1958); Narodnoye Khozyaystvo v 1962 g, p. 152 and 545; Vestnik Statistiki, No. 5, 1962, p. 87 and 91. (Total fuel consumption was obtained by taking total production and subtracting export. Inventory was ignored. Conversion factor for oil: 1 ton of nominal fuel = 1.43 tons of oil and oil products). Figure for 1962-63 taken from Gazovaya Promyshlennost', No. 5, 1963, p. 10 for import of gas to Central Region from the North Caucasus. Imports from other regions were estimated.

6 Yu. I. Bokserman: op. cit., p. 277, Table 106.


8 Referativnyy Zhurnal, No. 3E56, 1962.
gas supplied only eight and a half percent of the total fuel requirement, and even in the industrial quadrangle its share was probably below 15 percent. It is to exceed a quarter by 1966. The chief supplier is the North Caucasus: it sent to the Center 20 billion cubic meters in 1962 and was to raise this amount to 30 billion by this year. The Ukraine can spare only a fraction of that amount, since it also supplies the Baltic and, besides, its own fuel needs are very great. Due to the small capacity of the Saratov-Moscow line, Saratov Oblast supplies only up to 600 million cubic meters per year. The 32-inch diameter Saratov-Gorkiy trunkline is of much greater capacity and would be able to furnish 6 billion cubic meters per year to the latter city. At present, however, the resources of Saratov Oblast' cannot guarantee such massive deliveries, and Gorkiy receives only about half that amount. The Center, in fact, could use much more gas than it receives from all its suppliers but without new discoveries these reserves cannot be depleted much faster.

10 Referativnyy Zhurnal, No. 3E56, 1962.
13 Ibid., p. 5 and p. 7.
The Seven Year Plan (1958-65) envisaged a massive substitution of gas for the high-cost Moscow lignite and peat. It is clear, however, that this substitution is being restricted very largely to the industrial quadrangle. Except by way of some electricity, transmitted from stations on the coal field, and through limited underground gasification, local lignite will not contribute to the fuel economy of Moscow Oblast'. Even in power stations the extensive use of this coal is a debatable matter. In Tula Oblast', where more than nine-tenths of the production of Moscow lignite is concentrated, and where coal supplied 87 percent of all fuel requirement in 1958, output is being greatly reduced, and the share of coal in the fuel mix of the Oblast' will drop to 40 percent by the end of 1965. Similar reduction is being effected in Ryazan Oblast'. The difference in energy need is being supplied by gas and oil, the former being generally more important, and much more so near the capital. In contrast to the manufacturing core, coal (and peat) production is being expanded in the less industrialized oblasts (e.g. Smolensk and Kaluga).


15 Ibid., (Geograficheskiye Problemy), p. 68 and Tsentral'nyy Rayon, p. 172.
It seems that in this area no large-scale substitution of gas for coal is likely to take place in the near future. Neither are Yaroslavl' and Ivanovo Oblasts supplied adequately yet with natural gas, although the former is second only to Moscow Oblast' in industrial output, while the latter boast the greatest concentration of textile manufacturing in the country. One large-diameter pipeline (32 inches) from the Volga reaches these districts, but it works only at half capacity, transmitting about 3 billion cubic meters per year. Since it also serves Gorkiy and Cherepovets, it is not likely to have much gas available for Ivanovo and Yaroslavl'. (These cities are crossed by an oil pipeline, too, from the prolific Al'met'evsk field, and oil is likely to make a greater contribution to their fuel economy than natural gas.)

The distribution of natural gas among the sectors of economy in the Central Region differs somewhat from the national pattern, owing to very high consumption by power plants. In 1960, electric power stations took 34 percent, industrial enterprises nearly 40 percent and domestic consumers 11 percent. By that year all power stations within the capital were changed to gas though some used coal and fuel oil during the winter.

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16 Tsentral'nyy Rayon, p. 379 and 480-81.
18 Referativnyy Zhurnal, No. 3E56, 1962.
months. South of Moscow, electric stations utilize the local lignite to a considerable extent (e.g. Kashira and Stupino), while others work on peat. Natural gas, however, can be profitably utilized even by these stations during the summer period. As in any large mid-latitude city, seasonal fluctuation of gas consumption in Moscow is very considerable, demand in January being almost twice as great as in July. Other urban centers in the Region should exhibit a similar pattern. At the same time, underground storage capacity in the Soviet Union is very limited due to lack of exhausted natural reservoirs. Presently, storage capacity in the Center seems to be only about one billion cubic meters, but active capacity—the amount that can be withdrawn—is only about half that much. The Russians are, therefore, forced to dump large quantities of gas to power stations during the warm season in spite of frequent criticism against the excessive use of natural gas as boiler fuel. In the new price system, effective since January 1964, such stations receive gas two rubles below the regional price level (per 1000 cubic meter) which indicates that the Russians have resigned

20 *Tsentral'nyy Rayon*, p. 175.
themselves to the practice. Of all regions, such interruptible sales appear most common in the Center.

The position of domestic and municipal consumption in Moscow is very illuminating. The energy needs of this sector are almost exclusively supplied by gas, and yet this accounts for a mere 11 percent of total gas consumption in the Soviet capital—hardly more than the national average. For a city of six and a half million, which provides a greater degree of comfort than any other in the USSR and is, in addition, by far the leading scientific and cultural center, this is a remarkably low figure. This share, however, would appear significantly higher—although it would still be far below the North American level—if the gas used for toplifikatsiya were included (see page 43). Space heating by this method is practised on a very large scale in the industrial core of the Central Region, and by 1965 toplifikatsiya is to account for close to four-fifths of all space-heating. (Stations providing by-product heat for space-heating are called TETs's—Thermal Electric Centers. For their importance in Moscow, see also Table X as follows.)

In industry, the share of gas was higher than that of any other fuel in 1960, except for the Gorkiy area. Three years before, coal still dominated even in the city of Moscow.

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24 Tsentral'nyy Rayon, p. 174.
26 Tsentral'nyy Rayon, p. 273.
Table X
Forecast of Moscow City's Fuel Mix in 1966
(in 1000 tons of nominal fuel)

<table>
<thead>
<tr>
<th>Consumer Sectors</th>
<th>Natural Gas</th>
<th>LPG</th>
<th>Coal &amp; Coke</th>
<th>Fuel Oil</th>
<th>Wood</th>
<th>Kerosene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic</td>
<td>635</td>
<td>49</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>10</td>
</tr>
<tr>
<td>Municipal</td>
<td>577</td>
<td>1</td>
<td>137</td>
<td>300</td>
<td>10</td>
<td>---</td>
</tr>
<tr>
<td>Industrial</td>
<td>4863</td>
<td>4</td>
<td>590</td>
<td>129</td>
<td>20</td>
<td>---</td>
</tr>
<tr>
<td>TETs's</td>
<td>7009</td>
<td>---</td>
<td>721</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Other Electric Stations</td>
<td>1915</td>
<td>3</td>
<td>250</td>
<td>---</td>
<td>45</td>
<td>---</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>14999</strong></td>
<td><strong>57</strong></td>
<td><strong>1698</strong></td>
<td><strong>429</strong></td>
<td><strong>75</strong></td>
<td><strong>10</strong></td>
</tr>
</tbody>
</table>


The metal working, engineering, building material, printing, leather-wear and some half of the textile industry—concentrated chiefly in Moscow Oblast’—now almost exclusively utilize gas for their thermal energy need. Textile manufacturing in Ivanovo, however, seems to be much more inadequately supplied. When the great iron and steel complex at Novo-Lipetsk is completed, ferrous metallurgy will also become a major consumer of natural gas in the Central Region. The cost figures for the Lipetsk mill are very good regarding the iron ore (high grade K M A ore), but are very high with respect to coal, which will have to be hauled from the expensive Donets mines 600 kilometers away.

Every effort will be made, therefore, to reduce coke expenditure, and the mill could be expected to use more gas than any other of comparative size in the USSR. It is very conveniently located regarding pipelines, for the three trunklines from the North Caucasus pass very near. The large amount of scrap available in the Center means that many open-hearth furnaces will be used despite increasing reliance on oxygen converters. And open-hearth steel making, as shown in Chapter II, is dominated by natural gas.

The Central Region also accounts for the bulk of the Soviet chemical output. Approximately half of all plastics, synthetic rubber and chemical fibers, and nearly a fifth of all fertilizers are produced here. Up until now, coal and vegetable fats, starches, etc. were the chief raw materials. Even in 1962-63, one-third of all vegetable fats and two-thirds of all starch produced in the USSR as a whole was used as chemical raw materials, a very high share of that in the Center. At the same time, the coal-based chemical industry had to utilize imported Donets coal. Only in 1958 was natural gas first used, for instance, to manufacture fertilizers - at the Novomoskovsk Chemical combine. Today, the combine is producing ammonia,

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urea, ammonium nitrate, sulfuric acid, etc. It is planned to extend its range of products to include methane-based organic chemicals, such as methyl alcohol, chloromethanes and their derivatives. Until 1959 the plant worked at a deficit, reaching 350,000 rubles in 1958, due mainly to the high cost of raw material and fuel. Only since the changeover to natural gas did it begin to register profit. The cost of production of methyl alcohol and ammonia were reduced—in comparison to previous costs from coke—by 40 percent. A smaller plant, producing ammonia and liquid nitrogen fertilizers has recently gone on stream at Shchekinsk. However, since these seem to be the only ones working on natural gas, and since the Center produces probably two million tons of nitric fertilizers, at least 60 percent of their output in this region must still be based on coal.

The organic chemical industry, too, is still very largely dependent on "imported" coal and plant alcohols. Regional data is not available, but the Center, with its very high share of organic capacity, seems to conform closely to the national

34 Ibid., (Ekonomicheskaya Gazeta), p. 6.
pattern. Thus some half of the plastic plants appear to use coke-chemical intermediates and a fifth of the large synthetic rubber industry uses grain and wood derived ethyl alcohol as its major raw material. Aside from acetylene production—associated with the manufacturing of ammonia production at Novomoskovsk and Shchekinsk—natural gas hardly contributes yet to the organic chemical industry of the region.

It is a moot point, however, whether the construction of large petrochemical plants to supply the plastic rubber and fiber industries of the Center is economically justified. The region would have to receive LPG or still sufficiently "wet" natural gas from the Volga at costs no less (and often greater) than those of petrochemical intermediates. In addition, the manufacturing of these intermediates require high fuel and energy but low labour inputs in contrast to the manufacturing of plastics and synthetic fibers where the opposite situation applies. As shown before, the Center excels in labour but is badly deficient in energy. Many specialists, therefore, advise a separate location for the production of petrochemical intermediates near sources of raw material, fuel and electric power as in fact exist in the United States. Some petrochemical industry is being developed in the Center, but it is largely linked with the recently built refineries at Ryazan, Yaroslavl' and Gor'kiy.


37 Geograficheskiye Problemy Razvitiya Krupnykh Ekonomicheskikh Rayonov SSSR, p. 74-75.
THE LENINGRAD REGION

The Leningrad Region in this analysis includes the ring of oblasts around the second metropolis of the USSR. Besides Leningrad Oblast', it embraces Pskov, Novgorod and the western part of Vologda Oblast', as well as the southern quarter of the Karelian ASSR. The size of Germany (both East and West), the region is inhabited by a little over 8 million people, three and a half million of whom live in the city of Leningrad. No other region, not even the Center, is so thoroughly dominated by one metropolis. Outside Leningrad and its satellite towns, little industry is found aside from saw milling and food processing. Cherepovets, with its ferrous metallurgy, is the only exception, but its large, integrated iron and steel mill, too, was established for the purpose of supplying Leningrad.

The Leningrad Region holds a position of importance in the national economy out of all proportion to its population and natural resources. The Leningrad Oblast' alone contributes about 6 percent to the gross industrial production of the USSR, and the whole region, as outlined above, accounts for roughly the same share of total fuel consumption. Its local energy

39 Ibid., p. 336 and "Statisticheskiye Materialy," Vestnik Statistiki, No.5, 1962, p.91. The table gives 6.8 percent as the share of the whole North-West Economic Region, which includes, in addition to the above area, Murmansk and Arkhangeslsk Oblasts, the Komi ASSR and the rest of the Karelian ASSR. The population of these outer districts, however, is only a sixth of the whole North-West, and with the exception of Murmansk Oblast', the area is no more urbanized than the rest. Its fuel consumption, therefore, is not likely to exceed a sixth of that of the whole North-West, especially, since the share of hydro-electricity in the energy mix of Murmansk is very high.
ENERGY SUPPLY OF THE LENINGRAD AND BALTIC REGIONS

PRODUCTION:
- PEAT
- SHALE

POWER STATIONS:
- PEAT
- COAL
- OIL
- GAS
- GAS and OTHER FUELS
- GAS PIPELINE
- SHALE
- HYDROELECTRIC

Scale: 1 cm = 60 km
base, however, could hardly be less satisfactory. Aside from moderate resources of peat and shale no local fuel is available and the hydroelectric potentials of the region have now been almost fully developed.

For most of its energy needs, Leningrad has had to depend on fuels brought in from great distances. Industry in the city has grown up during Tsarist periods, based entirely on foreign coal (and metal), which could be imported cheaply by sea. Imports of foreign coal gradually ceased after the Revolution (by 1926), but despite careful utilization of local peat and shale, the great bulk of fuel consumed in the region had to be brought in from afar. Donets and later Pechora coal has supplied the greater part of the fuel required, while the southern section of the region (Pskov Oblast) has received lignite— even as late as 1960— from the western end of the Moscow Basin, where extraction is the costliest.

The Leningrad Region, therefore, is an area where an increase in the contribution of hydrocarbon fuels appear highly significant. However, the difficulties are great, especially for natural gas. Of all regions of European Russia, the above one lies farthest from the major gas (and oil) deposits: the North Caucasus is over 2000 kilometers away, the Eastern and the Western Ukraine are each over 1200, while the Volga is about 1500. Because of such distances, Leningrad is reached by only one natural gas pipeline today, which branches off from the

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*Geograficheskiye Problemy Krupnykh Rayonov SSSR*, p. 69.
North Caucasus - Moscow system at Serpukhov. (Leningrad also receives shale gas through two short pipelines from Estonia and from the city of Slantsy). The city of Cherepovets, in the eastern extremity of the region, is reached by a line from Saratov Oblast' on the Volga. The pipeline from Serpukhov may be doubled, while another from Bryansk and Minsk is a possibility through which both Dashava and Shebelinka gas could go to the head of the Finnish Bay.

Because of remoteness from the gas fields and the costliness of transporting natural gas, consumers in Leningrad must purchase this fuel at a higher price than in any other region of the USSR, two rubles higher, for instance, than in the Center. It must be remembered, however, that Leningrad has been receiving coal from fields just as far away. Coal transport by rail is not much cheaper than the transport of gas, and coal extraction costs are several times higher (see Table VII, Appendix).

Due to its less favorable location, however, Leningrad is receiving the benefits of natural gas much more slowly than Moscow. While Leningrad burned only 1.8 billion cubic meters of gas in 1961, Moscow - less than twice the size of the former city - burned four times as much. Two years later, Leningrad still received only about a third as much natural gas as the Soviet capital. In that year, it consumed 2.9 billion cubic

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42 Severo Zapad RSFSR, p. 174 and Yu. I. Bokserman, op. cit., p. 275, Table 105.
meters, while an additional 600 odd million cubic meters of shale gas was brought in from Estonia. Under these circumstances gas contributes much less to the fuel mix of the city than in Moscow. Although for domestic and municipal consumption, gas was available for nearly the entire population, in the total fuel balance of Leningrad its share (shale gas included) was below a quarter. Although Donets coal would still be imported in fairly large quantities, by the end of 1965 the planners hope to replace with natural gas the even more expensive coal from the Pechora Basin — which at present supplies over half of all coal consumed in the city. Earlier it was hoped that the share of gas in the fuel mix of Leningrad could be raised to 80 - 90 percent during the present plan but this does not seem possible any more.

Because, relative to its population, Leningrad receives much less gas than Moscow, seasonal fluctuations are less severe in the former city than in the latter. If an interesting plan materializes, Leningrad would actually receive more gas during the warmer half than during the colder half of the year. This would be done in order to increase the flow over the North

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43 Yu. I. Bokserman, op. cit., p. 279, Table 107.
44 Geograficheskiye Problemy Razvitiya Krupnykh Ekonomicheskikh Rayonov SSSR, P. 141, footnote 2.
45 Severo-Zapad RSFSR, p. 171 and 177.
Caucasus - Moscow pipelines, which are greatly underutilized from May to October. Since the trunkline to Leningrad is not working at full capacity at any time of the year, it could easily transmit the extra amount.

It will not be easy, however, to increase greatly the amount of natural gas sent to Leningrad, and new deposits will have to be tapped by about 1970 in order to satisfy demands. Aside from the chief metropolis and its satellite towns, Novgorod and Cherepovets are the only sizable cities today in the entire region that are supplied by natural gas. Consumption outside Leningrad is certain to be under a billion cubic meters per year.

The share of various industries in the consumption of gas is not known, but certain characteristics of this breakdown are possible to discern. Machine building and metal working, which accounts for over half of all the industry in Leningrad Oblast' are probably the largest consumers. Electric stations, on the other hand, burn relatively little—a fact partly due to the high share of hydroelectricity in the region (over half of all electricity consumed in the Leningrad conurbation, for instance, is generated by hydroplants). As yet all large thermal stations seem to be running on coal, peat and shale the year around, and due to the general shortage of gas in every branch

47 Yu. I. Bokserman: op. cit., p. 277 (Table 106), 279 and Table 107.
49 Geograficheskiye Problemy Krupnykh Rayonov SSSR, p. 141.
50 Severo-Zapad RSFSR, p. 172.
of industry, it is doubtful that gas will be used — at least in the near future — on a large scale for power generation even in Leningrad.

The chemical industry of the region does not utilize natural gas as raw material nor — it seems — for power, though may use it for space-heating. Synthetic material production is still based entirely on coal and plant alcohol, and the future petrochemical industry will be linked with the big oil refinery under construction at Kirishi. Natural gas, reaching Leningrad over a distance of 2000 kilometers, is far too dry for the production of olefines, and the manufacturing of acetylene would not be economic in a region which is short of fuel and not rich in electric power. Gas could be used in the production of much needed nitric fertilizers, as it may soon be in the recently completed Novgorod chemical plant. However, experience has shown that ammonia, urea, etc. can be manufactured from shale at no greater cost than from natural gas. It is possible, therefore, that the use of gas in the manufacturing of nitric fertilizers will be limited in the region, especially since it is so short of fuel.

Ferrous metallurgy consumes natural gas at the large integrated iron and steel complex at Cherepovets. The mill is the most expensive producer in the whole of the USSR due to the remoteness and high cost of both ore (from the Kola Peninsula)
and coal (from the Pechora Basin). Because of the high cost of pig iron and the ready availability of scrap (from Leningrad as well as from the Center), open-hearth furnaces are economic, and their capacity will be substantially increased. Both iron smelting and steel making, therefore, benefits greatly from the utilization of natural gas. These benefits, however, are severely limited by the modest amount of gas available. The deposits of Saratov Oblast', which also serve Gorkiy (fifth largest city of the USSR) Ivanovo and Yaroslavl, are unable to spare much for the city of Cherepovets, and it is significant that the pipeline works far below full capacity.

