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SPATIAL VARIATIONS IN ENERGY ACCESSIBILITY  
IN THE SOVIET UNION, 1960-1975

by

RUSSELL VICTOR OLSON, JR.

B.A., The Citadel, 1969

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of the  
Requirements for the Degree

MASTER OF ARTS

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SPATIAL VARIATIONS IN ENERGY ACCESSIBILITY  
IN THE SOVIET UNION, 1960-1975

by

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129 major administrative and industrial centers for 1960, 1970, and 1975. A general purpose contouring program mapped relative energy potential indices, and these maps showed that the areas with the highest energy accessibility [REDACTED] were also among the most important industrial areas. A correlation analysis between energy accessibility and urban population growth revealed that changes in energy accessibility have had a modest influence on urban population growth rates. Soviet industrial location and urban population growth have been relatively unrestrained by the location of energy resources.

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## TABLE OF CONTENTS

|                                                            | <u>Page</u> |
|------------------------------------------------------------|-------------|
| ACKNOWLEDGEMENTS . . . . .                                 | iii         |
| LIST OF TABLES . . . . .                                   | vi          |
| LIST OF FIGURES . . . . .                                  | vii         |
| CHAPTER I    INTRODUCTION . . . . .                        | 1           |
| Background . . . . .                                       | 1           |
| Problem Statement . . . . .                                | 5           |
| Research Objectives . . . . .                              | 8           |
| Outline of Chapter Contents . . . . .                      | 8           |
| CHAPTER II    LITERATURE REVIEW . . . . .                  | 11          |
| Introduction . . . . .                                     | 11          |
| Urban Growth . . . . .                                     | 11          |
| Industrial Location . . . . .                              | 16          |
| Natural Resources . . . . .                                | 20          |
| Potential Models . . . . .                                 | 24          |
| Summary . . . . .                                          | 26          |
| CHAPTER III    DATA AND METHODOLOGY                        |             |
| Introduction . . . . .                                     | 30          |
| An Energy Potential Model . . . . .                        | 33          |
| Energy Production Data . . . . .                           | 35          |
| Distance Measurement . . . . .                             | 43          |
| Energy Potential: Indices and Maps . . . . .               | 46          |
| CHAPTER IV    ANALYSIS OF ENERGY ACCESSIBILITY . . . . .   | 56          |
| Introduction . . . . .                                     | 56          |
| Nodal Rank Ordering and Energy Potential Maps . . . . .    | 56          |
| Urban Population Growth and Energy Accessibility . . . . . | 80          |
| Summary . . . . .                                          | 84          |
| CHAPTER V    CONCLUSION . . . . .                          | 87          |
| Introduction . . . . .                                     | 87          |
| Implications . . . . .                                     | 87          |
| Areas for Future Research . . . . .                        | 92          |

|                                                                                                               | <u>Page</u> |
|---------------------------------------------------------------------------------------------------------------|-------------|
| BIBLIOGRAPHY . . . . .                                                                                        | 95          |
| APPENDIX A    DISTANCES TO COAL SOURCES . . . . .                                                             | 100         |
| APPENDIX B    DISTANCES TO OIL SOURCES . . . . .                                                              | 107         |
| APPENDIX C    DISTANCES TO GAS SOURCES . . . . .                                                              | 117         |
| APPENDIX D    COAL, OIL, AND NATURAL GAS POTENTIAL INDICES BASED<br>ON DISTANCE AND TRANSPORT COSTS . . . . . | 124         |
| APPENDIX E    URBAN POPULATION DATA . . . . .                                                                 | 131         |

# LIST OF TABLES

| <u>Table</u> |                                                                                                                                                  | <u>Page</u> |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| 3.1          | Soviet Energy Production, in Million Metric Tons of<br>Standard Fuel and Percentage of Total . . . . .                                           | 34          |
| 3.2          | Regional Distribution of Soviet Coal Production . . . . .                                                                                        | 36          |
| 3.3          | Regional Distribution of Soviet Oil Production . . . . .                                                                                         | 37          |
| 3.4          | Regional Distribution of Soviet Natural Gas Production . .                                                                                       | 39          |
| 3.5          | Comparison of Selected Oil Pipeline and Rail Distances . .                                                                                       | 45          |
| 3.6          | Energy Accessibility Based on Distance . . . . .                                                                                                 | 47          |
| 3.7          | Energy Accessibility Based on Transport Costs . . . . .                                                                                          | 50          |
| 4.1          | Rankings by Relative Energy Potential Based on Distance .                                                                                        | 57          |
| 4.2          | Rankings by Relative Energy Potential Based on<br>Transportation . . . . .                                                                       | 62          |
| 4.3          | Correlation Coefficients and Significance Levels Between<br>Urban Population Data and Energy Accessibility Based on<br>Distance . . . . .        | 82          |
| 4.4          | Correlation Coefficients and Significance Levels Between<br>Urban Population Data and Energy Accessibility Based on<br>Transport Costs . . . . . | 83          |

## LIST OF FIGURES

| <u>Figure</u>                                                    | <u>Page</u> |
|------------------------------------------------------------------|-------------|
| 1.1    Population Distribution . . . . .                         | 4           |
| 1.2    Soviet Energy Sources . . . . .                           | 6           |
| 3.1    Nodes Used in Study . . . . .                             | 32          |
| 4.1    Soviet Energy Potential: 1960 Based on Distance . . . . . | 67          |
| 4.2    Soviet Energy Potential: 1970 Based on Distance . . . . . | 69          |
| 4.3    Soviet Energy Potential: 1975 Based on Distance . . . . . | 71          |
| 4.4    Soviet Energy Potential: 1960 Based on Transport Costs .  | 73          |
| 4.5    Soviet Energy Potential: 1970 Based on Transport Costs .  | 75          |
| 4.6    Soviet Energy Potential: 1975 Based on Transport Costs .  | 77          |

## CHAPTER I

### INTRODUCTION

#### Background

The Soviet Union is the only large industrialized country in the world to be completely self-sufficient in energy resources at the present and for the foreseeable future (Lydolph 1979, p. 261). Although the Soviet Union has imported natural gas from its neighbors to the south, Iran and Afghanistan (Ebel 1978, p. 165, Lydolph 1979, p. 280), and some coal from Poland (Lydolph 1979, p. 288), these imports reflect the uneven spatial distribution of energy resources within the U.S.S.R. and the desire of the Soviets to minimize transportation costs in providing energy to outlying areas of the country. In fact, the Soviet Union is a net exporter of coal, oil, and gas with oil being its primary hard currency earning export. It is largely through the export of energy resources that the Soviets have been able to gain the hard currency with which they have purchased the large quantities of feed grain needed to maintain livestock herds at levels sufficient to placate the desires of the Soviet consumer for more meat. This hard currency is also used to obtain the high technology items which the U.S.S.R. is either unable or unwilling to produce itself due to production bottlenecks inherent in its centrally planned economy.

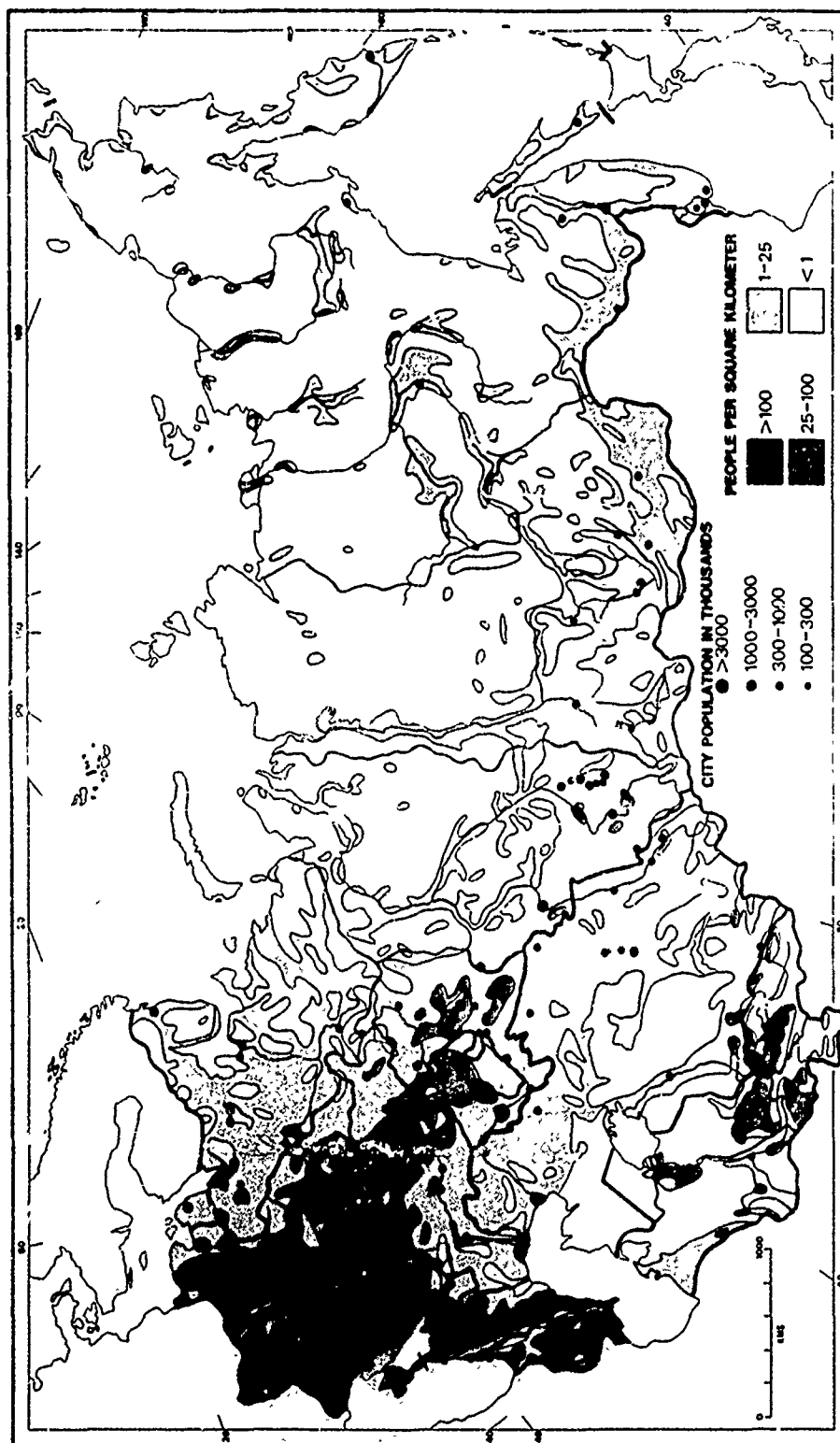
Even more important than their current position as major export items has been the use of energy resources to fuel the boilers of Soviet industry and thus provide the foundation upon which the steady growth of Soviet GNP during the past three decades has depended (Lydolph 1979, pp. 199-200; Cohn 1970). Dienes (1978) has demonstrated the uniqueness of the high level of energy intensity of Soviet economic development, and Dewdney (1976) has stated that "among the many factors that have favoured the industrial growth of the Soviet Union, none has been more important than that country's possession, within its own borders, of vast energy resources of all types" (p. 62). Unfortunately for the Soviets, "there is a striking lack of coincidence between the location of most of this industrial energy and the present centres of consumption" (Hooson 1966, p. 81). Three-fourths of the population and four-fifths of the industry of the Soviet Union are found in the European portion of the country, including the Urals and the Caucasus, while as much as 90% of the estimated energy reserves, including hydroelectricity, are located east of the Urals and the Caspian Sea (Dienes 1971).

When Soviet industrial energy needs were much more modest than they are now, adequate energy resources were easily accessible in locations favorably situated in the so-called "fertile triangle" of the country where most of the population is located (Figure 1.1). The Soviet Union possesses vast reserves of energy resources, but, as Hardt (1973) so aptly paraphrased Khrushchev, "the U.S.S.R. cannot fire its diesels with statistics" (p. 27). Consequently, the Soviets have been forced to search elsewhere for new sources of energy. The spatial distribution of energy resources within the Soviet Union has resulted in the exploitation of coal, oil, and gas fields that are far removed from the population

FIGURE 1.1

Source: Lydolph (1979, p. 156)





and industrial centers of the country. Examples of this include increased production at the coal basins of Pechora, Kansk-Achinsk, and Ekibastuz, as well as the discovery of the supergiant oil and gas fields of Tyumen Oblast in Western Siberia (Figure 1.2). The further burdening of an already overtaxed railroad network and the building of oil and gas pipelines have been necessary to make these energy resources accessible to the bulk of Soviet energy consumers.

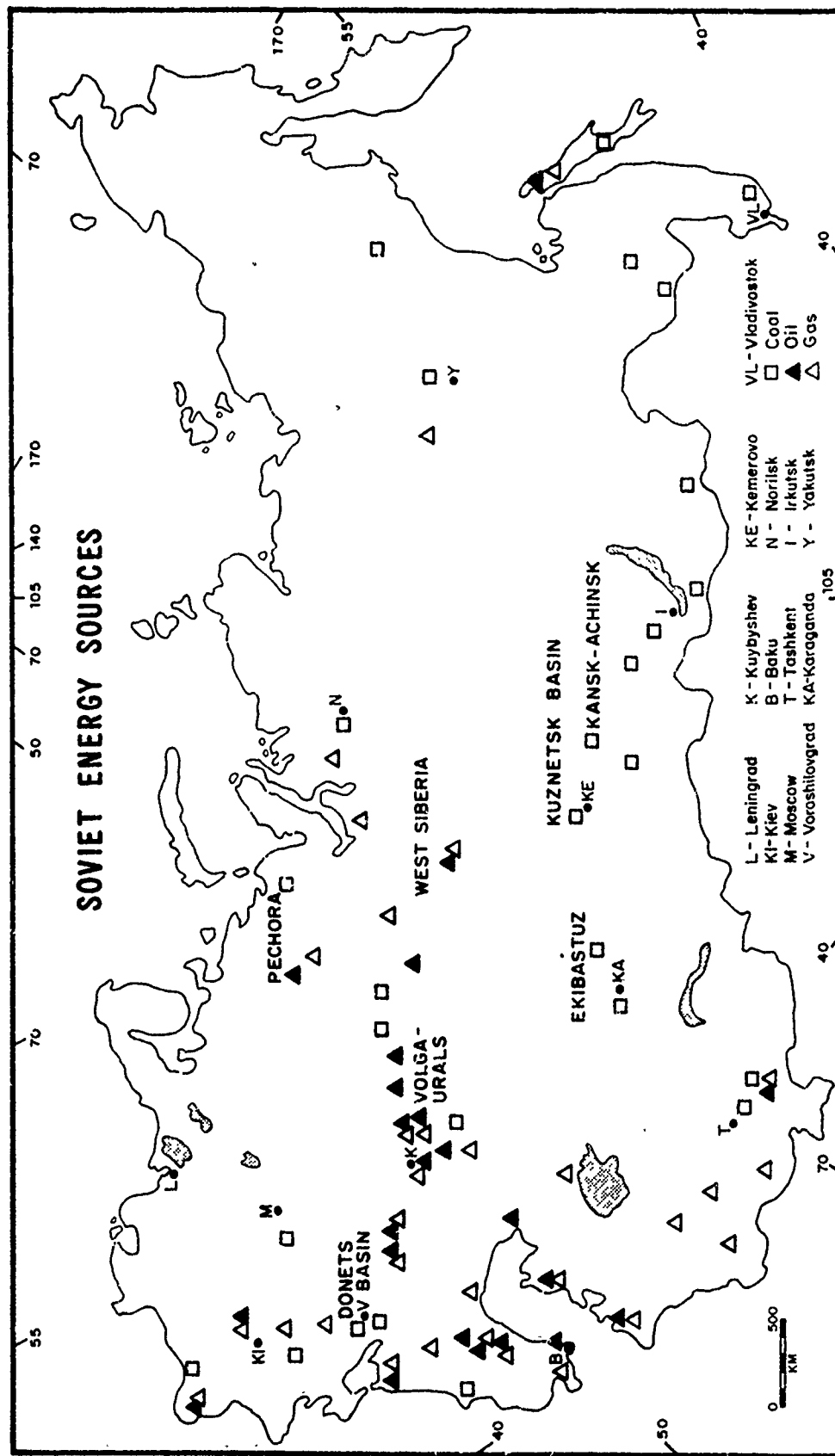
### Problem Statement

As the emphasis of Soviet energy production shifted eastward and links were built to make this energy available for use to the urban and industrial consuming centers of the European U.S.S.R., certain areas and nodes (industrial and administrative centers) have undoubtedly undergone significant changes (absolute and relative in comparison to other areas and nodes) in accessibility to energy. The purpose of this study is to examine the changes in energy accessibility in the Soviet Union through the use of an energy potential model and to determine what influences these changes might have had on urban growth and industrial location. The aim of this research is not to explain all the complex factors involved in Soviet urban growth and industrial location but only to investigate the interrelationship between energy accessibility on the one hand and urban growth and industrial location on the other.

Energy accessibility will be determined for 129 nodes, and energy potential maps of the Soviet Union will be compiled for the years 1960, 1970, and 1975. Only coal, oil, and gas will be used in this study. Peat, oil shale, firewood, and electricity from hydroelectric and nuclear power plants can be very important on a local level but contribute little

FIGURE 1.2

Source: Data for outline and cities taken from Soviet Union  
National Geographic Society, 1976,  
transverse polyconic projection



on a national basis. The three major types of energy together accounted for 89.2, 92.1, and 93.6 percentage of total Soviet production for the years 1960, 1970, and 1975 respectively (Dienes and Shabad 1979, pp. 32-34).

### Research Objectives

This study will attempt to provide answers to the following central research questions.

1. How can energy accessibility be measured through the use of a potential model?
2. What have been the changing patterns of energy accessibility in the Soviet Union? How has energy accessibility in the Soviet Union changed during the study period?
3. How do spatial patterns of energy accessibility correspond with industrial areas in the Soviet Union?
4. What is the relationship between energy accessibility and urban growth?
5. If energy accessibility has been an important factor in urban growth and industrial location, has its importance been increasing or decreasing? Is it likely to be an important factor in the future?

### Outline of Chapter Contents

Chapter II reviews major studies dealing with Soviet urban growth, industrial location, and natural resources. Specifically, it summarizes factors influencing Soviet urban growth, socialist principles of industrial location, links between resources and industrial output, links between industrial output and urban population, and the use of potential

models. Methodology is the theme of Chapter III, which discusses the selection of the data points and the types of energy and describes the energy potential model, the compilation of the data matrices, and the development of the energy potential maps. Chapter IV analyzes the data assembled in Chapter III in an effort to determine and evaluate whatever links may exist between energy accessibility on the one hand and urban growth and industrial location on the other. A summary of findings and the implications of this study are presented in Chapter V.

References

- Cohn, S.H. 1970. General Growth Performance of the Soviet Economy. In Economic Performance and the Military Burden in the Soviet Union, Subcommittee on Foreign Economic Policy of the Joint Economic Committee, Congress of the United States, pp. 9-17, Washington, D.C.: U.S. Government Printing Offices.
- Dewdney, J.C. 1976. The U.S.S.R. Kent, England: Wm. Dawson & Sons Ltd.
- Dienes, L. 1971. Issues in Soviet Energy Policy and Conflicts over Fuel Costs in Regional Development. Soviet Studies 23, 1:26-58.
- Dienes, L. 1978. Soviet Energy Policy and the Hydrocarbons. Washington, D.C.: Association of American Geographers Project on Soviet Natural Resources in the World Economy, Discussion Paper 2.
- Dienes, L. and Shabad, T. 1979. The Soviet Energy System. Washington, D.C.: V.H. Winston & Sons.
- Ebel, R.E. 1970. Communist Trade in Oil and Gas. New York: Praeger Publishers.
- Hardt, J.P. 1973. West Siberia: The Quest for Energy. Problems of Communism 22, 3:25-36.
- Hooson, D.J.M. 1966. The Soviet Union. London: University of London Press.
- Lydolph, P.E., 1979. Geography of the U.S.S.R., Topical Analysis. Elkhart Lake, Wisconsin: Misty Valley.

## CHAPTER II

### LITERATURE REVIEW

#### Introduction

This research has been undertaken in an effort to determine patterns of energy accessibility in the Soviet Union and to assess the significance of energy accessibility on urban growth and industrial location. The literature dealing with Soviet urban growth, industrial distribution, and natural resources is quite diverse, and this chapter reviews the published literature relevant to the establishment of links between urban population, industrial location, and natural resources, particularly energy. In order to place the relationship between energy accessibility and urban growth in proper perspective, it is necessary to summarize the many factors influencing urban growth and industrial location and to demonstrate how urban population can be used as a surrogate measure of industrial distribution. There are five sections in this review. The first three cover Soviet urban growth, industrial location, and natural resources. The fourth reviews uses of potential models, and the last section is a summary.

#### Urban Growth

In their study of Russian and Soviet urbanization, Lewis and Rowland (1969) asserted that "the growth of Soviet cities is the most

visible geographic change that has occurred in the U.S.S.R." (p. 776). Their definition of urbanization had two applications (Lewis and Rowland 1969, p. 779). Level of urbanization referred to the percentage of total population living in centers with a population of at least 15,000, and change in urbanization was the absolute change in the level of urbanization. Although they analyzed urbanization in terms of industrialization, transportation accessibility, and in-migration, they felt that urban population growth was so obviously the most important factor in urbanization that it was unnecessary to test the relationship. In some parts of their study, they even used urban population as an index of urbanization (Lewis and Rowland, 1969, pp. 779, 782, 785, and 789).

To determine national and regional patterns of urbanization, data for population centers of 50,000 and over were aggregated at the economic region level for the period 1959-1966 (Data were not available for centers under 50,000 for that period, but centers of 50,000 and over accounted for 76 percent urban population). During 1959-1966, the Donets-Dnepr, Central Chernozem, Volga-Vyatka, Northwest, and Belorussia regions exhibited the greatest increase in urbanization, and the most rapid urban growth occurred in Moldavia, Central Asia, Kazakhstan, Belorussia, and the Central Chernozem regions (Lewis and Rowland 1969, p. 789).

A rank correlation analysis of the effect of industrialization (as measured by the percentage of the total population in manufacturing) on urbanization (as measured by the percentage of the total population classified as urban) showed that between 1926 and 1961 industrialization was a significant factor (.05 level) in promoting the "city-forming process," with a Spearman rank correlation coefficient of +0.794. The level of urbanization in 1959 had a rank correlation of +0.828 with the

percentage of the total population in manufacturing in 1961 (Lewis and Rowland 1969, p. 791). Further analysis revealed that industrialization was more significant in stimulating the growth of large cities with a population of over 100,000 ( $r = +0.766$ ) than of small ones ( $r = +0.609$ ) for the period 1926-1961. The authors also mentioned that large cities produced 70-75% of Soviet gross industrial production (Lewis and Rowland 1969, p. 792). Transportation accessibility and in-migration were also noted as important factors in Russian and Soviet urbanization (Lewis and Rowland 1969, pp. 792-795).

Harris (1971) examined the growth of Soviet urban population between 1959 and 1970. At the regional level, variations in urban population growth were due primarily to the different stages each region had reached in the urban and demographic revolutions. "The urban revolution is marked by high rates of urban growth sustained by a massive rural-urban migration," and "the demographic revolution is characterized by falling death rates and falling birth rates but at different times" (Harris 1971, pp. 102-103). He stated that "among the major economic regions, variations in the rate of increase in urban population are inversely related to the proportion of the population urban, are positively connected with rate of natural increase in population, and are negatively associated with change in level of rural population" (Harris 1971, p. 110).

At the oblast level, high urban growth rates were associated with a low percentage of population urban, as in Rovno and Belgorod oblasts, in the Ukraine and the RSFSR, respectively, or with a high rate of natural increase, as in Guryev oblast in Kazakhstan and oblasts in Soviet Central Asia. A number of urban districts that had experienced the most

rapid urban growth during 1926-1939 displayed low urban growth rates during 1959-1970 (20 percent or less compared to the national average of 36 percent). These included Donetsk and Voroshilovgrad oblasts in the Donbas area, Tula oblast in the Moscow Coal Basin, and Kemerovo oblast in the Kuzbas region, all of which were heavily dependent on the coal industry "which has suffered from the competition of rapidly expanding petroleum and natural gas production" (Harris 1971, p. 116). Petroleum and natural gas discoveries helped account for rapid urban growth in oblasts in Soviet Central Asia, western Kazakhstan, and Western Siberia.

Of the 221 cities with 100,00 or more population in 1970, Harris (1971) briefly examined the growth of 28 cities with high growth rates (over 75 percent) and six cities with population decreases since 1959. Of the 28 cities with high growth rates, 16 were industrial cities, and 12 were diversified political-administrative centers. Of the 16 industrial cities, seven were associated with chemical industries, four with hydroelectric projects, three with iron and steel mills, and two with other industries. Of the seven industrial cities with chemical industries, Novgorod, Grodno, Rovno, and Cherkassy were old cities with fuel deficiencies that had had slow growth rates stimulated by the piping-in of natural gas (Harris 1971, p. 119). The six cities which showed population declines during 1959-1970 were coal-mining cities in the Donbas, Kuzbas, and Chelyabinsk coal basin (Harris 1971, p. 122-123).

A similar study by Lydolph and Pease (1972) found that during the period 1939-1959, most cities from the Volga eastward experienced high growth rates with particularly high rates for coal mining towns, while western cities grew less rapidly (Lydolph and Pease 1972, p. 252). This pattern of growth generally reversed itself during 1959-1970, and the

growth rate and absolute declines of coal mining centers across the country reflected the declining importance of coal in the Soviet energy mixture (Lydolph and Pease 1972, pp. 252-255). These declines give substance to the statement that "trends in industrialization are intimately related to trends in city growth" (Lydolph and Pease 1972, p. 252).