THE BALTIC REPUBLICS AND BYELORUSSIA

Byelorussia, the three Baltic Republics and the adjoining Kaliningrad Oblast' of the RSFSR form the poorest economic region of the inhabited portion of the USSR. Somewhat larger than the Leningrad Region, but with 15 and a half million inhabitants - only 44 percent of them urban - this area lacks both the raw material and energy resources as well as the skilled population necessary for industrial development. In contrast to the Leningrad Region which can at least profit from having close to a quarter of the hydro-potentials of European Russia

53 Severo-Zapad RSFSR, p. 191.
55 Narodnoye Khozvaistvo SSSR v 1962 g, p. 10, 20, 33 and 34.
nearby (in Karelia, Murmansk Oblast', Arkhangelsk Oblast', etc.), the Baltic, Byelorussia, and the neighbouring areas are very deficient also in this resource.

Even though manufacturing capacity is limited and plans for industrial development emphasize labour-intensive industries, the chronic poverty in energy has been and continues to be a major problem. More than 60 percent of the fuel needs of both Latvia and Lithuania are supplied by fuels brought in from other regions, while in Estonia—which relies extensively on its shale resources—the figure is about 27 percent. Byelorussia has leaned extensively on its very substantial, though uneconomic, peat resources and on firewood. These two materials made up nearly 60 percent of the fuel mix as late as 1958. Almost 40 percent was supplied by Donets, L'vov and even by Moscow Basin coal. The Baltic and Byelorussia, therefore, represents a region where the substitution of hydrocarbon fuels for solid fuels (especially coal and peat) is very economic—all the more so since it is closer to gas, though not to oil, fields than the Leningrad area. From Dashava (Western Ukraine) to Minsk the distance is only 600 kilometers, while Vilnius and Riga are an additional 100 and 350 kilometers away. Distances from the

56 Geograficheskiye Problemy Krupnykh Rayonov SSSR, p.141.
57 Ibid., p. 162.
large Shebelinka field in the Eastern Ukraine are only slightly greater. Dashava gas is 1.5 to 2 times cheaper even than Volga fuel oil and several times cheaper than coal (see also page 200).

The region is supplied with natural gas today through a three-pronged pipeline from the Dashava deposits— one prong leading to Minsk, another to Riga through Vilnius, the third to Grodno on the Polish border. Aside from the Grodno branch line which is probably smaller, these are large diameter lines of 28 and 32 inches. Once all five compressor stations are completed, daily capacity on the Dashava-Minsk section will exceed 22 million cubic meters, or 5.6 billion cubic meters per year, assuming a 70 percent load-factor. By the end of 1965, the Baltic Republics and Byelorussia are to receive annually six billion cubic meters of gas from the West-Ukrainian fields. Lithuania will take approximately 1.8 billion, Latvia 1.2 billion and Byelorussia about 3 billion. If the plan is fulfilled, natural gas will account for some 30 percent of the fuel mix in both Latvia and Lithuania and for 24 percent in Byelorussia.

It is a proof of the lingering idea of regional autarky and of the "marginal" importance of the Baltic Republics that it is not planned to introduce natural gas to Estonia in the near future. The exploitation of oil-shale— which at present

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supplies close to three-fourths of all fuel consumed—will be intensified. As today, demand for gas in the Republic will continue to be satisfied from shale, even though shale gas is four to five times more expensive to produce than natural gas. It is planned to reduce gradually the export of shale gas to Leningrad and utilize the amount at home. Eventually, Estonia may receive natural gas from Leningrad through the existing pipeline for shale-gas—a course of action much doubted by the writer. However, the price of gas at present is fixed in such a way that even in that case gas would be much more expensive in Estonia than in the other Baltic Republics.

Compared to more crucial areas of the European USSR, the region is still very poorly supplied. Only 242,000 apartments received natural gas in 1963 or 1.2 million people if we assume five persons per living quarters. This is merely 8 percent of the region's population, far below the average for Soviet Europe (16 percent) or even for the whole of the USSR. More than two-thirds of the apartments which consume gas in the region receive their supply not through the Dashava-Baltic pipeline system but by rail from gas processing plants (liquefied propane

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62 Geograficheskiye Problemy Krupnykh Rayonov SSSR, p. 163.
63 Ibid., p. 163.
64 T. Brents: op. cit., Gazovoye Delo, No. 8, 1963, p. 46.
and butane). This indicates that the greater part of the area is not considered vital enough to justify the construction of branch pipelines.

In the production of electrical energy per capita the Baltic lags behind most regions of the USSR. All Republics generate less than the national average - Byelorussia less than one-third as much. Map 8 shows the distribution of power stations and the modest share of natural gas in the production of electricity. Only a few stations are running on gas and two of these are not yet fully completed. The one serving Minsk is a thermal electric center, providing not only electricity but also by-product heating (toplifikatsiya) for the city. The most important, however, is the very large station thirty miles west of Vilnius. Its first section, with a capacity of 1.2 million kilowatts, will start functioning in 1965. Its ultimate capacity, however, will be double that.

Natural gas is not going to play a major role in the chemical industry either. Its only contribution is in the production of fertilizers. A large plant producing ammonia and its derivatives now uses gas at Grodno, while another one is under construction in Lithuania. As in the Leningrad Region, however,

66 Ibid., (Gazovaya Promyshlennost'), p. 55.
67 Geograficheskiye Problemy Krupnykh Rayonov SSSR, p. 164 and 181.
70 Geograficheskiye Problemy, p. 168.
much of the planned production of nitric fertilizers is to be based on the hydrogen gases of oil shales, which are actually claimed to be simpler and more economic raw materials than natural gas. The latter will be used primarily as fuel.

THE URAL REGION

The Ural Economic Region rivals the Eastern Ukraine as major center of heavy industry. It accounts for a third of steel smelting and rolled steel output and up to 30 percent of heavy machine building. In addition, a large portion of the nonferrous metallurgical capacity of the USSR is concentrated within its boundaries. Despite its industrial pre-eminence and large area (the size of Spain), the region still contains only 14 million people. Two thirds of these, however, live in cities, which have grown very fast over the last quarter of a century. The Urals received the lion's share of people and industry transferred from European Russia during the war and maintained its momentum up to the present day.

This region accounts for about a sixth of all fuel consumed in the USSR, roughly the same share as its rival, the Donets-Dnieper. Unlike the latter, however, the Urals has been

71 Ibid., p. 167-69.
72 Geograficheskiye Problemy Krupnykh Rayonov SSSR, p. 294
THE URAL REGION

- Oil field
- Bituminous coal
- Lignite
- Hydroelectric station
- Thermal station
- Iron and steel plant
- Gas pipeline
- Gas pipeline (under construction)
- Oil pipeline

Scale: 1 cm. 60 km.
perpetually handicapped by fuel and power shortage and today probably imports more fuel than any other region of the USSR. Coal has been the mainstay of the Uralian economy, accounting for 80 percent of all fuel consumed in 1958. Forty-one million tons of that coal, however, comprising close to a half of the total by weight but two-thirds by calorific content, had to be brought in from the Kuzbass and from the Karaganda-Ekibastuz fields 1500 and 800 miles away. The burden of such "imports" by rail, and the high cost of the Ural lignites themselves, makes it imperative to raise the share of natural gas and fuel oil in the energy-balance of the region.

While the Ural is conveniently situated with respect to the major oil-producing region of the country, the Volga, it lies far away from the principal proved reserves of natural gas. The only deposits that can spare large amounts are in Middle Asia and in the Lower Ob Valley, 1400 and 900 miles from Sverdlovsk respectively. The first branch of the Bukhara-Ural 42-inch trunkline was completed in the autumn of 1963 and is currently being doubled. Another 42-inch line is under construction from the Berezovo (Lower Ob) area, where the recent discovery of the large Punga field guarantees adequate supplies.

By the end of 1965, the Urals were to use over 25 billion cubic meters of natural gas, accounting for over 30 percent of

fuel requirement. There appears to be some delay in this plan, however. The Middle Asian pipeline transported, at most, seven billion cubic meters in 1964, planned output for 1965 in Uzbekistan has been scaled down to 17 billion, and the Berezovo line is but half finished today. Yet there is no doubt that very large quantities of gas will soon reach the Urals. The twin lines from Bukhara are to transport 21 billion cubic meters, while the line from the Lower Ob could easily handle 10 billion. Besides these two areas, the Urals also receive gas from the Volga. Over some years now, two small lines, from Bashkiria and from Orenburg Oblast' have been supplying a few hundred thousand cubic meters to the metallurgical works of Magnitogorsk and Orsk, and are now connected to the trunkline from Central Asia.

As in the Eastern Ukraine, the major consumers of gas are, and will be, the metallurgical plants. Of the 21 billion cubic meters, for instance, to be sent north from Gazli, over 12 billion will be used by metallurgical plants, four and a half billion by power stations and roughly a billion by the domestic

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78 Yu. I. Bokserman: op. cit., p.136 and Table 54,p.143.
and municipal sector. 1.8 billion will be needed to run the compressor stations of the pipeline itself. Gas will have a virtual monopoly in furnaces (except, of course, in blast furnaces), while the highly sulfurous fuel oil and local lignite will be (and are) used almost exclusively under boilers. Save for coking coal, "imports" of coal will nearly come to an end and production from local basins will be reduced.

SUMMARY

The four regions treated in this chapter are characterized by varying degrees of poverty in fuel resources, and they all import large quantities of natural gas from distant producing areas. Since gas is a quality fuel, the delivery of which, in addition, requires massive capital outlay, the amount consumed in each region depends primarily on the relative importance of that region to the national economy. Thus both the Industrial Center and the Urals (even today and certainly in the future) consume much more than the Leningrad area, Byelorussia and the Baltic combined. The contribution gas makes to the fuel balance is also considerably higher in the former two regions than in the latter ones. While, thanks to this fuel,
the output of lignite and peat is being reduced in the Center and in the Urals, the output of shale and peat is increased in the less vital western areas.

Though the industrial sector predominates everywhere, the pattern of consumption varies greatly according to the characteristics of each individual region. Thus in the Center power stations account for a disproportionately high share, due largely to heavy interruptible sales during the season of low demand. In the Urals, some three-fifths of all gas is to be used in metallurgical works. Since these are very stable consumers, exhibiting a minimum of seasonal fluctuation, large summer sales to power plants are unnecessary. Similarly, Leningrad and the Baltic also have their own distinct consumption patterns.
Chapter VI

REGIONS WHICH PRODUCE AND CONSUME
THE GREATER UKRAINE

Second in population and third in area, the Ukrainian SSR plays a decisive role in the economy of the Soviet Union. The industry of the Republic, however, is almost wholly concentrated in five oblasts (out of a total of 25) in the eastern extremity of the Ukraine. Less than a quarter of its area, this Dnieper-Donets Region contains 35 percent of the population and over half of all urban dwellers of the Republic. The adjoining western portion of Rostov Oblast' in the RSFSR is logically part of the Dnieper-Donets Region, and is so treated here. The rest of the Ukraine - together with the small Moldavian SSR is very highly rural (63 percent), contains no industry aside from Kiev and two or three other cities, and consumes little energy. These two, very different, parts of the Greater Ukraine, therefore, are dealt with separately.

The Donets-Dnieper Region

Though relatively less important than before the war, the Donets-Dnieper area is still vital to the Soviet economy, especially in the sphere of heavy industry. Despite wartime devastation and slower growth, it still matches the much larger Ural Region in output of iron and steel, while in fuel production it is but slightly behind the Volga. With about 17 percent of the total, it is the largest fuel consumer in the USSR.

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Coal and natural gas are the two fuels produced in that industrial heartland of the Ukraine. Coal is by far the most important. Out of a total of 203 million tons of hard coal equivalent (7000 Cal per ton) produced in 1961, natural gas accounted for only $8\frac{1}{3}$ percent ($16.8$ million tons of coal equivalent or $13.9$ billion cubic meters). Yet this region is the second largest producer of natural gas in the Soviet Union (after the North Caucasus) and, moreover, all this production comes from one single field, Shebelinka. In addition to gas, the Shebelinka deposit also contains condensates, and although still only partially extracted, the amount produced is surpassed only by Krasnodar Kray.

On account of the predominance of heavy industry in the economy, the Donets-Dnieper region is an exceptionally heavy consumer of fuel. As with production, the share of gas is much below that of coal, and, moreover, this share has been increasing more slowly, than, for instance, in the Central Region. In 1960, the Donets-Dnieper region seems to have consumed between eleven and twelve billion cubic meters of natural gas, matching

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2 "Statisticheskiye Materialy," Vestnik Statistiki, No. 5, 1962, p. 91; 16 percent is given for the Donets-Dnieper region excluding the Rostov-Shakhty area.

the amount utilized in the Center. Recent literature, however, complains of the slow growth of gas supply to the industries of the Eastern Ukraine and it is unlikely that more than 15 billion cubic meters are used today, even though 9 billion were planned to be utilized in Donets and Lugansk Oblasts alone by the end of 1965. Because of proximity to the Donets coal basin— which, however, produces very expensive coal— the price of gas is fixed higher than warranted by the presence of the prolific Shebelinka field and the nearness of the North Caucasian deposits. While not significant as a deterrent to use in an economy where planned allocation is still the general rule, the decision illustrates the problems of planning organs, which both want to increase consumption and also conserve gas for regions without alternative solid fuels.

4 Calculations from data supplied by Vestnik Statistiki, No. 5, 1962, p. 91 and 87, give 13.8 billion cubic meters for the region without the Rostov-Shakhty area. Referativnyy Zhurnal, No. 5, 1962, E15, gives 18.5 billion cubic meters for the Ukrainian SSR, from which the three southern oblasts plus Zakarpatiya must be excluded since they were not yet receiving gas. Bokserman claims that 3.5 billion cubic meters were consumed by the non-domestic and municipal sectors of Donets and Lugansk oblasts and 2.3 billion by those of Kharkov sovarkhoz (essentially Kharkov Oblast) in 1962 (Yu. I. Bokserman: "Za dal'neishey uluchsheniy ispol'zovaniya prirodnogo gaza, "Gazovaya Promyshlennost', No. 3, 1963, p.1 and Puti Razvitiya Novoy Tekhniki ... p. 240.


One may note that the Donets-Dnieper Region is both an exporter and an importer of natural gas. Shebelinka as yet supplies only Kharkov Oblast', the Dnieper Bend and Odessa and exports part of its production to the Center and even to Lenigrad. The Rostov area, the Donets Basin and Zhdanov receive gas entirely from the North Caucasus, although a pipeline is planned from Shebelinka to Lisichansk. By the end of 1965, the Ukraine as a whole is supposed to take 8 and a half billion cubic meters from the North Caucasus, and most of that will go to Donets and Lugansk Oblasts.

As can be expected, ferrous metallurgy is by far the largest consumer in the region. Since 1958, when the blast furnaces of the region first began to utilize gas, they experienced an up to 20 percent reduction in coke consumption, as the following table indicates.

Blasting with gas in the mills of Donets and Lugansk Oblasts alone (accounting for half of the pig iron production of the Ukraine) led to a saving of 25 million rubles in 1960 and 1961. Since coke is sold at cost price while gas at more than double that of production plus transport cost, the real saving was over 50 million rubles.

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7 Atlas SSSR, p. 139; Geograficheskiye Problemy, p. 194 and Referativnyy Zhurnal, No. 1, 1963, E59K.
### Table XI

<table>
<thead>
<tr>
<th>Mills</th>
<th>Coke Consumption per 1 ton of pig iron (in kilograms)</th>
<th>Reduction in Coke Consumption (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without use of Gas (1958)</td>
<td>Using Gas (1960-61)</td>
</tr>
<tr>
<td>Makayevka (Kirov mill)</td>
<td>864</td>
<td>707</td>
</tr>
<tr>
<td>Yenakiyevo</td>
<td>840</td>
<td>713</td>
</tr>
<tr>
<td>Zhdanav (Azovstal')</td>
<td>831</td>
<td>682</td>
</tr>
<tr>
<td>Donetsk</td>
<td>1046</td>
<td>856</td>
</tr>
<tr>
<td>Zhdanov (Ilyich mill)</td>
<td>1042</td>
<td>756</td>
</tr>
<tr>
<td>Zaporozhstal'</td>
<td>671</td>
<td>658 *</td>
</tr>
<tr>
<td>Dniepropodzerzhinsk</td>
<td>771.5</td>
<td>687 *</td>
</tr>
<tr>
<td>Lugansk</td>
<td>830</td>
<td>722 *</td>
</tr>
<tr>
<td>Dniepropetrovsk</td>
<td>818</td>
<td>743 *</td>
</tr>
</tbody>
</table>

* Indicates that data refer to 1960.


The steel mills of the Ukraine pioneered also in the utilization of natural gas in open-hearth furnaces. Since Volga oils are highly sulfurous and the sulfur is not removed during the refining process, the use of fuel oil from Volga crudes in these furnaces is not advantageous. High quality fuel oil (from Baku and Groznyy) is expensive and the metallurgical works of the Donbass are attempting to eliminate its use entirely.

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The open-hearth furnaces of the Ukraine have been operating mainly on a mixture of coke-oven and blast-furnace gases, which—though freely available—have low heat value. Considerable attention is, therefore, devoted to the more intensive utilization of natural gas. In 1960, out of the ten mills of the Eastern Ukraine, eight used some natural gas in their open-hearths, though only at Makayevka and Zaporozhe did its share exceed 40% of the total fuel-mix of these furnaces. The use of natural gas is increasing since by-product gases are more economically utilized in the chemical industry, especially in the production of fertilizers.

The Donets-Dnieper region produces close to four-fifths of all thermal electricity in the Ukraine. Though most stations run on coal—especially coal dust which no other consumer can utilize economically—natural gas nevertheless accounts for about a fifth of all fuel used by power plants. As can be expected, the share of gas is smallest in the stations of Donets and Lugansk Oblasts (less than 9%), but is higher in those of Zaporozhe and Dniepropetrovsk Oblasts and very high in those of Khar'kov Oblast. A relative decrease in the use of that quality fuel by power plants, however, seems likely, and the projected use of Dnieper brown coal in new thermal plants will

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10 Ibid., p. 94, Table 2 and p. 95-100.
further strengthen the preponderant position of coal in this sector. As light and consumer oriented industries are still poorly developed in the region, they do not consume much gas either.

In the still small-size chemical industry, East Ukrainian gas could play a major role, not only as fuel but also as raw material. The Shebelinka deposit is one of the major sources of condensates in the USSR, even though they are present in lower concentration than, for instance, in the fields of Krasnodar Kray. In addition, the gas contains a great deal of ethane and some propane, to pentane fractions as well (see Table V, Chapter II, p. 40). A very large chemical combine is now under construction at Shebelinka, which will utilize condensates and gas for the production of organic petrochemical products, as well as of nitric fertilizers. The fuel also will undoubtedly be gas. Two large plants in the region, at Lisichansk (Donets Basin) and at Novocherkassk (near Rostov) use Stavropol' gas for the manufacture of ammonia and its derivatives. Since this gas is very dry, it is not suitable for the making of olefins, but at least one of the plants (Novocherkassk) combines ammonia production with the manufac-

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13 Ibid., p. 203 and Voprosy Ratsional'nogo Ispol'zovaniya Toplivno-energeticheskikh Resursov, p. 33-34 (for Zaporozhe Oblast')
turing of acetylene and uses the latter as organic intermediate.

Nevertheless, an expansion of organic petrochemical capacity is more economically based on the condensates and gas of Shebelinka and LPG brought in from nearby Krasnodar Kray. Unfortunately, less than half of the condensates produced today from the wells of Shebelinka are separated from the gas (8.6 million tons in 1962), the rest is allowed to enter the trunk-lines, where they increase the friction, reduce the pressure and thus impair the efficiency of networks. Nor is the gas processed in order to strip off the lighter fractions (ethane to pentane), which are thus burned as fuels. A more rational utilization of the resources of Shebelinka is undoubtedly necessary if the Ukraine is to develop a sizable organic petrochemical industry - all the more so since the petroleum refining capacity of the Republic is extremely limited.

The Rest of the Ukraine and the Moldavian SSR

Very little information is available about the consumption of natural gas in the rest of the Ukraine. The Pre-Carpathian region of the Republic contains the old, but still important Dashava deposits, which produced 6 billion cubic meters in

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17 See two chapters, dealing with the use of Shebelinka condensates in the chemical industry, in Voprosy Ratsional'nogo Ispol'zovaniya Toplivno-energicheskikh Resursov, p.164-178.
1961. Probably less than half of this output is consumed in the Ukraine, since the Dashava fields are the only suppliers of the fuel-hungry Baltic and Byelorussia and even send gas to Moscow. Only two large cities in the Ukrainian SSR receive gas from these fields: Kiev and L'vov. The Dashava-Kiev pipeline pumped 3 billion cubic meters of gas in 1962 (2.6 billion in 1961), but a large portion of that—perhaps close to a half—continued on to Moscow. In 1959, domestic consumers in Kiev received less than 100 million cubic meters, which would indicate that total consumption by the city was below one billion. L'vov being only a third of the size of Kiev, used much less than that. The large cities of the Southern Ukraine, such as Kherson, Nikolayev and Odessa, as well as Kishinev in Moldavia, are now reached by a pipeline from Shebelinka, while another line from the Kuban to the Crimean Peninsula is projected across the Strait of Kerch.

It is doubtful that the Dashava fields could increase much the supply of gas to the Ukrainian cities. These deposits are relatively small, and, since the region is by now well prospected, further discoveries are unlikely. By 1966, they

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are called upon to deliver 6 billion cubic meters per year to Byelorussia and the Baltic, and these regions, therefore, will surely claim most of the increase in production. Many of the smaller cities in the Western Ukraine, however, receive propane and butane from gas-processing plants. 340 thousand apartments in the Republic as a whole were served with LPG in 1962, most of them west of the Dnieper.

The Western Ukraine produced 1258.7 million cubic meters of gas from oil wells in 1963. This amount will increase but slowly since the region produces only a small amount of petroleum, and 70 percent of the gases released with oil is now utilized. All of this, apparently, is consumed locally, but almost exclusively as fuel. The Western Ukraine has but one gas-processing plant of small capacity at Borislav. The bottled gas, delivered to households in the Republic, therefore, must come from other regions, probably the North Caucasus. As Table V (Chapter II, p. 40) shows, the oil-well gases of the Ukraine are rich in the ethane to pentane fractions: their use without processing is economically irrational.

In the Western Ukraine, thermal stations use much more gas than in the Donets-Dnieper Region, although the total amount of electricity generated is only about a seventh of the total.

23 Pravda, April 27, 1964, p. 2.
(The Western and Southern Ukraine combined produce but a fifth of all electricity in the Republic) In 1961 gas accounted for about two-thirds of the fuel used by power plants in the South West Economic Region which burned close to 3 million tons of nominal fuel equivalent. The three largest stations running on gas are the L'vov and Dobrotvor regional plants and the Kiev TETs. Another middle-sized one is nearing completion at Kuchurgan in Moldavia. The Western Ukraine contains a small but conveniently located coal basin near L'vov. There are authoritative voices urging the much greater use of this coal for the generation of electricity in order to free natural gas for other uses. In particular, the region is in great need of nitric fertilizers and gas could be utilized in their production.

THE VOLGA REGION

The economic region of the Volga extends from Volgograd northward along the great river and includes the lower Kama and Byelaya valleys as well. For the present analysis, the Mari and Chuvash ASSR's will also be treated as part of the region. This area, the size of France, contains roughly 18

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24 Voprosy Ratsional'nogo Ispol'zovaniya Toplivno-energeticheskikh Resursov, p. 16-19.
million people, with a rate of growth nearly twice the national average since 1939. Though its Industrial Revolution came later than that of the Urals and Kuznets Basin, it was just as spectacular. Between 1940 and 1956, industrial output in its central oblasts and ASSR’s increased faster than in any other part of the Soviet Union save for Novosibirsk Oblast’. Today the Volga contributes close to one-eighth of the manufacturing. The most dramatic increase took place in the production of energy: presently with as much as one-third of the total, the region is the largest fuel producer in the USSR, exceeding even the Donets-Pridnieper area or, indeed, the whole of the Ukraine. In contrast, it contributed only 8 percent even as late as 1955.

Natural gas represents less than a twentieth of the region’s fuel production, but it is of great importance both locally and on the national scale. Roughly a third of all gases produced are from oil wells (perhaps five billion cubic meters

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27 D. J. Hooson: op. cit., p. 69.
29 D.J. Hooson, op. cit., p. 68. (Hooson includes Perm Oblast’ and parts of Kirov Oblast’, too, in his region. However, since he excludes Volgograd Oblast’, the share—close to one-eighth—should be about correct for the present analysis.)
30 Yu. I. Bokserman: op. cit., p. 29, Table 19 and p. 7, Table 5; Promyshlennost’ SSSR, 1963, p. 194-95, 206-97, 214-15. The following conversion factors were used: 1 ton of hard coal=1 ton of nominal fuel; 1 ton of oil=1.43 ton of nominal fuel; 1000 cu.m. of free gas=1.21 ton of nominal fuel; 1000 cu.m. of oil-well gas=1.3 ton of nominal fuel.
31 D. B. Shimkin: op. cit., p. 31, Table 5.
32 See footnote 30.
in 1962-63), even though only 60 percent of these gases-- released in the course of petroleum production-- is utilized. In view of the emphasis given to the petrochemical industry, the importance of this resource cannot be overestimated.

In contrast to its high share of fuel production, the Volga is still a modest consumer of fuel, taking but 6.1 percent of the total in 1960. Most of the petroleum and perhaps a third of all natural gas produced leave the region to enter into the energy-mix of other areas. Though the greatest storehouse of hydrocarbon fuels in the USSR, the Volga still has to depend on imported coal for much of its energy need. Coal accounted for over 45 percent of the fuel-mix as late as 1958, while the share of oil and gas stood at 24 percent. By the end of 1965 oil and gas are to contribute 33 and 40 percent respectively but coal will still remain important, supplying over a fifth of all fuel consumed.

It is interesting to observe that at the former date


34 "Statisticheskiye Materialy," Vestnik Statistiki, No. 5, 1962, p. 91. This figure should be slightly higher since the official boundaries of the Volga Economic Region in 1960 were somewhat different from those used in the present analysis.


36 Ibid., (Geograficheskiye Problemy), p. 219.
natural gas was on par with oil in the fuel mix of the Volga and today probably exceeds it by a slight margin despite the fact that it represents but a twentieth of the region's hydrocarbon output. Oil being the more versatile and valuable product, is indispensable in every region, even in energy-saturated Central Siberia. It is also much cheaper to transport over long distances than gas. Finally, the shortage of gas-processing factories as yet prevents the large-scale processing of oil-well gases which, therefore, are mostly consumed locally and as fuel. At present, gas by pipeline is supplied to other regions from Saratov and Volgograd Oblasts and--to a very limited extent--from Orenburg Oblast' and Bashkiria, since only here are free gases produced in sufficient quantity to justify the construction of trunklines. A modest amount of LPG is sent to other regions by rail from the few gas-processing plants of the Middle Volga.

The Volga Region today produces a fifth of the country's natural gas, a share which is soon to be significantly reduced. The present production rate however, is severely taxing the resources of the area, and save for the Azerbaidzhan deposits, the Volga fields have the highest depletion rate in the USSR. Only Volgograd Oblast' is in a better position due to relatively large resources and low rate of production to date. A pipeline is already complete, however, to send Volgograd gas through

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37 Yu. I. Bokserman: op. cit., p. 29, Table 19.
the Saratov-Gor'kiy trunkline, which Saratov Oblast' is unable to supply to full capacity. The result of intensive exploration carried on through the past few years have been disappointing and the Soviet press recommends a switch to other areas. The Volga, therefore, could soon become an importer of natural gas especially if the present industrial build-up is accelerated—a step strongly urged. The tapping of the potentialities of the conveniently located Caspian Lowland is a course most frequently advised. However, it involves serious difficulties—mentioned on page 64—which could postpone the realization of this plan for decades.

Breakdown on the utilization of natural gas in the economy of the Volga Region as a whole is not available, but the data given for Saratov Oblast' is illuminating. The very high share of the building material industry (bricks, cement, glass)—much higher than the national average—attests the rapid development of the region and also points to the general lack of coal. The almost fourfold increase planned for consumption by the

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Table XII

Consumption of Natural Gas by Sectors of Economy in Saratov Oblast (in percent of total)

<table>
<thead>
<tr>
<th>Sector</th>
<th>1961</th>
<th>1965 (plan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal and domestic</td>
<td>8.4</td>
<td>10.6</td>
</tr>
<tr>
<td>Chemical industry</td>
<td>3.7</td>
<td>14.0</td>
</tr>
<tr>
<td>Building material industry</td>
<td>23.5</td>
<td>18.3</td>
</tr>
<tr>
<td>Machine building</td>
<td>8.5</td>
<td>9.0</td>
</tr>
<tr>
<td>Oil and gas industries</td>
<td>10.8</td>
<td>4.1</td>
</tr>
<tr>
<td>Other industries</td>
<td>18.8</td>
<td>2.3</td>
</tr>
<tr>
<td>Electric stations</td>
<td>26.3</td>
<td>41.7</td>
</tr>
</tbody>
</table>


Chemical industry shows the future importance of the Volga as the major supplier of petrochemical products in the USSR but also shows the embryonic nature of that industry to date. Gas consumption by electric stations, however, is certain to be higher in Saratov (and Volgograd) Oblast than in the northern part of the region and the difference is bound to increase sharply. First, since the crudes of the southern part of the Volga Region contain very little sulfur, they are used for high-octane motor fuels and for lubricants and not under boilers. Natural gas is, therefore, the principal fuel used by power stations, with coal making up most of the difference. Further north, however, in Kuybyshev Oblast', the Tatar and Bashkir ASSR's, fuel oil from the highly sulfurous crudes is extensively
employed for the generating of electricity, especially since the facilities for the removal of sulfur are still not adequate and the process is costly. At the same time, most gases here are from oil-wells and will be used more and more in the LPG and petrochemical industries rather than for common fuel.

Due to failure to increase reserves and due to unsatisfactory exploitation of oil-well gases, a shortage of gas in the Volga is already apparent, especially in Kuybyshev Oblast and the two ASSR's mentioned above. There were stoppages of gas to domestic and municipal consumers at times of peak demand in 1963, and a general shortage to the same sector was foreseen for 1964. Power stations would also need more gas, and in general, the relatively meager supply of that fuel is the chief cause behind the continued imports of coal.

Despite difficulties, discussed later, the Volga Region exhibits in the whole of the USSR the most favourable conditions for the creation of a large petrochemical complex, especially for the manufacturing of organic chemicals. The region has an abundance of all three alternate raw materials for the production of olefins: wet natural gas, refinery gases and liquid hydrocarbons. It accounts for nearly two-thirds of all output of oil-well gases and boasts perhaps 40 percent of Soviet petro-

\[41\]
Geograficheskiye Problemy Krupnykh Ekonomicheskikh Rayonov, p. 220.

\[42\]
leum refining capacity. It also has an unrivaled advantage for the production of sulfuric acid - mainly from oil, but also from natural gas.

As shown above, natural gas in the Volga does not have a monopoly as a petrochemical raw material. Its competitive position, however, is very favorable. Of all regions of the country, it is here that wet gases are produced in the largest quantities, and they are very rich in the ethane to pentane fractions (see Table V, Chapter II, p. 40). Their liquefied propane-butane fractions have considerable economic advantages for the manufacturing of olefins over both petroleum feedstocks and refinery gases, as the following table indicates.

Table XIII
Cost of Ethylene in the Volga Region From Three Different Sources (in percent)

<table>
<thead>
<tr>
<th></th>
<th>Liquefied oil well gases</th>
<th>Liquid petroleum Products</th>
<th>Refinery Gases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of ethylene</td>
<td>100</td>
<td>120</td>
<td>154</td>
</tr>
<tr>
<td>Capital investment</td>
<td>100</td>
<td>125</td>
<td>175</td>
</tr>
</tbody>
</table>


Despite such favorable indices, the utilization of oil-well gases as petrochemical raw material is proceeding slowly. At the beginning of 1964, the whole of the Volga Region had but seven gas processing plants. Two of these went on stream only in 1963. Some plants still do not work at full capacity, and one (at Saratov) operates so inefficiently that its costs are six to twelve times as high as those of the other factories. The two plants most frequently mentioned (Tuymazy and Minni-bayevo)—and thus presumably the largest ones—have capacities of about 200 thousand tons of LPG per year.

Because of the slow construction of gas-processing works the greater portion of oil-well gases produced in the Middle Volga (63 percent in 1962) are still used without processing. (And, as mentioned, the utilized amount itself is only a fraction (58 percent) of the total quantity released from the reservoirs.) At the same time, the synthetic industry of the region—small though it is at present—finds itself short of petrochemical intermediates and has to depend largely on grain and wood alcohol, glycerine, animal fat and coal-derived raw materials. Only some 15 percent of the organic chemical industry around Kuybyshev, for instance, is based on oil and gas, and


much of the hydrocarbon feedstocks used in the Middle Volga—nearly a third in 1961—are actually imported into the region. The modest petrochemical industry is linked more to oil refineries than to gas processing plants, but even in this case it uses the uneconomic dry gases of refineries while the much more valuable LRG's (liquid refinery gases) are burned as fuel.

Neither is the extraction and utilization of sulfur proceeding satisfactorily. Although sour gases in the USSR are not common, many of those of the Volga area are sulfurous, the oil-well gases of Kuybyshev Oblast very highly so (see Table V, Chapter II, p. 40). Because Volga oils also have very high sulfur content, the region is in an ideal position for the manufacturing of sulfur, sulfuric acid and of fertilizers which need this acid. Despite this fact, no sulfur is yet extracted from gas and but little from oil according to available evidence. The gas processing plants of the Volga seem to process only sweet gases. No such plant exists yet in Kuybyshev Oblast, where gases, especially those from oil wells, are very sour, and the first factory to process sulfur from oil was to go on stream only in 1964-65. Meanwhile, sulfuric acid for the Volga chemical factories is brought in from the Urals and the Moscow Region at great cost from plants which utilize mineral sulfur.

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and pyrite and operate at considerable deficits.

A massive petrochemical industry along the Volga will require great amounts of both electricity and steam. Favouring multi-purpose projects, Russian planners feel that large thermal electric centers (TETs's) used with excellent results for space heating in many large cities of the country, would provide both steam and electricity in the most economic manner. (Although at present the Volga is the third largest producer of electricity in the USSR, most of this is generated by hydro stations.) Due to the merely moderate resources of natural gas, however, the substantial increase in fuel consumption—resulting from the construction of new TETs's—would have to be met by the more expensive fuel oil, which however, is needed throughout the country. The production of ammonia and urea, of which the region consumes a twelfth to a tenth of the nation's total, would also have to start soon, since these fertilizers are very expensive to transport. This, too, will increase the strain on the gas resources of the Volga.

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Despite occasional gestures to the contrary, the non-Slavic republics of the Transcaucasus have remained largely outside the mainstream of Soviet economic life. The only exception is Baku, where the oil-extracting and refining industries have continued to be important. Outside Baku, however, little industrial development has taken place, and the most notable one, the construction of the iron and steel work at Rustavi, proved to be an economic failure.

It is not surprising, therefore, that notwithstanding the relatively large population (10½ million), half of which is urban, fuel consumption in the Transcaucasus is very limited, amounting to less than 3 percent of the country's total in 1960. In spite of the presence of rich hydrocarbon resources, fuel oil and natural gas have satisfied only a part of this limited fuel need - a little over two-thirds in 1958 and some four-fifths in 1960. While negligible in Azerbaydzhan, expensive coal—mainly from Georgia, but also from the Donets—has played an important role in the fuel mix of the other two republics. Neither is the use of fuel oil as advantageous as

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53 D.I. Maslakov: op. cit., p. 159 and Vestnik, Statistiki, No. 5, 1962, p. 87. There is considerable discrepancy, too large for a two-year interval, regarding the share of coal in the fuel mix of the Transcaucasus. In all probability, it is caused by different allocation of fuel consumption among the three republics.
it seems at first glance, since much of it is "imported" over long distances from the Volga. The high quality Baku crudes are more needed for the manufacturing of benzine, ligroin and high-octane gasoline, and what fuel oil is produced is generally sent to the Urals, the Ukraine and Leningrad.

Under these circumstances, a sharp increase in the consumption of natural gas is planned in all three republics in order to reduce the share of coal and "imported" fuel oil in the energy-mix. The increase is most marked in Georgia and Armenia, which have no resources of natural gas and have to bring it in from Azerbaydzhan and the North Caucasus. In 1963, Armenia received 800 million cubic meters of gas, which was to be raised (LPG supplies included) to 2½ billion by the end of 1965. The plan for Georgia is probably less, since the Republic will continue to exploit its coal deposits. Part of that gas will have to come from the North Caucasus, since the capacity of the Karadag-Tbilisi-Yerevan pipeline--which has only one compressor station at its point of origin--is today limited to 1.8 billion cubic meters. The share of gas in the fuel mix of Azerbaydzhan exceeded 80 percent in 1960, while three years

54 Geograficheskiye Problemy Krupnykh Rayonov SSSR, p. 272, footnote 2.
later it reached 35 percent in Armenia. According to plan, natural gas is to supply 60 percent of all fuel consumed in the Transcaucasus by the end of the present year.

Such intensive utilization, however, is out of proportion to the reserves of the region which are very moderate in size. At the present rate of production, the reserves of the Transcaucasus will be exhausted within 8 years. It is significant that output from gas wells actually declined between 1961 and 1964, and only by a substantial increase in the production of oil-well gases was the loss compensated. Unlike the Volga region, Azerbaydzhan today utilizes over four-fifths of its oil well gases: thus any further increase in their production is tied to an increase of petroleum output, which, however, is relatively stationary, owing to long exploitation.

Despite the marginal nature of the region, gas "import" to the Transcaucasus is now necessary. The difficult pipeline built in 1963 across the Great Caucasus (Ordzhonikidze-Tbilisi)

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58 Ibid., p. 272.
60 Ibid., p. 5, Table 2 and Promyshlennost' SSSR, 1963, p. 217.
is capable of transporting 1.6 billion cubic meters at present, and this amount can be raised to two billion later on. In the more distant future, the "import" of gas across the Caspian from Central Asia is a possibility. Some, still vague, studies have been made to that effect, but the technical and economic problems are many.

An important feature of gas-consumption in the Transcaucasus is that notwithstanding its relative scarcity, gas is extensively used in power stations. As mentioned, oil is both too expensive and of high quality to be burnt as boiler fuel, and coal reserves are also inadequate. Thermal electricity, generated by natural gas is especially important in Azerbaydzhan where hydroplants produce less than 30 percent of electric power. A number of new thermal plants that use mainly gas are now completed or under construction, not only in Azerbaydzhan, but also in the other republics which rely on water power. (e.g. Ali-Bayramlinsk-- capacity 300,000 kw, Yerevan TET's-- capacity 550,000 kw, Razdansk TETs-- capacity 100,000 kw, Kirovakan, Rustavi and Leninakan) As yet electrical out-

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put per capita in the Transcaucasus is well below the national average, and because of the very rapid population growth the extension of generating capacity is necessary. The increasing use of gas in electric stations, therefore, seems inevitable even with the continued effort to harness the large hydro-potentials of the region. (This may be obviated however, by transmission of electricity from Central Asia.)