Lydolph and Pease (1972) felt that the growing importance of oil and natural gas would smooth the way for the location of industries in the western heavily populated areas. They wrote:

The discovery and exploitation of huge deposits of oil and gas in such remote regions as Western Siberia and the Mangyshlak Peninsula of Central Asia will bring boom times to these areas and will produce a few workers' settlements of considerable size, but these energy sources will be removed from their regions of origin for consumption elsewhere and will not provide an impetus for widespread settlement of these empty areas. Western Siberia's anticipated role as producer of one-third of all Soviet oil in 1980 will have its primary impact not on potential changes within the region itself, but rather on its contribution to total Soviet energy production, the increased supplies of easily transported fluid fuels, permitting the establishment of people-oriented industries serving the labor and markets of the Soviet West (Lydolph and Pease 1972, p. 261).

Urbanization continued unabated during the 1970-1979 intercensal period, and patterns of urban growth corresponded closely with those of the 1959-1970 period (Lydolph et al. 1978, p. 525; Bond and Lydolph 1979, pp. 461-475). The growth rates of most cities with populations over 100,000 declined from the 1959-1970 period, but this seemed "to be related more to stages of development than to geographical location" (Lydolph et al. 1978, p. 528). Although "no universally applicable axiom emerges relating magnitudes of growth to city functions" (Bond and Lydolph 1979, p. 471), diversified political-administrative centers, such as Minsk and Yerevan, had moderate and steady annual growth rates, and industrial cities displayed both the highest and the lowest growth

rates. The industrial cities with the highest growth rates were based on automotive activities along the Kama and Volga, oil and gas exploitation in West Siberia, and, in one case, the construction of a new iron and steel industry in the Kursk Magnetic Anomaly area. Cities with low or negative growth rates were in older industrial areas, such as coal mining centers in the Donets and Kuznetsk basins and metallurgical areas in the Urals (Bond and Lydolph 1979, pp. 471-475).

Urban growth and industrialization have been closely linked throughout the Soviet period. Prior to 1959, the eastern part of the country experienced high urban growth rates, especially coal mining areas including those in the western part of the country. During the intercensal periods 1959-1970 and 1970-1979, the western cities grew at a faster rate than did the eastern cities, but the annual growth rates were generally lower for all cities during the 1970-1979 period. Cities in Soviet Central Asia and the Transcaucasus exhibited high growth rates during both periods because of their initial low levels of urbanization and high natural population increase. The impact of the changing nature of the energy mixture was demonstrated by the low growth rates or population declines of coal mining cities during 1959-1970 and 1970-1979 while some cities had slow growth stimulated by the piping-in of natural gas. Oil and gas were expected to have more impact on the nation as a whole than on the producing regions.

#### Industrial Location

Although Western literature on Soviet industrial location is replete with references to Soviet location theory, Rodgers (1974) has observed that "no distinctive and coherent body of ideas than can

legitimately be called 'socialist location theory' has been produced in the U.S.S.R. or in any other socialist state" (p. 235). It is possible though to identify the following general Soviet industrial planning goals or principles (Huzinec 1977; Koropecjy 1970; Lonsdale 1961; Lydolph and Pease 1972; Rodgers 1974):

1. Locate industry close to sources of raw materials and to markets in order to minimize transport costs.
2. Plan regional industrial development to make all regions as economically self-sufficient as possible.
3. Promote regional specialization to take advantage of favorable conditions and to utilize natural resources most effectively.
4. Raise the level of development of the underdeveloped regions of the country to that of the most advanced.
5. Eliminate the socioeconomic differences between rural and urban areas by distributing industry throughout the country.
6. Create and maintain the greatest possible capacity for defense.

Several of these objectives are incompatible or mutually exclusive, and the emphasis placed on them has shifted through time. These principles have often been used as justification for decisions made for pragmatic or political reasons. This is especially true as Soviet planners have wrestled with the problems of:

development of well-populated, industrially underdeveloped regions; rejuvenation or diversification of old industrial areas with the attraction of growth industries; and integration of harsh pioneer areas, rich in natural resources, into the mainstream of the country's economic life (Dienes 1971, p. 27; Dienes 1972, p. 437).

Studies have endeavored to detect motives behind regional economic development which might reveal adherence to one or more of the planning

principles. Dienes (1972) examined the rate of capital return and marginal capital product in Soviet industry during the 1960s and found that "regional investment allocation evidently was guided by strategic considerations" (p. 446) because "the under-industrialized western regions, where capital and labor productivity are satisfactory or high, have been slighted in favor of more easterly provinces" (p. 437).

In his study of Soviet industrial location policy, Koropecy (1970) noted the concentration of industry in large cities and the importance of large cities in total industrial output. Soviet writers were then bemoaning "the excessive concentration of industrial development primarily in large and major cities" (Mikhailov and Solovev 1969, p. 130). Manufacturing plants were attracted to cities because labor and capital productivity were generally higher in such locations. Advances in technology tended to occur more rapidly in urban areas. These factors contributed to the location of industry in Soviet cities and the growth of cities during the 1960s (Koropecy 1970, pp. 280-284). Koropecy concluded by pointing out that no single principle dominated Soviet industrial location policy and that among all the forces at work the most important one was probably the one which reflected the political interests of the ruling group (Koropecy 1970, p. 285). This conclusion was supported by Abouchar (1979) who stated that "no single broad social or economic policy emerges . . . behind the pattern of attained and planned industrial growth rates since 1965" (p. 102).

Rodger (1974) used average numbers of industrial production personnel on a region scale (generally oblast and autonomous republic level with some union republic data) to reveal shifts of industry in the U.S.S.R. 1940-1955 and 1955-1965. In 1940, there was a high correlation

( $r^2 = 0.75$ ) between the distribution of urban population and industrial employment (Rodgers 1974, p. 229). The German invasion of World War II was largely responsible for a general eastward shift of industry between 1950 and 1955 (Rodgers 1974, pp. 233-235). The shifts between 1955 and 1965 were more complex with no single area of industrial expansion. The areas with the highest growth were the Baltic republics, Belorussia, Moldavia, the Ukraine, the northern and western Caucasus, and the middle and lower Volga Valley (Rodgers 1974, p. 235).

Thinking that the reasons behind the 1955-1965 patterns might have been connected with regional variations in energy production, Rodgers (1974) calculated fuel and power output by region for 1965 and regressed those values on the shifts in industrial employment with results that were statistically insignificant. Rodgers argued that these results reflected the shift in emphasis from coal to oil and gas, whose relative ease of movement permitted a "high degree of locational freedom" (Rodgers 1974, p. 237). To test the relationship between changes in industrial location and the distribution of markets, population distribution for 1965 was used as a surrogate measure for markets, and the correlation between the regional population values and the shifts in industrial employment was "quite strong" ( $r^2 = 0.42$ ). An  $R^2$  of 0.46 resulted from a multiple regression with the 1955-1965 shifts in industrial employment as the dependent variable and population and fuel outputs for 1965 as the independent variables (Rodgers 1974, p. 237). This further underscored that the role of energy was less important than might otherwise have been expected in industrial location.

Additional analyses revealed that "there was remarkably limited evidence of the implementation of the equality principle" (Rodgers 1974,

p. 238). Rodgers (1974) concluded that "if there is a conscious regional planning policy in the U.S.S.R., it appears to support growth rather than equity" (p. 238). This observation was also noted by Fuchs and Demko (1979) who wrote that continued spatial inequalities in socialist states "can be explained in terms of the priority placed on efficiency or military security as opposed to equity in industrial location decisions" (p. 304).

The principles of industrial location ascribed to socialist planners are somewhat contradictory, and no clear guiding principle has emerged although military considerations and growth appear to be the most important factors. Industry is concentrated in large cities, and industrial growth has been highest in the western regions of the country in recent years. Markets were much more important than energy production in changes in industrial location.

#### Natural Resources

"The study of the role of natural resources in the location of the economy and population has been an important and traditional research area in economic geography" (Runova 1976, p. 73). Mints and Kakhanovskaya (1974) developed a generalized resource potential index in an effort to quantitatively assess the natural resource potential of regions in the U.S.S.R. The natural resources included in their study were coal, oil, natural gas, iron ore, hydroelectric resources, timber resources, arable land, natural forage, and other major resources, such as chemical raw materials or nonferrous metals if particularly significant for a given region. The areal units for which data were available were union republics, krays, oblasts, and autonomous republics (Mints and

Kakhanovskaya 1974, pp. 556-557). The resource data were converted to annual productivity indicators. In the case of mineral resources, reserves were divided by the estimated periods of extraction. Additionally, reserve estimates were limited to those likely to be accessible in the next ten to 15 years. Once annual productivity indicators were determined, they were expressed in monetary units using rounded current prices, and the values were then arithmetically manipulated to determine the resource potential of each region (Mints and Kakhanovskaya 1974, pp. 559-561). The prices chosen for their calculations are probably the most controversial part of their study, considering the complex and often irrational pricing system of centrally planned economies.

The values were replaced with percentages to show the relative contribution of each resource to the resource potential of a region and each region to the total national potential. The results were somewhat startling, showing that the European part of the country (including the Urals) accounted for more than 40% of the nation's total potential, whereas Siberia and the Far East accounted for only 33%. This was due largely to the way values for mineral reserves were calculated and to the significant role of agriculture which represented 69% of the total resource potential in Kazakhstan, 65% in the European south, 64% in the middle and northern latitudes of the European U.S.S.R., and 61% in Soviet Central Asia. In Siberia and the Far East, agriculture accounted for only around 15% of total resource potential (Mints and Kakhanovskaya 1974, p. 561).

A choropleth map of resource density by unit area showed high values for southern agricultural areas, particularly those with significant mineral and hydroelectric resources. A map of resource availability

on a per capita basis showed high values for the eastern regions (Mints and Kakhanovskaya 1974, pp. 562-563). Mints and Kakhanovskaya (1974) felt that "the results obtained and the maps compiled on that basis may already be useful in small-scale research on regional-planning and resource-use problems covering the Soviet Union as a whole or some of its major regions" (p. 556).

In a later study, Mints (1976) stated that "the resource factor plays a steadily declining role in shaping the spatial structure of the economy as a whole" (p. 9), in part, because of advances in transportation technology which make it easier to transport energy and raw materials (Mints 1976, p. 10). Although West Siberia is rich in oil and gas reserves, such reserves should be considered part of the energy base of the European part of the U.S.S.R., because the hostile environment precludes the establishment of local processing industries in areas as the West Siberian gas fields (Mints 1976, p. 12). Mints (1976) observed that recent trends to locate oil refineries in market areas are expected to continue (p. 15) and that "the existing spatial distribution of population and current migration trends are likely to become key factors in industrial location" (p. 21). His statement refers to the availability of labor in the western regions where most of the markets are, the continuous labor shortage in Siberia and the eastern regions, and the lack of success with inducing labor to stay in labor-short areas.

Using the resource potential data determined by Mints and Kakhanovskaya (1974), Runova (1976) examined the links between the distribution of resources, economic activity, and population at the economic region level. The results of a linear correlation analysis on a pairwise basis showed that the correlations were extremely low between resources

as a whole and the distribution of total economic output ( $r = +0.02$ ) and between resources and total population ( $r = +0.04$ ). The correlations between industrial resources and industrial output and between industrial resources and urban population were also quite low ( $r = +0.03$  for both relationships). There was a strong relationship ( $r = +0.96$ ) between the distribution of industrial output and urban population. The difficulty of working with data at the economic region level was underscored when the great centers of production (the Central Region) and of resources (West Siberia) were omitted from the analysis. The correlations between total resources and total economic output ( $r = +0.43$ ) and for total resources and population ( $r = +0.65$ ) were then much higher (Runova 1976, pp. 83-85).

Dienes examined Soviet energy policy and regional development (Dienes 1971) and the problems of allocation in the Soviet fuel supply (Dienes 1973). Both studies were concerned with the concept of marginal fuel costs and the regional allocation of energy resources. A linear programming solution yielded an optimal fuel mix for each region (Dienes 1971, pp. 45-48; Dienes 1973, pp. 9-14). This linear programming solution was followed by a discussion of the heated debates between the "pro-Siberian" planners who wanted to severely curtail industrial location west of the Urals and the "pro-European" planners who had chafed under the relatively slow development of western mineral reserves, such as the Kursk Magnetic Anomaly (Dienes 1971, pp. 49-56; Dienes 1973, pp. 16-20). Dienes felt that resistance to a strongly pro-Siberian energy-oriented investment policy would grow because "taking workers and industry to energy sources has proved less effective than hoped for, and Soviet

planners are learning what Adam Smith knew: 'Of all baggage, people are the most expensive to move'" (Dienes 1971, pp. 57-58).

Efforts to quantify natural resource potential have been largely descriptive and highly aggregated. The relationship between resources on the one hand and industrial output and urban population on the other was rather weak, but the relationship between the distribution of industrial production and urban population was quite strong. The importance of resources as a factor in industrial location is expected to decline because of advances in transportation technology. The harsh environment of the eastern regions and the availability of labor in the western region is expected to further encourage the location of industry in the western market areas.

#### Potential Models

Although the concept of potential models has been criticized (Houston 1969; Taaffe and Gauthier 1973, pp. 97-99; Yeates 1974, pp. 130-131), potential models have been widely used as macrogeographic tools by human geographers in a variety of ways. Some of their uses have been to construct potential maps showing possible interactions between people or between producers and markets, to discover empirical regularities in the distribution of population, and to analyze patterns of transport costs and the effects of highway location on such patterns (Lukermann and Porter 1960; Stewart and Warntz 1958; Taaffe and Gauthier 1973, pp. 90-92). This section reviews some uses of potential models which are particularly relevant to this study.

Harris (1954) pioneered the use of potential models and maps constructed from them when he examined the importance of market accessibility

as a factor in industrial location in the United States. He calculated an index of accessibility to markets with a market potential model using the formula,  $P = \sum \left( \frac{M}{d} \right)$ , where  $P$  = the market potential for a given city,  $M$  = county retail sales, and  $d$  = straight line distance as modified by a generalized estimate of freight rates. Two assumptions underlay this model. One was that county retail sales provided a good measure of the overall market for goods, and the other was that straight line distances measured from a map could be used instead of actual route distances because of the dense transportation network of the United States (Harris 1954, pp. 316-323).

New York City was found to have the highest market potential, and utilizing the values of the other cities in his study expressed as a percentage below New York City, Harris (1954) drew an isarithmic market potential map of the United States with contours representing lines of equal market potential. Harris (1954) relied on visual inspection to show how closely the area with the highest market potential coincided with the American Manufacturing Belt (Harris 1954, pp. 323-326).

Fifteen years later, Houston (1969) compiled several market potential maps of the Soviet Union employing total population, urban population, and total population weighted by retail sales per capita by republic as measures of market size. Distances between the 128 points used in calculating market potential indices were shortest rail and/or rail-ferry distances instead of straight line distances because of the nature of the Soviet transportation network which is a great deal less dense than that of the United States (Houston 1969, pp. 218-220). Since he was concerned primarily with an analysis of the concept of potential models, Houston (1969) made no interpretation of their application to

the U.S.S.R., but the market potential generally matched population distribution and was highest around Moscow.

In his monograph, Cities of the Soviet Union, Harris (1970) determined population potential indices for the entire country and compiled potential maps based on total, rural, and urban population. Harris (1970) used population by oblasts or similar administrative units and direct airline distances between the geographical centers of the oblasts at which the entire population was considered to be concentrated (Harris 1970, p. 187). Harris (1970) stated that urban population potential "measures on a country-wide basis and in a highly generalized and abstract form many elements of industrial location: market, labor, industrial materials for complex industries, and of the interaccessibility of such elements" (p. 194).

#### Summary

Soviet urban growth has been highest in the Soviet West, Transcaucasia, and Central Asia and has been affected primarily by trends in industrialization and stages in the urban and demographic revolutions. Although no single principle has been dominant, Soviet industrial location policy has appeared to favor maximizing national economic growth and defense considerations. The pull of markets and the availability of labor apparently have been strong factors in industrial location and have resulted in the concentration of industrial production in large cities in the western regions of the country. Analyses have shown the relationship between the distribution of urban population and industrial output to be quite strong.

Urban population and industrial distribution are inextricably linked in the U.S.S.R., but not much effort has been made to link urban and industrial growth to accessibility to energy, except for occasional comments on the impact of energy on the growth of individual cities or clusters of cities. Those studies which sought to examine the relationship of energy on the one hand and the distribution of urban population and industrial production on the other attained results that were surprisingly low. These low results were probably due to the fact that they were not considering the availability of energy. Rather, the energy data were in a highly aggregated form either as regional energy production data or submerged in regional industrial resource data. No one has examined nationwide patterns of energy accessibility, and the links between urban growth and energy accessibility have not been rigorously tested on a macrogeographic basis. Any link which can be established between urban growth and energy accessibility will provide additional information on the nature of Soviet urban-industrial growth policies.

# References

- Abouchar, A. 1979. Regional Industrial Policies of the U.S.S.R. in the 1970s. In Regional Development in the U.S.S.R., NATO Colloquium 25-27 April 1979, pp. 93-103. Newtonville, Mass.: Oriental Research Partners.
- Bond, A.R. and Lydolph, P.E. 1979. Soviet Population Change and City Growth 1970-79. A Preliminary Report. Soviet Geography: Review and Translation 20, 8:461-488.
- Dienes, L. 1971. Issues in Soviet Energy Policy and Conflicts over Fuel Costs in Regional Development. Soviet Studies 23, 1:26-58.
- Dienes, L. 1972. Investment Priorities in Soviet Regions. Annals of the Association of American Geographers 62, 3:437-454.
- Dienes, L. 1973. Geographical Problems of Allocation in the Soviet Fuel Supply. Energy Policy 1, 1:3-20.
- Fuchs, R.J. and Demko, G.J. 1979. Annals of the Association of American Geographers 69, 2:304-318.
- Harris, C.D. 1954. The Market as a Factor in the Localization of Industry in the United States. Annals of the Association of American Geographers 64, 4:315-348.
- Harris, C.D. 1970. Cities of the Soviet Union. Washington, D.C.: Association of American Geographers.
- Harris, C.D. 1971. Urbanization and Population Growth in the Soviet Union, 1959-1970. The Geographical Review 61, 1:102-124.
- Houston, C. 1969. Market Potential and Potential Transportation Costs: An Evaluation of the Concepts and Their Surface Patterns in the U.S.S.R. The Canadian Geographer 13, 3:216-236.
- Huzinec, G.A. 1977. A Reexamination of Soviet Industrial Location Theory. The Professional Geographer 29, 3:259-265.
- Koropecy, I.S. 1970. Industrial Location in the U.S.S.R. During the Postwar Period. In Economic Performance and the Military Burden in the Soviet Union, Subcommittee on Foreign Economic Policy of the Joint Economic Committee, Congress of the United States, pp. 233-295. Washington, D.C.: U.S. Government Printing Office.
- Lewis, R.A. and Rowland, R.H. 1969. Urbanization in Russia and the U.S.S.R.: 1897-1966. Annals of the Association of American Geographers, 59, 4:776-796.
- Lonsdale, R.E. 1961. Industrial Location Planning in the Soviet Union. The Professional Geographer 13, 6:11-15.

- Lukermann, F. and Porter, P.W. 1960. Gravity and Potential Models in Economic Geography. Annals of the Association of American Geographers 50, 4:493-504.
- Lydolph, P.E., Johnson, R., Mintz, J., and Mills, M.E. 1978. Recent Population Trends in the U.S.S.R. Soviet Geography: Review and Translation 19, 8:505-539.
- Lydolph, P.E. and Pease, S.R. 1972. Changing Distributions of Population and Economic Activities in the U.S.S.R. Tijdschrift voor Economische en Sociale Geografie 63, 4:244-261.
- Mikhailov, S. and Solovev, N. 1969. Small and Medium-Size Cities and the Location of Industry in the U.S.S.R. In Contemporary Soviet Economics, vol. 2, ed. M. Yanowitch, pp. 129-136. White Plains, New York: International Arts and Sciences Press, Inc.
- Mints, A.A. and Kakhanovskaya, T.G. 1974. An Attempt at a Quantitative Evaluation of the National Resource Potential of Regions in the U.S.S.R. Soviet Geography: Review and Translation 15, 9:554-565.
- Mints, A.A. 1976. A Predictive Hypothesis of Economic Development in the European Part of the U.S.S.R. Soviet Geography: Review and Translation 17, 1:1-27.
- Rodgers, A. 1974. The Locational Dynamics of Soviet Industry. Annals of the Association of American Geographers 64, 2:226-240.
- Runova, T.G. 1976. The Location of the Natural Resource Potential of the U.S.S.R. in Relation to the Geography of Productive Forces. Soviet Geography: Review and Translation 17, 2:73-85.
- Stewart, J.Q. and Warntz, W. 1958. Macrogeography and Social Science. The Geographical Review 48, 2:167-184.
- Taaffe, E.J. and Gauthier, H.L. Jr. 1973. Geography of Transportation. Englewood Cliffs, N.J.: Prentice-Hall, Inc.
- Yeates, M. 1974. An Introduction to Quantitative Analysis in Human Geography. New York: McGraw-Hill Book Company.

## CHAPTER III

### DATA AND METHODOLOGY

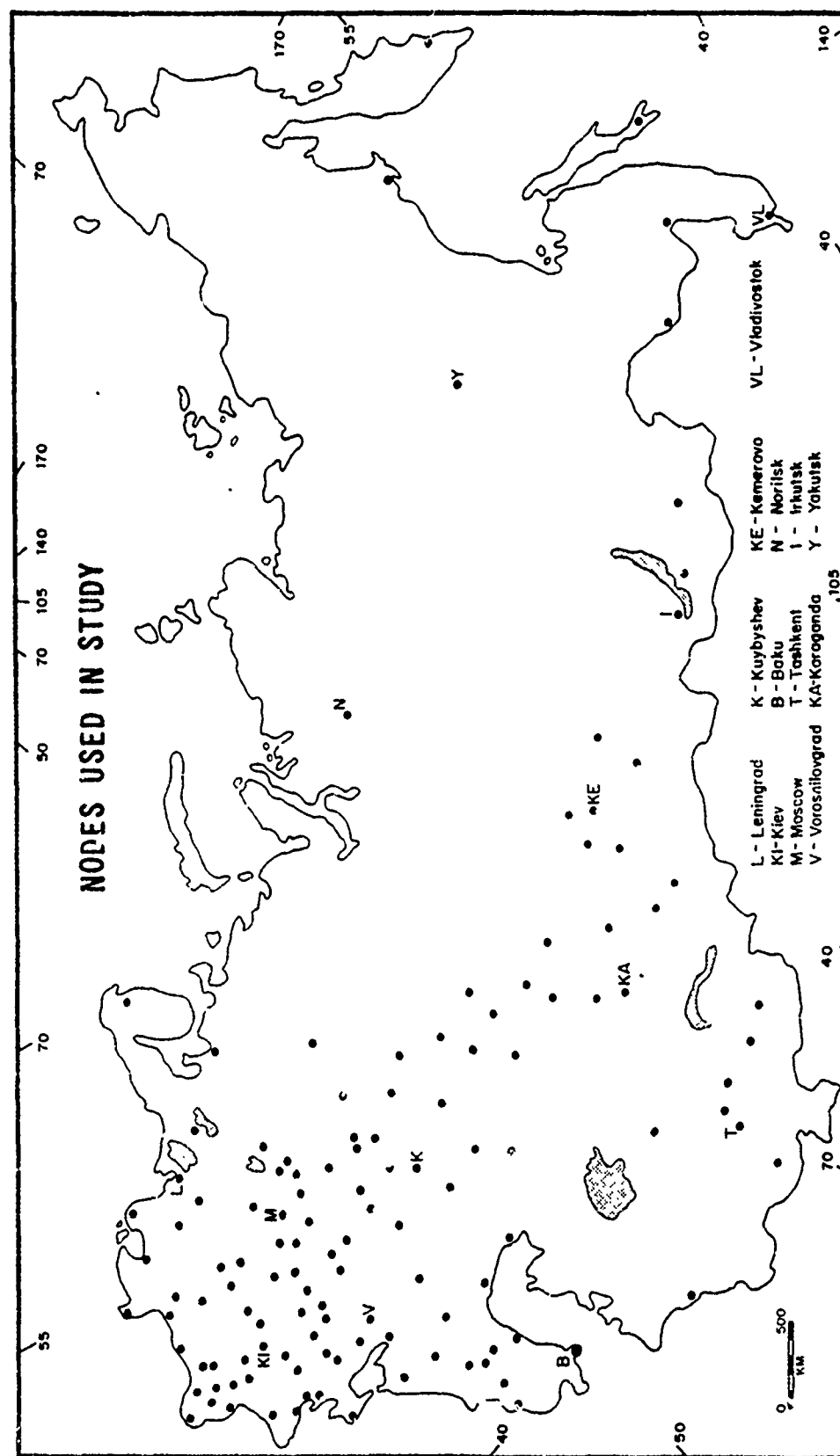
#### Introduction

This chapter deals with how energy accessibility was determined for 129 cities of the Soviet Union. This introductory section discusses the selection of the nodes, years, and types of energy used in this study. Five sections follow. The first describes an energy potential model used to calculate energy accessibility. The next two sections cover the computation of energy production data and the measurement of distances needed in the energy potential model. The last section presents the energy potential indices and map compilations.