Conditions for the developing petrochemical industry may be compared to those of the Mid-Volga region. All three principal raw materials—oil-well gases, refinery gases and liquid refinery products—are present in relative abundance, to which the condensates of Karadag should also be added. As in the Middle Volga—but to a far greater extent—the strain on gas reserves may create fuel problems for the industry. The use of fuel oil for the production of steam and electricity is far less economic in Azerbaydzhan, since Baku crudes are five times as expensive as crudes from Kuybyshev Oblasts.

As petrochemical raw materials, oil-well gases in Azerbaydzhan probably do not have the same advantage over liquid refinery products as in the Volga (see Table XIII, p. 146).

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67 Narodnoye Khozyaistvo SSSR v 1962 g., p. 9.
69 Geograficheskiye Problemy, p. 270, footnote 5.
The reason for this assumption lies in the fine quality of Baku crudes and in the cost and composition of oil well gases. Despite the high extraction cost, most refinery products—including the light benzine fractions, which are the chief petroleum-based feedstocks of the chemical industry—are considerably cheaper to manufacture from Baku oils than from those of the Volga. At the same time, the oil-well gases of Azerbaydzhan must be much more expensive than those of the Mid-Volga, since their cost depends directly on the extraction cost of crude petroleum. Finally, they are much less rich in propane and butane than the gases of the other region (see Table V, Chapter II, p. 40). It appears, therefore, that the use of liquid refinery products in Azerbaydzhan is at least as economic as the use of wet natural gas, and the greater portion of the emerging petrochemical industry seems to be oriented to the huge refinery complex of the Apsheron Peninsula, still the largest of the USSR. The use of both raw materials, however, will be ultimately handicapped by the relative shortage of fuel—natural gas—and by scarcity of water.
SUMMARY

The three regions in this chapter differ significantly from those of the previous one. First, they all are producers of natural gas and second, they are all affluent in other sources of fuel, although only in the Volga can the rival fuel be called reasonably cheap. Only in the first two regions are reserves large enough to allow "exports" to other areas and such exports from the Volga are relatively modest. The deposits of the Transcaucasia are small and barely enable the region to supply its own needs even at the risk of early depletion.

In the Volga and the Transcaucasia, the two principal oil producing areas of the USSR, natural gas takes a much greater share in the energy supply than its reserves would warrant. Being the less versatile of the two hydrocarbon fuels, and the one more expensive to transport, gas is called upon to free petroleum products for use in other regions and for supraregional consumption. (Roughly half of all petroleum is used by transport, agriculture and the military). This is especially true of the Transcaucasia, where-- owing to the fine quality of the crudes-- relatively little fuel oil is produced by the refineries, and what is produced is sent out of the region.

The relative abundance of wet natural gas in both these areas makes them attractive to the still embryonic but developing petrochemical industry. However, fuel (and water) shortage will probably limit expansion in the Baku area, while in the Volga Region a greater reliance on fuel oil (more expensive
than natural gas) for thermal energy may become necessary.

Despite the far greater resources of natural gas in the Greater Ukraine, this fuel contributes much less to the regional energy balance--both in the eastern and western parts of the region--than in the Volga and the Transcaucasus. The Eastern Ukraine is the largest coal producer in the country and a citadel of ferrous metallurgy. Coal here is king and will likely remain so. The largely rural Western Ukraine which also contains a small but important coal-basin, "exports" the greater part of its gas output to still poorer areas.
Chapter VII

PRODUCING REGIONS
The economic region of the North Caucasus includes the lands between the Lower Don and the crest of the Great Caucasus mountain chain. The industrial complex of the Don mouth and of the Russian portion of the Donets Basin - though officially part of the region, have been excluded here, since they are intimately tied to the Eastern Ukraine and have similar economies.

The North Caucasus is still predominantly rural and agricultural: only some 40 percent of its ten and a half million people live in cities, and it has much fewer industrial workers per total population than the national average. The population resource is very much underutilized. Industry is entirely lacking in many of the smaller cities and is insufficiently developed or imbalanced in the larger ones. Almost as a symbol to such an imbalance one may cite an oversized petroleum refinery industry - too large both for the local oil fields and for the region's capacity to consume and work up its products.

1 Promyshlennost' SSSR, 1957, p. 23-4 and Narodnoye Khozyaystvo RSFSR, 1957, p. 11-47. Quoted from Cole and German, op. cit., p. 238-39. Data refers to 1955. However, Narodnoye Khozyaystvo RSFSR 1962, p. 54-59, indicates that industrial growth in the North Caucasus has been rather slow over the last decade, and thus the number of industrial workers per total population in 1962 could not have been much different.

2 Geograficheskiye Problemy, p. 263.

This somewhat lopsided and insufficiently developed region is an old, but now relatively unimportant, producer of petroleum, with small and hardly increasing output. However, it was dramatically rejuvenated in the early fifties by the sudden discovery of very large quantities of natural gas. It is now the greatest storehouse of gas in the European USSR, whose reserves in the A B (i.e. "proved recoverable"), though not in less tangible, category still exceeds those of Central Asia. In 1963, the North Caucasus produced 26.4 billion cubic meters from gas wells - nearly 30 percent of the country's total - and perhaps an additional 900 million cubic meters from oil wells. Together with its crude oil output (around 8 million tons) the region accounts for over 5 percent of the total fuel production of the USSR.

Only about a fifth of the gas produced is consumed within the North Caucasus, the rest is sent out through Rostov and the

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5 Estimated by assuming the same gas-oil ratio as in Azerbaydzhan, where oil fields are in similar depth and have been exploited for about the same length of time. For data on oil production in the North Caucasus see Footnote 6.
6 D.B. Shimkin: op. cit., p. 90, Table XIV. Latest data available is for 1956, given as approximately 6.7 million tons. Latest precise figure is for 1955 - 6,452,000 tons. Production in 1963 is unlikely to have been much over 8 million tons, judging from the rate of growth since 1937.
7 The conversion rates are explained in footnote 30, p.140, Chapter VI. Total fuel production in 1963: Promyshlennost' SSSR, 1963, p. 191.
8 A.L. Kozlov et al: "Ekonomicheskiy analiz razrabotki Severo-Stavropol'skogo mestorozhdeniya," Gazovaya Promyshlennost', No. 11, 1963, p. 5 and Neftyanye Khozyaistva, Feb. 1962, p. Above sources give amount of gas transported from the North Caucasus. Latter source for Krasnodar Kray gives only daily "export". From the amount remaining, the quantity estimated to go to the Lower Don area was subtracted.
Donets Basin to the Central Region and Leningrad. An unknown but small portion is carried over the Caucasus Range to Georgia and Armenia. The North Caucasus, therefore, is a gas exporting region par excellence. As such, it differs from the other chief producers of European Russia, the Ukraine and the Volga, which consume the major part of their output.

At least until now, the cost of production in Stavropol' Kray was the lowest in the USSR - being 5 rubles or 2.5 times lower per 1000 cubic meters than the average for the USSR. (For more detail, see page 197). This advantage, however, seems to be coming to an end due to the rapid diminishing of pressure in the large North-Stavropol' field, which accounts for practically all the output of the Kray. Always fairly low, due to the large extent of the field, the pressure will drop to a mere 12 atmospheres-- less than a fifth of the original-- by the end of the decade. Already, the gas must be pumped out of the deposit, requiring the setting up of a large number of compressors at the wells. It is certain to add appreciably to the cost of production. By the beginning of 1963, over 41 billion cubic meters were taken out of the field amounting to 18 percent of the original reserve. Output in that year reached 13 billion. Such rate, it is supposed can be maintained for another 8 to 10 years.

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Ibid., p. 8-9.

Ibid., p. 6.
The deposits of Krasnodar Kray on the western part of the North Caucasus are the largest producers of condensates in the USSR. Though still only partly removed from the gas, output increased nearly tenfold between 1958 and 1961, from a mere 15,000 to 138,700 tons. The plan calls for 720,000 tons by 1965.

Krasnodar Kray can boast a wide variety of petrochemical raw materials. In addition to the increasing volume of condensates—composed of aromatic and naphtenic hydrocarbons up to 50-60 percent—it's gases are fairly rich in the ethane to penthane fractions (see Table V, p. 40). Besides gas-derived feedstocks, however, refinery products are also available in large quantities, since the North Caucasus contains a large share of the refining capacity of the country. Yet the region's proximity to Rostov and the Donbass does not bode well for the North Caucasus as a future center of organic synthesis. Up to four-fifths of the production of gas in Krasnodar Kray, for instance, is accounted for by the Northern border region of the Kray, within 150 kilometers from Rostov. The cost of transporting natural gas and LPG is more than offset by the market advantages of the Lower Don-Donbass area, which, in addition,

already has a small-size chemical industry based on coal. When Soviet planners talk about developing an organic petrochemical industry in the North Caucasus, it is the Lower Don and Russian Donbass to which they generally refer.

The present organic capacity of the region is linked more with the refineries, especially with the one at Groznyy where a very large chemical plant has been recently completed. In all probability, however, the plant burns natural gas to supply its fuel and energy needs. Without fail, gas will be used on a large scale for the manufacturing of ammonia and its derivatives since the North Caucasus consumes perhaps a twelfth of all nitric fertilizers in the USSR. Ammonia production is to be based on the partial combustion method, which also yields an appreciable amount of acetylene. Then, via acetylene, gas will be used also as organic feedstock. This combination is most likely to apply to Stavropol'Kray, where gases are exceedingly dry. It is here, too, that the construction of a carbon black plant has started, although the production of that chemical from natural gas is a rather wasteful process. It must be mentioned that these plans for petrochemical developments may be curtailed by the water problem. The rivers of the North Caucasus

17 Geograficheskiye Problemy, p. 243.
are very greatly mineralized, containing an exceedingly high concentration of calcium and magnesium. While this is no disadvantage when used for cooling purposes, the high mineral content makes these waters unsuitable for use in chemical processing (e.g. hydration) without previous treatment. The cost of purification, however, may prove too great.

Aside from the above mentioned chemical industries, natural gas is unlikely to attract manufacturing to the area because of proximity to the industrialized Eastern Ukraine. Agriculture contributes over a third of all production in the region and much of the manufacturing consists of food processing and agricultural machine building. Here natural gas as fuel already seems to play an important role, though total consumption by these industries is not large. Probably more important as a consumer is the huge oil-refining industry of the region, concentrated at Groznyy and Krasnodar. A pipeline connects Groznyy with the large deposit of North-Stavropol¹, but-- in addition to dry gas-- both refinery complexes have oil-well gases available to them from near-by oil-fields.

18 A. A. Sokolov: Gidrografiya SSSR, Gidrometeoizdat, Leningrad, 1964, p. 174-75.
Central Asia was the last major addition to the Russian Empire and, even more than the Transcaucasus, has remained outside the mainstream of economic life. Its ties with the Slavic core land of Russia has been essentially colonial down to the present day. A few staple crops, marketed in European Russia, has formed the mainstay of the economy, and though the region can now boast a range of consumer industries, nearly all capital goods must still be supplied from more developed areas. Combined profits from the industries of the Uzbek, Kirgiz, Tadzhik and Turkmen SSR's represented in 1962 less than three percent of the total industrial revenue of the USSR.

Central Asia here includes the four Mid-Asian Republics plus that portion of Kazakhstan which lies south of the desert belt. This region contains 20 million people, of which only seven and one-half million live in cities. Despite the large population (nine percent that of the country), Central Asia accounts for a mere 3.2 percent of the fuel consumption of the USSR. It is far behind the rest of Russia in the production

21 Narodnoye Khozyaistvo SSSR v 1962 g., p. 23-24. Of the Kazakh SSR, only Alma Ata Oblast and the Southern Kazakh Kray was included, since the rest of Kazakhstan does not form part of Central Asia.
22 "Statisticheskiye Materialy," Vestnik Statistiki, No.5, 1962, p. 91, Fuel consumption for Central Asia, excluding Southern Kazakhstan, was given as 2.4 percent. To calculate fuel consumption in Southern Kazakhstan, the same relationship was assumed to hold between population and energy consumption as in the four Central Asian Republics.
and consumption of electricity; it produces little over a third per capita than the average for the USSR and, as the region still has separate grids, there is no "import" from other areas.

This still backward region has a variety of fuel resources, but none of them amounted to very much until the end of the last decade. Its coal-fields are small, and—with the exception of Angrensk lignite, which can be quarried—are difficult to mine. The presence of oil has long been known and the outlook is encouraging, but prospecting was not yet rewarded with any spectacular find. The late fifties, however, saw the discovery of very large amounts of natural gas, and the prospects for further strikes are excellent. "Proved recoverable" reserves in Central Asia now almost match those in the North Caucasus, but prospective resources are far in excess.

Though it is natural gas which dominates the fuel resources of Central Asia, output is not yet large. In 1963 less than 3.4 billion cubic meters were produced, and the plan for 1965 calls for 19 billion. Gas supplied less than a fifth of the fuel consumed in 1962 and will supply less than half (47%) even in 1965. Coal is still important and will remain so, with shares of one-half and one-third—in the above years. Only

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23 Narodnoye Khozyaystvo SSSR v 1962 g., op. cit., p. 95.
a fraction of the gas produced in Middle Asia is to be used at home. Practically the entire output of the giant Gazli field is to be sent to the Urals, which means that the needs of Central Asia will have to be met from the much smaller Mubarek fields in Uzbekistan and from other scattered deposits. Less than nine billion cubic meters per year is planned to be consumed in the region after 1965, but small though this amount is in view of the large population, it may not be available unless reserves in the A B category are expanded.

Despite the excellent prospects for further discovery in Central Asia, the amount of drilling done is very inadequate and in Uzbekistan has been actually declining since 1959. From 1959 to 1962 (inclusive) Uzbekistan received five percent of the total amount of drilling for gas in the USSR; in 1962 it received less than two percent. While there was probably an increase in drilling in Turkmenia, the total amount for gas (not oil) is certain to have been less than in Uzbekistan. Since this region is the most promising of all areas in the USSR, this is an astonishingly small share. (See Table XIV below).

The future plans for gas production in Central Asia are very ambitious. Besides its own needs, the region is supposed to send around 44 billion cubic meters annually to other regions of the country, mainly to the Urals and the mining complexes of

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Northern Kazakhstan, after 1970. It is abundantly clear, however, that there is no hope of fulfilling that plan without a radical change in the practice of prospecting. It is also clear that whether fulfilled or not, Middle Asia will be producing mainly for the benefits of more vital and economically better developed areas.

Table XIV

Drilling for gas and increase of reserves in the Uzbek SSR and in the USSR as a whole

<table>
<thead>
<tr>
<th>Year</th>
<th>Uzbek SSR</th>
<th>USSR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Drilling footage (1000 meters)</td>
<td>Increase of A B reserves (bill. cu.m.)</td>
</tr>
<tr>
<td>1959</td>
<td>86.5</td>
<td>293.3</td>
</tr>
<tr>
<td>1960</td>
<td>92.2</td>
<td>58.5</td>
</tr>
<tr>
<td>1961</td>
<td>65.4</td>
<td>17.4</td>
</tr>
<tr>
<td>1962</td>
<td>29.2</td>
<td>19.9</td>
</tr>
<tr>
<td>1959-62 (inclusive)</td>
<td>273.3</td>
<td>349.3</td>
</tr>
</tbody>
</table>

* Increase calculated by subtracting A B reserves at the beginning of each year from the ones given for the following year.

** It seems that the amount produced each year is subtracted from the reserves. Output in 1962 was 73.5 billion cubic meters. This means there was practically no addition to reserves in that year.


Though gas from gas-wells dominate the reserves of Central Asia, one should not forget that a certain amount of natural gas

is also available from oil wells. The Nebit Dag region produces almost a third as much oil as Azerbaydzhan and about a billion cubic meters of gas is released in the course of petroleum production. Roughly four-fifths of that gas, however, is vented into the atmosphere, suggesting a rate of utilization which is lowest in the USSR.

Because of the rapidly growing population, the extension of power-producing capacity is imperative. It is especially important in Uzbekistan, which contains half the population of Central Asia and accounts for half the industrial and some two-thirds of agricultural electricity consumption in the region. Although the share of hydro in the electricity production of Middle Asia is very high (over one-half), and the giant Nurek station now under construction will guarantee that it will remain so, several new thermal stations are being built today which will doubtlessly increase the share of thermal electricity. Up to now, natural gas produced less than a tenth of all thermal electricity in the region, three-quarters of which was generated by coal. (See table below.)

30 Narodnoye Khozyaystvo v 1962 g., p. 23-24 and V. A. Shelest et al, op. cit., p. 65. Uzbekistan and Tadzhikistan jointly account for about 90 percent of the electricity consumed by agriculture in Middle Asia. The share of Uzbekistan, therefore, must be at least two-thirds.
Fuel consumption by thermal stations in Central Asia

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Central Asia (without Southern Kazakhstan)</th>
<th>Of which:</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Uzbek SSR</td>
<td>Kirgiz SSR</td>
<td>Tadzhik SSR</td>
<td>Turkmen SSR</td>
</tr>
<tr>
<td><strong>Natural state:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal (1000 ton)</td>
<td>2836.6</td>
<td>2531.9</td>
<td>114.1</td>
<td>190.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Liquid fuel (1000 ton)</td>
<td>240.5</td>
<td>3.2</td>
<td>9.2</td>
<td>0.1</td>
<td>228.0</td>
</tr>
<tr>
<td>Gas (mill. cu. meters)</td>
<td>172.5</td>
<td>95.9</td>
<td>---</td>
<td>---</td>
<td>76.6</td>
</tr>
<tr>
<td><strong>Converted to nominal fuel (1000 tons)</strong></td>
<td>2114.5</td>
<td>1517.3</td>
<td>81.0</td>
<td>106.5</td>
<td>409.7</td>
</tr>
<tr>
<td>Coal</td>
<td>1584.2</td>
<td>1410.0</td>
<td>67.8</td>
<td>106.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Liquid fuel</td>
<td>333.6</td>
<td>5.0</td>
<td>13.2</td>
<td>0.2</td>
<td>315.2</td>
</tr>
<tr>
<td>Gas</td>
<td>196.7</td>
<td>102.3</td>
<td>---</td>
<td>---</td>
<td>94.4</td>
</tr>
</tbody>
</table>

As percentages

<table>
<thead>
<tr>
<th></th>
<th>Coal</th>
<th>Liquid fuel</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Asia</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Uzbek SSR</td>
<td>75.0</td>
<td>92.9</td>
<td>6.8</td>
</tr>
<tr>
<td>Kirgiz SSR</td>
<td>99.8</td>
<td>16.4</td>
<td>---</td>
</tr>
<tr>
<td>Tadzhik SSR</td>
<td></td>
<td>0.2</td>
<td>23.1</td>
</tr>
<tr>
<td>Turkmen SSR</td>
<td></td>
<td>76.9</td>
<td>100.0</td>
</tr>
</tbody>
</table>


Several new power plants are now under construction (e.g. at Tashkenêt, Navoinski, Bukhara, Dzhambul, Ashkhabad, Dushanbe and Krasnovodsk) and though some of these are rather small, they will appreciably increase the share of gas in the fuel mix of electric
stations. A very long range and somewhat visionary plan en-
visages an incredible expansion of generating capacity, based
mainly on natural gas as fuel and with the power marketed mostly
in European Russia and the Urals. The magnitude of such expan-
sion (an almost 30-fold increase in fuel consumption by power
plants over what may be a 20 year period) is open to question,
and the recent trend against the use of gas as boiler fuel must
also be considered. What is significant, however, is that even
in such long range plans, Middle Asia is considered primarily
as a source of energy for other regions, and it is possible
that much of this energy will leave the area in the form of
electricity.

A broadening of the industrial base in Central Asia would
unquestionably result in increased consumption of natural gas.
A development of two industries -- both heavy consumers of gas--
is imminent in the near future. These are the building mater-
ials and the chemical industries, especially the production of
fertilizers. None of the four Republics, for instance, are able
to meet their need for cement: the Tadzhik and Turkmen SSR's
produce less than half of what they consume, the Kirgiz SSR less
than a tenth and demand is not fully satisfied even in Uzbekistan.
The whole region has but seven cement plants, and outside

32 Izvestiya, Nov. 4, 1962; D.G. Zhimerin: op. cit.,
p. 418 and 429; Pravda Vostoka, Oct. 10, 1962, quoted from US
33 V. A. Shelest et al, op. cit., p. 172-75, 184, and
p. 187, Table 32.
Uzbekistan (where the distance is only 600 km.), the average distance for the transport of cement is over 1000 km., exceeding 1200 km. in the Kirgiz SSR. More factories are planned in the region to reduce these monstrous hauls. As the proportion of thermal energy used in the building material sector is very high, reaching nine-tenths of the total use of energy in some cases, the construction of such plants would appreciably increase the amount of gas consumed in Middle Asia, especially since no other fuel in the area is able to provide heat at low enough cost.

Even more important would be the development of the chemical industry, and a significant increase at least in the production of fertilizers is definitely decided on. It is for nitric fertilizers--for which natural gas is the cheapest raw material--that Middle Asia has the greatest need on account of intensive cotton cultivation. Today the four Mid-Asian Republics account for twelve percent of the consumption of ammonia-based fertilizers and Southern Kazakhstan perhaps for another two percent. (Kazakhstan, as a whole, consumes five percent. The exact share of Southern Kazakhstan is impossible to ascertain.)

34 Ibid., p. 55-56.
36 N. Nekrasov: op. cit., Planovoye Khozyaystvo, No. 8, 1964, p. 9; V.A. Shelest (op. cit., p. 38) claims about 50 percent for the four Middle Asian Republics, but this is obviously a mistake.
Only in Uzbekistan are fertilizers produced on more than a very minor scale, and the Kirgiz and Tadzhik Republics do not produce them at all. The output of nitric fertilizers cannot be determined but the output of nitric and phosphorous fertilizers combined (potassium fertilizers are not produced and hardly consumed in Central Asia) in the four Republics amounts to little more than three percent of the national total. As a result these badly transportable products are shipped in from the Moscow Region, the Donbass, the Kuzbass and the Urals. Annual transport costs for the "import" of nitrogen fertilizers alone exceeds eight million rubles and is more than double that amount for all fertilizers. In view of the large market and reserves of natural gas, a sharp increase in the production of ammonia and its derivatives is called for. Yet, in spite of frequent urging in the Soviet press, only two nitrogen fertilizer plants are under construction today in Central Asia. (At Navoinsk and at Fergana.)

It is clear that in the current Seven Year Plan the development of the petrochemical industry in Middle Asia is very limited and is entirely restricted to the production of ferti-
lizers. Many authors in recent literature urge the creation of a large-scale organic petrochemical industry in the region for which both raw materials and cheap energy are available in abundance. There are no serious plans for using the oil-well gases of Nebit-Dag for organic synthesis and the industry would be based on acetylene produced from natural gas. There is much to be said for such a course of action, especially since the production of acetylene can be combined with that of ammonia and its derivatives. Cost figures for such products as methyl alcohol, vinyl acetate, vinyl chloride, acetate fibers, nitron, etc., are very favorable. (See Chapter IX, p. 211 and Appendix, Tables VIII-XII).

Two things, however, limit the potentialities of Central Asia for the petrochemical industry. The first is the great water-shortage which also creates serious problems of waste disposal. Most petrochemical processes consume a prodigious amount of water and therefore are ill-suited for Middle Asia, although the manufacturing of acetate fibers and of nitron is less restricted by high water-demand. The second is the peripheral position of the region. Not only is it separated from the major consuming regions of the USSR by hundreds of miles of


desert and steppe but it also lies off the main axis of pioneer development. In addition, it is still a predominantly non-Slavic area, whose people are the least integrated into Soviet economic life. Nevertheless, the rapid growth of the already dense and very clustered population, which is far from adequately utilized, will probably cause a quickening of industrialization. Certain branches of the chemical industry, based on natural gas, could therefore, be expected to develop.

Domestic needs, too, are very poorly supplied at present— even more poorly than, for instance, in the Baltic and Byelorussia. At the beginning of 1963, less than 260 thousand quarters were served by gas in the four Republics of Middle Asia, and two-thirds of these received it in cylinders. That means that natural gas was available to less than a tenth of the population even if six people are counted per quarter. (in view of the large families common in the area). The completion of the Middle-Asian pipeline network, will undoubtedly bring this figure up. The construction of this network began at the same time as that of the Bukhara-Ural, but while the latter is now being doubled, the former— though much shorter and of smaller diameter— is still far from finished. No better commentary is needed on the marginal position of Central Asia and the essentially "colonial" position of its gas industry.

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42 Geograficheskiye Problemy, p. 487.
SUMMARY

As gas regions, the North Caucasus and Central Asia closely resemble each other. Each of them can boast roughly one-third of the country's proved recoverable reserves \((A+B)\) and close to one-third of its balance reserves \((A+B+C_1)\), although Central Asia has much greater potential than its rival. Owing to better location, the North Caucasus produces much more today. In two-three years, however, the two regions should draw equal and by the next decade Middle Asia will probably have the larger output.

Both regions are (or will be) primarily "exporters" of natural gas and feed the two biggest pipeline systems of the Soviet Union. The North Caucasus (excluding the Lower Don Valley) consumes but a fifth of its output while Middle Asia will have to be content with at most a quarter. A share much greater than three-fourths may leave Middle Asia if more of the very large reserves, believed to exist in the region, are proved and brought into production. Expensive coal will continue to supply a significant portion of fuel requirement in both regions to allow such "exports."

Middle Asia and the Northern Caucasus are both predominantly agricultural areas and will likely remain so. The production of fertilizers is, therefore, the first industry to be attracted by the large scale resources of natural gas. In the future, Middle Asia may become an important producer of polymers for it has cheap energy and a large labour force. Its marginal position and tight water balance, however, may limit such devel-
opments despite very favorable projected production costs. In the North Caucasus, proximity to the industrial Rostov-Donets area and, it seems, higher energy costs are the limiting factors, although the raw material base is excellent. It seems certain that both regions will continue to be suppliers of other provinces and only a small portion of their production will be consumed at home.
Chapter VIII

POTENTIAL REGION ---
SIBERIA AND NORTHERN KAZAKHSTAN
From the Urals to the Pacific Ocean and from Lake Balkhash to the Arctic Sea, stretches a tract of land as large as Canada and Argentina combined. The greater portion of it is frozen wasteland or otherwise unresponsive territory, but its southwestern quarter forms the tapering eastern part of Russia's economic triangle. Into that funnel, ending at Lake Baykal, has poured perhaps a fifth of all investment since the Revolution, though much of that was channelled to one limited area, the Kuznets Basin. Since 1950, however, this zone has been the scene of more intensive economic activity both in agriculture and industry. The Virgin Land Program and the recent power developments in the Yenisey-Angara region have gradually brought the whole area as far as Lake Baykal into the mainstream of Soviet economic life.

This long belt may be divided into two major regions. The western one embraces the southern portion of the West Siberian Lowland and the northern half of Kazakhstan, the eastern one extends from the Ob to Lake Baykal. (It includes Semipalatinsk, Novosibirsk and the whole of the Kuzbass) The two regions have nearly equal population of between eleven and twelve million, but the latter is considerably more urbanized and contains

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N. M. Budtolayev et al: "Problemy ekonomicheskogo razvitiya Zapada i Vostoka Sovetskogo Soyuza, Vestnik Moskovskogo Universiteta, Seriya Geografiya, No. 4, 1963, p. 8, Table 2."
a greater number of large cities.

West Siberia-Northern Kazakhstan (as delimited) accounts for 6 to 7 percent of total fuel consumption, Central Siberia for over 10%. In the former region, the larger part of this is consumed by agriculture and food processing as only two cities, Omsk and Karaganda, are large centers of industry. In the latter region, on the other hand, most of the fuel consumption is accounted for by industry (including the generation of electricity).

2 Narodnoye Khozyaystvo SSSR v 1962 g, p. 20-23 and 25-27.

3 Different methods of calculation yield fairly close results. Consumption in Central Siberia may be calculated from coal and oil consumption, the latter mainly estimate. 38% of Kuzbass coal is used within the Kuznets-Novosibirsk region, while almost all the coal mined in East Siberia is used locally. 7000 Cal were assigned to 1 ton of Kuzbass and Irkutsk coal and 4000 Cal to 1 ton of Kansk-Achinsk coal. Similar result is arrived at by allocating 80% of total fuel consumption in East Siberia (given in Vestnik Statistiki) to the area south of the Angara and west of Lake Baykal and adding to it 38% of Kuzbass coal output (see above) and the estimated amount of petroleum consumption in the Kuznets-Novosibirsk region. Fuel consumption in West Siberia-Northern Kazakhstan (as delimited) may be calculated by adding to the total fuel consumption of Northern Kazakhstan the fuel consumption of West Siberia minus coal and oil consumption in the Kuznets-Novosibirsk region (see above). Respective shares of Northern and Southern Kazakhstan are determined in Chapter 7, page 167, footnote 22.

The rest of Siberia and even the Far East are marginal areas, devoid of the bustling activity which characterizes the southern belt west of Lake Baykal. The vast expanse of land north of the Angara River and the Stanovoy Range (an area as large as the United States) contains but 1.3 million people, while Transbaykalia and the lands of the Amur (with Sakhalin Island) have 1.8 and 3.9 million respectively. This enormous territory probably accounts for less than 5% of the country's fuel consumption, and--aside from a few isolated areas--is developing slower than the more crucial regions of Siberia.

At present, natural gas plays no part in the fuel supply of Siberia and Northern Kazakhstan aside from field uses of some casing head gas in the Emba oil fields and Sakhalin Island. This brief consideration and the foregoing regional breakdown, therefore, serves only to help assess its possible future significance. The belt of land as far as Lake Baykal clearly represents a huge market for energy. Its headlong growth and the continued emphasis given to it mean that its share can only increase in the future. This is particularly true of Central Siberia, which will be considered first.

Central Siberia

What works against Central Siberia's becoming a major market for natural gas is its distance from the present (and

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5 Estimated from data in Vestnik Statistiki, No.5, 1962, p. 91, and figures arrived at in footnote 3.
probably also future) supplying areas, coupled with opulence in other forms of energy. The region contains over half the accessible reserves of coal and over half the accessible water-power potential of the Soviet Union. At the same time, it has only negligible quantities of natural gas, and the known deposits of Siberia--along the Lower Ob and in Yakutia--lie very far away. (The former, in any case, are being linked to the economy of the Ural Region).

In the larger, eastern half of Central Siberia, natural gas would have to compete with the cheapest coal of the USSR. More than half of the region's coal resources by weight (55%) and close to half by calorific content are found in the conveniently located Kansk-Achinsk Basin, extending along the Trans-Siberian railway east and west of Krasnoyarsk. Here extraction costs from large open-cast mines are as low as 0.50 to 0.70 rubles, or 1.10 to 1.50 rubles per ton of nominal fuel (7000 Cal). As Table VII, p. 70 shows, the transport cost of natural gas--converted to tons of nominal fuel--over a distance of 1000 km is 1.62 rubles per ton, even without capital charges. This means that from Achinsk to Irkutsk (where coal again can be quarried, though at a somewhat higher cost), natural gas would be more expensive unless found locally.

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6 D. J. Hooson; *op. cit.*, p. 102.
7 *Geograficheskiye Problemy...*, p. 388.
As discussed in Chapter III, the Angara-Lena Downwarp is partially within the Central Siberian Region and holds promise for gas finds. Any sizable deposit found here will doubtlessly be exploited. However, as the region is already saturated with cheap energy, far beyond its capacity to use it, there appears no urgency for such an additional resource. Any discovery will likely be the result of prospecting for oil rather than gas, for the former is a much more indispensable material owing to its diverse uses.

If gas is found, its three most likely consumers will be the household sector, the chemical and machine building industries, though even here-- with the possible exception of machine building-- the lack of gas is no serious hindrance. Space-heating in the fast-growing cities is carried on by large TETs's, which presently account for about one-third of the total installed thermal capacity of the region. The culinary needs of households in the cities are easily supplied by electricity, of which the region produces far more than it can presently use. As for the chemical industry, natural gas would be used chiefly as raw material, not as fuel. As cost figures in Chapter IX, p. 211 and Appendix, Tables 8-12 show, organic synthesis via acetylene-- produced by the electric cracking of methane is indeed competitive in this region. However, if the search for local supplies of oil is substantiated (and the recent Markovo strike is very promising), obviating the imports of crude

Referativny Zhurnal, 1964, No. 3, E44.
from the Volga, refinery liquids will prove to be a cheaper source of raw material for organic petrochemicals than natural gas. Even with Bashkir crude, the cracking of petroleum emulsion is thought to be very cheap. (Chapter IX, Table XXIII, p. 213)

The future position of gas in the Kuzbass-Novosibirsk area is much more favourable. Kuznets coal-- while far cheaper than any to the west-- is more expensive than Kansk-Achinsk coal. One ton from open-cast mines costs 2.5 to 2.9 rubles, while coking coal-- mined from underground-- costs about 6.5 rubles. The Kuzbass is the third largest metallurgical center in the Soviet Union and the only producer of pig iron in Siberia. Although its coking coal is the cheapest in the country, a reduction in coke expenditure is much hoped for. As for steel making, the open-hearth furnaces of the region operate almost exclusively on coke oven and blast furnace gases for want of better fuel. Here, indeed, is a large market for natural gas, to which the developing chemical industry of the Basin could be added.

Beside having a greater need for natural gas than the eastern half of Central Siberia, this region also lies closer to actual and potential areas of supply. Though gas found in the western half of the West-Siberian Depression will unquestionably go to the Urals rather than the Kuzbass, a large enough section of this petroliferous province is at a reason-

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9 Geograficheskaya Problemy..., p. 338.
able distance from the Kuznets Basin to warrant the construction of a pipeline following successful strikes. Indeed, the recent find at Okhteure—though over 600 km away—has already given rise to plans for a pipeline. Deposits much closer than that could soon be discovered.

North Kazakhstan-West Siberia

This region is much less industrialized than Central Siberia and consumes much less energy. The major centers of consumption are the single large city of Omsk in the north and the mining towns of the south, with ferrous and non-ferrous metallurgy at Karaganda and Dzhezkazgan.

Omsk today boasts the largest petroleum refining capacity in Siberia, has a wide range of industries and is growing rapidly. It is favourably situated as a potential market for the natural gas of West Siberia for it is on the edge of petro­liferous territory. If natural gas is to supply the city, however, the deposits would have to be discovered in fairly close proximity. The isolated position of the city makes it a small market compared to Novosibirsk and the Kuzbass, which would not justify the construction of a long pipeline.

Temir Tau, a satellite of Karaganda, is an expanding iron and steel center. Though Karaganda coking coal is cheaper than that of the Kuzbass, it is considerably more costly to cokify; hence a reduction of coke needed would be very welcome.

Oil and Gas Journal, June 8, 1964, p. 114.
As in the Kuzbass, the open-hearth furnaces at Temir Tau must work on a mixture of coke-oven and blast-furnace gases. Their conversion to natural gas could greatly raise the efficiency of the steel plant. An extension of the Central Asian pipeline from Tashkent to Karaganda is projected. This, however, represents a stretch of a thousand km through barren, desert country, and there is no evidence that even preliminary work has started yet.

If gas is discovered in the southern part of the West Siberian Lowland, it would be more logical to supply Karaganda from that direction. A pipeline from the north could also supply Omsk and Petropavlovsk as well as a number of towns in the Virgin Land. The latter is not a large market, though Tselinograd is developing a range of industries associated with agriculture, but it is a far more responsive territory economically than the desert further south.

The agricultural lands of the Virgin Lands and West Siberia could become a fairly large consumer of liquid gases. Natural gasoline can readily be used as tractor fuel, while the households of rural and small-town inhabitants, numbering 7 to 8 million, would need a fairly large amount of propane and butane. By far the greater part of this vast steppeland is devoid of wood and has very little peat, which leaves the population without local fuel resources. The distribution of bottled gas is the least expensive solution. Gas distributing stations in the region are already in operation at Karaganda, Uralsk and Guryev and L.P.G. pools are now under construction at Aktyubinsk,
Kokchetav, Tselinograd and Pavlodar, with others projected.

The rest of Siberia and the Far East

Elsewhere, natural gas has and will have only local significance. Through a difficult pipeline to be built on permafrost, the Vilyuy field will supply the city of Yakutsk. Several sources mention the eventual pumping of gas to Norilsk from the Taz deposit, which is believed to be of a magnitude comparable to Shebelinka or Gazli. Finally, the fields of northern Sakhaline may serve Komsomolsk, with its small steel mill, if the technical difficulty of bridging the Tartar Strait is surmounted. Since the open hearth furnaces of Komsomolsk lack suitable supplies of cheap fuel (there is no blast furnace, hence no by-product gases are available) and seem to be fired by fuel oil transported across Siberia by rail, the availability of gas would be significant.

These developments, however, will scarcely affect the over-all economy of Siberia, let alone of the USSR as a whole. The form of energy-supply may be drastically changed in a few given cities, for instance Norilsk, but the availability of gas will not appreciably increase total fuel consumption. The growth of these areas depends entirely on conditions elsewhere. With large regions, more richly endowed and much better located, still

in a semi-developed stage, the lands of Northern Siberia and the Amur will no doubt continue to be economically dormant.
Chapter IX

REGIONAL COST ANALYSIS
The USSR is a country of continental proportion, even if one excludes the largely marginal areas of Northern Siberia and the Far East. Its energy resources and markets are very unevenly distributed. One of the most urgent tasks of Soviet planners, therefore, is to determine the rational energy-mix for each major economic region.

Since natural gas was able to cover only 12.4% of the fuel requirement in 1963, it is obvious that the major problem of the planners is the rational allocation of this fuel among the various areas and among the different consumers within these areas. Such an allocation means the maximization of savings (derived from the replacement of more expensive fuels by natural gas) not merely in any particular region, but in the whole of the USSR. Obviously, the cost advantage of gas versus other fuels is of vital importance in any given region, but—owing to the present disequilibrium between supply and demand—a high cost difference does not everywhere guarantee large-scale substitution.

In the following pages the costs of natural gas, natural gas liquids and a few petrochemicals derived from them are examined in various regions of the USSR. A brief look is also given to the pricing of these fuels and the pricing zones set up in 1964.