For the purpose of determining the patterns of energy accessibility in the Soviet Union, 129 nodes were selected (Figure 3.1). These nodes are cities which are either union republic capitals or centers of autonomous republics, oblasts, or krais (except for Norilsk). Although they do not include all of the almost 200 capitals or administrative centers of the country, they do provide adequate coverage of the ecumene of the Soviet Union and represent almost half of the 272 cities with populations of 100,000 or over in 1979. In addition to being administrative centers, many, if not most, of these 129 cities are also industrial cities. Large cities were selected in favor of smaller cities because census data for them were readily available.

FIGURE 3.1

Source: Data for outline and cities taken from Soviet Union,  
National Geographic Society, 1976,  
transverse polyconic projection



Only coal, oil, and natural gas were used in this study. Shale oil, peat, firewood, and hydroelectric and nuclear power plans can be very important on a local level but contribute little on a national basis. As can be seen from Table 3.1, the three major types of energy together accounted for 89.2, 92.1, and 93.6 percentage of total soviet energy production for the years 1960, 1970, and 1975 respectively. Considering the nearly ubiquitous availability of firewood, this omits only a small portion of the total Soviet energy production mixture.

The years 1960, 1970, and 1975 were selected for study because they are reasonably close to the census years of 1959, 1970, and 1979. It would have been preferable to use a year closer to 1979 than 1975, but, in 1977, the Soviet government imposed a virtual lid of secrecy on the publication of regional production data for coal, oil, and natural gas (Shabad 1978; Shabad 1979). This affected data for 1976 as well, and consequently, 1975 is the last year for which energy production data in a disaggregate form are available.

#### An Energy Potential Model

Energy potential indices were calculated using:

$$EP_i = \sum_{j=1}^n \frac{AP_j}{d_{ij}}$$

where  $EP_i$  = energy potential of a city

$AP_i$  = annual production of an energy source expressed in standard fuel units, and

$d_{ij}$  = distance from an energy source to a city as measured along rail routes for coal, rail and pipeline for oil, and pipeline for natural gas.

Exponents of one were applied to each  $AP_j$  and  $d_{ij}$ . Actual route distances were used in computations rather than straight line distances

Table 3.1

Soviet Energy Production, in Million Metric Tons of Standard Fuel<sup>a</sup> and Percentage of Total

| Type of Energy     | 1950       |      | 1960       |      | 1970       |      | 1975       |      |
|--------------------|------------|------|------------|------|------------|------|------------|------|
|                    | Production | %    | Production | %    | Production | %    | Production | %    |
| Petroleum          | 54.2       | 17.0 | 211.4      | 29.5 | 502.5      | 39.6 | 701.9      | 43.3 |
| Natural gas        | 7.3        | 2.3  | 54.4       | 7.6  | 233.5      | 18.4 | 342.9      | 21.2 |
| Coal and lignite   | 205.7      | 64.5 | 373.1      | 52.1 | 432.7      | 34.1 | 471.8      | 29.1 |
| Peat               | 14.8       | 4.6  | 20.4       | 2.8  | 17.7       | 1.4  | 18.5       | 1.1  |
| Oil shale          | 1.3        | 0.4  | 4.8        | 0.7  | 8.8        | 0.7  | 10.8       | 0.6  |
| Firewood           | 27.9       | 8.8  | 28.7       | 4.0  | 26.6       | 2.1  | 25.4       | 1.6  |
| Hydroelectricity   | 7.5        | 2.4  | 23.8       | 3.3  | 45.6       | 3.6  | 42.8       | 2.6  |
| Nuclear power      | --         | --   | --         | --   | 1.3        | 0.1  | 6.9        | 0.4  |
| Total <sup>b</sup> | 318.7      | 100  | 716.6      | 100  | 1268.7     | 100  | 1621.0     | 99.9 |

<sup>a</sup>One ton of SF (standard fuel) is equal to seven million kilocalories.<sup>b</sup>Percent totals may not equal exactly 100% due to rounding.

Sources: Dienes and Shabad (1979, pp. 32-34) and Lydolph (1979, p. 262).

in order to make the results more realistic. Energy potential indices were calculated using both route distances and route distances modified by estimated transport costs.

#### Energy Production Data

Before energy production data could be entered into the energy potential model, two tasks had to be performed with the available regional energy production data. First, the data had to be disaggregated from regional data to point data in order to have energy source points from which to measure distance to the cities under study. Because the spatial distribution of energy production is not homogeneous within regions, the geographic center of each region for which energy data were available could not be used as the energy source point for that region. Instead, the selection of points for energy sources was based on an examination of the locations of energy producing fields within each region, and the actual positions of the energy source centers were determined by the distribution of coal, oil, and natural gas fields within a region. The sources consulted in the determination of the energy source point and the points themselves are contained in the appropriate production data tables (Tables 3.2, 3.3, and 3.4).

The other task involved the standardizing of coal, oil, and natural gas production data by converting them into standard fuel units. The term standard fuel (or conventional fuel) is often employed by the Soviets for comparing different forms of energy. Standard fuel has a heat content of 7,000 kilocalories per kilogram (Ebel 1970, p. xix; Elliot 1974, p. 266), and conversion factors may be applied to the various types of fuel to obtain standard fuel equivalents.

Table 3.2

Regional Distribution of Soviet Coal Production  
(in Million Metric Tons of Standard Fuel)

| Region                   | 1960  | 1970  | 1975  | XSF <sup>a</sup> | Center <sup>b</sup> |
|--------------------------|-------|-------|-------|------------------|---------------------|
| Pechora Basin            | 17.4  | 20.0  | 21.8  | 0.90             | Vorkuta-Inta        |
| Moscow Basin             | 17.9  | 14.2  | 13.0  | 0.38             | Tula                |
| Donets Basin             |       |       |       |                  |                     |
| Rostov                   | 26.4  | 24.9  | 24.5  | 0.75             | Shakhty             |
| Ukraine                  | 128.7 | 142.1 | 141.8 | 0.75             | Gorlovka            |
| Lvov-Volhynia            | 3.9   | 10.3  | 11.7  | 0.81             | Chervonograd        |
| Dneper Basin             | 3.3   | 2.8   | 3.2   | 0.25             | Aleksandriya        |
| Georgia                  | 1.9   | 1.4   | 1.3   | 0.61             | Kutaisi             |
| Bashkir                  | 1.1   | 2.1   | 2.7   | 0.29             | Kamertau            |
| Perm                     | 11.9  | 8.0   | 6.1   | 0.90             | Kizel               |
| Sverdlovsk               | 6.5   | 5.2   | 2.9   | 0.29             | Serov               |
| Chelyabinsk              | 10.7  | 9.2   | 8.2   | 0.43             | Korkino             |
| Kuznetsk Basin           | 69.0  | 87.3  | 102.8 | 0.75             | Kemerovo            |
| Kansk-Achinsk            | 4.5   | 9.0   | 13.4  | 0.48             | Krasnoyarsk         |
| Chernogorsk <sup>c</sup> | 3.1   | 4.1   | 3.7   | 0.75             | Abakan              |
| Norilsk <sup>c</sup>     | 1.9   | 2.5   | 2.2   | 0.70             | Norilsk             |
| Cheremkhovo              | 12.1  | 12.1  | 10.2  | 0.73             | Cheremkhovo         |
| Azey                     | 0.4   | 2.7   | 4.3   | 0.43             | Tulun               |
| Buryat                   | 0.4   | 0.6   | 0.6   | 0.43             | Gusinozersk         |
| Chita                    | 2.6   | 2.9   | 5.2   | 0.70             | Karymskoye          |
| Yakut                    | 0.7   | 1.1   | 1.4   | 0.70             | Yakutsk             |
| Amur                     | 4.1   | 5.5   | 5.8   | 0.43             | Raychikhinsk        |
| Khabarovsk               | 0.7   | 0.9   | 1.1   | 0.71             | Urgal               |
| Maritime                 | 5.0   | 6.5   | 7.1   | 0.70             | Artem               |
| Sakhalin                 | 3.5   | 3.4   | 3.5   | 0.70             | Uglegorsk           |
| Magadan                  | 0.9   | 1.0   | 1.5   | 0.80             | Kadykchan           |
| Karaganda                | 22.7  | 31.6  | 37.0  | 0.80             | Karaganda           |
| Ekibastuz                | 4.0   | 14.0  | 27.5  | 0.60             | Ekibastuz           |
| Uzbekistan               | 2.2   | 2.3   | 3.2   | 0.61             | Angren              |
| Fergana <sup>d</sup>     | 3.0   | 2.9   | 3.0   | 0.61             | Anoizhan            |
| Total                    | 370.5 | 430.6 | 470.7 | 0.67             |                     |

<sup>a</sup> Factors used to convert 1975 raw production data into standard fuel units. These values were multiplied by 1.03 and 1.10 to obtain factors for 1970 and 1960 respectively.

<sup>b</sup> Distances were measured from these energy source centers to the nodes under study.

<sup>c</sup> Estimates based on 1965 production.

<sup>d</sup> Represents the combined production of the Kirghiz and Tadzhik SSRs.

Sources: Dienes and Shabad (1979); Elliot (1974); Hodgkins (1961); Lydolph (1977); Lydolph (1970); Shabad (1969).

Table 3.3

Regional Distribution of Soviet Oil Production  
(in Million Metric Tons of Standard Fuel)

| Region                      | 1960 <sup>a</sup> | 1970 <sup>a</sup> | 1975 <sup>a</sup> | Center <sup>b</sup> |
|-----------------------------|-------------------|-------------------|-------------------|---------------------|
| Komi                        | 1.2               | 10.9              | 15.7              | Pechora             |
| Krasnodar                   | 10.0              | 8.4               | 8.9               | Krasnodar           |
| Stavropol                   | 2.3               | 9.2               | 10.0              | Neftekumsk          |
| Chechen-Ingush              | 4.7               | 28.6              | 12.9              | Groznyy             |
| Dagestan                    | 0.3               | 3.1               | 2.9               | Makhachkala         |
| Tatar                       | 66.2              | 145.7             | 148.3             | Almetyevsk          |
| Bashkir                     | 36.2              | 56.1              | 55.9              | Tuymazy             |
| Kuybyshev                   | 31.5              | 50.0              | 49.8              | Kuybyshev           |
| Saratov <sup>c</sup>        | 2.9               | 1.9               | 1.9               | Saratov             |
| Volgograd <sup>c</sup>      | 7.2               | 10.0              | 9.6               | Zhirnovsk           |
| Perm                        | 3.3               | 23.0              | 31.9              | Perm                |
| Orenburg                    | 1.7               | 10.6              | 19.9              | Pokrovka            |
| Udmurt                      | h                 | 0.7               | 4.9               | Sarapul             |
| Belorussia                  | h                 | 6.0               | 11.4              | Rechitsa            |
| West Ukraine <sup>d</sup>   | 3.1               | 4.0               | 2.7               | Dolina              |
| East Ukraine <sup>d</sup>   | h                 | 15.9              | 15.6              | Gadyach             |
| Azerbaijan                  | 25.5              | 28.9              | 24.6              | Baku                |
| Tyumen                      |                   |                   |                   |                     |
| Shaim                       | h                 | 6.0               | 7.2               | Shaim               |
| Samotlore                   | h                 | 34.0              | 197.3             | Megion              |
| Tomsk <sup>e</sup>          | h                 | 4.9               | 7.2               | Strezhevoy          |
| Sakhalin                    | 2.3               | 3.6               | 3.4               | Okha                |
| Kazakhstan                  |                   |                   |                   |                     |
| Emba                        | 2.2               | 3.9               | 5.4               | Makat-Dossor        |
| Mangyshlak                  | h                 | 14.9              | 28.7              | Uzen                |
| Fergana Valley <sup>f</sup> | 3.0               | 3.3               | 2.7               | Andizhan            |
| Turkmenia                   | 7.6               | 20.7              | 22.3              | Nebit Dag           |
| Georgia <sup>g</sup>        | h                 | h                 | 0.4               |                     |
| Total                       | 211.2             | 504.3             | 701.5             |                     |

<sup>a</sup> A factor of 1.43 was used to convert raw regional production data into standard fuel units.

<sup>b</sup> Distances were measured from these energy source centers to the nodes under study.

<sup>c</sup> Estimates for 1970 and 1975 based on 1960 and 1965 data.

<sup>d</sup> Estimates based on relative contribution to total Ukrainian production.

<sup>e</sup> Combined into one source with center near Megion when determining distances to nodes.

<sup>f</sup> Represents the combined production of the Uzbek, Kirghiz, and Tadzhik SSRs.

<sup>g</sup> Not used because contribution to any node's energy potential was so slight.

Table 3.3--Continued

<sup>h</sup> Negligible or no production.

Sources: Campbell (1968); Dienes and Shabad (1979); Ebel (1961);  
Ebel (1970); Elliot (1974); Lydolph (1977); Lydolph (1979); Lydolph  
and Shabad (1960); Shabad (1969).

Table 3.4

Regional Distribution of Soviet Natural Gas Production  
(in Million Metric Tons of Standard Fuel)

| Region                  | 1960 <sup>a</sup> | 1970 <sup>a</sup> | 1975 <sup>a</sup> | Center <sup>b</sup> |
|-------------------------|-------------------|-------------------|-------------------|---------------------|
| Komi                    | 1.2 <sup>e</sup>  | 8.1               | 22.0              | Vuktyl              |
| Krasnodar               | 6.1               | 29.1              | 9.4               | Tikhoretsk          |
| Stavropol               | 9.8               | 19.4              | 13.6              | Stavropol           |
| Chechen-Ingush          | 0.4               | 5.0               | 4.2               | Groznyy             |
| Dagestan <sup>d</sup>   | 0.1               | 1.9               | 1.2               | Makhachkala         |
| Tatar                   | 1.7               | 4.6               | 5.2               | Almetyevsk          |
| Bashkir                 | 1.6 <sup>d</sup>  | 2.2               | 1.7               | Belebey             |
| Kuybyshev               | 1.2 <sup>d</sup>  | 2.7               | 2.5               | Kuybyshev           |
| Saratov                 | 3.0               | 4.0               | 1.2               | Saratov             |
| Volgograd               | 3.1               | 4.7               | 3.6               | Kotovo              |
| Astrakhan <sup>d</sup>  | f                 | 0.9               | 0.6               | Astrakhan           |
| Perm                    | f                 | 1.1               | 1.3               | Perm                |
| Orenburg                | 0.6 <sup>d</sup>  | 1.5 <sup>d</sup>  | 23.9              | Orenburg            |
| Azerbaijan              | 7.0 <sup>d</sup>  | 6.5               | 11.8              | Baku                |
| West Ukraine            | 6.2               | 14.4              | 8.2               | Borislav            |
| East Ukraine            | 11.0              | 57.4              | 73.6              | Shebelinka          |
| Belorussia <sup>e</sup> | f                 | 0.2               | 0.7               | Rechitsa            |
| Tyumen                  |                   |                   |                   |                     |
| Punga-Igrim             | f                 | 10.9              | 4.3               | Punga-Igrim         |
| Medvezhye               | f                 | f                 | 35.1 <sup>d</sup> | NE of Nadym         |
| Ob oil gas              | f                 | 0.1 <sup>c</sup>  | 2.6 <sup>d</sup>  | Samotlor            |
| Norilsk <sup>d</sup>    | f                 | 0.5               | 3.1               | Messoyakha          |
| Yakut <sup>d</sup>      | f                 | 0.2               | 0.6               | Tas-Tumus           |
| Sakhalin <sup>c</sup>   | 0.4               | 0.9               | 1.2               | Okha                |
| Kazakhstan              |                   |                   |                   |                     |
| Bazay                   | f                 | 1.8               | 1.8               | Bazay               |
| Uzen                    | f                 | 0.7 <sup>c</sup>  | 4.4               | Uzen                |
| Uzbekistan              | 0.5 <sup>c</sup>  | 37.8              | 44.3              | Gazli               |
| Turkmenia               |                   |                   |                   |                     |
| West Turkmen            | 0.3 <sup>c</sup>  | 1.6 <sup>c</sup>  | 3.6               | Kum-Dag             |
| North Turkmen           | f                 | 11.6 <sup>d</sup> | 36.7              | Achak               |
| South Turkmen           | f                 | 2.4 <sup>d</sup>  | 21.4              | Mary                |
| Kirghizia <sup>c</sup>  | f                 | 0.4               | 0.3               |                     |
| Tadzhikistan            | f                 | 0.5 <sup>d</sup>  | 0.5 <sup>e</sup>  | Dushanbe            |
| Total                   | 54.2              | 233.1             | 344.6             |                     |

<sup>a</sup> Factors to convert raw regional production data into standard fuel units were 1.20 for 1960, 1.18 for 1970, and 1.19 for 1975.

<sup>b</sup> Distances were measured from these energy source centers to the nodes under study.

<sup>c</sup> Not used because of lack of transportation link to any node in this study.

Table 3.4--Continued

<sup>d</sup>Applied only to local nodes because of lack of access to nationwide network.

<sup>e</sup>Not used because contribution to any particular node's energy potential was negligible.

<sup>f</sup>Negligible or no production.

Sources: Campbell (1968); Dienes and Shabad (1979); Ebel (1970); Elliot (1974); Lydolph (1977); Lydolph (1979); Lydolph and Shabad (1960); Shabad (1969).

The quality and caloric value of Soviet coal varies tremendously between regions. In 1975, a ton of hard coal (anthracite and bituminous) ranged from 0.57 to 0.93 ton of standard fuel and lignite or brown coal from 0.29 to 0.57 ton of standard fuel. The average heat content of a ton of Soviet coal has declined slightly over time from 0.73 ton of standard fuel in 1960, 0.69 ton in 1970, to 0.67 ton in 1975 (Dienes and Shabad 1979, pp. 32-33, 110-111). This decline meant that the factors needed to convert raw coal production data into standard fuel units (Table 3.2) varied not only by region but also through time. Regional conversion factors were first obtained for 1975 from several sources (Dienes and Shabad 1979; Elliot 1974; Lydolph 1979; Shabad 1969). If a precise conversion factor could not be found for a coal basin, an estimate was made based on the description of the type and quality of the coal and the range of values for hard and brown coal. Because the average heat content of Soviet coal has declined through time, the regional conversion factors for 1975 were multiplied by 1.03 to obtain values for 1970 factors and 1.10 for 1960. These conversion factors, when applied to the raw production data, gave totals (Table 3.2) that were fairly close to the actual aggregated production figures for coal in terms of standard fuel (Table 3.1).

Oil and natural gas also vary somewhat in quality (such as paraffin content for oil and sulfur content for natural gas), but their heat content is sufficiently uniform among regions that one conversion factor was used for all regions when transforming raw regional production data into standard fuel units (Table 3.3 for oil; Table 3.4 for gas). The conversion factors for oil and natural gas were calculated by dividing total standardized production (in standard fuel units) for each (Dienes

and Shabad 1979, p. 32) by total raw production for each (Dienes and Shabad 1979, pp. 46 and 70). A ton of oil had a heat content equivalent to 1.43 tons of standard fuel in 1975, and this value was also used for 1970 and 1960. The heat value of 1000 cubic meters of natural gas in 1975 was approximately 1.19 tons of standard fuel, and this value varied only slightly over time with values of 1.18 for 1970 and 1.20 for 1960.

The eastward shift in Soviet energy production is evident in all three major fuels. The Kuznetsk, Kansk-Achinsk, Karaganda, and Ekibastuz basins have all greatly expanded their output since 1960 (Table 3.2). The oil fields of the Volga-Urals area, including the Tatar and Bashkir ASSRs, and Kuybyshev, Perm, and Orenburg oblasts, more than doubled their combined production from 1960 to 1970, while the Baku oil fields' production remained stagnant. Almost 800 kilometers east of the Urals, the newly developed middle-Ob oil fields of Tyumen Oblast were the largest single source of energy in the Soviet Union in 1975 (Table 3.3). The shifts in gas production were rather erratic (Table 3.4). The North Caucasus gas fields of Krasnodar and Stavropol krais were up sharply in production in 1970 from 1960 and down in 1975, while the eastern Ukraine gas fields experienced dramatic increases in production from 1960 to 1970 and 1975. Similar increases occurred in Orenburg and Tyumen oblasts, Uzbekistan, and Turkmenia. The Komi ASSR in the northeastern part of the Northwest economic region achieved substantial increases in oil and gas production and a modest increase in production at its Pechora coal basin from 1960 to 1975. These production trends suggest that the patterns of energy potential will be somewhat different from those of population or market potential and will shift eastward through time.

### Distance Measurement

After the regional energy production data had been converted into standard fuel units and assigned to a specific point within each region, it was necessary to measure the distances from each of the coal, oil, and gas source points to each of the 128 cities (Norilsk was treated as a closed system. Its energy accessibility was determined by the coal and natural gas which were available to it in its immediate area.). The basic unit of distance measurement was 100 kilometers because of the great distances involved in working with the Soviet Union and also because of the degree of generalization already effected by assignment of regional data to points. For those nodes located at or within 150 kilometers of an energy source point, the distance was recorded as one unit.

The shortest distances along rail and rail-ferry routes were determined between the 128 cities and 29 coal sources. Houston greatly facilitated what still proved to be a laborious and time-consuming task by graciously supplying the railroad distance matrix he used in his study of market potential surface patterns in the Soviet Union (Houston 1969). Marine and river transport routes were not considered except for Yuzhno-Sakhalinsk, Magadan, Yakutsk, and Petropavlovsk-Kamchatskiy. This was not a serious omission because almost all coal in the Soviet Union is transported by rail with marine and river shipments never accounting for more than 4% of total coal loadings during the period of this study (Elliot 1974, p. 173; Lydolph 1979, p. 421). The basic pattern of the Soviet rail network remained virtually unchanged from 1960 to 1975, and the distance matrix tabulated for 1960 required only slight modifications for use in 1970 and 1975 (Appendix A). The Soviets completed rail

links between Astrakhan and Guryev on the north shore of the Caspian Sea in 1967, Makat and Beyneu along the northeast edge of the Caspian Depression in 1965, and Beyneu and Kungrad across the Ust-Urt Plateau in 1970 (Lydolph 1977, p. 330; Yonge 1975). These added rail links had an appreciable effect on the distances for only four cities--Astrakhan, Volgograd, Guryev, and Aktyubinsk.

Distances between the oil sources and 128 cities were measured along the shortest pipeline, rail, and rail-ferry routes. River and marine tankers engaged in domestic trade carried only 6% of crude oil shipments in 1960, while pipelines and railroad tanker cars handled 72% and 22% respectively. The share carried by pipelines has increased since 1960, and that of rail and tankers has decreased (Dienes and Shabad 1979, pp. 62-63). It was possible to obtain actual lengths, general locations, and dates of completion of major pipelines from a number of sources (Campbell 1968; Dienes and Shabad 1979; Ebel 1961; Ebel 1970; Elliot 1974; Fullard 1965; Fullard 1972; Hassmann 1953; Hodgkins 1961; Kish 1960; Kish 1970; Lydolph 1977; Lydolph 1979; Lydolph and Shabad 1960; National Geographic Society 1976; Shabad 1961b; Shabad 1969; Taaffe and Kingsbury 1965). Pipelines were generally built parallel to rail lines, and their distances were often similar (Table 3.5). This similarity meant that if actual oil pipeline lengths were unknown adjusted rail distances could be used. If no rail link existed between two points connected by a pipeline, the pipeline distance was estimated. The similarity between pipeline and rail distances also meant that only relatively minor changes had to be made in the distance matrices (Appendix B) to reflect the expansion of the oil pipeline network from 1960

Table 3.5

## Comparison of Selected Oil Pipeline and Rail Distances

| Origin     | Terminus   | Length (km) | Rail Distance (km) |
|------------|------------|-------------|--------------------|
| Omsk       | Irkutsk    | 2470        | 2475               |
| Omsk       | Chita      | 3500        | 3488               |
| Tuymazy    | Leningrad  | 1500        | 1800               |
| Kuybyshev  | Mozyr      | 1350        | 1700               |
| Unecha     | Polotsk    | 375         | 445                |
| Polotsk    | Klaipeda   | 475         | 550                |
| Polotsk    | Ventspils  | 475         | 551                |
| Kuybyshev  | Bryansk    | 1185        | 1318               |
| Omsk       | Pavlodar   | 420         | 664                |
| Gorkiy     | Ryazan     | 415         | 634                |
| Michurinsk | Kremenchug | 700         | 869                |
| Ryazan     | Moscow     | 250         | 197                |

Sources: Ebel (1961, p. 149); Houston (1969); USSR Geological Ministry (1966); Yonge (1975).

to 1975. The major changes in the distance matrices consisted of bringing new oil sources into the transportation network.

Natural gas travels only by pipeline in the Soviet Union, and all cities did not have access to the natural gas pipeline network. Forty-two of the cities in this study had access to natural gas in 1960, 90 in 1970, and 94 in 1975. The distance matrices for natural gas (Appendix C) were derived in the same manner as for oil with respect to pipeline locations, construction dates, and lengths (Sources the same as for oil plus Shabad 1961a). The distance matrices for natural gas changed significantly from 1960 to 1975 as new gas fields were brought into production, the natural gas pipeline network expanded, and additional cities gained access to the network.

#### Energy Potential: Indices and Maps

Coal, oil, and natural gas potential indices for 1960, 1970, and 1975 were calculated for each city (Appendix D) by an SAS matrix algebra problem (Helwig and Council 1979) using the previously determined energy production and distance data. These indices were added together to give total energy potential indices for 1960, 1970 and 1975 (Table 3.6), and the highest energy potential index for each year was divided into the others for that year to give relative measures of energy accessibility (Table 3.6). The same procedure was followed to arrive at total energy potential indices based on transport costs (Table 3.7). A generalized transport cost ratio of 5:1:4 was used to represent estimated transport costs for coal, oil, and natural gas (Campbell 1968, p. 211; Dienes and Shabad 1979, p. 43 note 45 and p. 236 note 41; Elliot 1975, p. 271).