Of all fuels, natural gas is the cheapest to produce. In 1962 extraction costs of 1000 cu. meters of gas from gas wells amounted to 0.51 rubles. Converted to nominal fuels, average production costs of various fuels in recent years were as follows (rubles per ton):
Table XVI

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Cost</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural gas</td>
<td>0.42</td>
<td>1960</td>
</tr>
<tr>
<td>Crude oil</td>
<td>2.10</td>
<td>1960</td>
</tr>
<tr>
<td>Coal</td>
<td>11.37</td>
<td>1958</td>
</tr>
<tr>
<td>Peat</td>
<td>5.30</td>
<td>1958</td>
</tr>
<tr>
<td>Shale</td>
<td>14.83</td>
<td>1958</td>
</tr>
<tr>
<td>Wood</td>
<td>34.00</td>
<td>1958</td>
</tr>
</tbody>
</table>

Sources: Yu. I. Bokserman: op. cit., p. 15; R.E. Ebel: op. cit., p. 99-100; S.D. Fel'd (1964): op. cit., p. 62. Production costs of gas and oil were calculated using the following conversion factors: 1 ton of crude oil = 1.43 ton of nominal fuel, 1000 cu. m. of gas from gas wells = 1.21 ton of nominal fuel. Costs of other fuels were given per ton of nominal fuel by Fel'd. Fel'd also gives costs for crude oil and natural gas (for 1958). However, for natural gas he includes gases from oil-wells, the cost of which cannot be meaningfully determined (see below). These figures, therefore, were not used.

Since output of oil-well gases is intimately tied to that of crude petroleum, extraction costs of these gases cannot be independently appraised.

The above costs do not include costs of prospecting and exploration and are, therefore, somewhat unfairly weighed in favour of the two hydrocarbon fuels. Authoritative sources, however, disagree widely about the investment required (for both gas and oil) when prospecting is included: it is not possible, therefore, to arrive at an unequivocal figure about overall costs. Different sources, however, are in agreement about straight production costs from the various deposits in

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recent years, and the figures are given below:

### Table XVII

Extraction costs of natural gas, including transport cost by field gathering system (rubles per 1000 cu.m.)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Average for USSR</td>
<td>1.48</td>
<td>0.64</td>
<td>0.59</td>
<td>0.53</td>
<td>0.51</td>
</tr>
<tr>
<td>Komi ASSR</td>
<td>1.58</td>
<td>2.44</td>
<td>2.66</td>
<td>2.52</td>
<td>2.77</td>
</tr>
<tr>
<td>Kuybyshev Ob.</td>
<td>1.71</td>
<td>1.47</td>
<td>1.53</td>
<td>1.62</td>
<td>1.82</td>
</tr>
<tr>
<td>Saratov Ob.</td>
<td>2.23</td>
<td>1.58</td>
<td>1.02</td>
<td>0.84</td>
<td>0.72</td>
</tr>
<tr>
<td>Volgograd Ob.</td>
<td>----</td>
<td>0.64</td>
<td>0.59</td>
<td>0.55</td>
<td>0.57</td>
</tr>
<tr>
<td>Krasnodar Kray</td>
<td>----</td>
<td>0.77</td>
<td>0.80</td>
<td>0.70</td>
<td>0.70</td>
</tr>
<tr>
<td>Stavropol' Kray</td>
<td>18.67</td>
<td>0.23</td>
<td>0.16</td>
<td>0.20</td>
<td>0.18</td>
</tr>
<tr>
<td>Chechen-Ingus ASSR</td>
<td>8.65</td>
<td>12.02</td>
<td>18.82</td>
<td>3.94</td>
<td>5.60</td>
</tr>
<tr>
<td>Dagestan ASSR</td>
<td>----</td>
<td>13.14</td>
<td>12.64</td>
<td>9.97</td>
<td>8.97</td>
</tr>
<tr>
<td>Poltava Ob.</td>
<td>----</td>
<td>----</td>
<td>1.16</td>
<td>1.32</td>
<td>1.23</td>
</tr>
<tr>
<td>Khar'kov Ob.</td>
<td>----</td>
<td>0.33</td>
<td>0.29</td>
<td>0.26</td>
<td>0.24</td>
</tr>
<tr>
<td>L'vov Ob.</td>
<td>----</td>
<td>0.49</td>
<td>0.49</td>
<td>0.44</td>
<td>0.39</td>
</tr>
<tr>
<td>Ivan-Franko Ob.</td>
<td>0.68</td>
<td>7.20</td>
<td>5.77</td>
<td>5.96</td>
<td>6.25</td>
</tr>
<tr>
<td>Uzbek SSR</td>
<td>----</td>
<td>3.70</td>
<td>2.94</td>
<td>1.95</td>
<td>1.21</td>
</tr>
<tr>
<td>Kirgiz SSR</td>
<td>----</td>
<td>----</td>
<td>2.13</td>
<td>2.59</td>
<td>3.00</td>
</tr>
</tbody>
</table>

* The reorganization of the industry is responsible for the excessive change in cost from the previous year.

Two important conclusions can be drawn from the table:

a) extraction costs of natural gas vary greatly in the different fields,

b) all major fields and the whole of the USSR experienced a gradual reduction of costs over the years. Since the beginning of large-scale production, extraction has been cheapest in Stavropol' Kray (North-Stavropol' field), followed by Kharkov Oblast (Shebelinka) and L'vov Oblast. The Uzbek SSR (mainly the Gazli deposit) has been, up to now, a relatively expensive producer, due to desert conditions, remoteness and the resulting difficulties in development. By the end of 1965, however, planned cost at Gazli is supposed to be no greater than in the well developed region of Stavropol' Kray, and may even be less. There is evidence that production cost has increased recently in the latter area, caused by the drop in field pressure (see page 163). In every producing field, the amortization of facilities—wells, compressors, gathering lines, etc.—make up by far the largest share of extraction cost, reaching two-thirds of the total in North-Stavropol'. (For precise breakdown, see Appendix, Table VI).

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Though long distance transport increases cost by as much as four-five times, natural gas is still the cheapest fuel in every region of the Soviet Union except Siberia and the Far East. The tables below present comparative costs of various fuels in the major regions of the USSR for 1959 and projected costs at major points of consumption in 1965. Despite the high cost of transport for natural gas, this fuel is much cheaper than the others in all regions of European Russia, though it must yield to coal east of the Urals. Here coal is quarried in large open-cast mines very near to places of consumption, while the recently discovered gas deposits of Siberia lie 1500 - 2000 kms away from the populated belt along the Trans-Siberian Railway.

Until very recently the price of gas was seriously out of balance with its cost, and in most regions was fixed at the 5 level of the price for coal. In January 1964 a new price system came into effect. Though more rational than the former, it still only partially reflects the competitive position of this fuel in the various regions of the country. Five zones are established, the price being the same everywhere within each zone. Zone I comprises the major gas producing regions, such as the North Caucasus, the Western Ukraine, part of the Volga (for Kharkov Oblast, see below), within which the price is fixed at 9.5 rubles per 1000 cubic meters. Zone II includes the minor producing regions, e.g. the Transcaucasus, the Komi ASSR, probably the Middle Volga, etc., and areas which are traversed by

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5 T. Brents: *op. cit.*, *Gazovoye Delo*, No. 8, 1963, p. 44.
Table XVIII

Costs of various fuels and required capital investments in the major regions of the USSR (1959) (rubles* per ton of nominal fuel)

<table>
<thead>
<tr>
<th>Region</th>
<th>Oil</th>
<th>Natural Gas</th>
<th>Local fuel</th>
<th>Oil</th>
<th>Natural Gas</th>
<th>Local fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltic and Byelorussia</td>
<td>4.5</td>
<td>3.0</td>
<td>8.0 shale</td>
<td>7.0</td>
<td>2.75</td>
<td>2.76</td>
</tr>
<tr>
<td>Northwest</td>
<td>6.0</td>
<td>3.5</td>
<td>10.0 shale</td>
<td>7.25</td>
<td>3.25</td>
<td>3.3</td>
</tr>
<tr>
<td>Center</td>
<td>4.5</td>
<td>3.0</td>
<td>13.5 peat</td>
<td>7.0</td>
<td>2.75</td>
<td>4.5</td>
</tr>
<tr>
<td>Volga</td>
<td>4.0</td>
<td>1.5</td>
<td>12.5 shale</td>
<td>6.5</td>
<td>1.5</td>
<td>3.25</td>
</tr>
<tr>
<td>Donbass</td>
<td>4.5</td>
<td>2.5</td>
<td>8.5 coal</td>
<td>7.0</td>
<td>2.25</td>
<td>2.25</td>
</tr>
<tr>
<td>West Sib.</td>
<td>5.5</td>
<td>3.5</td>
<td>4.55 coal</td>
<td>7.5</td>
<td>3.25</td>
<td>1.35</td>
</tr>
<tr>
<td>East Sib.</td>
<td>6.5</td>
<td>5.0</td>
<td>1.8 coal</td>
<td>8.5</td>
<td>4.35</td>
<td>0.74</td>
</tr>
</tbody>
</table>

* Given in old rubles and converted to present value.


large diameter trunklines. Here the price is 11 rubles per 1000 cu. meters. To this zone are assigned also Poltava and Kharkov Oblasts (with the huge Shebelinka field) since the lowering of the price here is not thought expedient due to proximity to the Donets Basin. Zone III includes all the Ukraine save for L'vov, Kharkov and Poltava Oblasts. The price here is set at 12 rubles. To Zone IV belong the Center and the Baltic, except Estonia, with a price of 13 rubles per 1000 cu. meters. Zone V embraces Leningrad and Novgorod Oblasts, which are farthest from centers of production, and also Estonia where natural gas is penalized
Table XIX

Projected costs of various fuels in 1965 at major consuming centers of the USSR and regional capital investment (rubles per ton of nominal fuel)

<table>
<thead>
<tr>
<th>Points of consumption</th>
<th>Natural Gas</th>
<th>Coal</th>
<th>Peat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regions from which cities are supplied</td>
<td>Total Cost</td>
<td>Capital Outlay (Total)</td>
<td>Deposits from which cities are supplied</td>
</tr>
<tr>
<td>Leningrad</td>
<td>East Ukraine</td>
<td>North Caucasus</td>
<td>2.41</td>
</tr>
<tr>
<td></td>
<td>North Caucasus</td>
<td>Donbass</td>
<td>22.98</td>
</tr>
<tr>
<td></td>
<td>Vorkuta</td>
<td>Latvia</td>
<td>6.37</td>
</tr>
<tr>
<td>Riga</td>
<td>West Ukraine</td>
<td>Donbass</td>
<td>15.45</td>
</tr>
<tr>
<td>Moscow</td>
<td>East Ukraine</td>
<td>Donbass</td>
<td>14.28</td>
</tr>
<tr>
<td></td>
<td>North Caucasus</td>
<td>Moscow Oblast'</td>
<td>5.80</td>
</tr>
<tr>
<td>Gor'kiy</td>
<td>Volga</td>
<td>Donbass</td>
<td>14.71</td>
</tr>
<tr>
<td>Rostov</td>
<td>North Caucasus</td>
<td>Donbass</td>
<td>13.14</td>
</tr>
<tr>
<td>Saratov</td>
<td>Volga</td>
<td>Donbass</td>
<td>14.28</td>
</tr>
<tr>
<td>Tbilisi</td>
<td>North Caucasus</td>
<td>Donbass</td>
<td>14.94</td>
</tr>
<tr>
<td></td>
<td>Karadag</td>
<td>Chelyabinsk</td>
<td>12.16</td>
</tr>
<tr>
<td>Sverdlovsk</td>
<td>Central Asia</td>
<td>Donbass</td>
<td>15.26</td>
</tr>
<tr>
<td></td>
<td>Kuzbass</td>
<td>Byelorussia</td>
<td>6.00</td>
</tr>
<tr>
<td>Minsk</td>
<td>Western Ukraine</td>
<td>Donbass</td>
<td>15.26</td>
</tr>
<tr>
<td></td>
<td>L'vov-Volynsk</td>
<td>19.70</td>
<td>26.43</td>
</tr>
<tr>
<td>Kiev</td>
<td>Western Ukraine</td>
<td>Donbass</td>
<td>15.26</td>
</tr>
<tr>
<td></td>
<td>Ukraine</td>
<td>5.63</td>
<td></td>
</tr>
<tr>
<td>Tashkent</td>
<td>Central Asia</td>
<td>Donbass</td>
<td>15.26</td>
</tr>
<tr>
<td></td>
<td>Kuzbass</td>
<td>15.04</td>
<td>27.02</td>
</tr>
<tr>
<td>Alma-Ata</td>
<td>Central Asia</td>
<td>Donbass</td>
<td>15.26</td>
</tr>
<tr>
<td></td>
<td>Kuzbass</td>
<td>15.04</td>
<td>27.02</td>
</tr>
<tr>
<td></td>
<td>Karaganda</td>
<td>11.22</td>
<td>20.95</td>
</tr>
</tbody>
</table>
on account of the existing large-scale facilities for the production of shale gas. Here natural gas is priced at 15 rubles.

One can perceive the problem of allocation behind this scheme. Since natural gas can cover only a portion of the energy need, the use of high-cost fuels will have to continue in some areas. Here gas is priced higher than otherwise warranted to discourage wasteful consumption (e.g. under boilers) by plants which-- due to loosening control-- can now choose their suppliers to a degree. Comparing these prices to costs (Tables XVII-XIX) the differences appear very great. Indeed of all mineral fuel industries, the gas industry registers the largest profit today in the USSR. It must be remembered, however, that prospecting and exploration costs are not included in the costs given in these tables (XVII-XIX). These are high and must be covered.

The production costs of natural gas liquids depend partly on the cost and chemical composition of wet gases from which these liquids are extracted and partly on the efficiency of gas-processing plants. Production costs fall off sharply as the concentration of liquids in the gas increases. The diagram below, given for two major gas-processing plants in the Middle Volga, illustrates this fact.

6 Ibid., p. 46-47.

Note for Table XIX: For greater detail of costs and capital investments (i.e. for output and transport) see Appendix, Table VII.

Though the above diagram is given only for propane and natural gasoline, it can be safely assumed that the same situation applies to condensates. For this reason, assuming similar stripping techniques, the cost of producing one ton of condensates in Krasnodar Kray—where its average concentration in the gas is 26.4 gram per cu. meters—must be much lower than at Shebelinka, where only 4.5 grams per cu. meter are present.

Cost figures of LPG and natural gasoline in nine important gas-processing plants are listed below for three years. Five of the works are located in the Volga Region, three in the Caucasus and one in the Western Ukraine. The wide variation in cost is immediately apparent.

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Table XX

Cost of LPG and natural gasoline in gas-processing plants of the USSR (rubles per ton).

<table>
<thead>
<tr>
<th>Plants</th>
<th>Plan</th>
<th>Realization</th>
<th>1959</th>
<th>1960</th>
<th>1961</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuyumazy</td>
<td>10.27</td>
<td>11.57</td>
<td>9.32</td>
<td>8.45</td>
<td></td>
</tr>
<tr>
<td>Minibayevvo</td>
<td>7.24</td>
<td>15.03</td>
<td>11.54</td>
<td>9.62</td>
<td></td>
</tr>
<tr>
<td>Mukhanovsky</td>
<td>6.68</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Shkapovo</td>
<td>6.12</td>
<td>---</td>
<td>---</td>
<td>17.13</td>
<td></td>
</tr>
<tr>
<td>Groznyy</td>
<td>---</td>
<td>22.18</td>
<td>24.50</td>
<td>25.45</td>
<td></td>
</tr>
<tr>
<td>Baku</td>
<td>---</td>
<td>35.82</td>
<td>31.58</td>
<td>25.61</td>
<td></td>
</tr>
<tr>
<td>Borislav</td>
<td>---</td>
<td>33.47</td>
<td>---</td>
<td>33.44</td>
<td></td>
</tr>
<tr>
<td>Saratov</td>
<td>---</td>
<td>79.92</td>
<td>73.32</td>
<td>90.72</td>
<td></td>
</tr>
<tr>
<td>Krasnodar</td>
<td>---</td>
<td>55.00</td>
<td>61.88</td>
<td>55.10</td>
<td></td>
</tr>
</tbody>
</table>


As with dry natural gas, the prices of natural gas liquids are centrally fixed, but seem to exhibit greater variations. The prices for LPG and natural gasoline are not available, but some data on condensates has been found. At Shebelinka the price is fixed at 23.70 rubles and reflects the low productivity due to the low concentration of condensates in the gas. In Krasnodar Kray, on the other hand—though production is certain to be much cheaper on account of the greater concentration of these liquids—the price is fixed independently of production cost and is set at the price of crude oil, as 4.90 rubles. 8

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8 Ibid., p. 67.
This indicates that there must be an officially delimited, strictly bound, market area for both producers. As the distance between them is only 500 km, condensates from Krasnodar Kray should be much cheaper at Shebelinka than the local product.

In trying to gain some idea (however vague) of the comparative economic position of petrochemicals derived from natural gas in the various regions of the USSR, one is forced to think more in terms of the future than the present. A mere 457,000 tons of natural gas liquids were used to produce petrochemicals in 1962, against over 14 million tons in the United States. Even in 1965, for instance, nearly half of all ethyl alcohol is to be manufactured from potatoes and grain (in 1961, 62% were made from these sources).

As for dry natural gas, it is beginning to be used in greater quantities as basic feedstock for three chemicals: ammonia (and its derivatives), methyl alcohol and carbon black. Since 1963, half of all ammonia is produced from natural gas (ammonia produced from synthesis gas, obtained during the manufacturing of acetylene is included). Natural gas should play a similar role in the production of other nitric fertilizers such as urea and ammonium nitrate. (The amount of gas consumed

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to produce these fertilizers is unfortunately not available.
For the manufacturing of methyl alcohol, one billion cubic meters were used in 1963 and about a third of all methyl alcohol was produced from natural gas. Of all petrochemicals, probably carbon black accounts for the largest amount of gas: 2.5 bill. cu. meters were planned to be burned for carbon black in 1964.

Practically no data is available about the production costs of nitric fertilizers, which are, in any case, different when ammonia and its derivatives are produced in conjunction with acetylene. Even the largest plants operate at varying levels of technical efficiency and need different amounts of gas of identical chemical composition and calorific content to produce the same amount of analogous products. (e.g. the Novomoskovsk, Lisichansk and Nevinnomysk plants-- all using Stavropol' gas-- differ by as much as 23% in the number of cubic meters required to make one ton of ammonia) Situated some 800 kms farther away from their mutual source of gas-supply and, therefore, incurring significant transport charges on every cubic meter used, the Novomoskovsk (south of Moscow) chemical combine nevertheless manufactures ammonium nitrate about 30%

13 Ibid., (Gazovaya Promyshlennost') p. 3.
14 R. Sheyenko: "Pob' em proizvodstva mineral'nykh udobreniy," Ekonomicheskiye Nauki, No. 1, 1964, p. 10. (By 245 cu. meters. About 1060 cu. meters are required to produce one ton of ammonia.)
cheaper than the Lisichansk combine (Lugansk Oblast'). Absolute cost is available only for the Chirchik plant, near Tashkent, which uses gas from the Bukhara deposits about 500 kms away. Here one ton of ammonium nitrate cost 31 rubles in 1962. Chirchik is one of the large plants with technical efficiency apparently comparable to the Lisichansk combine. Assuming that, cost at Novomoskovsk should not be much more than 20 rubles and at Nevinnomysk (south of Stavropol')—where less gas is needed per ton of ammonia than at Novomoskovsk— it should be somewhat less.

These figures cannot be taken with too great a certainty, but they do illustrate the fact that it is not yet possible to make a rational economic analysis about the production cost of fertilizers at various points. These factories changed over to natural gas from coal and coke-gas only in the present decade, and conditions within the plants have greater effects on costs than the price of raw materials and fuel.

Excessively long hauls, however, can more than triple the cost of fertilizers in many regions. The average shipping distance for nitric fertilizers in 1960 was 1290 km, due to extreme concentration of production in a few areas. According to Fedorenko, the cost of transporting 100,000 tons a distance of 1000 km amounts to 5,650,000 rubles, that is 56.5 rubles

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15 Ibid., p. 7.
16 Ibid., p. 9-10.
per ton. In the Western Ukraine, therefore, which still does not supply its own needs, a ton of ammonium nitrate from the Lisichansk factory should cost somewhere between 80 and 90 rubles (and more from the other coal-based fertilizer plants of the Donets Basin)—though advantageous freight charges should keep it lower than that. It is averred, as late as 1964, that nitric fertilizers can be "economically" (italics added) distributed from the Eastern Ukraine within an area of nearly 570,000 sq. km—a huge territory which must include the whole of the Ukraine, part of the Baltic, Byelorussia and the Central Chernozem Region. Such transport by rail is undoubtedly carried on today, although the delivery of the required amount of natural gas (presumably by pipelines of 28 inches diameter or over) is alleged to cost half as much as the transport of these finished products. (5.6 million rubles for 100,000 tons of fertilizer delivered over a distance of 1000 km against 2.25 million rubles for 100 million cubic meters of gas delivered over the same distance. This cost for the gas may include capital charges, for it is higher than given by Savelev on page 70.) These figures, too should be treated with caution. A more recent statement claims that transport costs of nitric fertilizers are at most 30% higher than the delivery costs of the required amount of natural gas by major trunklines.

20 Ibid., p. 103.
Practically no sulfur is extracted yet from natural gas. Fortunately for Soviet planners only a few, relatively small deposits yield sour gas (see Table V, Chapter II, p. 40), and sulfur, therefore, does not interfere with long-distance transport. The lack of urgency to remove sulfur, however, has deprived the chemical industry of a cheap raw material. Most plants today use mineral sulfur for the production of sulfuric acid, essential in the manufacturing of superphosphate, similar phosphoric fertilizers and a host of other chemical products. At present, sulfuric acid in the USSR sells for 18 rubles at the place of production (mainly the Center, the Urals and the Eastern Ukraine), but the factories are obliged to spend 17 rubles on the mineral sulfur alone. (Whether this is less in the Urals, where sulfur is mined, than in the other regions, or whether a uniform price is set on sulfur is not indicated). It is evident, that under such conditions all factories using mineral sulfur must work at a huge deficit. Sulfur produced from gas and oil should be 4 - 5 times cheaper than that.

Production costs of carbamide (urea) and of methyl alcohol— which are manufactured most cheaply from natural gas but which also require high energy inputs— vary in different regions with the cost of raw material and energy. (Usually, but not necessarily, natural gas provides the energy as well.) The most favoured regions, therefore, are Central Asia, the Volga

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and East Siberia. In the latter area the small amount and relatively expensive gas of Irkutsk Oblast could provide the raw material even at present, while the very cheap coal could satisfy the energy need—which in the case of methyl alcohol, at least—is consumed chiefly in the form of electricity.

Table XXI
Tentative costs of carbamide and methyl alcohol (from natural gas) in various regions.
(In percentages. Costs in the North-West are taken as 100%)

<table>
<thead>
<tr>
<th>Economic regions</th>
<th>Carbamide</th>
<th>Methyl Alcohol</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>cost</td>
<td>raw material</td>
</tr>
<tr>
<td>North-West</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Center</td>
<td>90.4</td>
<td>96.7</td>
</tr>
<tr>
<td>Volga</td>
<td>70.1</td>
<td>75.8</td>
</tr>
<tr>
<td>North-Caucasus</td>
<td>81.9</td>
<td>84.6</td>
</tr>
<tr>
<td>West Siberia</td>
<td>77.5</td>
<td>87.8</td>
</tr>
<tr>
<td>East Siberia</td>
<td>70.8</td>
<td>75.0</td>
</tr>
<tr>
<td>Far East</td>
<td>109.5</td>
<td>115.4</td>
</tr>
<tr>
<td>Central Asia</td>
<td>70.6</td>
<td>73.7</td>
</tr>
</tbody>
</table>


Production costs of organic intermediates and their regional variations are almost all forecasts. In Chapter II, p.34-41 the respective positions of LPG's (via olefins) and of dry natural gas (via acetylene) as petrochemical raw materials were discussed in a general way. Due to the concentration of LPG production (combined with general scarcity), in regions reached by gas
pipelines the production of acetylene may be more economic than the production of olefins from LPG's imported by rail. If the region has a large enough oil refinery, however, olefins from refinery liquids are likely to be cheaper. The following pages compare the end costs of acetylene (from dry natural gas) and of two olefins from liquid hydrocarbons in three types of regions of the Soviet Union. Tables VIII-X in the Appendix compare the costs of three further products which can be made from dry natural gas as well as liquid products (unfortunately only percentage figures are available).

Type I regions in the following table represent those where hydrocarbon resources are abundant and energy cost moderate but not cheap, such as the Middle Volga, the Baku area and to a much lesser extent the Western Ukraine. Type II includes those regions which have limited hydrocarbon resources, especially natural gas, but boast low cost energy. Central Siberia is the most obvious representative of this type. Finally, Type III embraces those regions which have extensive resources of natural gas and cheap energy, e.g. Central Asia and the North Caucasus (especially the former). These examples are not given by the source cited, but the criteria of grouping make it fairly clear which regions should be included in each group.

These are no doubt tentative comparisons, but the conclusions that may be drawn from them fit well into the general analysis of the use of olefins and acetylene in the organic petrochemical industry of the USSR. (ChapterII, p. 38-41).

Table XXII

Cost indices of acetylene, ethylene and propylene in various regions of the USSR (in percentages)

<table>
<thead>
<tr>
<th>Methods of production</th>
<th>Capital outlay</th>
<th>Projected costs in three types of regions (in percentages)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Acetylene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partial oxydization (oxygen pyrolysis) of methane from natural gas</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>High temperature pyrolysis of liquid products</td>
<td>115</td>
<td>95</td>
</tr>
<tr>
<td>Electric cracking of methane from natural gas</td>
<td>70</td>
<td>---</td>
</tr>
<tr>
<td>From coal via calcium carbide</td>
<td>115</td>
<td>---</td>
</tr>
<tr>
<td>Ethylene</td>
<td>40</td>
<td>70</td>
</tr>
<tr>
<td>Propylene</td>
<td>20</td>
<td>55</td>
</tr>
</tbody>
</table>

Source: Khimicheskaya Promyshlennost', No. 8, 1963, p.4.

Where olefins can be produced—in areas which have resources of LPG's and refinery liquids—they serve as a much more attractive base for the petrochemical industry than acetylene. Propylene is especially economic, though it is a less versatile basic chemical than ethylene (or acetylene). But ethylene, too, costs 1.3 to 1.5 times less than acetylene and its production requires much less capital investment. In regions of type II and III, however—such as Central Siberia and Middle Asia—the manufacturing of acetylene by electric cracking appears very attractive indeed and is considered cheaper than the production of ethylene (mostly from "imported" petroleum), and in Region III cheaper even than that of propylene. The much higher capital
investment necessary-- interests on which are not included in
the comparison of costs-- makes the picture somewhat less bright
for acetylene, however. Acetylene by partial combustion (oxydi-
zation) appears much more expensive, and approximately on par
in all three types of regions (This, however, does not seem to
be a realistic assumption on account of the heavy transport cost
natural gas must incur in Region II). In reality it is much
cheaper, for over 10,000 cubic meters of synthesis gas is ob-
tained along with a ton of acetylene, and this by-product is
valued at over 40% of the production cost of the acetylene, an
amount which must be deducted. In the future, the bulk of
acetylene is to be produced by this method-- a plan which is
related to the increase in the manufacturing of nitric fertili-
zers for which synthesis gas is a basic raw material.

Table XXIII provides detailed cost comparisons for the
production of acetylene in two regions of the USSR -- the Lower
Don area and Central Siberia. Production costs are compared
both for the partial combustion of methane (natural gas) and for
the electric cracking of liquid feedstocks. (It is not made
clear whether the gas used in Central Siberia would be local or
"imported". Only very small amounts of natural gas are found
here at present, though discoveries are not unlikely. "Imports"

24 L.V. Semenov et al: "Perspektivy i ekonomicheskaya
effektivnost' ispol'zovaniya lovushechnykh emulsii ... v
proizvodstve atsetilena," Khimiya i Tekhnologiya, No. 7, 1963,
p. 42, Table 1.
25 G. Borisovich: op. cit., Khimicheskaya Promyshlennost',
No. 8, 1963, p. 4.
Table XXIII

Production costs of acetylene in two localities and by two different manufacturing methods

<table>
<thead>
<tr>
<th></th>
<th>Novo Cen kask Sib</th>
<th>No. of units</th>
<th>Total Cost (rubles)</th>
<th>Novocher- Cent- kask</th>
<th>No. of units</th>
<th>Total Cost (rubles)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Price of unit</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic materials:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural gas (1000 cu.m.)</td>
<td>1.00</td>
<td>6.4</td>
<td>6.4</td>
<td>10.62</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Oxygen (1000 cu.m.)</td>
<td>6.00</td>
<td>3.6</td>
<td>21.8a</td>
<td>21.8a</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Petrol. emulsion (ton)</td>
<td>3.00</td>
<td>2.00</td>
<td>---</td>
<td>---</td>
<td>3.055</td>
<td>9.18</td>
</tr>
<tr>
<td>Auxiliary mat. (kg)</td>
<td>1.00</td>
<td>1.00</td>
<td>6.0</td>
<td>6.0</td>
<td>6.00</td>
<td>6.00</td>
</tr>
<tr>
<td><strong>Energy costs:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity (1000 kwh)</td>
<td>5.00</td>
<td>1.57</td>
<td>7.85</td>
<td>10.18</td>
<td>50.90</td>
<td>40.72</td>
</tr>
<tr>
<td>Water (ton)</td>
<td>0.012</td>
<td>0.012</td>
<td>0.54</td>
<td>0.27</td>
<td>0.27</td>
<td>0.27</td>
</tr>
<tr>
<td>Steam (cu.m.)</td>
<td>2.15</td>
<td>6.87</td>
<td>14.77</td>
<td>14.77</td>
<td>14.77</td>
<td>14.77</td>
</tr>
<tr>
<td>Condensate (cu.m.)</td>
<td>0.54</td>
<td>0.54</td>
<td>0.5</td>
<td>0.5</td>
<td>0.27</td>
<td>0.27</td>
</tr>
<tr>
<td>Wages &amp; salaries (rubles)</td>
<td>---</td>
<td>---</td>
<td>1.41</td>
<td>1.41</td>
<td>---</td>
<td>1.09</td>
</tr>
<tr>
<td>Amortization (rubles)</td>
<td>---</td>
<td>---</td>
<td>6.39</td>
<td>6.39</td>
<td>---</td>
<td>2.76</td>
</tr>
<tr>
<td>Shop &amp; Dept. expenses (ru.)</td>
<td>---</td>
<td>---</td>
<td>14.68</td>
<td>14.68</td>
<td>---</td>
<td>12.72</td>
</tr>
<tr>
<td><strong>Total plant cost</strong></td>
<td>---</td>
<td>---</td>
<td>86.27</td>
<td>89.12</td>
<td>---</td>
<td>100.51</td>
</tr>
<tr>
<td><strong>By-products:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synthesis gas (1000 cu.m.)</td>
<td>4.00</td>
<td>10.3</td>
<td>41.20</td>
<td>41.20</td>
<td>3.3</td>
<td>13.2</td>
</tr>
<tr>
<td>Carbon black (kg)</td>
<td>0.11</td>
<td>0.11</td>
<td>---</td>
<td>---</td>
<td>312.0</td>
<td>34.32</td>
</tr>
<tr>
<td><strong>End cost of 1 ton of acetylene by the combustion method (rubles)</strong></td>
<td>---</td>
<td>---</td>
<td>45.07</td>
<td>47.92</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>End cost of 1 ton of acetylene by electric cracking using:</strong> (rubles)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) 30% pet. emulsion</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>52.99</td>
<td>38.34b</td>
</tr>
<tr>
<td>b) 17% pet. emulsion</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>50.86</td>
<td>37.74b</td>
</tr>
</tbody>
</table>

a) Oxygen, whose production requires a considerable amount of electricity should be cheaper in Siberia.

b) Figures add up to slightly different end costs: 39.74 and 37.61. Either there is a minor error somewhere or there are additional factors influencing cost.

to the area east of the Yenissey do not appear probable but could be expected to the Kuznets Basin. In any case, however, the price of gas is set improbably low as explained further below).

It is clearly shown by the table that the cost of electricity makes up half the total cost of acetylene produced by electric cracking (If methane and not liquid feedstocks were cracked, even more electricity would be required.) The partial combustion method, therefore, is clearly more economic in a region, such as the Lower Don-North Caucasus, where natural gas is abundant and cheap but electricity is fairly expensive—especially when these regions are also in need of fertilizers.

The actual costs of acetylene, however, are likely to be considerably higher than those given in the table for both areas. The cost of raw materials seems unbelievably low. The chemical industry purchases gas at a price which excludes turnover and sales tax— which cuts the price by one half — and Novocherkassk is situated very close to the major deposits of the North Caucasus. Yet a price of one ruble per 1000 cubic meter is possible only if the pipelines purchase gas at cost and deliver it to the plant, making hardly any profit. (The producing enterprises and the pipelines form different departments of the State Gaz Trust (Gazprom) with separate planned profits for each). Such a course is possible, but it is certainly not sanctioned in all areas of the USSR. In Siberia, however, 1.77 rubles per 1000 cubic meter would be far too low even at cost price. A

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higher price for natural gas, however, would simply strengthen the argument of the previous pages about the competitive position of acetylene produced by partial combustion of methane. The difference between producing areas and those to which gas has to be transported would be accentuated. (Petroleum emulsion—light petroleum fractions suspended in water—cost less in Siberia than at Novocherkassk, despite the 'import' of oil from the Middle Volga, because at the latter place Caucasian crudes would be used, which are five times more expensive than crudes from the Middle Volga).

Tables VIII - XII in the Appendix illustrate the limitations of dry natural gas as raw material for organic synthesis. Dry gas can be economic only in those regions where it is plentiful, provided that these regions have cheap electricity (then electric cracking is used) or require nitric fertilizers in large quantities (then partial combustion is employed) and have, by and large, no access to LPG's or low-cost refinery products (at present, from Volga crudes).
CONCLUSION
The Soviet natural gas industry is very young: its large-scale development is the work of the past fifteen years, and especially of the last decade. Since 1950, output increased about 20 fold, and today the USSR produces about one-fourth as much as the United States. Though its proved reserves are still only a quarter of those of the latter, its ultimate reserves are far in excess, judging from the extent of promising sedimentary basins. Many of the deposits however, even today and more in the future, are inconveniently located with respect to the major consuming areas.

Notwithstanding the general eastwardly shift, the bulk of the Soviet population and industry is still found in European Russia, the Urals included, and three-fourths of all fuel is consumed west of Chelyabinsk and the Caspian Sea. As the coal resources and hydro potentials of this area are generally meager and expensive to exploit, it is here that the benefits of cheap natural gas are felt today. Outside European Russia gas consumption is as yet negligible.

Although all the economic regions of the European USSR receive gas today, the amount utilized by them and the contribution this fuel makes to the regional fuel balance varies greatly. The Central Region is by far the largest consumer, accounting for over a third of all gas used in 1962, but will soon be matched by the Urals. The Eastern Ukraine and the Volga are moderate consumers, while all other regions use only small amounts.
All areas could use much more gas than it is available to them at present, and Soviet planners are faced with the problem of allocating this still somewhat scarce resource. Although natural gas is expensive to transport, it is still the cheapest fuel in all regions of European Russia. However, cost advantage alone cannot determine whether gas will be substituted for other fuels. The relative importance of any one area, the value and transportability of alternative sources of energy, and the total saving accruing to the national economy by the replacement must all be considered. Thus while the production of lignite and/or peat is being reduced in the industrial core of the Central Region and in the Urals, it is being expanded in the more outlying areas of the Center, in the Baltic and Byelorussia. Similarly shale production has ceased in the Volga and the North Caucasus, but is being intensified in Estonia.

The share of gas in the fuel mix of the various regions does not necessarily vary according to the amount utilized, since many regions are unimportant consumers of fuel. The share is over a half in the Transcaucasus, over a third in the Volga and about a quarter in the industrial core of the Central Region. On the other hand, it is nil in Estonia, small or very small in the Leningrad Region and the Eastern Ukraine and relatively low even in the rest of the Ukrainian SSR. Very large supplies do not necessarily lead to a correspondingly high share of natural gas in the fuel mix of a region. In both Central Asia and the North Caucasus natural gas satisfies less than half of the very modest fuel need.
Because the production of natural gas is highly concentrated, large areas have and will have no output on their own. The Center, the Urals, the Leningrad Region and the Baltic have to be supplied from distant deposits through long-distance trunklines. The first two regions, in particular, are served by the two longest and largest pipeline-systems of the country. While the above regions need to "import" all their gas, the two richest provinces-- the North Caucasus and Central Asia-- utilize only a fraction of their output at home.

The areal discordance between the major producing and consuming areas is likely to increase in the future. In 1963 some three-quarters of all free gas output came from the North Caucasus and the Ukraine, while the Volga produced roughly an additional one-sixth and the bulk of the oil-well gases in the country. In that year the ratio of "industrial reserves" \( (A/B) \) to output in European Russia had fallen to an 18 year supply, while in the Ukraine, the Volga and Azerbaydzhan it was well below that figure. Obviously, new fields must be brought into production if output targets are to be met, and the necessary increase in reserves will have to come largely from Central Asia and West Siberia. At the same time, Middle Asia will remain but a minor consumer relative to more important regions in European Russia, while the swampy wilderness of the West Siberian Lowland will utilize no part of its output.

Only a small amount of natural gas is processed today, with the result that the production of natural gas liquids is as yet quite insignificant. A major consequence of this fact
is that only a very small share of Soviet gas output is consumed today as chemical raw material, since NGL's (natural gas liquids) constitute the most important natural gas-derived feedstocks for the chemical industry. Another is the relative significance of dry gas for organic products. Methane (via acetylene) is given a greater emphasis vis a vis NGL's in Soviet plans than it is receiving in the United States, especially since the manufacturing of acetylene can be profitably combined with the production of nitric fertilizers in many regions.

The development of the natural gas liquid industry, nevertheless, is given increasing attention as a prerequisite for the creation of a large petrochemical industry. In those regions, where wet gases are produced in significant quantities, such as the Middle Volga, the Caucasus and, to a much lesser extent, Central Asia and the Western Ukraine, an increasing share of wet gases will be processed in the future. Only in the Volga Region, however, are other conditions favourable enough for the large-scale production of organic intermediates from LPG's.

Still, in all regions, even in the Middle Volga, where wet oil-well gases predominate over free gases, natural gas is utilized overwhelmingly as fuel. Each region, and even sub-region, has its own distribution pattern, but the industrial sector (the consumption by power plants included) everywhere takes a share not far from the national average of over 85 percent. Nowhere, not even in the city of Moscow, do household and municipal consumers utilize directly more than a tenth of the total output, although some of the gas burned in electric
stations does end up in this sector as by-product heat.