Table 3.6

## Energy Accessibility Based on Distance

| MODE          | TEP60 <sup>a</sup> | TEP70 <sup>a</sup> | TEP75 <sup>a</sup> | RFP50 <sup>b</sup> | RFP70 <sup>b</sup> | RFP75 <sup>b</sup> |
|---------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| LENINGRAD     | 30                 | 54                 | 65                 | 16                 | 21                 | 24                 |
| MURMANSK      | 19                 | 29                 | 35                 | 10                 | 11                 | 13                 |
| PETROZAVODSK  | 25                 | 39                 | 46                 | 14                 | 15                 | 17                 |
| NOVGOROD      | 32                 | 58                 | 59                 | 17                 | 23                 | 26                 |
| VOLOGDA       | 34                 | 66                 | 80                 | 18                 | 26                 | 30                 |
| ARKHANGELSK   | 24                 | 39                 | 46                 | 13                 | 15                 | 17                 |
| SYKTYVKAR     | 25                 | 52                 | 68                 | 14                 | 20                 | 25                 |
| MOSCOW        | 51                 | 86                 | 99                 | 28                 | 33                 | 37                 |
| YAROSLAVL     | 39                 | 73                 | 98                 | 21                 | 28                 | 33                 |
| VLADIMIR      | 43                 | 84                 | 97                 | 23                 | 33                 | 36                 |
| IVANOV        | 39                 | 78                 | 91                 | 21                 | 30                 | 34                 |
| KALININ       | 41                 | 72                 | 85                 | 22                 | 28                 | 32                 |
| KALUGA        | 57                 | 89                 | 101                | 31                 | 35                 | 38                 |
| KOSTROMA      | 37                 | 72                 | 87                 | 20                 | 28                 | 32                 |
| RYAZAN        | 50                 | 85                 | 99                 | 27                 | 33                 | 37                 |
| TULA          | 61                 | 96                 | 107                | 33                 | 37                 | 40                 |
| KAZAN         | 76                 | 148                | 158                | 41                 | 58                 | 62                 |
| GORKIY        | 48                 | 89                 | 105                | 26                 | 35                 | 39                 |
| KIROV         | 36                 | 62                 | 75                 | 20                 | 24                 | 28                 |
| YOSHKAR_OLA   | 52                 | 104                | 123                | 28                 | 40                 | 46                 |
| SARANSK       | 52                 | 91                 | 109                | 28                 | 35                 | 41                 |
| CHEBOKSARY    | 58                 | 108                | 126                | 32                 | 42                 | 47                 |
| ULYANOVSK     | 68                 | 119                | 133                | 37                 | 46                 | 49                 |
| BELGOROD      | 67                 | 127                | 144                | 36                 | 49                 | 54                 |
| VORONEZH      | 58                 | 104                | 118                | 32                 | 40                 | 44                 |
| KURSK         | 56                 | 101                | 114                | 30                 | 39                 | 42                 |
| OREL          | 52                 | 92                 | 104                | 28                 | 36                 | 39                 |
| BRYANSK       | 49                 | 86                 | 100                | 27                 | 33                 | 37                 |
| LIPETSK       | 52                 | 96                 | 108                | 28                 | 37                 | 40                 |
| TAMBOV        | 51                 | 91                 | 103                | 28                 | 35                 | 38                 |
| PENZA         | 57                 | 99                 | 116                | 31                 | 39                 | 43                 |
| ASTRAKHAN     | 47                 | 69                 | 76                 | 22                 | 27                 | 28                 |
| VOLGOGRAD     | 62                 | 98                 | 114                | 34                 | 38                 | 42                 |
| KUYBYSHEV     | 95                 | 177                | 206                | 52                 | 69                 | 77                 |
| SARATOV       | 69                 | 114                | 133                | 38                 | 44                 | 49                 |
| ROSTOV        | 126                | 195                | 187                | 68                 | 76                 | 79                 |
| KRASNODAR     | 66                 | 121                | 113                | 36                 | 47                 | 42                 |
| STAVROPOL     | 62                 | 110                | 111                | 34                 | 43                 | 41                 |
| MAKHACHKALA   | 40                 | 75                 | 73                 | 22                 | 29                 | 27                 |
| NALCHIK       | 42                 | 92                 | 93                 | 23                 | 36                 | 35                 |
| ORDZHONIKIDZE | 49                 | 108                | 102                | 27                 | 42                 | 39                 |
| GROZNYI       | 49                 | 111                | 104                | 27                 | 43                 | 39                 |
| KIEV          | 44                 | 92                 | 105                | 24                 | 36                 | 39                 |
| ZAPOROZHYE    | 67                 | 119                | 132                | 36                 | 46                 | 49                 |
| KHARKOV       | 84                 | 169                | 193                | 46                 | 66                 | 72                 |
| LVOV          | 41                 | 79                 | 83                 | 22                 | 31                 | 31                 |
| KISHINEV      | 30                 | 59                 | 68                 | 16                 | 23                 | 25                 |
| TALLIN        | 26                 | 48                 | 58                 | 14                 | 19                 | 22                 |
| RIGA          | 26                 | 49                 | 60                 | 14                 | 19                 | 22                 |
| VILNIUS       | 28                 | 54                 | 65                 | 15                 | 21                 | 24                 |
| KALININGRAD   | 24                 | 37                 | 44                 | 13                 | 14                 | 16                 |
| SMOLENSK      | 37                 | 73                 | 86                 | 20                 | 28                 | 32                 |
| PSKOV         | 28                 | 44                 | 52                 | 15                 | 17                 | 19                 |
| MINSK         | 34                 | 61                 | 76                 | 18                 | 24                 | 23                 |
| TBILISI       | 32                 | 62                 | 70                 | 17                 | 24                 | 26                 |
| BAKU          | 59                 | 92                 | 101                | 32                 | 36                 | 38                 |

Table 3.6--Continued

| NODE              | TEP60 | TEP70 | TEP75 | PEP60 | PEP70 | PEP75 |
|-------------------|-------|-------|-------|-------|-------|-------|
| YEREVAN           | 26    | 50    | 58    | 14    | 19    | 22    |
| LUTSK             | 31    | 55    | 72    | 17    | 25    | 27    |
| RGVNO             | 32    | 67    | 75    | 17    | 26    | 29    |
| UZHGOROD          | 28    | 58    | 70    | 15    | 26    | 26    |
| IVANO_FRANKOVSK   | 30    | 73    | 75    | 16    | 29    | 23    |
| TERNOPOL          | 36    | 70    | 77    | 20    | 27    | 29    |
| ZHITOMIR          | 39    | 75    | 85    | 21    | 29    | 32    |
| VINNITSA          | 36    | 70    | 81    | 20    | 27    | 30    |
| KHMELNITSKIY      | 32    | 69    | 78    | 17    | 27    | 29    |
| CHERNOVSTY        | 29    | 59    | 67    | 16    | 23    | 25    |
| CHERNIGOV         | 40    | 87    | 103   | 22    | 34    | 38    |
| SUMY              | 47    | 111   | 124   | 26    | 43    | 46    |
| POLTAVA           | 59    | 162   | 186   | 32    | 63    | 69    |
| CHEKASSY          | 51    | 99    | 111   | 28    | 39    | 41    |
| KIROVOGRAD        | 43    | 63    | 70    | 23    | 25    | 25    |
| ODESSA            | 34    | 69    | 79    | 18    | 27    | 29    |
| NIKOLAYEV         | 43    | 83    | 94    | 23    | 32    | 35    |
| KHERSON           | 43    | 83    | 94    | 23    | 32    | 35    |
| SIMFEROPOL        | 42    | 60    | 65    | 23    | 23    | 24    |
| CHEPROPETROVSK    | 76    | 133   | 148   | 41    | 52    | 55    |
| DOVETSK           | 164   | 241   | 254   | 99    | 94    | 94    |
| VOROSHILOVGRAD    | 184   | 257   | 269   | 100   | 100   | 100   |
| GRONNO            | 26    | 52    | 62    | 14    | 20    | 23    |
| VITEBSK           | 34    | 53    | 79    | 18    | 21    | 29    |
| MOGILEV           | 36    | 57    | 85    | 20    | 22    | 32    |
| GOMEL             | 38    | 78    | 93    | 21    | 30    | 35    |
| OREST             | 32    | 60    | 69    | 17    | 23    | 26    |
| UFA               | 73    | 135   | 162   | 40    | 53    | 60    |
| IZHEVSK           | 52    | 105   | 131   | 29    | 41    | 49    |
| ORENBURG          | 48    | 84    | 136   | 26    | 33    | 51    |
| PERM              | 59    | 124   | 154   | 32    | 48    | 57    |
| SVERDLOVSK        | 41    | 78    | 106   | 22    | 30    | 39    |
| CHELYABINSK       | 50    | 88    | 114   | 27    | 34    | 42    |
| TYUMEN            | 33    | 59    | 82    | 18    | 23    | 30    |
| KURGAN            | 39    | 65    | 86    | 21    | 25    | 32    |
| OMSK              | 33    | 53    | 73    | 18    | 21    | 27    |
| NOVOSIBIRSK       | 42    | 63    | 91    | 23    | 25    | 34    |
| TCMSK             | 40    | 60    | 56    | 22    | 23    | 36    |
| BARNAUL           | 33    | 49    | 70    | 18    | 19    | 26    |
| KRASNOYARSK       | 30    | 47    | 71    | 16    | 18    | 26    |
| IRKUTSK           | 28    | 37    | 46    | 15    | 14    | 17    |
| CHITA             | 16    | 23    | 32    | 9     | 9     | 12    |
| ABAKAN            | 28    | 43    | 59    | 15    | 17    | 22    |
| KEMEROVO          | 86    | 118   | 156   | 47    | 46    | 58    |
| ULAN_UBE          | 16    | 24    | 33    | 9     | 9     | 12    |
| VLADIVOSTOK       | 13    | 19    | 23    | 7     | 7     | 9     |
| KHABAROVSK        | 10    | 15    | 19    | 5     | 6     | 7     |
| BLAGOVESHCHENSK   | 11    | 16    | 21    | 6     | 6     | 8     |
| YUZHNO_SAKHALINSK | 9     | 14    | 17    | 5     | 5     | 6     |
| MAGADAN           | 8     | 12    | 15    | 4     | 5     | 6     |
| YAKUTSK           | 10    | 15    | 19    | 5     | 6     | 7     |
| PETROPAVLOVSK_KAM | 7     | 12    | 14    | 4     | 5     | 5     |
| GURYEV            | 29    | 72    | 91    | 15    | 28    | 34    |
| AKTYUBINSK        | 37    | 73    | 95    | 20    | 28    | 35    |
| URALS             | 42    | 68    | 79    | 23    | 26    | 29    |
| KUSTANAY          | 40    | 72    | 95    | 22    | 28    | 35    |

Table 3.6--Continued

| NODE            | TEP60 | TEP70 | TEP75 | REP60 | REP70 | REP75 |
|-----------------|-------|-------|-------|-------|-------|-------|
| PETROPAVLOVSK   | 35    | 56    | 76    | 10    | 23    | 28    |
| KOKCHETAV       | 32    | 54    | 71    | 17    | 21    | 26    |
| TSELI NOGRAD    | 35    | 57    | 75    | 19    | 22    | 28    |
| KARAGANDA       | 47    | 72    | 90    | 26    | 29    | 33    |
| KZYL_ORDA       | 24    | 39    | 48    | 13    | 15    | 18    |
| CHIMKENT        | 23    | 45    | 60    | 13    | 19    | 22    |
| OZHAMBUL        | 21    | 43    | 57    | 11    | 17    | 21    |
| SEMI PALATINSK  | 24    | 37    | 50    | 13    | 14    | 19    |
| PAVLODAR        | 32    | 58    | 86    | 17    | 23    | 32    |
| UST_KAMENOGORSK | 24    | 37    | 49    | 13    | 14    | 18    |
| AL TA ATA       | 20    | 39    | 52    | 11    | 15    | 19    |
| ASHKHADAD       | 23    | 38    | 63    | 13    | 15    | 23    |
| DUSHANBE        | 15    | 27    | 49    | 9     | 11    | 18    |
| TASHKENT        | 23    | 47    | 61    | 13    | 19    | 23    |
| FRUNZE          | 20    | 40    | 54    | 11    | 16    | 20    |
| NORILSK         | 2     | 2     | 3     | 1     | 1     | 1     |
| ELISTA          | 37    | 54    | 59    | 20    | 21    | 22    |

<sup>a</sup>Total energy potentials for 1960, 1970, and 1975 based on distance.

<sup>b</sup>Relative energy potentials for 1960, 1970, and 1975 as percentages of Voroshilov-grad.

Table 3.7  
Energy Accessibility Based on Transport Costs

| NODE          | TEP60 <sup>a</sup> | TEP70 <sup>a</sup> | TEP75 <sup>a</sup> | REP60 <sup>b</sup> | REP70 <sup>b</sup> | REP75 <sup>b</sup> |
|---------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| LENINGRAD     | 15                 | 31                 | 39                 | 19                 | 21                 | 24                 |
| MURMANSK      | 9                  | 19                 | 25                 | 12                 | 13                 | 15                 |
| PETROZAVODSK  | 13                 | 26                 | 32                 | 17                 | 19                 | 20                 |
| NGVGOROD      | 15                 | 34                 | 41                 | 20                 | 23                 | 25                 |
| VOLOGDA       | 18                 | 40                 | 50                 | 23                 | 27                 | 30                 |
| ARKHANGELSK   | 13                 | 26                 | 32                 | 17                 | 18                 | 20                 |
| SYKTYVKAR     | 13                 | 32                 | 42                 | 17                 | 22                 | 26                 |
| MOSCOW        | 24                 | 48                 | 58                 | 31                 | 33                 | 35                 |
| YAROSLAVL     | 20                 | 45                 | 55                 | 26                 | 31                 | 33                 |
| VLADIMIR      | 25                 | 53                 | 62                 | 32                 | 36                 | 37                 |
| IVANVO        | 22                 | 49                 | 58                 | 29                 | 33                 | 35                 |
| KALININ       | 20                 | 42                 | 51                 | 26                 | 29                 | 31                 |
| KALUGA        | 24                 | 47                 | 56                 | 31                 | 32                 | 34                 |
| KUSTROMA      | 20                 | 45                 | 55                 | 26                 | 30                 | 33                 |
| RYAZAN        | 25                 | 50                 | 59                 | 32                 | 34                 | 36                 |
| TULA          | 25                 | 50                 | 58                 | 33                 | 34                 | 35                 |
| KAZAN         | 58                 | 121                | 135                | 75                 | 82                 | 82                 |
| GORKIY        | 29                 | 61                 | 72                 | 38                 | 41                 | 44                 |
| KIROV         | 21                 | 45                 | 57                 | 27                 | 31                 | 35                 |
| YOSHKAR_OLA   | 37                 | 78                 | 92                 | 48                 | 53                 | 55                 |
| SARANSK       | 31                 | 62                 | 74                 | 41                 | 42                 | 45                 |
| CHEBOKSARY    | 39                 | 80                 | 93                 | 51                 | 54                 | 56                 |
| ULYANOVSK     | 51                 | 101                | 113                | 66                 | 68                 | 68                 |
| BELGOROD      | 24                 | 57                 | 66                 | 31                 | 39                 | 40                 |
| VORONEZH      | 25                 | 53                 | 61                 | 32                 | 36                 | 37                 |
| KURSK         | 23                 | 50                 | 59                 | 29                 | 34                 | 35                 |
| OREL          | 22                 | 47                 | 56                 | 28                 | 32                 | 34                 |
| BRYANSK       | 21                 | 45                 | 55                 | 28                 | 31                 | 33                 |
| LIPETSK       | 24                 | 51                 | 60                 | 31                 | 35                 | 36                 |
| TAMBOV        | 26                 | 54                 | 63                 | 34                 | 37                 | 38                 |
| PENZA         | 34                 | 67                 | 78                 | 44                 | 46                 | 47                 |
| ASTRAKHAN     | 23                 | 48                 | 54                 | 30                 | 33                 | 33                 |
| VOLGOGRAD     | 30                 | 57                 | 66                 | 39                 | 39                 | 40                 |
| KUYBYSHEV     | 77                 | 147                | 166                | 100                | 100                | 100                |
| SARATOV       | 44                 | 79                 | 91                 | 57                 | 54                 | 55                 |
| ROSTOV        | 39                 | 71                 | 72                 | 50                 | 48                 | 43                 |
| KRASNODAR     | 32                 | 58                 | 59                 | 42                 | 39                 | 36                 |
| STAVROPOL     | 26                 | 51                 | 54                 | 34                 | 35                 | 33                 |
| MAKHACHKALA   | 24                 | 56                 | 54                 | 31                 | 38                 | 32                 |
| NALCHIK       | 23                 | 55                 | 55                 | 30                 | 38                 | 33                 |
| ORDZHONIKIDZE | 26                 | 71                 | 62                 | 34                 | 48                 | 38                 |
| GROZNYI       | 28                 | 75                 | 67                 | 36                 | 51                 | 40                 |
| KIEV          | 18                 | 47                 | 55                 | 23                 | 32                 | 33                 |
| ZAPOROZHIE    | 23                 | 49                 | 56                 | 30                 | 34                 | 34                 |
| KHARKOV       | 29                 | 67                 | 78                 | 37                 | 46                 | 47                 |
| LYOV          | 18                 | 37                 | 41                 | 24                 | 25                 | 25                 |
| KISHINEV      | 13                 | 30                 | 35                 | 17                 | 20                 | 21                 |
| TALLIN        | 13                 | 28                 | 35                 | 16                 | 19                 | 21                 |
| RIGA          | 13                 | 29                 | 36                 | 17                 | 19                 | 22                 |
| VILNIUS       | 14                 | 31                 | 38                 | 18                 | 21                 | 23                 |
| KALININGRAD   | 12                 | 23                 | 30                 | 16                 | 16                 | 18                 |
| SMOLENSK      | 18                 | 40                 | 49                 | 23                 | 27                 | 30                 |
| PSKOV         | 14                 | 29                 | 36                 | 19                 | 20                 | 22                 |
| MINSK         | 16                 | 35                 | 44                 | 20                 | 24                 | 27                 |
| TBILISI       | 18                 | 35                 | 40                 | 23                 | 24                 | 24                 |
| BAKU          | 41                 | 66                 | 68                 | 53                 | 45                 | 41                 |

Table 3.7--Continued

| NODE              | TEP60 | TEP70 | TEP75 | REP60 | REP70 | REP75 |
|-------------------|-------|-------|-------|-------|-------|-------|
| YEREVAN           | 14    | 29    | 34    | 18    | 20    | 20    |
| LUTSK             | 14    | 33    | 38    | 18    | 22    | 23    |
| ROVNO             | 14    | 34    | 41    | 19    | 22    | 24    |
| UZHGOROD          | 14    | 32    | 36    | 18    | 22    | 22    |
| IVANO_FRANKOVSK   | 15    | 36    | 39    | 19    | 24    | 23    |
| TERNOPOL          | 15    | 34    | 40    | 20    | 23    | 24    |
| ZHITOMIR          | 17    | 38    | 45    | 22    | 26    | 27    |
| VINNITSA          | 15    | 36    | 43    | 20    | 24    | 26    |
| KHMELNITSKIY      | 14    | 35    | 41    | 19    | 24    | 24    |
| CHERNOVSTY        | 14    | 30    | 36    | 19    | 21    | 22    |
| CHERNIGOV         | 18    | 49    | 61    | 23    | 33    | 37    |
| SUMY              | 20    | 59    | 67    | 26    | 40    | 40    |
| POLTAVA           | 22    | 70    | 81    | 29    | 48    | 49    |
| CHERKASSY         | 19    | 47    | 54    | 25    | 32    | 33    |
| KIROVOGRAD        | 17    | 36    | 42    | 23    | 24    | 25    |
| ODESSA            | 15    | 34    | 40    | 19    | 23    | 24    |
| NIKOLAYEV         | 17    | 40    | 46    | 23    | 27    | 28    |
| KHERSON           | 17    | 40    | 46    | 23    | 27    | 28    |
| SIMFEROPOL        | 17    | 33    | 37    | 22    | 22    | 22    |
| ONEPROPETROVSK    | 25    | 54    | 62    | 33    | 37    | 37    |
| ODNETSK           | 44    | 77    | 85    | 57    | 52    | 51    |
| VOROSHILOVGRAD    | 48    | 80    | 88    | 63    | 55    | 53    |
| GRODNO            | 12    | 29    | 36    | 16    | 20    | 21    |
| VITEBSK           | 16    | 34    | 46    | 21    | 23    | 28    |
| MOGILEV           | 17    | 36    | 50    | 22    | 25    | 30    |
| GOMEL             | 17    | 44    | 56    | 22    | 30    | 33    |
| BREST             | 15    | 32    | 39    | 19    | 22    | 23    |
| UFA               | 56    | 109   | 126   | 72    | 74    | 76    |
| IZHEVSK           | 36    | 79    | 98    | 47    | 54    | 59    |
| ORENBURG          | 33    | 66    | 88    | 43    | 45    | 53    |
| PERM              | 40    | 97    | 121   | 52    | 66    | 73    |
| SVERDLOVSK        | 23    | 52    | 73    | 29    | 35    | 44    |
| CHELYABINSK       | 27    | 57    | 75    | 35    | 39    | 45    |
| TYUMEN            | 18    | 41    | 63    | 23    | 28    | 38    |
| KURGAN            | 21    | 45    | 64    | 28    | 31    | 39    |
| OMSK              | 16    | 33    | 50    | 21    | 22    | 30    |
| NOVOSIBIRSK       | 15    | 29    | 50    | 19    | 19    | 30    |
| TOMSK             | 14    | 26    | 57    | 18    | 18    | 34    |
| BARNAUL           | 13    | 24    | 40    | 17    | 16    | 24    |
| KRASNOYARSK       | 11    | 21    | 39    | 14    | 15    | 23    |
| IRKUTSK           | 10    | 16    | 25    | 12    | 11    | 15    |
| CHITA             | 6     | 12    | 18    | 8     | 8     | 11    |
| ABAKAN            | 10    | 21    | 33    | 14    | 14    | 20    |
| KEMEROVO          | 23    | 38    | 62    | 30    | 26    | 37    |
| ULAN_UDE          | 6     | 13    | 20    | 8     | 9     | 12    |
| VLADIVOSTOK       | 5     | 9     | 12    | 6     | 6     | 7     |
| KHABAROVSK        | 4     | 9     | 12    | 6     | 6     | 7     |
| BLAGOVESHCHENSK   | 5     | 9     | 13    | 6     | 6     | 8     |
| YUZHNO_SAKHALINSK | 3     | 8     | 11    | 4     | 5     | 6     |
| MAGADAN           | 4     | 7     | 10    | 5     | 5     | 6     |
| YAKUTSK           | 4     | 9     | 12    | 6     | 6     | 7     |
| PETROPAYLOVSK_KAM | 3     | 7     | 9     | 4     | 5     | 6     |
| GURYEY            | 17    | 46    | 58    | 22    | 31    | 35    |
| AKTYUBINSK        | 23    | 50    | 64    | 29    | 34    | 38    |
| URALSK            | 26    | 50    | 61    | 34    | 34    | 37    |
| KUSTANAY          | 22    | 45    | 61    | 28    | 31    | 37    |

Table 3.7—Continued

| NODE            | TEP60 | TEP70 | TEP75 | REP60 | REP70 | REP75 |
|-----------------|-------|-------|-------|-------|-------|-------|
| PETROPAVLOVSK   | 18    | 38    | 53    | 24    | 26    | 32    |
| KOKCHETAV       | 16    | 34    | 48    | 21    | 23    | 29    |
| TSELINOGRAD     | 16    | 31    | 44    | 21    | 21    | 26    |
| KARAGANDA       | 17    | 33    | 44    | 23    | 22    | 26    |
| KZYL_ORDA       | 14    | 27    | 34    | 18    | 18    | 21    |
| CHIMKENT        | 12    | 25    | 34    | 15    | 17    | 21    |
| DZHAMBUL        | 11    | 24    | 32    | 14    | 16    | 19    |
| SEMIPALATINSK   | 10    | 20    | 30    | 14    | 14    | 18    |
| PAVLODAR        | 13    | 28    | 43    | 17    | 19    | 26    |
| UST_KAMENOGORSK | 10    | 20    | 29    | 14    | 14    | 17    |
| ALMA_ATA        | 10    | 21    | 29    | 12    | 14    | 17    |
| ASHKHABAD       | 13    | 27    | 37    | 17    | 18    | 22    |
| DUSHANBE        | 9     | 17    | 26    | 11    | 12    | 16    |
| TASHKENT        | 12    | 26    | 34    | 15    | 18    | 20    |
| FRUNZE          | 10    | 22    | 31    | 14    | 15    | 18    |
| NORILSK         | 0     | 0     | 1     | 1     | 0     | 0     |
| ELISTA          | 18    | 33    | 37    | 23    | 23    | 23    |

<sup>a</sup>Total energy potentials for 1960, 1970, and 1975 based on distance.

<sup>b</sup>Relative energy potentials for 1960, 1970, and 1975 as percentages of Voroshilov-grad.

A Dell Foster digitizer was employed to determine the co-ordinates (X, Y) of the 129 nodes under study and the boundary of the Soviet Union using a base map with a scale of 1:10,140,000 (National Geographic Society 1976). Z-values for each node were the relative energy potential indices as calculated for distance and transport costs for 1960, 1970, and 1975. A general purpose contouring program, GPCP-II (CALCOMP 1972), and a CALCOMP drum plotter created six isarithmic energy potential maps.