Variations in the regional pattern of consumption are great and are influenced by a multitude of factors. While in the Eastern Ukraine, thermal stations utilize relatively small amounts, and in the Donets Basin the share of gas in the fuel mix of power plants is very low, in the Central Region, the Volga and the Transcaucasus, electric stations are very heavy consumers, accounting for a considerably higher share than the national average. The demand for, and value of, the alternative fuel, as well as the seasonal fluctuation in consumption, account for such differences. Since power plants can use practically any fuel with relatively little change in their efficiency, they burn the less valuable ones—coal in the Donbass and, generally, in the Eastern Ukraine; natural gas in the Volga and the Transcaucasus. In the Central Region, the great imbalance in seasonal consumption and the small scale of underground storage compels planners to allocate very large amounts of gas to thermal stations on an interruptible basis.

In regions which boast large iron and steel plants, and where natural gas is available, ferrous metallurgy is a most important consumer. The use of gas in the blast furnace reduces greatly the amount of coke needed, which—aside from the Kuzbass—is expensive everywhere in the USSR. Steel making in open-hearth furnaces is becoming more and more the domain of natural gas since Soviet fuel oils are either sulfurous or expensive and by-product gases have low heat value. In addition, iron and steel plants are attractive to planners, because they are very large
users and are little affected by seasonal fluctuations. In both the Eastern Ukraine and the Urals, therefore, ferrous metallurgy predominates consumption and its share will be very significant in the Central Region once the huge Novo-Lipetsk complex is completed.

In the Center, Leningrad and the Urals, though not yet in the Eastern Ukraine, gas is utilized extensively in machine building. In all regions of European Russia, again with the exception of the Eastern Ukraine, and increasingly so in Middle Asia, it appears to play a major role in the building material industry as well, since the great amount of thermal energy required by this industry cannot be produced at low enough cost by other fuels.

In the not too distant future, the Kuznets Basin and parts of North Kazakhstan and West Siberia will probably receive natural gas. Yet gas consumption will continue to be concentrated in European Russia and the Urals to an overwhelming degree, and the share of various regions is not likely to change greatly in the future. The Center and the Urals will remain the largest consumers, followed by the Eastern Ukraine and the Volga. The one region which will probably increase its presently small share of gas consumption is the Leningrad area, but only after new fields have been brought into production.

The sectoral distribution of consumption is more likely to change except in the household and municipal sectors. There are no plans to increase the share of household consumption in the future (indeed, it has been falling since the mid-fifties),
and household and municipal consumers will continue to account for slightly less than ten percent of the total amount utilized. Little variation is to be expected in the different regions except in the manner of supply. Just as today, households in the more marginal areas (e.g. Central Asia, Byelorussia and the Western Ukraine) will probably receive a very large portion of their supply in liquefied form to save investments on distribution lines. Industry will continue to receive 85 percent or more of total supply in every region, but within this sector some changes seem likely. These changes, however, will tend to reinforce the regional distribution pattern of today.

Presently, there is a decrease in the relative importance of electric stations in the total consumption, and authoritative voices criticize the indiscriminate use of gas as boiler fuel. Yet owing to the areal discordance between the concentration of population and reserves of solid fuels, as well as to the limited facilities for storage, the share of electric stations will surely remain considerably higher than in the United States. A significant relative decline can be expected only in the Ukraine and, perhaps, in the adjoining part of the North Caucasus.

The iron and steel industry has greatly expanded its share of consumption since the end of the last decade, and this increase is likely to continue until the Ural mills and the new Lipetsk complex receive enough gas for their needs. Beyond that, there may be some further growth if natural gas is introduced to the Kuznets Basin. The chemical industry, especially the petro-
chemical, is going to receive an increasing share, both in the form of natural gas liquids and of dry natural gas if Soviet plans materialize. Except for the production of fertilizers, however, this increase will be concentrated in a few regions, such as the Volga and, to a much lesser extent, the Caucasus, the Eastern Ukraine and, perhaps, Middle Asia.

The share of natural gas in the fuel mix can be expected to increase still further, and—given a decade or so—the Soviet fuel structure will approximate that of the United States. However, if production is to increase as planned (to over 300 billion cubic meters by 1970 and to circa 700 billion by 1980) proved reserves must be enormously extended—mostly in climatically harsh environment, far from population centers. Such expansion will certainly require much larger investments in the natural gas industry than it has so far received.


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Trud, October 12, 1961.


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APPENDIX TABLES
Table I

The fuel mix of the United States from 1880 to 1920 (in percent)

<table>
<thead>
<tr>
<th>Year</th>
<th>Coal</th>
<th>Oil</th>
<th>Natural Gas</th>
<th>Nat. Gas liquids</th>
<th>Hydro-power</th>
<th>Wood</th>
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<td>n.a.</td>
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<td>1895</td>
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<td>1.9</td>
<td>.3</td>
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<td>30.1</td>
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<td>2.6</td>
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<td>2.9</td>
<td>13.9</td>
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<td>76.8</td>
<td>6.1</td>
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<td>3.3</td>
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<td>3.8</td>
<td>3.9</td>
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<td>1920</td>
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<td>.2</td>
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Table II

Gross Consumption of Commercial Sources of Energy
(million metric tons coal equivalent)

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<tr>
<th></th>
<th>Solid</th>
<th>Liquid</th>
<th>Gas</th>
<th>Electricity (hydro, geothermal and imported)</th>
<th>Total</th>
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<td><strong>North America</strong></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>1929</td>
<td>559.8</td>
<td>179.2</td>
<td>73.3</td>
<td>45.7</td>
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<td>1937</td>
<td>457.4</td>
<td>200.7</td>
<td>105.5</td>
<td>50.4</td>
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<td>1950</td>
<td>488.6</td>
<td>403.7</td>
<td>251.0</td>
<td>86.9</td>
<td>1230.2</td>
</tr>
<tr>
<td><strong>Latin America</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1929</td>
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<td>15.0</td>
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<td>45.1</td>
<td>4.9</td>
<td>6.4</td>
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<tr>
<td><strong>Oceania</strong></td>
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<td></td>
<td></td>
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</tr>
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<td>2.4</td>
<td>---</td>
<td>0.8</td>
<td>15.2</td>
</tr>
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<td>1937</td>
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<td>1.2</td>
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</tr>
<tr>
<td>1950</td>
<td>20.7</td>
<td>8.6</td>
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<td>2.7</td>
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<td><strong>Europe</strong></td>
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<tr>
<td>1929</td>
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<td>1.7</td>
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Table III
Technical Indices of Blast-furnace Smelting

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<tr>
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<th>Air Blasting without natural gas</th>
<th>Blasting with natural gas</th>
<th>Blasting with gas, enriched by oxygen</th>
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<td>Blast temperature</td>
<td>1200</td>
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<td>Coke consumption</td>
<td>0.538</td>
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<tr>
<td>Volumetric efficiency</td>
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<td>Productivity (percentage)</td>
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<tr>
<td>Natural gas consumption</td>
<td>---</td>
<td>145</td>
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<tr>
<td>Oxygen consumption</td>
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<tr>
<td>Blast consumption</td>
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<td>Oxygen content in blast (percent)</td>
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Table IV

Transport Costs of Natural Gas. Cost variations according to length and diameter of pipelines and the volume of gas transported (rubles per 1000 cubic meters)

<table>
<thead>
<tr>
<th>Inside diameter and thickness of pipe wall (Millimeters)</th>
<th>Inside diameter and thickness of pipe wall</th>
<th>Transport of gas (billion cubic meters per year)</th>
<th>Distance, km.</th>
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<tr>
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<td>5.7</td>
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## Table V

Cost Structure of Gas Transport over the Kiev Network

*(comprising the Dashava-Kiev, Kiev-Bryansk and Shebelinka-Poltava lines)*

<table>
<thead>
<tr>
<th>Item</th>
<th>Percent of total 1960</th>
<th>1961</th>
<th>1962</th>
<th>1000 rubles per 1 km 1960</th>
<th>1961</th>
<th>1962</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wages</td>
<td>20.3</td>
<td>19.3</td>
<td>18.1</td>
<td>0.81</td>
<td>0.72</td>
<td>0.53</td>
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<tr>
<td>Materials and reagents</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
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<tr>
<td>Energy</td>
<td>7.6</td>
<td>6.5</td>
<td>2.1</td>
<td>0.31</td>
<td>0.24</td>
<td>0.06</td>
</tr>
<tr>
<td>Amortization</td>
<td>61.4</td>
<td>63.4</td>
<td>69.8</td>
<td>2.47</td>
<td>2.36</td>
<td>2.13</td>
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<tr>
<td>Maintenance and inventory</td>
<td>2.7</td>
<td>2.8</td>
<td>3.0</td>
<td>0.11</td>
<td>0.11</td>
<td>0.08</td>
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<tr>
<td>Transport expenses</td>
<td>1.1</td>
<td>1.1</td>
<td>0.4</td>
<td>0.05</td>
<td>0.04</td>
<td>0.02</td>
</tr>
<tr>
<td>Administration and organization</td>
<td>4.0</td>
<td>3.9</td>
<td>3.6</td>
<td>0.16</td>
<td>0.14</td>
<td>0.11</td>
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<tr>
<td>Other economic expenses</td>
<td>2.4</td>
<td>2.5</td>
<td>2.5</td>
<td>0.09</td>
<td>0.09</td>
<td>0.07</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>100%</strong></td>
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Table VI

Cost structure of natural gas extraction

<table>
<thead>
<tr>
<th>Item of Expense</th>
<th>North-Stavropol'</th>
<th>Ukraine</th>
<th>Saratov Ob.</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>kop./1000 cu.m.</td>
<td>%</td>
<td>percent</td>
</tr>
<tr>
<td>Wages</td>
<td>1.7</td>
<td>9.5</td>
<td>17.5</td>
</tr>
<tr>
<td>Amortization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-of wells</td>
<td>11.7</td>
<td>66.0</td>
<td>50.0</td>
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<tr>
<td>-of other equip-</td>
<td>5.4</td>
<td>30.4</td>
<td>30.3</td>
</tr>
<tr>
<td>-ment</td>
<td>6.3</td>
<td>35.6</td>
<td>19.7</td>
</tr>
<tr>
<td>Repair</td>
<td>0.4</td>
<td>2.1</td>
<td>0.5</td>
</tr>
<tr>
<td>Other production</td>
<td>0.7</td>
<td>3.9</td>
<td>---</td>
</tr>
<tr>
<td>cost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Departmental cost</td>
<td>1.3</td>
<td>7.3</td>
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<tr>
<td>General industrial cost</td>
<td>0.8</td>
<td>4.5</td>
<td>32.0</td>
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<tr>
<td>Administration</td>
<td>1.2</td>
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<tr>
<td>Total Cost</td>
<td>17.8</td>
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Table VII

Projected costs of natural gas and coal in 1965 at major consuming centers and necessary capital investments (rubles per ton of nominal fuel)

<table>
<thead>
<tr>
<th>Points of consumption</th>
<th>NATURAL GAS</th>
<th>COAL</th>
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<tr>
<td></td>
<td>Gas Fields</td>
<td>Capital Outlay</td>
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<tr>
<td></td>
<td>Out-put</td>
<td>Trans-put</td>
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<tr>
<td>Leningrad</td>
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<td></td>
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<tr>
<td>East Ukraine</td>
<td>0.41</td>
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<tr>
<td>North Caucasus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riga</td>
<td>0.65</td>
<td>2.1</td>
</tr>
<tr>
<td>West Ukraine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moscow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Caucasus</td>
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<td>1.4</td>
</tr>
<tr>
<td>East Ukraine</td>
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<td></td>
</tr>
<tr>
<td>Volga</td>
<td>0.52</td>
<td>0.8</td>
</tr>
<tr>
<td>Gor'kiy</td>
<td>0.46</td>
<td>0.19</td>
</tr>
<tr>
<td>Rostov</td>
<td>0.52</td>
<td>0.04</td>
</tr>
<tr>
<td>Saratov</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volga</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tbilisi</td>
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<td></td>
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<tr>
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<td>0.7</td>
<td>0.8</td>
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<td>Karadag</td>
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<td></td>
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<tr>
<td>Sverdlovsk</td>
<td>Central Asia</td>
<td>0.22</td>
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<tr>
<td>Minsk</td>
<td>Western Ukraine</td>
<td>0.55</td>
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<tr>
<td>Kiev</td>
<td>Western Ukraine</td>
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<tr>
<td>Tashkent</td>
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<tr>
<td>Alma-Ata</td>
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## Table VIII

Cost indices of vinyl chloride in various regions

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<th>Method of production</th>
<th>Capital Outlay</th>
<th>Projected costs in three types of regions (in percent)</th>
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<tr>
<td></td>
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<td>I</td>
</tr>
<tr>
<td>Hydrochlorination (with regeneration of HCl) of acetylene produced by:</td>
<td></td>
<td>75</td>
</tr>
<tr>
<td>a) high temperature pyrolysis</td>
<td>85</td>
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</tr>
<tr>
<td>b) electric cracking</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>From dichlorehthane and acetylene in conjunction (acetylene made by pyrolysis)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>portion of acetylene: 0.3 ton</td>
<td>90</td>
<td>105</td>
</tr>
<tr>
<td>portion of acetylene: 0.2 ton</td>
<td>75</td>
<td>90</td>
</tr>
<tr>
<td>As above, with acetylene made by electric cracking</td>
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<td></td>
</tr>
<tr>
<td>portion of acetylene: 0.3 ton</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>portion of acetylene: 0.2 ton</td>
<td>65</td>
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## Table IX

Cost indices of acetaldehyde, produced from acetylene and ethylene, in various regions

<table>
<thead>
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<th>Method of production</th>
<th>Capital Outlay</th>
<th>Projected costs in three types of regions (in percent)</th>
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<tr>
<td></td>
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<td>I</td>
</tr>
<tr>
<td>Acetylene</td>
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<td>100</td>
</tr>
<tr>
<td>Hydration of acetylene, produced by partial combustion of methane</td>
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</tr>
<tr>
<td>Hydration of acetylene, produced by electric cracking of methane</td>
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<td></td>
</tr>
<tr>
<td>Hydration of acetylene, produced by high temperature pyrolysis</td>
<td>110</td>
<td>100</td>
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<tr>
<td>Ethylene</td>
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<td>95</td>
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<tr>
<td>Dehydration of ethyl alcohol produced through hydration of ethylene</td>
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<td>105</td>
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<tr>
<td>Straight oxydization of ethylene</td>
<td>95</td>
<td>60</td>
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*Source: Khimicheskaya Promyshlennost*, No. 8, 1963,
Table X

Projected costs and capital investment of acetylene in various regions (in percent)

<table>
<thead>
<tr>
<th>Economic Regions</th>
<th>Central Region</th>
<th>Volga Region</th>
<th>Leningrad Region</th>
<th>Middle Asia</th>
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<tbody>
<tr>
<td>End cost of acetylene</td>
<td>100</td>
<td>76</td>
<td>104</td>
<td>74</td>
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<tr>
<td>Cost of raw material</td>
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<tr>
<td>(natural gas)</td>
<td>100</td>
<td>45</td>
<td>131</td>
<td>31</td>
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<tr>
<td>Energy costs</td>
<td>100</td>
<td>62</td>
<td>103</td>
<td>60</td>
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<tr>
<td>Capital investment</td>
<td>100</td>
<td>91</td>
<td>102</td>
<td>90</td>
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* On basis of East Ukrainian and Saratov gas.
** On basis of East Ukrainian gas.

Table XI

Projected costs of olefins in various regions (in percent)

<table>
<thead>
<tr>
<th>Economic Regions</th>
<th>Tentative end costs</th>
<th>Expenditure on:</th>
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<tr>
<td></td>
<td></td>
<td>raw material</td>
</tr>
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<td></td>
<td></td>
<td>energy</td>
</tr>
<tr>
<td>Leningrad</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Center</td>
<td>94</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>82</td>
</tr>
<tr>
<td>Volga (a) liquid</td>
<td>77</td>
<td>79</td>
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<tr>
<td>petroleum products</td>
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<td>49</td>
</tr>
<tr>
<td>(b) L.P.G.'s</td>
<td>60</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23</td>
</tr>
<tr>
<td>North Caucasus (a)</td>
<td>94</td>
<td>111</td>
</tr>
<tr>
<td>petroleum products</td>
<td></td>
<td>59</td>
</tr>
<tr>
<td>(b) L.P.G.'s</td>
<td>70</td>
<td>63</td>
</tr>
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<td></td>
<td></td>
<td>30</td>
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<td>East Siberia (Bashkir</td>
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<td>121</td>
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<td>oil)</td>
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<td>47</td>
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<td>Far East</td>
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<td>105</td>
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<tr>
<td></td>
<td></td>
<td>82</td>
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</tbody>
</table>

* probably from petroleum products.
** may be from condensates.

Source: N. Fedorenko & A. Vayn: op. cit., Planovoye Khozyaystvo, No. 5, 1964, p. 27, Table 4 and Table 3.
Projected costs of vinyl chloride and vinyl acetate on the basis of acetylene from natural gas and acetylene plus ethylene from petroleum products (in percent)

<table>
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<tr>
<th>Economic Regions</th>
<th>Vinyl chloride</th>
<th>Vinyl acetate</th>
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<tbody>
<tr>
<td></td>
<td>From natural</td>
<td>From petroleum</td>
</tr>
<tr>
<td>Leningrad</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Center</td>
<td>88.3</td>
<td>99.2</td>
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<tr>
<td>Volga</td>
<td>68.8</td>
<td>80.4</td>
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<tr>
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<td>88.0</td>
<td>92.3</td>
</tr>
<tr>
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<td>65.7</td>
<td>81.3</td>
</tr>
<tr>
<td>West Siberia</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>East Siberia</td>
<td>67.8</td>
<td>82.9</td>
</tr>
<tr>
<td>Far East</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

**Note:** Percents may be compared only within vertical columns. Data for natural gas and petroleum products cannot be compared.

* Vinyl chloride and vinyl acetate can be produced via acetylene as well as ethylene. It is not shown in the table which route is chosen. The cheaper route is generally via ethylene, but this chemical cannot be produced from dry gas while acetylene can be made from any feedstock. One suspects that in the Volga and perhaps in the Center too, these figures were arrived at on the basis of LPG and not dry gas. This would allow production via ethylene, and would explain why cost is no higher in the Center than in the North Caucasus, which is a major gas-producing area.

**Source:** N. Fedorenko & A. Vayn: *op. cit., Planovoye Khozyaystvo*, 1964, No. 5, p. 28-29.
Table XIII

Projected Cost of Following Products:
(In percent)

<table>
<thead>
<tr>
<th>Two Regions</th>
<th>Methyl alcohol</th>
<th>Vinyl-acetate</th>
<th>Phenol</th>
<th>Caprolactone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Asia</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>East Siberia</td>
<td>107</td>
<td>87.4</td>
<td>95.0</td>
<td>94.5</td>
</tr>
</tbody>
</table>

SOURCES for MAPS

Map 1, 2 & 3: Sources for Table III (p. 13) and Table VI (p.48);
Oil and Gas Journal, June 8, 1964, p. 114; "V gazprom SSSR," Gazovaya Promyshlennost', No. 8, 1964, p. 44;
Izvestiya, March 29, 1964, p. 5 and others.

Modified.

Map 5: Yu. I. Bokserman: op. cit., p. 95-143 and inset map between p. 68 and 69; N. K. Nam: op. cit.,
Gazovoye Delo, No. 5, 1963, p. 40-41; R. E. King; op. cit.,
American Assoc. of Petroleum Geologists, 1964, p. 1342;
Oil and Gas Journal, June 8, 1964, p. 114; "V gazprom SSSR," Gazovaya Promyshlennost', No. 3, 1964, p. 441;
Izvestiya, March 29, 1964, p. 5 and March 15, 1965, p. 4, and others.


Maps 7 - 16: For these regional maps, various atlases and sketch maps were used as well as newspaper reports on construction of plants, power stations, etc.