### References

- CALCOMP 1972. GPCP-II User's Manual. Anaheim, Ca: California Computer Products, Inc.
- Campbell, R.W. 1968. The Economics of Soviet Oil and Gas. Baltimore, Md.: The Johns Hopkins Press.
- Dienes, L. and Shabad, T. 1979. The Soviet Energy System: Resource Use and Policies. Washington, D.C.: V.H. Winston and Sons.
- Ebel, R.E. 1961. The Petroleum Industry of the Soviet Union. Arlington, Va.: Royer and Royer, Inc.
- Ebel, R.E. 1970. Communist Trade in Oil and Gas. New York: Praeger Publishers.
- Elliot, I.F. 1974. The Soviet Energy Balance. New York, N.Y.: Praeger Publishers, Inc.
- Fullard, H., ed. 1965. Soviet Union in Maps. London: George Philip & Son, Ltd.
- Fullard, H., ed. 1972. Soviet Union in Maps. London: George Philip & Son Ltd.
- Hassmann, H. 1953. Oil in the Soviet Union. Princeton, N.J.: Princeton University Press.
- Helwig, J.T. and Council, K.A., eds. 1979. SAS User's Guide, 1979 Edition. Raleigh, N.C.: SAS Institute, Inc.
- Hodgkins, J.A. 1961. Soviet Power: Energy Resources, Production and Potentials. Englewood Cliffs, N.J.: Prentice-Hall, Inc.
- Hooson, D.J.M. 1966. The Soviet Union. London: University of London Press.
- Houston, C. 1969. Market Potential and Potential Transportation Costs: An Evaluation of the Concepts and Their Surface Patterns in the USSR. The Canadian Geographer 13, 3:216-236.
- Kish, G. 1960. Economic Atlas of the Soviet Union. Ann Arbor: The University of Michigan Press.
- Kish, G. 1970. Economic Atlas of the Soviet Union. Ann Arbor: The University of Michigan Press.
- Lydolph, P.E. 1977. Geography of the U.S.S.R. New York: John Wiley & Sons.

- Lydolph, P.E. 1979. Geography of the U.S.S.R., Topical Analysis. Elkhart, Wisconsin: Misty Valley Publishing.
- Lydolph, P.E. and Shabad, T. 1960. The oil and Gas Industries in the U.S.S.R. Annals of the Association of American Geographers 50, 4: 461-486.
- National Geographic Society. 1976. Soviet Union. Washington, D.C.: National Geographic Society.
- Shabad, T. 1961a. News Notes. Soviet Geography: Review and Translation 2, 1:76.
- Shabad, T. 1961b. News Notes. Soviet Geography: Review and Translation 2, 3:80-81.
- Shabad, T. 1969. Basic Industrial Resources of the U.S.S.R. New York: Columbia University Press.
- Shabad, T. 1978. News Notes. Soviet Geography: Review and Translation 19, 4:273-285.
- Shabad, T. 1979. News Notes. Soviet Geography: Review and Translation 20, 4:255-265.
- Taaffe, R.N., and Kingsbury, R.C. 1965. An Atlas of Soviet Affairs. New York: Frederick A. Praeger.
- USSR Geological Ministry. 1966. USSR Railroads: Directions and Stations. Moscow: Central Board in Geology and Cartography.
- Yonge, J.R. 1975. U.S.S.R. Railways. Exeter, England: The Quail Map Company.

## CHAPTER IV

### ANALYSIS OF ENERGY ACCESSIBILITY

#### Introduction

This chapter analyzes the spatial patterns of energy accessibility in the Soviet Union and its effect on Soviet urban population growth. Three sections follow. The first discusses the rank ordering of the 129 nodes based on their energy potentials and describes the six energy potential maps for 1960, 1970, and 1975 based on relative energy potential values determined by distance and distance modified by transport costs. The second section presents the results of correlation analyses between energy accessibility and urban growth. The last section is a summary.

#### Nodal Rank Ordering and Energy Potential Maps

Three regions dominate the top positions when the 129 nodes are rank ordered by their relative energy potentials based on distance for 1960, 1970, and 1975 (Table 4.1). These regions are the eastern Ukraine (Voroshilovgrad, Donetsk, Poltava, Dnepropetrovsk, Kharkov, Zaporozhye, Sumy), the western North Caucasus region (Rostov, Krasnodar, Stavropol), and the area of the Volga-Urals oil fields (Kuybyshev, Kazan, Ufa, Saratov, Perm, Ulyanovsk). Voroshilovgrad and Donetsk occupy the top two positions throughout primarily because of their favorable positions with respect to the Donets Basin. Rostov and Kharkov are near the Donets Basin and are also close to the gas fields of the North Caucasus and

Table 4.1  
Rankings by Relative Energy Potential Based on Distance

| РБС <sup>а</sup> | УОДЕ           | РЕРТО <sup>б</sup> | ОБС <sup>а</sup> | УОДЕ           | РЕРТО <sup>б</sup> | РБС <sup>а</sup> | УОДЕ           | РЕРТО <sup>б</sup> |
|------------------|----------------|--------------------|------------------|----------------|--------------------|------------------|----------------|--------------------|
| 1                | ВОРОШИЛОВГРАД  | 100                | 1                | ВОРОШИЛОВГРАД  | 100                | 1                | ВОРОШИЛОВГРАД  | 100                |
| 2                | ДОНЕЦК         | 89                 | 2                | ДОНЕЦК         | 94                 | 2                | ДОНЕЦК         | 94                 |
| 3                | ПОСТОВ         | 68                 | 3                | ПОСТОВ         | 76                 | 3                | КУЙБЫШЕВ       | 77                 |
| 4                | КУЙБЫШЕВ       | 52                 | 4                | КУЙБЫШЕВ       | 69                 | 4                | ХАРКОВ         | 72                 |
| 5                | КЕМЕРОВО       | 47                 | 5                | ХАРКОВ         | 66                 | 5                | ПОСТОВ         | 70                 |
| 6                | ХАРКОВ         | 46                 | 6                | ПОЛТАВА        | 63                 | 6                | ПОЛТАВА        | 69                 |
| 7                | КАЗАН          | 41                 | 7                | КАЗАН          | 58                 | 7                | КАЗАН          | 62                 |
| 8                | ДНЕПРОПЕТРОВСК | 41                 | 8                | УФА            | 53                 | 8                | УФА            | 60                 |
| 9                | УФА            | 40                 | 9                | ДНЕПРОПЕТРОВСК | 52                 | 9                | КЕМЕРОВО       | 58                 |
| 10               | САРАТОВ        | 38                 | 10               | БЕЛГОРОД       | 49                 | 10               | ПЕРМ           | 57                 |
| 11               | УЛЯНОВСК       | 37                 | 11               | ПЕРМ           | 48                 | 11               | ДНЕПРОПЕТРОВСК | 55                 |
| 12               | БЕЛГОРОД       | 36                 | 12               | КРАСНОДАР      | 47                 | 12               | БЕЛГОРОД       | 54                 |
| 13               | КРАСНОДАР      | 36                 | 13               | КЕМЕРОВО       | 46                 | 13               | ОРЕНБУРГ       | 51                 |
| 14               | ЗАПОРОЖЬЕ      | 36                 | 14               | УЛЯНОВСК       | 46                 | 14               | УЛЯНОВСК       | 49                 |
| 15               | ВОЛГОГРАД      | 34                 | 15               | ЗАПОРОЖЬЕ      | 46                 | 15               | ЗАПОРОЖЬЕ      | 49                 |
| 16               | СТАВРОПОЛЬ     | 34                 | 16               | САРАТОВ        | 44                 | 16               | САРАТОВ        | 49                 |
| 17               | ТУЛА           | 33                 | 17               | СТАВРОПОЛЬ     | 43                 | 17               | ИЗЕВСК         | 49                 |
| 18               | ЧЕБОКСАРЫ      | 32                 | 18               | ГРОЗНЫЙ        | 43                 | 18               | ЧЕБОКСАРЫ      | 47                 |
| 19               | ВОРОНЕЖ        | 32                 | 19               | СУМЫ           | 43                 | 19               | СУМЫ           | 46                 |
| 20               | БАКУ           | 32                 | 20               | ЧЕРНОУСОВ      | 42                 | 20               | УСМАНЬ-ОЛА     | 46                 |
| 21               | ПОЛТАВА        | 32                 | 21               | ОРОЗНИКИДЗЕ    | 42                 | 21               | ВОРОНЕЖ        | 44                 |
| 22               | ПЕРМ           | 32                 | 22               | ИЗЕВСК         | 41                 | 22               | ПЕНЗА          | 43                 |
| 23               | КАЛУГА         | 31                 | 23               | ВОРОНЕЖ        | 40                 | 23               | КРАСНОДАР      | 42                 |
| 24               | ПЕНЗА          | 31                 | 24               | УСМАНЬ-ОЛА     | 40                 | 24               | КАПСК          | 42                 |
| 25               | КУРСК          | 30                 | 25               | ПЕНЗА          | 39                 | 25               | ВОЛГОГРАД      | 42                 |
| 26               | МОСКОВ         | 28                 | 26               | КУРСК          | 39                 | 26               | ЧЕЛЫБИНСК      | 42                 |
| 27               | УСМАНЬ-ОЛА     | 28                 | 27               | ЧЕРКАССЫ       | 39                 | 27               | СТАВРОПОЛЬ     | 41                 |
| 28               | САРАНСК        | 28                 | 28               | ВОЛГОГРАД      | 38                 | 28               | ЧЕРКАССЫ       | 41                 |
| 29               | ОРЕЛ           | 28                 | 29               | ТУЛА           | 37                 | 29               | САРАНСК        | 41                 |
| 30               | ЛИПЕЦК         | 28                 | 30               | ЛИПЕЦК         | 37                 | 30               | ТЮЛЬ           | 40                 |
| 31               | ТАМБОВ         | 28                 | 31               | БАКУ           | 36                 | 31               | ЛИПЕЦК         | 40                 |
| 32               | ЧЕРКАССЫ       | 28                 | 32               | ОРЕЛ           | 36                 | 32               | ГРОЗНЫЙ        | 39                 |
| 33               | ИЗЕВСК         | 28                 | 33               | КИЕВ           | 36                 | 33               | ОРЕЛ           | 39                 |
| 34               | РЯЗАНЬ         | 27                 | 34               | НАЛЧИК         | 36                 | 34               | КИЕВ           | 39                 |
| 35               | БРЯНСК         | 27                 | 35               | КАЛУГА         | 35                 | 35               | ГОРКИ          | 39                 |
| 36               | ОРОЗНИКИДЗЕ    | 27                 | 36               | САРАНСК        | 35                 | 36               | СВЕРДЛОВСК     | 39                 |
| 37               | ГРОЗНЫЙ        | 27                 | 37               | ТАМБОВ         | 35                 | 37               | ОРОЗНИКИДЗЕ    | 38                 |
| 38               | ЧЕЛЫБИНСК      | 27                 | 38               | ГОРКИ          | 35                 | 38               | БАКУ           | 38                 |
| 39               | ГОРКИ          | 26                 | 39               | ЧЕЛЫБИНСК      | 34                 | 39               | КАЛУГА         | 38                 |
| 40               | СУМЫ           | 26                 | 40               | ЧЕРНИГОВ       | 34                 | 40               | ТАМБОВ         | 38                 |
| 41               | ОРЕНБУРГ       | 26                 | 41               | МОСКОВ         | 33                 | 41               | ЧЕРНИГОВ       | 38                 |
| 42               | КАРАГАНДА      | 26                 | 42               | РЯЗАНЬ         | 33                 | 42               | МОСКОВ         | 37                 |
| 43               | КИЕВ           | 24                 | 43               | БРЯНСК         | 33                 | 43               | РЯЗАНЬ         | 37                 |
| 44               | ВЛАДИМИР       | 23                 | 44               | ОРЕНБУРГ       | 33                 | 44               | БРЯНСК         | 37                 |
| 45               | НАЛЧИК         | 23                 | 45               | ВЛАДИМИР       | 33                 | 45               | ВЛАДИМИР       | 36                 |
| 46               | КИРОВСКОЕ      | 23                 | 46               | НИКОЛАЕВ       | 32                 | 46               | ТОМСК          | 36                 |
| 47               | НИКОЛАЕВ       | 23                 | 47               | ХЕРСОН         | 32                 | 47               | НАЛЧИК         | 35                 |
| 48               | ХЕРСОН         | 23                 | 48               | ЛВОВ           | 31                 | 48               | НИКОЛАЕВ       | 35                 |
| 49               | СИМФЕРОПОЛЬ    | 23                 | 49               | СВЕРДЛОВСК     | 30                 | 49               | ХЕРСОН         | 35                 |
| 50               | НОВОСИБИРСК    | 23                 | 50               | ИВАНОВО        | 30                 | 50               | ГОМЕЛЬ         | 35                 |
| 51               | УРАЛЬСК        | 23                 | 51               | ГОМЕЛЬ         | 30                 | 51               | КУСТАНAY       | 35                 |
| 52               | КАЛИНИН        | 22                 | 52               | МАХАЧКАЛА      | 29                 | 52               | АКТИУБИНСК     | 35                 |
| 53               | АСТРАХАНЬ      | 22                 | 53               | ЗИТОМИР        | 29                 | 53               | ИВАНОВО        | 34                 |
| 54               | МАХАЧКАЛА      | 22                 | 54               | КАРАГАНДА      | 28                 | 54               | ГУРЬЕВ         | 34                 |
| 55               | ЛВОВ           | 22                 | 55               | КАЛИНИН        | 28                 | 55               | НОВОСИБИРСК    | 34                 |
| 56               | ЧЕРНИГОВ       | 22                 | 56               | КУСТАНAY       | 28                 | 56               | КАРАГАНДА      | 33                 |

Table 4.1--Continued

| OBS NODE            | REP60 | OBS NODE           | REP70 | OBS NODE           | REP75 |
|---------------------|-------|--------------------|-------|--------------------|-------|
| 57 SVERDLOVSK       | 22    | 57 YAROSLAVL       | 28    | 57 YAROSLAVL       | 31    |
| 58 TOMSK            | 22    | 58 KOSTROMA        | 28    | 58 ZHITOMIR        | 32    |
| 59 KUSTANAY         | 22    | 59 SMOLENSK        | 28    | 59 KALININ         | 32    |
| 60 YAROSLAVL        | 21    | 60 AKTYUBINSK      | 28    | 60 KOSTROMA        | 32    |
| 61 IVANOV           | 21    | 61 IVANO_FRANKOVSK | 28    | 61 SMOLENSK        | 32    |
| 62 ZHITOMIR         | 21    | 62 GUR'YEV         | 28    | 62 KURGAY          | 32    |
| 63 GOMEL            | 21    | 63 ASTRAKHAN       | 27    | 63 PAVLODAR        | 32    |
| 64 KURGAN           | 21    | 64 TERNOPOL        | 27    | 64 MOGILEV         | 32    |
| 65 KOSTROMA         | 20    | 65 VINNITSA        | 27    | 65 LVOV            | 31    |
| 66 KIROV            | 20    | 66 ODESSA          | 27    | 66 VINNITSA        | 30    |
| 67 SMOLENSK         | 20    | 67 KHMELNITSKIY    | 27    | 67 VOLOGDA         | 30    |
| 68 TERNOPOL         | 20    | 68 URALSK          | 26    | 68 TYUMEN          | 30    |
| 69 VINNITSA         | 20    | 69 VOLOGDA         | 26    | 69 TERNOPOL        | 29    |
| 70 MOGILEV          | 20    | 70 ROVNO           | 26    | 70 ODESSA          | 29    |
| 71 AKTYUBINSK       | 20    | 71 UZHGOROD        | 26    | 71 KHMELNITSKIY    | 29    |
| 72 ELISTA           | 20    | 72 KIROVOGRAD      | 25    | 72 URALSK          | 29    |
| 73 PETROPAVLOVSK    | 19    | 73 NOVOSIBIRSK     | 25    | 73 VITEBSK         | 29    |
| 74 TSELINGRAD       | 19    | 74 KURGAY          | 25    | 74 IVANO_FRANKOVSK | 29    |
| 75 VOLOGDA          | 18    | 75 LUTSK           | 25    | 75 ASTRAKHAN       | 28    |
| 76 MINSK            | 18    | 76 KIROV           | 24    | 76 ROVNO           | 28    |
| 77 ODESSA           | 18    | 77 MINSK           | 24    | 77 KIROV           | 28    |
| 78 VITEBSK          | 18    | 78 TBILISI         | 24    | 78 MINSK           | 26    |
| 79 TYUMEN           | 18    | 79 SIMFEROPOL      | 23    | 79 PETROPAVLOVSK   | 28    |
| 80 OMSK             | 18    | 80 TOMSK           | 23    | 80 TSELINGRAD      | 28    |
| 81 BARNAIL          | 18    | 81 PETROPAVLOVSK   | 23    | 81 MAKHACHKALA     | 27    |
| 82 NOVGOROD         | 17    | 82 TYUMEN          | 23    | 82 LUTSK           | 27    |
| 83 TBILISI          | 17    | 83 NOVGOROD        | 23    | 83 OMSK            | 27    |
| 84 LUTSK            | 17    | 84 BREST           | 23    | 84 UZHGOROD        | 26    |
| 85 ROVNO            | 17    | 85 PAVLODAR        | 23    | 85 KIROVOGRAD      | 26    |
| 86 KHMELNITSKIY     | 17    | 86 KISHINEV        | 23    | 86 TBILISI         | 26    |
| 87 BREST            | 17    | 87 CHERNOVSTY      | 23    | 87 NOVGOROD        | 26    |
| 88 KOKCHETAV        | 17    | 88 MOGILEV         | 22    | 88 BREST           | 26    |
| 89 PAVLODAR         | 17    | 89 TSELINGRAD      | 22    | 89 KOKCHETAV       | 26    |
| 90 LENINGRAD        | 16    | 90 ELISTA          | 21    | 90 BARNAIL         | 26    |
| 91 KISHINEV         | 16    | 91 VITEBSK         | 21    | 91 KRASNODARSK     | 26    |
| 92 IVANO_FRANKOVSK  | 16    | 92 OMSK            | 21    | 92 KISHINEV        | 25    |
| 93 CHERNOVSTY       | 16    | 93 KOKCHETAV       | 21    | 93 CHERNOVSTY      | 25    |
| 94 KRASNODARSK      | 16    | 94 LENINGRAD       | 21    | 94 SYKTYVKAR       | 25    |
| 95 VILNIUS          | 15    | 95 VILNIUS         | 21    | 95 SIMFEROPOL      | 24    |
| 96 PSKOV            | 15    | 96 SYKTYVKAR       | 20    | 96 LENINGRAD       | 24    |
| 97 UZHGOROD         | 15    | 97 GRODNO          | 20    | 97 VILNIUS         | 24    |
| 98 IRKUTSK          | 15    | 98 BARNAIL         | 19    | 98 GRODNO          | 23    |
| 99 ABAKAN           | 15    | 99 TALLIN          | 19    | 99 TASHKENT        | 23    |
| 100 GUR'YEV         | 15    | 100 RIGA           | 19    | 100 ASHKHABAD      | 23    |
| 101 PETROZAVODSK    | 14    | 101 YEREVAN        | 19    | 101 ELISTA         | 22    |
| 102 SYKTYVKAR       | 14    | 102 KRASNODARSK    | 18    | 102 TALLIN         | 22    |
| 103 TALLIN          | 14    | 103 CHIMKENT       | 18    | 103 RIGA           | 22    |
| 104 RIGA            | 14    | 104 TASHKENT       | 18    | 104 YEREVAN        | 22    |
| 105 YEREVAN         | 14    | 105 PSKOV          | 17    | 105 CHIMKENT       | 22    |
| 106 GRODNO          | 14    | 106 ABAKAN         | 17    | 106 ABAKAN         | 22    |
| 107 ARKHANGELSK     | 13    | 107 DZHAMBUL       | 17    | 107 DZHAMBUL       | 21    |
| 108 KALININGRAD     | 13    | 108 FRUNZF         | 16    | 108 FRUNZF         | 20    |
| 109 KZYL_ORDA       | 13    | 109 PETROZAVODSK   | 15    | 109 PSKOV          | 19    |
| 110 CHIMKENT        | 13    | 110 ARKHANGELSK    | 15    | 110 ALMA-ATA       | 19    |
| 111 SEMIPALATINSK   | 13    | 111 KZYL_ORDA      | 15    | 111 SEMIPALATINSK  | 19    |
| 112 UST_KAMENOGORSK | 13    | 112 ASHKHABAD      | 15    | 112 KZYL_ORDA      | 18    |

Table 4.1--Continued

| OBS NODE               | REP60 | OBS NODE               | REP70 | OBS NODE               | REP75 |
|------------------------|-------|------------------------|-------|------------------------|-------|
| 113 ASHKHABAD          | 13    | 113 ALMA_ATA           | 15    | 113 UST_KAMENOGORSK    | 13    |
| 114 TASHKENT           | 13    | 114 IRKUTSK            | 14    | 114 DUSHANBE           | 18    |
| 115 DZHAMBUL           | 11    | 115 KALININGRAD        | 14    | 115 PETROZAVODSK       | 17    |
| 116 ALMA_ATA           | 11    | 116 SEMIPALATINSK      | 14    | 116 ARKHANGELSK        | 17    |
| 117 FRUNZE             | 11    | 117 UST_KAMENOGORSK    | 14    | 117 IRKUTSK            | 17    |
| 118 MURMANSK           | 10    | 118 MURMANSK           | 11    | 118 KALININGRAD        | 16    |
| 119 CHITA              | 9     | 119 DUSHANBE           | 11    | 119 MURMANSK           | 13    |
| 120 ULAN_UDE           | 9     | 120 CHITA              | 9     | 120 CHITA              | 12    |
| 121 DUSHANBE           | 9     | 121 ULAN_UDE           | 9     | 121 ULAN_UDE           | 12    |
| 122 VLADIVOSTOK        | 7     | 122 VLADIVOSTOK        | 7     | 122 VLADIVOSTOK        | 9     |
| 123 BLAGOVESHCHENSK    | 6     | 123 BLAGOVESHCHENSK    | 6     | 123 BLAGOVESHCHENSK    | 8     |
| 124 KHABAROVSK         | 5     | 124 KHABAROVSK         | 6     | 124 KHABAROVSK         | 7     |
| 125 YUZHYO_SAKHALINSK  | 5     | 125 YAKUTSK            | 6     | 125 YAKUTSK            | 7     |
| 126 YAKUTSK            | 5     | 126 YUZHYO_SAKHALINSK  | 5     | 126 YUZHYO_SAKHALINSK  | 6     |
| 127 MAGADAN            | 4     | 127 MAGADAN            | 5     | 127 MAGADAN            | 6     |
| 128 PETROPAVLLOVSK_KAM | 4     | 128 PETROPAVLLOVSK_KAM | 5     | 128 PETROPAVLLOVSK_KAM | 5     |
| 129 NORILSK            | 1     | 129 NORILSK            | 1     | 129 NORILSK            | 1     |

<sup>a</sup>Approximate rankings by rounded relative energy potentials. Rankings mentioned in text are by unrounded absolute energy potential indices.

<sup>b</sup>Relative energy potential for 1960, 1970, and 1975 as percentage of Voroshilovgrad.

eastern Ukraine respectively. Poltava's rise from 21st place in 1960 to 6th place in 1970 and 1975 was caused by the rapid increase in production of the east Ukrainian gas fields. Kuybyshev and the other cities in the Volga-Urals oil fields area owe their rankings to their proximity to oil producing sources. Kemerovo is not near any of the three regions mentioned but owes its high rankings to its location in the middle of the Kuznetsk Basin along with some contribution from the West Siberian oil fields in 1975.

A number of nodes outside major production areas showed large changes in rank from 1960 to 1975. The old oil producing center of Baku experienced an increase in its energy accessibility from 1960 to 1975 but dropped in ranking from 19th place in 1960 to 40th place in 1975. Largely because of its gas fields, Orenburg rose from 39th place in 1960 and 44th place in 1970 to 13th place in 1975. Simferopol, on the Crimean Peninsula, experienced only a modest increase in its absolute energy accessibility from 1960 to 1975, and its relative accessibility remained virtually the same, but most other nodes increased their relative energy accessibility. Simferopol, consequently, steadily declined in rank from 49th place in 1960, 80th place in 1970, to 96th place in 1975. Guryev, on the other hand, underwent proportionally substantial absolute and relative increases in energy accessibility from 1960 to 1975 and rose from 97th place in 1960, 60th place in 1970, to 54th place in 1975. The areas with the lowest energy potentials throughout the period 1960-1975 were the Baltic, Central Asia, East Siberia, Far East, and Northwest regions.

The general patterns of energy accessibility do not appear to have changed much from 1960 to 1975, and the correlations were quite high

between the values for 1960 and 1970 ( $r = +0.96$ ), 1970 and 1975 ( $r = +0.98$ ), and 1960 and 1975 ( $r = +0.94$ ). Practically all nodes underwent increases in energy accessibility relative to Voroshilovgrad which experienced some of the lowest percent increases in absolute energy potential during the period 1960-1975 because of the virtually stagnant, albeit high, production of the Donets Basin.

A different pattern was evident when the rankings were by relative energy accessibility based on distance modified by transport costs (Table 4.2). The low cost of transporting oil compared to coal and gas resulted in those nodes in or near oil producing areas dominating the top positions. Additional cities (Cheboksary, Izhevsk, Penza, Saransk) in or near the Volga-Urals oil fields join those nodes in that region which were among the top when rankings were by energy accessibility based on distance. Nodes in the eastern Ukraine and others, such as Kemerovo, which were dependent on coal for a large portion of their energy accessibility dropped sharply from their earlier rankings by energy accessibility based on distance. Rostov and other cities in the North Caucasus region generally declined in rankings from 1960 to 1975. Baku, whose oil production dipped slightly from 1960 to 1975, fell from 8th place in 1960 to 21st place in 1975 as oil production greatly increased in other areas of the Soviet Union. Orenburg remained in the top 20 positions during 1960-1975 because of its location near the Volga-Urals oil fields and its own gas fields. Cities in the eastern Urals region (Chelyabinsk, Sverdlovsk, Kurgan) rose in rankings from 1960 to 1975 as a result of the influence of the Volga-Urals oil fields and the newly discovered oil fields of West Siberia. Simferopol and Guryev moved through positions as before when the rankings were based on distance

Table 4.2  
Rankings by Relative Energy Potential Based on Distance Modified by Transport Costs

| Obs <sup>a</sup> NODE | RCP40 <sup>b</sup> | Obs <sup>a</sup> NODE | REP70 <sup>b</sup> | Obs <sup>a</sup> NODE | REP70 <sup>b</sup> |
|-----------------------|--------------------|-----------------------|--------------------|-----------------------|--------------------|
| 1 KJYBYSHEV           | 100                | 1 KJYBYSHEV           | 100                | 1 KJYBYSHEV           | 100                |
| 2 KAZAN               | 75                 | 2 KAZAN               | 92                 | 2 KAZAN               | 92                 |
| 3 UFA                 | 72                 | 3 UFA                 | 74                 | 3 UFA                 | 76                 |
| 4 ULYANOVSK           | 66                 | 4 ULYANOVSK           | 68                 | 4 PERM                | 73                 |
| 5 VOROSHILOVGRAD      | 63                 | 5 PERM                | 66                 | 5 ULYANOVSK           | 68                 |
| 6 SARATOV             | 57                 | 6 VOROSHILOVGRAD      | 55                 | 6 IZHEVSK             | 59                 |
| 7 DONETSK             | 57                 | 7 SARATOV             | 54                 | 7 CHEROKSARY          | 56                 |
| 8 BAKU                | 53                 | 8 CHEROKSARY          | 54                 | 8 SARATOV             | 55                 |
| 9 PERM                | 52                 | 9 IZHEVSK             | 54                 | 9 YOSHKAR_OLA         | 55                 |
| 10 CHEROKSARY         | 51                 | 10 YOSHKAR_OLA        | 53                 | 10 VOROSHILOVGRAD     | 53                 |
| 11 ROSTOV             | 50                 | 11 DONETSK            | 52                 | 11 ORENBURG           | 53                 |
| 12 YOSHKAR_OLA        | 48                 | 12 GROZNY             | 51                 | 12 DONETSK            | 51                 |
| 13 IZHEVSK            | 47                 | 13 ROSTOV             | 48                 | 13 POLTAVA            | 49                 |
| 14 PENZA              | 44                 | 14 ORDZHONIKIDZE      | 48                 | 14 PENZA              | 47                 |
| 15 ORENBURG           | 43                 | 15 POLTAVA            | 48                 | 15 KHARKOV            | 47                 |
| 16 KRASNODAR          | 42                 | 16 PENZA              | 46                 | 16 SARANSK            | 45                 |
| 17 SARANSK            | 41                 | 17 KHARKOV            | 46                 | 17 CHELYABINSK        | 45                 |
| 18 VOLGOGRAD          | 39                 | 18 BAKU               | 45                 | 18 GORKIY             | 44                 |
| 19 GORKIY             | 38                 | 19 ORENBURG           | 45                 | 19 SVERDLOVSK         | 44                 |
| 20 KHARKOV            | 37                 | 20 SARANSK            | 42                 | 20 ROSTOV             | 43                 |
| 21 GROZNY             | 36                 | 21 GORKIY             | 41                 | 21 BAKU               | 41                 |
| 22 CHELYABINSK        | 35                 | 22 SJMY               | 40                 | 22 GROZNY             | 40                 |
| 23 TAMBOV             | 34                 | 23 KRASNODAR          | 39                 | 23 SUMY               | 40                 |
| 24 STAVROPOL          | 34                 | 24 VOLGOGRAD          | 39                 | 24 VOLGOGRAD          | 40                 |
| 25 ORDZHONIKIDZE      | 34                 | 25 CHELYABINSK        | 39                 | 25 BELGOROD           | 40                 |
| 26 URALS              | 34                 | 26 BELGOROD           | 39                 | 26 KJRGAN             | 39                 |
| 27 TULA               | 33                 | 27 MAKHACHKALA        | 38                 | 27 ORDZHONIKIDZE      | 38                 |
| 28 DNEPROPETROVSK     | 33                 | 28 NALCHIK            | 38                 | 28 TAMBOV             | 38                 |
| 29 VLADIMIR           | 32                 | 29 TAMBOV             | 37                 | 29 AKTYUBINSK         | 38                 |
| 30 RYAZAN             | 32                 | 30 DNEPROPETROVSK     | 37                 | 30 TYUMEN             | 38                 |
| 31 VORONEZH           | 32                 | 31 VLADIMIR           | 36                 | 31 DNEPROPETROVSK     | 37                 |
| 32 MOSCOW             | 31                 | 32 VORONEZH           | 36                 | 32 VLADIMIR           | 37                 |
| 33 KALUGA             | 31                 | 33 STAVROPOL          | 35                 | 33 VORONEZH           | 37                 |
| 34 BELGOROD           | 31                 | 34 LIPETSK            | 35                 | 34 URALS              | 37                 |
| 35 LIPETSK            | 31                 | 35 SVERDLOVSK         | 35                 | 35 CHERNIGOV          | 37                 |
| 36 MAKHACHKALA        | 31                 | 36 URALS              | 34                 | 36 KUSTANAY           | 37                 |
| 37 ASTRAKHAN          | 30                 | 37 TULA               | 34                 | 37 KEMEROVO           | 37                 |
| 38 NALCHIK            | 30                 | 38 RYAZAN             | 34                 | 38 KRASNODAR          | 36                 |
| 39 ZAPOROZHIE         | 30                 | 39 ZAPOROZHIE         | 34                 | 39 LIPETSK            | 36                 |
| 40 KEMEROVO           | 30                 | 40 KURSK              | 34                 | 40 RYAZAN             | 36                 |
| 41 IVANOV             | 29                 | 41 AKTYUBINSK         | 34                 | 41 TULA               | 35                 |
| 42 KURSK              | 29                 | 42 MOSCOW             | 33                 | 42 KURSK              | 35                 |
| 43 POLTAVA            | 29                 | 43 ASTRAKHAN          | 33                 | 43 MOSCOW             | 35                 |
| 44 SVERDLOVSK         | 29                 | 44 IVANOV             | 33                 | 44 IVANOV             | 35                 |
| 45 AKTYUBINSK         | 29                 | 45 CHERNIGOV          | 33                 | 45 KIROV              | 35                 |
| 46 OREL               | 28                 | 46 KALUGA             | 32                 | 46 GURIEV             | 35                 |
| 47 BRYANSK            | 28                 | 47 OREL               | 32                 | 47 ZAPOROZHIE         | 34                 |
| 48 KJRGAN             | 28                 | 48 CHERKASSY          | 32                 | 48 KALUGA             | 34                 |
| 49 KUSTANAY           | 28                 | 49 KIEV               | 32                 | 49 OREL               | 34                 |
| 50 KIROV              | 7                  | 50 BRYANSK            | 31                 | 50 TOMSK              | 34                 |
| 51 YAROSLAVL          | 26                 | 51 KJRGAN             | 31                 | 51 NALCHIK            | 33                 |
| 52 KALININ            | 26                 | 52 KUSTANAY           | 31                 | 52 STAVROPOL          | 33                 |
| 53 KOSTROMA           | 26                 | 53 KIROV              | 31                 | 53 ASTRAKHAN          | 33                 |
| 54 SUMY               | 26                 | 54 YAROSLAVL          | 31                 | 54 CHERKASSY          | 33                 |
| 55 CHERKASSY          | 25                 | 55 GURIEV             | 31                 | 55 KIEV               | 33                 |
| 56 LVOV               | 24                 | 56 KOSTROMA           | 30                 | 56 BRYANSK            | 33                 |

Table 4.2--Continued

| OBS NODE           | REP60 | OBS NODE           | REP71 | OBS NODE           | REP75 |
|--------------------|-------|--------------------|-------|--------------------|-------|
| 57 PETROPAVLOVSK   | 24    | 57 GOMFL           | 30    | 57 YAROSLAVL       | 33    |
| 58 VOLGODA         | 23    | 58 KALININ         | 29    | 58 KOSTROMA        | 33    |
| 59 KIEV            | 23    | 59 TYUMEN          | 28    | 59 GOMFL           | 33    |
| 60 SMOLENSK        | 23    | 60 VOLGODA         | 27    | 60 MAKHACHKALA     | 32    |
| 61 TBILISI         | 23    | 61 SMOLENSK        | 27    | 61 PETROPAVLOVSK   | 32    |
| 62 CHERNIGOV       | 23    | 62 NIKOLAYEV       | 27    | 62 KALININ         | 31    |
| 63 KIROVOGRAD      | 23    | 63 KHERSON         | 27    | 63 VOLGODA         | 30    |
| 64 NIKOLAYEV       | 23    | 64 KEMEROVO        | 26    | 64 SMOLENSK        | 30    |
| 65 KHERSON         | 23    | 65 PETROPAVLOVSK   | 26    | 65 MOGILEV         | 30    |
| 66 TYUMEN          | 23    | 66 ZHITOMIR        | 26    | 66 OMSK            | 30    |
| 67 KARAGANDA       | 23    | 67 LVOV            | 25    | 67 NOVOSIBIRSK     | 30    |
| 68 ELISTA          | 23    | 68 MOGILEV         | 25    | 68 KOKCHETAV       | 29    |
| 69 ZHITOMIR        | 22    | 69 TBILISI         | 24    | 69 NIKOLAYEV       | 28    |
| 70 SIMFEROPOL      | 22    | 70 KIROVOGRAD      | 24    | 70 KHERSON         | 28    |
| 71 MOGILEV         | 22    | 71 MINSK           | 24    | 71 VITEBSK         | 28    |
| 72 GOMFL           | 22    | 72 VINNITSA        | 24    | 72 ZHITOMIR        | 27    |
| 73 GURYEV          | 22    | 73 IVANO_FRANKOVSK | 24    | 73 MINSK           | 27    |
| 74 VITEBSK         | 21    | 74 KHMELNITSKIY    | 24    | 74 VINNITSA        | 26    |
| 75 OMSK            | 21    | 75 ELISTA          | 23    | 75 KARAGANDA       | 26    |
| 76 KOKCHETAV       | 21    | 76 VITEBSK         | 23    | 76 SYKTYVKAR       | 26    |
| 77 TSELINGRAD      | 21    | 77 KOKCHETAV       | 23    | 77 TSELINGRAD      | 26    |
| 78 NOVGOROD        | 20    | 78 NOVGOROD        | 23    | 78 PAVLODAR        | 26    |
| 79 MINSK           | 20    | 79 TERNOPOL        | 23    | 79 LVOV            | 25    |
| 80 TERNOPOL        | 20    | 80 POVNO           | 23    | 80 KIROVOGRAD      | 25    |
| 81 VINNITSA        | 20    | 81 ODESSA          | 23    | 81 NOVGOROD        | 25    |
| 82 LENINGRAD       | 19    | 82 KARAGANDA       | 22    | 82 TBILISI         | 24    |
| 83 PSKOV           | 19    | 83 SIMFEROPOL      | 22    | 83 KHMELNITSKIY    | 24    |
| 84 ROVNO           | 19    | 84 OMSK            | 22    | 84 TERNOPOL        | 24    |
| 85 IVANO_FRANKOVSK | 19    | 85 BREST           | 22    | 85 ROVNO           | 24    |
| 86 KHMELNITSKIY    | 19    | 86 LUTSK           | 22    | 86 ODESSA          | 24    |
| 87 ODESSA          | 19    | 87 UZHGOROD        | 22    | 87 LENINGRAD       | 24    |
| 88 BREST           | 19    | 88 SYKTYVKAR       | 22    | 88 BARNAIL         | 24    |
| 89 NOVOSIBIRSK     | 19    | 89 TSELINGRAD      | 21    | 89 IVANO_FRANKOVSK | 23    |
| 90 VILNIUS         | 18    | 90 LENINGRAD       | 21    | 90 ELISTA          | 23    |
| 91 YEREVAN         | 18    | 91 VILNIUS         | 21    | 91 BREST           | 23    |
| 92 LUTSK           | 18    | 92 CHERNOVSTY      | 21    | 92 LJTSK           | 23    |
| 93 UZHGOROD        | 18    | 93 PSKOV           | 20    | 93 VILNIUS         | 23    |
| 94 CHERNOVSTY      | 18    | 94 YEREVAN         | 20    | 94 KRASNYYARSK     | 23    |
| 95 TOMSK           | 19    | 95 KISHINEV        | 20    | 95 SIMFEROPOL      | 22    |
| 96 KZYL_ORDA       | 18    | 96 GRODNO          | 20    | 96 UZHGOROD        | 22    |
| 97 PETROZAVODSK    | 17    | 97 NOVOSIBIRSK     | 19    | 97 CHERNOVSTY      | 22    |
| 98 ARKHANGELSK     | 17    | 98 RIGA            | 19    | 98 PSKOV           | 22    |
| 99 SYKTYVKAR       | 17    | 99 PAVLODAR        | 19    | 99 RIGA            | 22    |
| 100 KISHINEV       | 17    | 100 TALLIN         | 19    | 100 ASHKHABAD      | 22    |
| 101 RIGA           | 17    | 101 TOMSK          | 18    | 101 KISHINEV       | 21    |
| 102 BARNAIL        | 17    | 102 KZYL_ORDA      | 18    | 102 GRODNO         | 21    |
| 103 PAVLODAR       | 17    | 103 PETROZAVODSK   | 18    | 103 TALLIN         | 21    |
| 104 ASHKHABAD      | 17    | 104 ARKHANGELSK    | 18    | 104 KZYL_ORDA      | 21    |
| 105 TALLIN         | 16    | 105 ASHKHABAD      | 19    | 105 CHIMKENT       | 21    |
| 106 KALININGRAD    | 16    | 106 TASHKENT       | 18    | 106 YEREVAN        | 20    |
| 107 GRODNO         | 16    | 107 CHIMKENT       | 17    | 107 PETROZAVODSK   | 20    |
| 108 CHIMKENT       | 15    | 108 BARNAIL        | 16    | 108 ARKHANGELSK    | 20    |
| 109 TASHKENT       | 15    | 109 KALININGRAD    | 16    | 109 TASHKENT       | 20    |
| 110 KRASNYYARSK    | 14    | 110 DZHAMBJL       | 16    | 110 ABAKAN         | 20    |
| 111 ABAKAN         | 14    | 111 KRASNYYARSK    | 15    | 111 DZHAMBJL       | 19    |
| 112 DZHAMBJL       | 14    | 112 FRUNZE         | 15    | 112 KALININGRAD    | 19    |

Table 4.2--Continued

| OBS NODE               | RFP60 | OBS NODE               | RFP70 | OBS NODE               | RFP75 |
|------------------------|-------|------------------------|-------|------------------------|-------|
| 113 SEMIPALATINSK      | 14    | 113 ARAKAN             | 14    | 113 FRUNZE             | 10    |
| 114 UST_KAMENOGORSK    | 14    | 114 SEMIPALATINSK      | 14    | 114 SEMIPALATINSK      | 10    |
| 115 FRUNZE             | 14    | 115 UST_KAMENOGORSK    | 14    | 115 UST_KAMENOGORSK    | 17    |
| 116 MJRMANSK           | 12    | 116 ALMA_ATA           | 14    | 116 ALMA_ATA           | 17    |
| 117 IRKUTSK            | 12    | 117 MJRMANSK           | 13    | 117 DUSHANBE           | 16    |
| 118 ALMA_ATA           | 12    | 118 DUSHANBE           | 12    | 118 MJRMANSK           | 15    |
| 119 DUSHANBE           | 11    | 119 IRKUTSK            | 11    | 119 IRKUTSK            | 15    |
| 120 CHITA              | 8     | 120 ULAN_UDE           | 9     | 120 ULAN_UDE           | 12    |
| 121 ULAN_UDE           | 8     | 121 CHITA              | 8     | 121 CHITA              | 11    |
| 122 VLADIVOSTOK        | 6     | 122 VLADIVOSTOK        | 6     | 122 BLAGOVESHCHENSK    | 8     |
| 123 Khabarovsk         | 6     | 123 Khabarovsk         | 6     | 123 VLADIVOSTOK        | 7     |
| 124 BLAGOVESHCHENSK    | 6     | 124 BLAGOVESHCHENSK    | 6     | 124 Khabarovsk         | 7     |
| 125 YAKUTSK            | 6     | 125 YAKUTSK            | 6     | 125 YAKUTSK            | 7     |
| 126 MAGADAN            | 5     | 126 MAGADAN            | 5     | 126 MAGADAN            | 6     |
| 127 YUZHNOD_SAKHALINSK | 4     | 127 YUZHNOD_SAKHALINSK | 5     | 127 YUZHNOD_SAKHALINSK | 6     |
| 128 PETROPAVLOVSK_KAM  | 4     | 128 PETROPAVLOVSK_KAM  | 5     | 128 PETROPAVLOVSK_KAM  | 6     |
| 129 NDRILSK            | 1     | 129 NDRILSK            | 0     | 129 NDRILSK            | 0     |

<sup>a</sup>Approximate rankings by rounded relative energy potentials. Rankings mentioned in text are by unrounded absolute energy potential indices.

<sup>b</sup>Relative energy potential for 1960, 1970, and 1975 as percentage of Kuybyshev.

alone, but their changes in rankings were not quite as large. The areas with the lowest energy potential based on transport costs during 1960-1975 were generally the same as those when energy accessibility was determined by distance. The overall patterns of energy accessibility based on transport costs varied even less through time than those for distance, with correlation coefficients of +0.97 for 1960 and 1970, +0.97 for 1970 and 1975, and +0.95 for 1960 and 1975.

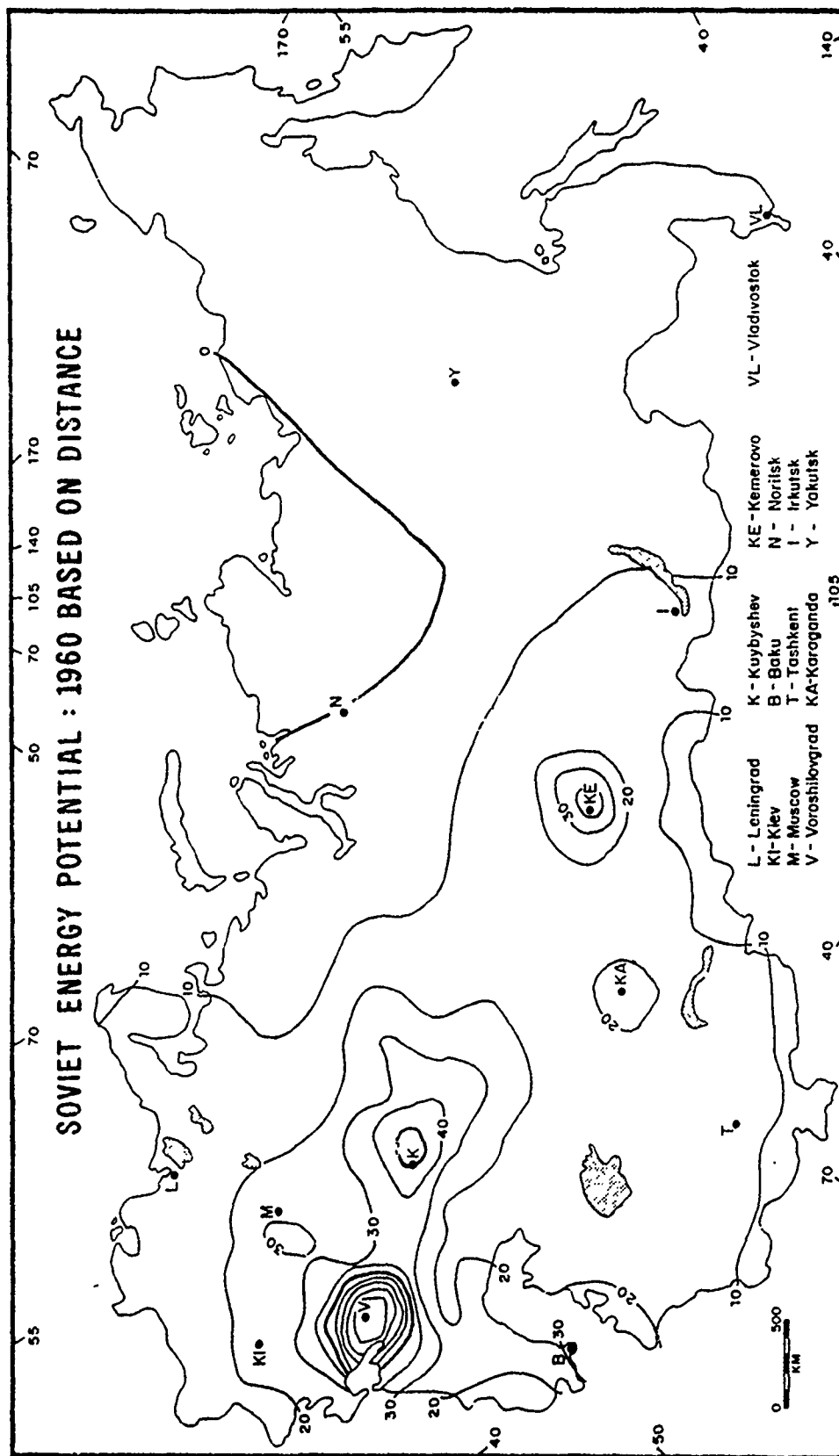
The patterns of energy accessibility using unmodified distance are similar to those determined by distance modified by transport costs. The correlations between the two sets of values were high with correlation coefficients of +0.78 for 1960, +0.83 for 1970, and +0.84 for 1975. This similarity occurs because, although the top positions changed from one set of rankings to the other, the bulk of the nodes remained fairly constant in their positions. Moscow, for example, fluctuated between 32nd and 43rd places when the rankings were based on distance and between 34th and 44th places when transport costs were used. Moscow's values were somewhat higher than might otherwise have been expected because of its distance from major sources of energy, but Moscow benefits from being the center of the transportation network in the European USSR. Energy thus has a shorter distance to travel to get to Moscow than to other nodes around Moscow.

The energy potential indices of the 129 nodes were used to construct maps showing energy accessibility as calculated using distance and distance modified by transport costs for 1960, 1970, and 1975 (Figures 4.1 through 4.6). On the basis of the indices determined for each node, contour lines of equal energy potential were drawn. For easier comparison, the values of the contour lines are expressed as percentages

FIGURE 4.1

Source: Data for outline and cities taken from Soviet Union,  
National Geographic Society, 1976,  
transverse polyconic projection.





## FIGURE 4.2

Source: Data for outline and cities taken from Soviet Union,  
National Geographic Society, 1976,  
transverse polyconic projection.



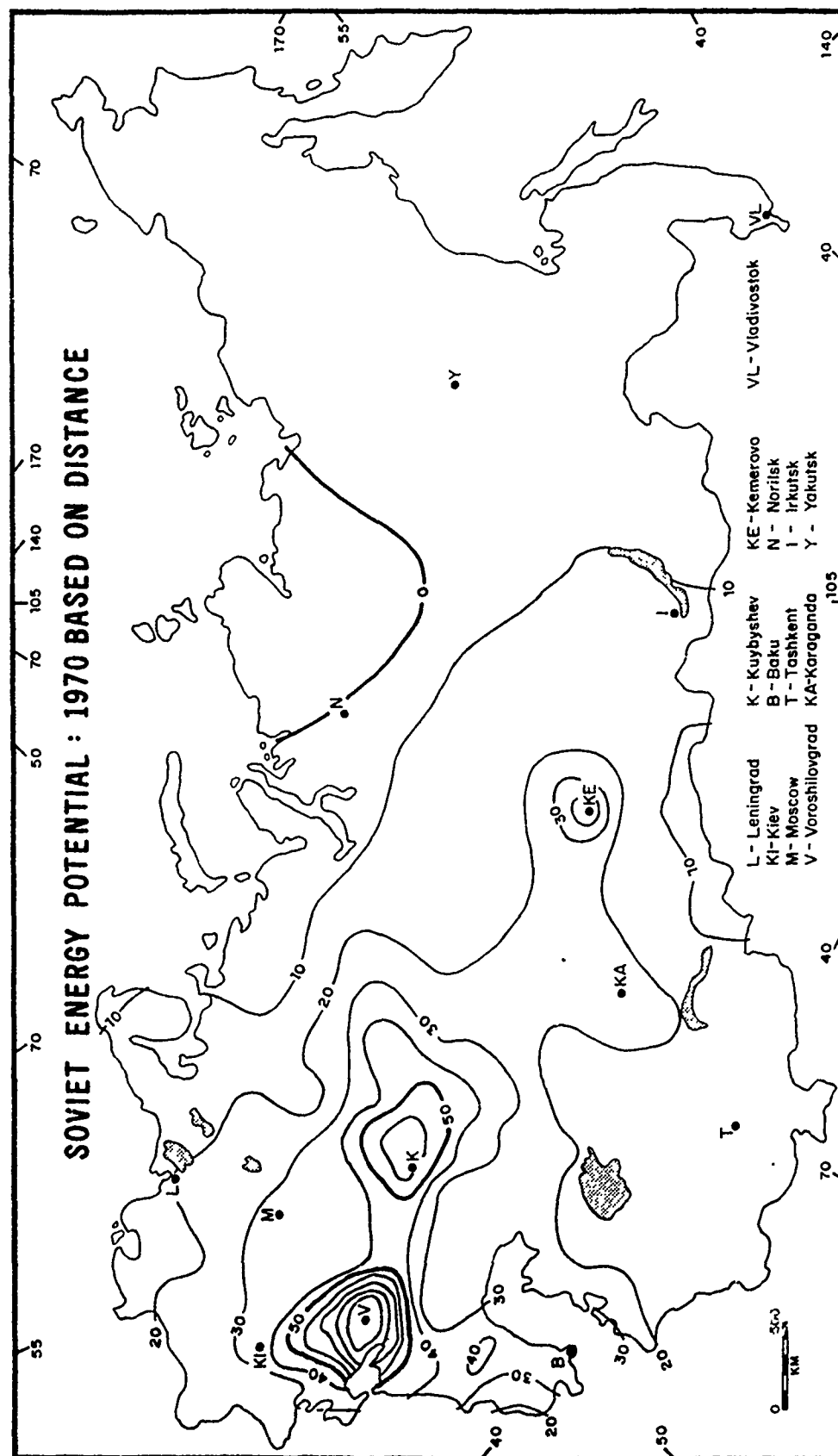
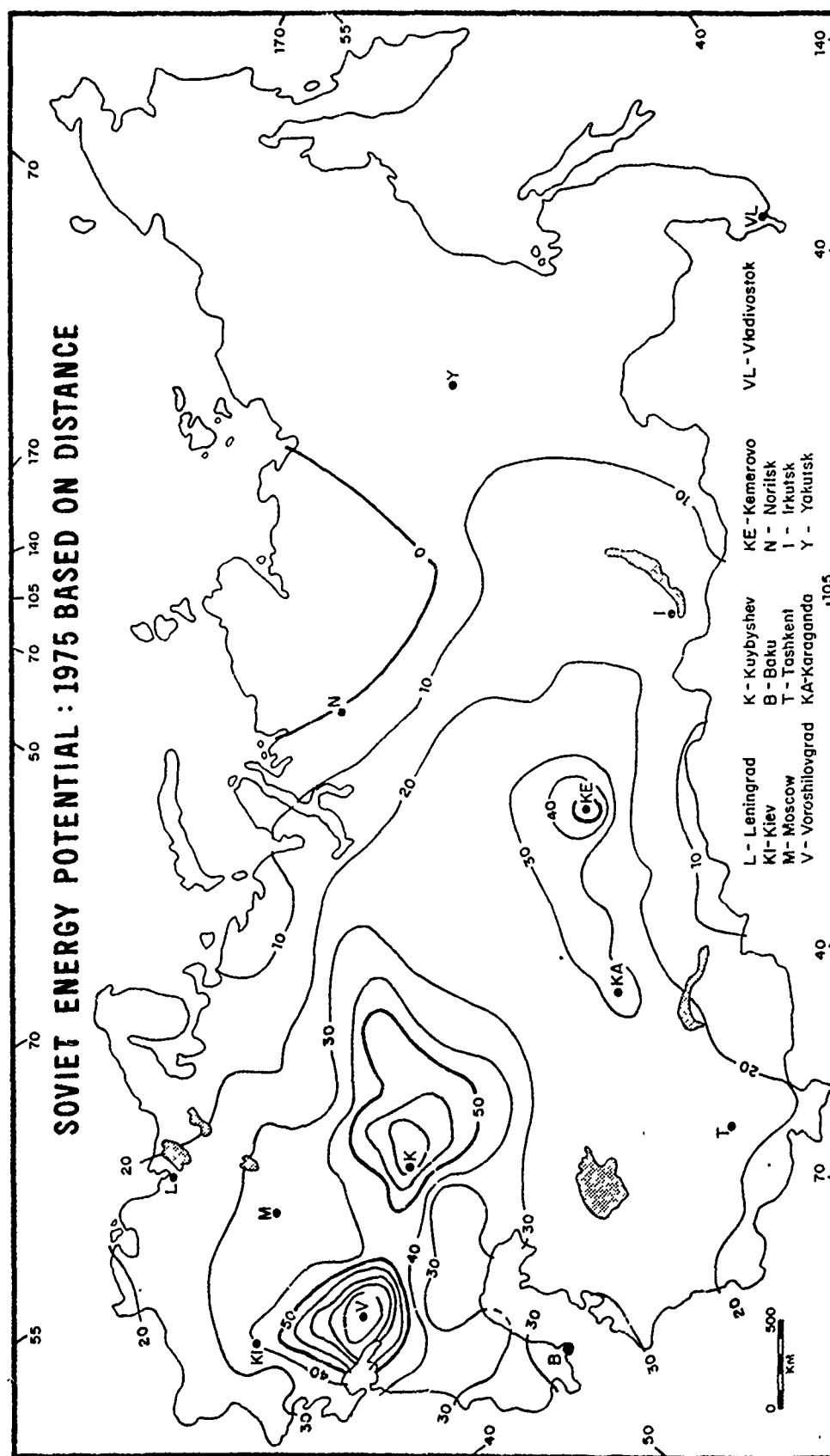


FIGURE 4.3

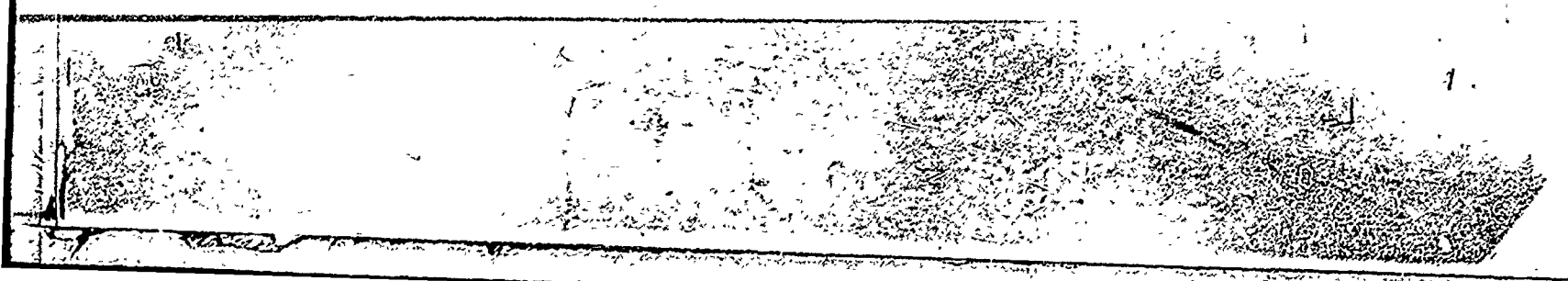
Source: Data for outline and cities taken from Soviet Union,  
National Geographic Society, 1976  
transverse polyconic projection.

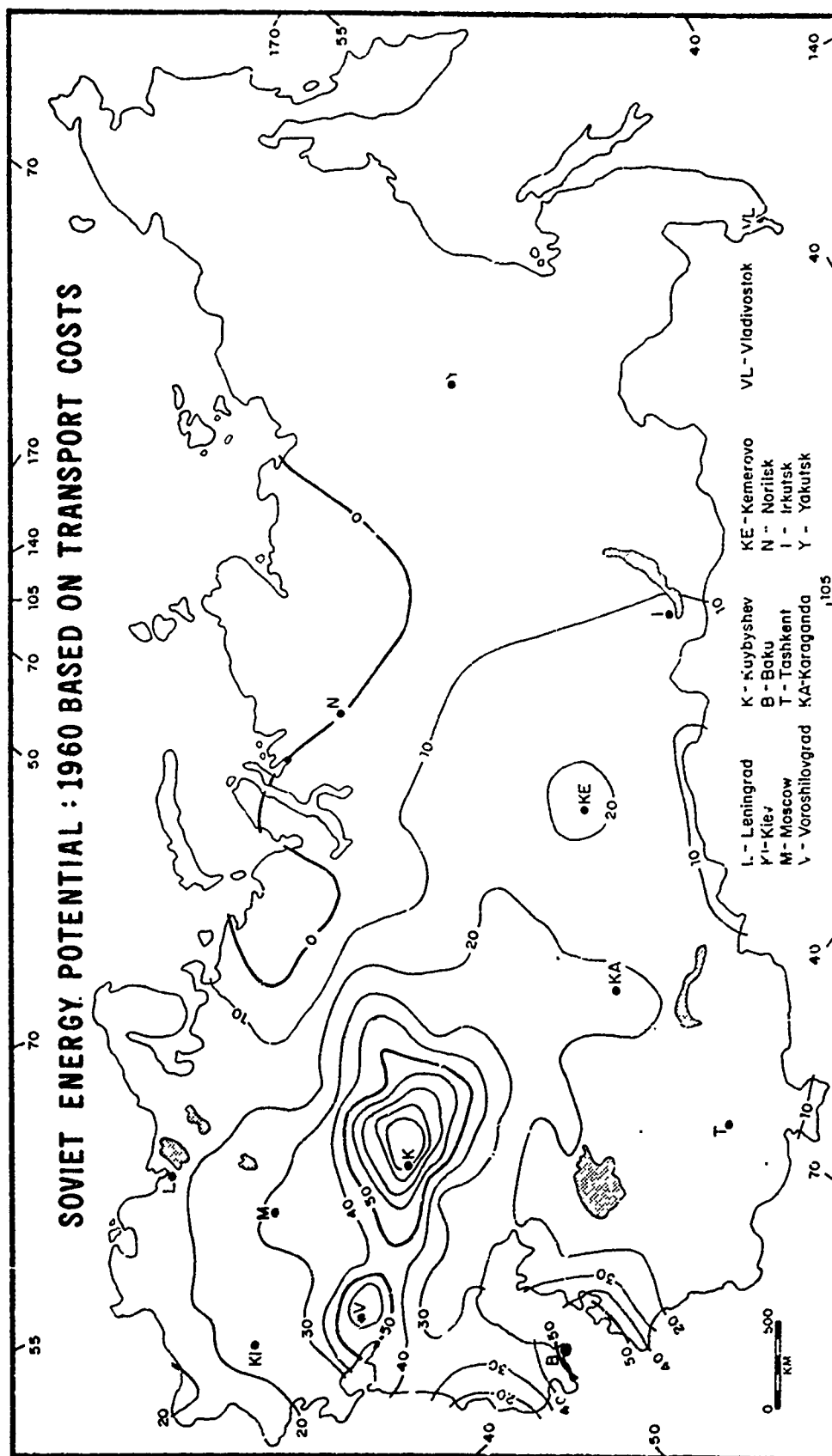




## FIGURE 4.4

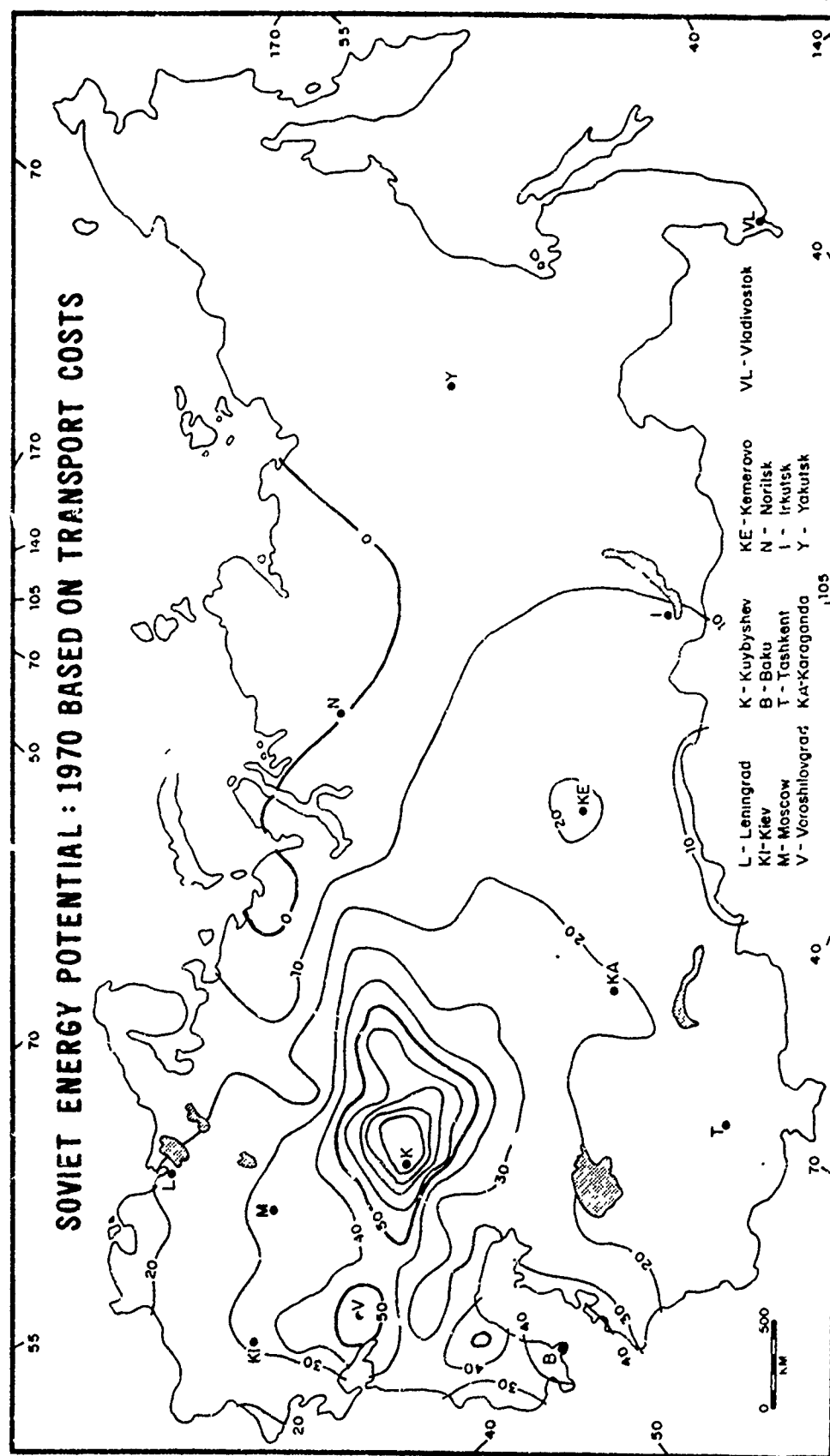
Source: Data for outline and cities taken from Soviet Union,  
National Geographic Society, 1976,  
transverse polyconic projection.





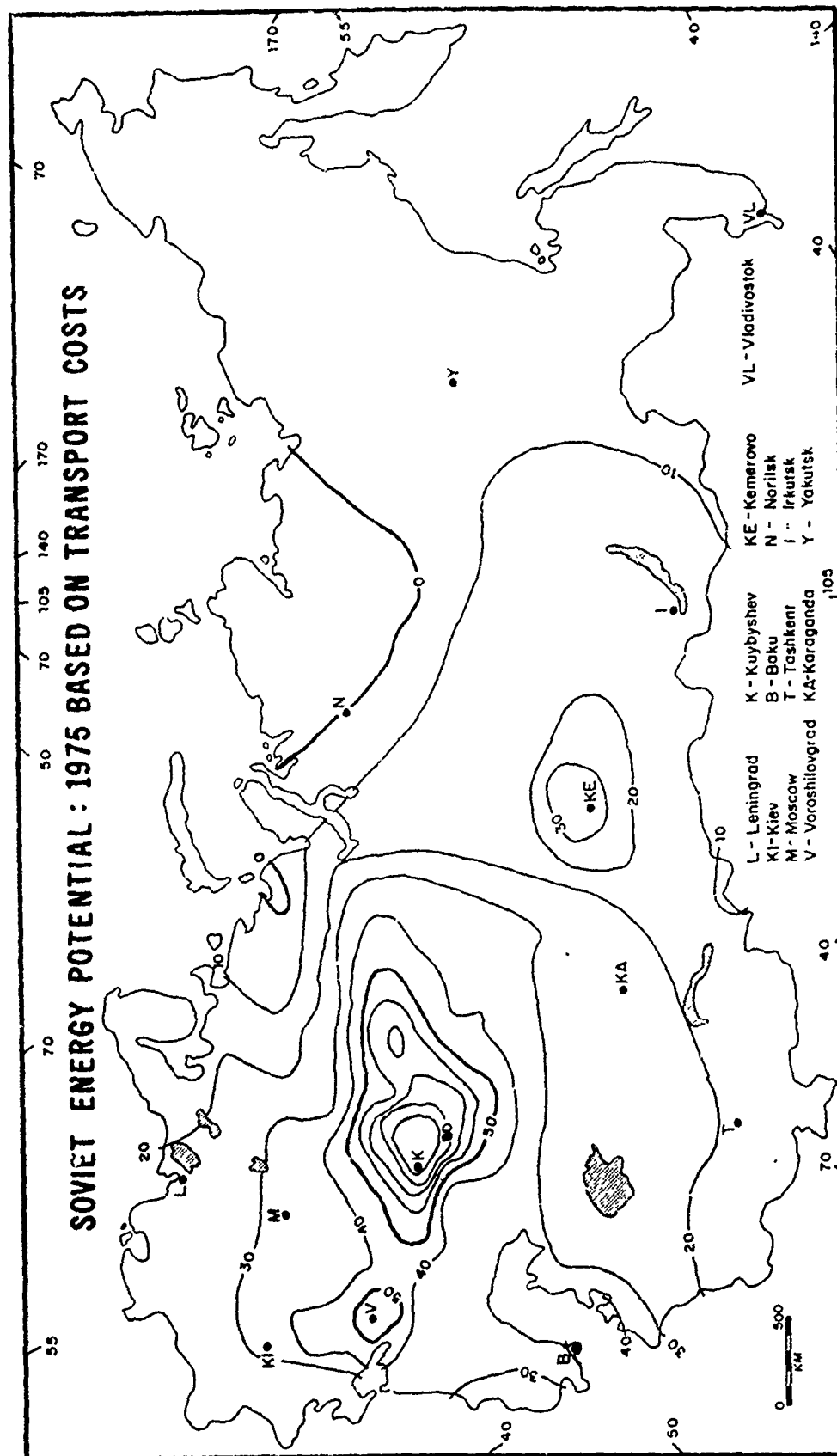
## FIGURE 4.5

Source: Data for outline and cities taken from Soviet Union,  
National Geographic Society, 1976,  
transverse polyconic projection.



## FIGURE 4.6

Source: Data for outline and cities taken from Soviet Union,  
National Geographic Society, 1976,  
transverse polyconic projection.



of the nodes having the highest energy potential. The contour interval is ten percentage, and the zero and 50 percentage lines are darker than the other lines. These nodes are Voroshilovgrad for the maps based on distance and Kuybyshev for the maps based on transport costs.

The 1960 energy potential map based on distance alone (Figure 4.1) contained two major peaks and one minor peak. The dominant peak occurs in the eastern Ukraine and North Caucasus area where Voroshilovgrad, Donetsk, and Rostov are so favorably located in the Donets Basin. This peak subsumes a large part of the Donets-Dnepr industrial complex. A secondary major peak rises over the Volga-Urals oil fields and straddles the boundary between the Volga and the Urals industrial regions. A minor peak is centered over Kemerovo and the Kuznetsk Basin and is coincident with the Kuzbas heavy industrial region. There is a slight rise around Baku, and closed contour lines surround the Moscow and Karaganda coal basins. Despite the region's huge energy reserves, the nodes in the trans-Baikal area have the lowest relative energy accessibility values in the U.S.S.R. because of their great distance from major energy producing sources.

The Donets Basin peak also dominates the 1970 energy potential map based on distance (Figure 4.2), but the Volga-Urals peak increases its relative height and area because of the doubling of oil production in that region between 1960 and 1970. A slight spur now runs from Voroshilovgrad westward to Kharkov and Poltava because of the five-fold increase in production of the east Ukrainian natural gas fields and the discovery of oil near Poltava. A notable prolongation extends eastward from Kuybyshev through Ufa generally along the Trans-Siberian Railroad to Kemerovo and encompasses Karaganda. A minor peak appears in the

North Caucasus region around Groznyy and Ordzhonikidze because of a dramatic but temporary spurt in production of the Chechen-Ingush ASSR oil fields.

The size and shape of the Voroshilovgrad energy potential peak remained virtually unchanged in 1975 (Figure 4.3), while the Volga-Urals peak grew in height and expanded its base northward and eastward to include the cities of the eastern Urals region. This expansion was influenced by production from the middle-Ob oil fields of Tyumen Oblast. Increased coal production at the Kuznetsk Basin aided by input from the middle-Ob oil fields, enabled the Kemerovo peak to grow and expand with a prolongation southwestward to include Karaganda.

The Volga-Urals oil fields peak towers over the map of relative energy potential based on distance modified by transport costs in 1960 (Figure 4.4). Two secondary peaks are centered over the Donetsk Basin and the Baku oil fields. A closed contour line surrounds Kemerovo because of the Kuznetsk Basin. The peaks at Voroshilovgrad and Kuybyshev bulge toward each other as though they might coalesce, but this never happens because the production of the Donetsk Basin rose only slightly from 1960 while the Volga-Urals production doubled from 1960 to 1970.

The patterns vary little from 1960 to 1970 (Figure 4.5). The peak at Voroshilovgrad has shrunk a bit, but a slight prolongation now runs northwestward through the gas and oil fields near Kharkov and Poltava. The peak at Kuybyshev has expanded its base, and the distended ridge running northeast to Perm is more pronounced. The spasmodic increase in production of the Groznyy oil fields is evident in the minor peak appearing in the eastern North Caucasus region.

The Grozny peak disappears by 1975 (Figure 4.6), and the peak at Voroshilovgrad has diminished even more. The base of the Volga-Urals peak expands eastward and northward as the cities of the eastern Urals region increase their energy potentials because of the influence of the West Siberian oil fields along the Ob. There is a small rise in the Kuznetsk Basin area, but the values there are generally less than those in the Central region around Moscow.

A few general observations can be made about both series of energy potential maps. The areas with the lowest energy accessibility were the Far East, East Siberia, the Northwest, Soviet Central Asia, the Baltic states, and the area along the western border of the country. The latter three areas contain some of the highest concentrations of population in the Soviet Union and some of the nodes with the highest urban population growth rates as well as the Leningrad industrial region. On all maps, major peaks occur in or near the Donets-Dnepr, Volga, and Urals industrial areas, and minor peaks often rise at the Baku, Karaganda, and Kuznetsk industrial centers. The nodes of the long-established industrialized region around Moscow displayed moderate energy potential values largely because of their locations with respect to the Donets Basin and Volga-Urals oil fields. The dramatic increases in the oil and natural gas production of West Siberia were reflected by modest eastward and northward shifts in the base of the Volga-Urals peak.

#### Urban Population Growth and Energy Accessibility

The relationship between urban population growth and energy accessibility was analyzed using urban population data from the 1959, 1970, and 1979 censuses (Appendix E) and nodal energy potential indices for 1960,

1970, and 1975 based on distance and transport costs. Norilsk and Elista were not included in the correlation analyses because Norilsk had been treated as a separate system with no energy inputs from sources other than those in its immediate area and because population data for Elista were not available for the entire period of study.

The results of the correlation analysis between the urban population data and energy accessibility based on distance revealed that energy accessibility has had little impact on urban population growth (Table 4.3). Those nodes with high growth rates were, in fact, located away from areas of high energy accessibility as indicated by the negative signs of the correlation coefficients between urban population growth and energy potential. A small positive relationship exists, however, between changes in energy accessibility and urban population growth. Evidence of a lag effect is present in that the change in energy accessibility 1960-1970 had a higher correlation with urban population growth 1970-1979 than did the change in energy accessibility 1960-1970 with urban population growth 1959-1970. The evidence of a lag effect is also supported by the lack of any significant correlation between urban population growth 1970-1979 and the change in energy accessibility 1970-1975. As might be expected, the correlation coefficients between urban population and urban population growth demonstrates that larger cities tend to grow at slower rates than small cities. The substantial correlation between urban population growth 1959-1970 and urban population growth 1970-1979 shows that the patterns of growth were somewhat similar during both periods.

The correlation coefficients matrix for urban population data and energy accessibility calculated using transport costs again indicates

Table 4.3  
CORRELATION COEFFICIENTS AND SIGNIFICANCE LEVELS BETWEEN  
URBAN POPULATION DATA AND ENERGY ACCESSIBILITY BASED ON DISTANCE

|         | POP93 <sup>a</sup> | POP70 <sup>a</sup> | GROWTH1 <sup>b</sup> | GROWTH2 <sup>c</sup> | TEPAC <sup>d</sup> | TEP70 <sup>d</sup> | TEP75 <sup>d</sup> | CHANGE1 <sup>e</sup> | CHANGE2 <sup>f</sup> | CHANGE3 <sup>g</sup> |
|---------|--------------------|--------------------|----------------------|----------------------|--------------------|--------------------|--------------------|----------------------|----------------------|----------------------|
| POP93   | 1.00000<br>0.0000  | 0.98692<br>0.0701  | -0.35560<br>0.0001   | -0.32300<br>0.0002   | 0.14326<br>0.1081  | 0.13379<br>0.1338  | 0.1413<br>0.1130   | 0.05790<br>0.5136    | -0.74865<br>0.5670   | -0.04165<br>0.3615   |
| POP70   | 0.98692<br>0.1001  | 1.00000<br>0.0000  | -0.34005<br>0.0001   | -0.33369<br>0.0001   | 0.14002<br>0.0945  | 0.14110<br>0.1131  | 0.15103<br>0.0991  | -0.09194<br>0.5620   | -0.04110<br>0.6457   | -0.04404<br>0.4401   |
| GROWTH1 | -0.35560<br>0.1071 | -0.34005<br>0.0701 | 1.00000<br>0.0000    | 0.69994<br>0.0001    | -0.17415<br>0.3092 | -0.12489<br>0.1613 | -0.11625<br>0.1931 | 0.21716<br>0.0142    | 0.03014<br>0.3697    | 0.27070<br>0.0021    |
| GROWTH2 | -0.32300<br>0.1002 | -0.33369<br>0.0701 | 0.69994<br>0.0001    | 1.00000<br>0.0000    | -0.22150<br>0.0123 | -0.16656<br>0.0613 | -0.17260<br>0.0523 | 0.25748<br>0.0034    | -0.00007<br>0.3994   | 0.23350<br>0.0087    |
| TEPAC   | 0.14326<br>0.1081  | 0.14002<br>0.0945  | -0.17415<br>0.0902   | -0.22150<br>0.0123   | 1.00000<br>0.0000  | 0.95587<br>0.0001  | 0.93647<br>0.0001  | -0.06927<br>0.4390   | -0.38515<br>0.0001   | -0.16330<br>0.0001   |
| TEP70   | 0.13379<br>0.1234  | 0.14110<br>0.1131  | -0.12489<br>0.1613   | -0.16656<br>0.0613   | 0.95587<br>0.0001  | 1.00000<br>0.0000  | 0.97449<br>0.0001  | 0.14261<br>0.0300    | -0.45644<br>0.0001   | -0.16152<br>0.0011   |
| TEP75   | 0.1413<br>0.1130   | 0.15103<br>0.0991  | -0.11625<br>0.1931   | -0.17260<br>0.0523   | 0.93647<br>0.0001  | 0.97449<br>0.0001  | 1.00000<br>0.0000  | 0.16404<br>0.0000    | -0.30368<br>0.0005   | -0.09957<br>0.5037   |
| CHANGE1 | -0.05790<br>0.5136 | -0.09194<br>0.5620 | 0.21716<br>0.0142    | 0.25748<br>0.0034    | -0.06927<br>0.4390 | 0.14261<br>0.0300  | 0.16908<br>0.0574  | 1.00000<br>0.0000    | -0.37243<br>0.0000   | 0.67661<br>0.0001    |
| CHANGE2 | -0.04110<br>0.4401 | -0.04404<br>0.4401 | 0.03014<br>0.3697    | -0.00007<br>0.3994   | -0.38515<br>0.0001 | -0.45644<br>0.0001 | -0.37368<br>0.0005 | -0.32230<br>0.0002   | 1.00000<br>0.0000    | 0.46622<br>0.0001    |
| CHANGE3 | -0.04165<br>0.3615 | -0.04403<br>0.4403 | 0.27070<br>0.0021    | 0.23350<br>0.0082    | -0.16330<br>0.0001 | -0.16452<br>0.0001 | -0.09997<br>0.5037 | 0.67961<br>0.0001    | 0.46622<br>0.0000    | 1.00000<br>0.0000    |

<sup>a</sup>Population 1959 and 1970

<sup>b</sup>Urban population growth 1959-1970

<sup>c</sup>Urban population growth 1970-1979

<sup>d</sup>Total energy potential 1960, 1970, and 1975

<sup>e</sup>Change in energy potential 1960-1970

<sup>f</sup>Change in energy potential 1970-1975

<sup>g</sup>Change in energy potential 1970-1975

<sup>h</sup>Correlation coefficient

<sup>i</sup>Significance levels

Table 4.4  
CORRELATION COEFFICIENTS AND SIGNIFICANCE LEVELS BETWEEN  
URBAN POPULATION DATA AND ENERGY ACCESSIBILITY BASED ON TRANSPORT COSTS

|         | POP59 <sup>a</sup>              | POP70 <sup>a</sup> | GROWTH1 <sup>b</sup> | GROWTH2 <sup>c</sup> | TEP60 <sup>d</sup> | TEP70 <sup>d</sup> | TEP75 <sup>d</sup> | CHANGE1 <sup>e</sup> | CHANGE2 <sup>f</sup> | CHANGE3 <sup>g</sup>            |
|---------|---------------------------------|--------------------|----------------------|----------------------|--------------------|--------------------|--------------------|----------------------|----------------------|---------------------------------|
| POP59   | 1.00000<br>0.0000               | 0.99692<br>0.0001  | -0.35560<br>0.0001   | -0.32800<br>0.0002   | 0.15116<br>0.0899  | 0.12710<br>0.1544  | 0.13497<br>0.1303  | -0.10613<br>0.2350   | -0.03770<br>0.6739   | -0.11038 <sup>1</sup><br>0.2167 |
| POP70   | 0.99692<br>0.0001               | 1.00000<br>0.0000  | -0.34005<br>0.0001   | -0.33049<br>0.0001   | 0.15968<br>0.0729  | 0.13571<br>0.1292  | 0.14503<br>0.1038  | -0.10379<br>0.2455   | -0.03496<br>0.6964   | -0.10496<br>0.2402              |
| GROWTH1 | -0.35560<br>0.0001              | -0.34005<br>0.0001 | 1.00000<br>0.0000    | 0.69994<br>0.0001    | -0.15007<br>0.0922 | -0.09836<br>0.2713 | -0.09326<br>0.2970 | 0.26767<br>0.0023    | 0.00667<br>0.9406    | 0.22470<br>0.0111               |
| GROWTH2 | -0.32800<br>0.0002              | -0.33049<br>0.0001 | 0.69994<br>0.0001    | 1.00000<br>0.0000    | -0.24947<br>0.0047 | -0.19473<br>0.0282 | -0.20144<br>0.0231 | 0.32617<br>0.0002    | -0.32791<br>0.7554   | 0.23394<br>0.0081               |
| TEP60   | 0.15116<br>0.0899               | 0.15568<br>0.0729  | -0.15007<br>0.0922   | -0.24947<br>0.0047   | 1.00000<br>0.0000  | 0.96941<br>0.0001  | 0.95160<br>0.0001  | -0.13957<br>0.1200   | -0.44741<br>0.0001   | -0.50754<br>0.0001              |
| TEP70   | 0.12710<br>0.1544               | 0.13571<br>0.1292  | -0.09836<br>0.2713   | -0.19473<br>0.0282   | 0.96941<br>0.0001  | 1.00000<br>0.0000  | 0.97410<br>0.0001  | 0.08845<br>0.3229    | -0.50827<br>0.0001   | -0.39826<br>0.0001              |
| TEP75   | 0.13497<br>0.1303               | 0.14503<br>0.1038  | -0.09326<br>0.2970   | -0.20144<br>0.0231   | 0.95160<br>0.0001  | 0.97410<br>0.0001  | 1.00000<br>0.0000  | 0.26827<br>0.5900    | -0.32835<br>0.0002   | -0.25729<br>0.0035              |
| CHANGE1 | -0.10613<br>0.2350              | -0.10379<br>0.2455 | 0.26767<br>0.0023    | 0.32617<br>0.0002    | -0.13867<br>0.1200 | 0.08945<br>0.3229  | 0.04827<br>0.5900  | 1.00000<br>0.0000    | -0.29827<br>0.0007   | 0.47491<br>0.0001               |
| CHANGE2 | -0.03770<br>0.6739              | -0.03496<br>0.6964 | 0.00667<br>0.9406    | -0.02791<br>0.7554   | -0.44741<br>0.0001 | -0.50827<br>0.0001 | -0.32835<br>0.0002 | -0.29827<br>0.0007   | 1.00000<br>0.0000    | 0.69211<br>0.0001               |
| CHANGE3 | -0.11038 <sup>1</sup><br>0.2167 | -0.10496<br>0.2402 | 0.22470<br>0.0111    | 0.23394<br>0.0081    | -0.50754<br>0.0001 | -0.39826<br>0.0001 | -0.25729<br>0.0035 | 0.47491<br>0.0001    | 0.69211<br>0.0001    | 1.00000<br>0.0000               |

<sup>a</sup>Population 1959 and 1970

<sup>b</sup>Urban population growth 1959-1970

<sup>c</sup>Urban population growth 1970-1979

<sup>d</sup>Total energy potential 1960, 1970, and 1975

<sup>e</sup>Change in energy potential 1960-1970

<sup>f</sup>Change in energy potential 1970-1975

<sup>g</sup>Change in energy potential 1960-1975

<sup>h</sup>Correlation coefficients

<sup>i</sup>Significance levels.

that those nodes with high growth rates tended to have low energy potential (Table 4.4). Changes in energy accessibility based on transport costs have a stronger relationship with urban population growth than did energy accessibility based on distance. The stronger relationship of energy accessibility based on transport costs with urban population growth reflects the superiority of transport costs over sheer distance as a measure of impedance. Evidence of a lag effect of changes in energy accessibility on urban population growth is even more pronounced than before. This is exhibited by the higher correlation coefficient between the change in energy accessibility 1960-1970 and urban population growth 1970-1979.

#### Summary

The analysis of energy accessibility revealed peaks and troughs which were fairly stable through time and relatively invariant with regard to the way energy accessibility was calculated. Nodes in two areas, the Donets Basin and the Volga-Urals oil fields, had the highest energy potential indices. Voroshilovgrad in the eastern Ukraine was ranked first when energy accessibility was determined by distance alone, and Kuybyshev was first when transport costs were used. East Siberia, the Far East, the Northwest, the Baltic states, Belorussia, the western Ukraine, Moldavia, and Soviet Central Asia had the lowest accessibility to energy based on actual energy production. Areas with moderate levels of energy accessibility were the Kuznetsk Basin, the North Caucasus, and Baku. Moscow and the Central industrial region had modest levels of energy accessibility. The energy potential patterns as determined by distance were fairly similar to those determined by transport costs. These

patterns also changed little between 1960 and 1975 despite the eastward shift in emphasis of energy production. The huge oil and gas fields of Western Siberia were simply too far away from any of the nodes studied to have more than a modest impact on energy potential patterns, although there was a gradual eastward expansion of the base of the Volga-Urals peak between 1960 and 1975.

Three major industrial regions of the Soviet Union, the Donets-Dnepr, Volga, and Urals, are nearly coincident with the areas of highest energy accessibility. The Central, Karaganda, Baku, and Kuznetsk Basin industrial areas had energy accessibility values ranging from moderate to moderately high respectively. Leningrad and the emerging industrial area around Tashkent had low energy potential values. Some of the areas with the lowest energy potentials were also those with high urban population growth rates, such as Soviet Central Asia, Belorussia, Lithuania, and Moldavia. This high urban population growth was generally due to high birth rates and rural to urban migration potential. On the other hand, many nodes in the well-established, industrial regions which have high energy accessibility values displayed relatively low growth rates. These low growth rates were the result of an already high level of urbanization, low rates of natural increases in population, and lack of rural to urban migration potential.

The correlation analysis between urban population growth and energy accessibility supported the apparent disconformity between patterns of high urban population growth and high energy accessibility. Changes in energy accessibility were, however, positively correlated with urban population growth. A lag effect was evident in the correlation between

the change in energy accessibility 1960-1970 and urban population growth 1970-1979.

The role of energy accessibility in Soviet urban population growth appears to be relatively modest at best. Reasons for this modest role will be considered in the final chapter.

## CHAPTER V

### CONCLUSION

#### Introduction

"Coal is the actual bread of industry; without this bread, industry cannot function" (Lenin as quoted by Hodgkins 1961, p. 40). What Lenin said about coal in the early 1920s can now be applied to oil and gas as well. Energy, in whatever form, is absolutely essential for most endeavors of modern man. Because of the essential nature of energy to industry, it was intuitively appealing to strive to establish a link between energy accessibility and urban population growth, which can be regarded a fair indicator of industrial growth under the Soviet system. The purpose of this research, then, was to determine the patterns of energy accessibility in the Soviet Union, examine the spatial and temporal variations of such patterns, and investigate the influence of energy accessibility on urban population growth. This purpose was accomplished, but the study would be incomplete without a discussion of the implications of the results of this research on urban population growth, industrial location, and regional development. Two sections follow. The first deals with implications; the second suggests areas for future research.

#### Implications

There have been excellent works on the growth of Soviet cities and the Soviet energy system, but this is the first in-depth study examining

the interrelationships between energy and urban population growth on a macrogeographic basis. This work is also unique in that it represents a new application of potential models to determine patterns of energy accessibility. There are several implications regarding the results of this study.

The influence of energy accessibility on urban population growth on a nation-wide level proved to be relatively modest. Although access to energy can dramatically affect the growth of individual cities or groups of cities (Bond and Lydolph 1979; Harris 1971; Lydolph *et al.* 1978), other factors are clearly more important in determining Soviet urban population growth. Regional variations in levels of urbanization, rural to urban migration potential, and natural increase in population result in high urban population growth for nodes with relatively low levels of energy accessibility. Lithuania, Belorussia, Moldavia, and Central Asia are examples. Rural to urban migration was a major factor in the high urban population growth in Lithuania, Belorussia, and Moldavia. Natural increase in population was less important in those three republics, although Lithuania had the highest rate among the Baltic states, Belorussia had the highest rate among the Slavic republics, and Moldavia was above the national average. Levels of urbanization were important in Moldavia and Soviet Central Asia, both of which are still predominately rural. Natural increase in population was the dominant factor in urban population growth in Central Asia which had rates of natural increase in population two to three times higher than the national average (Bond and Lydolph 1979).

Nodes in the Donets-Dnepr, Volga, Urals, and Kuzbas industrial regions all had relatively high energy potential indices, but their urban

population growth was generally well below the national average. These well-established industrial regions were characterized by high levels of urbanization, low rural to urban migration potential, and low natural increase in population. In addition, increasing mechanization of coal mining and the decreasing importance of coal in the Soviet energy budget adversely affected urban population growth of cities in coal mining regions such as the Donets, Kuznetsk, and Karaganda basins (Bond and Lydolph 1979; Harris 1971).

Energy may act as a catalyst for economic activities, and a city undoubtedly requires a certain minimum level of energy to survive or prosper. Despite the wide range in levels of energy accessibility, all cities in this study apparently had access to enough energy to sustain urban population growth. Any amount of energy over the minimum requirement may have been largely superfluous, though there was a small positive correlation between changes in energy accessibility and urban population growth.

The eastward shift in energy production and grandiose construction projects such as the Baikal Amur Mainline or BAM in Siberia and the Far East do not necessarily portend an eastward shift in urban population growth and industry. The eastward shift in energy production to sites that are far away from the market areas of the western part of the U.S.S.R. has been forced on the Soviets by the need for more energy to fuel economic growth and to earn hard currency from energy exports. The Soviets are building the BAM for several reasons: (1) to relieve the overburdened Trans-Siberian Railroad, (2) to open remote resource areas for exploitation, (3) to bolster defense capabilities in Siberia and the

Far East, and (4) to strengthen foreign and domestic commercial ties (Lydolph 1979, pp. 424-425).

The eastward shift in energy production and the completion of the Baikal Amur Mainline may stimulate some settlement in areas of Siberia and the Far East which are now largely uninhabited. Some cities in those areas may exhibit spectacular growth rates, such as Surgut near the Samotlor oil fields of Western Siberia, but these will be resource oriented "boom towns" whose growth is closely dependent on production trends. The hostile environment and labor shortage in much of Siberia and the Far East are severe constraints on regional development in those areas, and the Soviets will probably meet with only limited success with their plans to urbanize and industrialize areas such as the lower reaches of the Yenisey (Myakinenkov 1975).

The high urban population growth demonstrated by nodes with low accessibility to energy supports the notion that the Soviets have yielded to the pull of the market as a factor in industrial location as suggested by Soviet geographer A.A. Mints (1976) and American geographers, Lydolph and Pease (1972). Energy resource location will more than likely continue to be a lesser important factor in industrial location. The "fluid" nature of oil and natural gas and the rapidly expanding pipeline networks have doubly blessed the Soviets by facilitating the export of oil and natural gas to Eastern and Western Europe and by enabling the Soviets to develop the energy-poor western areas of their own country. Future emphasis will likely be on developing mineral resources, such as the Kursk Magnetic Anomaly, in the market areas of the western U.S.S.R. where there is an available labor pool (Lydolph and Pease 1972).

The findings and maps compiled as the result of this study might be useful in small-scale economic planning for the Soviets. The data points for which energy accessibility was calculated were major administrative and industrial nodes generally within the "fertile triangle" of the Soviet Union. The energy potential indices and maps thus represent or portray energy accessibility of market areas within the Soviet Union rather than areas that are sparsely inhabited. Siberia and the Far East may possess vast reserves of energy resources, but such reserves are like the coal field described by Harris (1954) as "useless until it falls within the technological capabilities of specific human groups and until it can be utilized in a favorable economic environment" (p. 315).

Contour maps of energy potential would probably be more useful to Soviet economic planners in making industrial location decisions than existing choropleth maps of resource potential (See: Mints and Kakhanovskaya 1975). Soviet geographers have long advocated the location of industry in small and medium-size cities of their country (Mikhailov and Solovev 1969). Industry could be located in such cities in or near areas of high energy accessibility such as between the Donets Basin and the Volga-Urals oil fields. This would minimize transport costs because the industry would be fairly close to energy sources as well as still within the market area of the Soviet Union. This would also achieve other aims which the Soviets have been striving for, such as a reduction in the excessive concentration of industrial production in large cities and a more equitable distribution of population and industrial production (Koropeckyj 1970; Mikhailov and Solovev 1969).

### Areas for Future Research

The aims of this study were achieved, but future research might be undertaken in a number of related areas. Changes in energy accessibility based on generalized transport costs had slightly stronger correlations with urban population growth than did changes in energy accessibility based on distance alone. This suggests that transport costs are a superior measure of friction in accessibility studies than sheer distance. The same generalized transport costs were used throughout the period of study, and exponents of 1.0 were used in calculating energy potential indices. Additional research might be directed toward determining how the transport cost ratio for coal, oil, and natural gas has changed over time and what the actual exponents should be.

A temporal series of energy potential maps with energy producing sources used as data points rather than nodes in the energy consuming market area of the Soviet Union would more clearly show the dramatic eastward shift in energy production. For planning purposes, energy potential maps could be drafted based on projected production rather than on actual production. What would be the effect of including the energy imports from Poland, Afghanistan, or Iran on the patterns of energy accessibility within the Soviet Union? Conversely, should some allowance be made for the coal, oil, and natural gas that the Soviets export?

Large cities were selected for study because census data were readily available. The influence of energy accessibility on medium-size (50,000-100,000 population) should be examined. Medium-size cities might be more sensitive to changes in energy accessibility than large cities. A study utilizing medium-size cities rather than large cities

might possibly reveal more information concerning Soviet regional development priorities. Other variables, such as changes in industrial production or percentage of labor force engaged in manufacturing, could be used instead of urban population growth. Use of other variables, though, would present problems of data availability and aggregation. Urban population data were used because the Soviets are not as reticent in publishing population data as they are with economic data.

The results of this study could be included in a model for urban population growth. Additional variables could include an index of rural to urban migration potential, the rate of natural increase in population, and the population of the city. Similar energy accessibility studies could be done for other large countries of the world, such as the People's Republic of China or Brazil, which do not have homogeneous distributions of population or energy resources.

The purpose of this research was accomplished. Temporal and spatial variations in energy accessibility were determined and mapped, and the influence of energy accessibility on urban population growth was examined. Spatial patterns of energy accessibility have not varied a great deal despite the intense sectoral and spatial shifts in energy production. Energy accessibility has had a limited effect on urban population growth because other factors more profoundly influence Soviet urban population and because Soviet regional development policy appears to follow a course relatively unrestrained by energy resource locations. Although this work cannot be considered exhaustive, it has provided some additional insight on the interrelationship between energy accessibility and human activity in the Soviet Union.

### References

- Bond, A.R. and Lydolp, P.E. 1979. Soviet Population Change and City Growth 1970-79: A Preliminary Report. Soviet Geography: Review and Translation 20, 8:461-
- Harris, C.D. 1954. The Market as a Factor in the Localization of Industry in the United States. Annals of the Association of American Geographers 64, 4:315-348.
- Harris, C.D. 1971. Urbanization and Population Growth in the Soviet Union, 1959-1970. The Geographical Review 61, 1:102-124.
- Hodgkins, J.A. 1961. Soviet Power: Energy Resources, Production and Potentials. Englewood Cliffs, N.J.: Prentice-Hall, Inc.
- Koropeckyj, I.S. 1970. Industrial Location in the USSR During the Post-war Period. In Economic Performance and the Military Burden in the Soviet Union. Subcommittee on Foreign Economic Policy of the Joint Economic Committee, Congress of the United States, pp. 233-294. Washington, D.C.: U.S. Government Printing Office.
- Lydolp, P.E. 1979. Geography of the U.S.S.R., Topical Analysis. Elkhart, Wisc.: Misty Valley Publishing.
- Lydolp, P.E., Johnson, R., Mintz, J., and Mills, M.E. 1978. Recent Population Trends in the USSR. Soviet Geography: Review and Translation 19, 8:505-539.
- Lydolp, P.E. and Pease, S.R. 1972. Changing Distributions of Population and Economic Activities in the U.S.S.R. Tijdschrift voor Economische en Sociale Geografie 63, 4:244-261.
- Mints, A.A. 1976. A Predictive Hypothesis of Economic Development in the European Part of the USSR. Soviet Geography: Review and Translation 17, 1:1-27.
- Mints, A.A. and Kakhanovskaya, T.G. 1974. An Attempt at a Quantitative Evaluation of the National Resource Potential of Regions in the USSR. Soviet Geography: Review and Translation 15, 9:554-565.
- Mikhailov, S. and Solovev, N. 1969. Small and Medium-Size Cities and the Location of Industry in the USSR. In Contemporary Soviet Economics, vol. 2, ed. M. Yanowitch, pp. 129-136. White Plains, N.Y.: International Arts and Sciences Press, Inc.
- Myakinenkov, V.M. 1975. Prospects of the Development of Production and Settlement in the Northern Yenisey Region. Soviet Geography: Review and Translation 16, 9:578-583.

## BIBLIOGRAPHY

- Abouchar, A. 1979. Regional Industrial Policies of the U.S.S.R. in the 1970s. In Regional Development in the U.S.S.R., NATO Colloquium 25-27 April 1979, pp. 93-103. Newtonville, Mass.: Oriental Research Partners.
- Bond, A.R. and Lydolph, P.E. 1979. Soviet Population Change and City Growth 1970-79. A Preliminary Report. Soviet Geography: Review and Translation 20, 8:461-488.
- CALCOMP 1972. GPCP-II User's Manual. Anaheim, Ca: California Computer Products, Inc.
- Campbell, R.W. 1968. The Economics of Soviet Oil and Gas. Baltimore, Md.: The Johns Hopkins Press.
- Cohn, S.H. 1970. General Growth Performance of the Soviet Economy. In Economic Performance and the Military Burden in the Soviet Union, Subcommittee on Foreign Economic Policy of the Joint Economic Committee, Congress of the United States, pp. 9-17, Washington, D.C.: U.S. Government Printing Office.
- Dewdney, J.C. 1976. The U.S.S.R. Kent, England: Wm. Dawson & Sons Ltd.
- Dienes, L. 1971. Issues in Soviet Energy Policy and Conflicts Over Fuel Costs in Regional Development. Soviet Studies 23, 1:26-58.
- Dienes, L. 1972. Investment Priorities in Soviet Regions. Annals of the Association of American Geographers 62, 3:437-454.
- Dienes, L. 1973. Geographical Problems of Allocation in the Soviet Fuel Supply. Energy Policy 1, 1:3-20.
- Dienes, L. 1978. Soviet Energy Policy and the Hydrocarbons. Washington, D.C.: Association of American Geographers Project on Soviet Natural Resources in the World Economy, Discussion Paper 2.
- Dienes, L. and Shabad, T. 1979. The Soviet Energy System. Washington, D.C.: V.H. Winston & Sons.
- Ebel, R.E. 1961. The Petroleum Industry of the Soviet Union. Arlington, Va.: Royer and Royer, Inc.

- Ebel, R.E. 1970. Communist Trade in Oil and Gas. New York: Praeger Publishers.
- Elliot, I.F. 1974. The Soviet Energy Balance. New York, N.Y.: Praeger Publishers, Inc.
- Fuchs, R.J. and Demko, G.J. 1979. Annals of the Association of American Geographers 69, 2:304-318.
- Fullard, H., ed. 1965. Soviet Union in Maps. London: George Philip & Son, Ltd.
- Fullard, H., ed. 1972. Soviet Union in Maps. London: George Philip & Son Limited.
- Hardt, J.P. 1973. West Siberia: The Quest for Energy. Problems of Communism 22, 3:25-36.
- Harris, C.D. 1954. The Market as a Factor in the Localization of Industry in the United States. Annals of the Association of American Geographers 64, 4:315-348.
- Harris, C.D. 1970. Cities of the Soviet Union. Washington, D.C.: Association of American Geographers.
- Harris, C.D. 1971. Urbanization and Population Growth in the Soviet Union, 1959-1970. The Geographical Review 61, 1:102-124.
- Hassmann, H. 1953. Oil in the Soviet Union. Princeton, N.J.: Princeton University Press.
- Helwig, J.T. and Council, K.A., eds. 1979. SAS User's Guide, 1979 Edition. Raleigh, N.C.: SAS Institute, Inc.
- Hodgkins, J.A. 1961. Soviet Power: Energy Resources, Production and Potentials. Englewood Cliffs, N.J.: Prentice-Hall, Inc.
- Hooson, D.J.M. 1966. The Soviet Union. London: University of London Press.
- Houston, C. 1969. Market Potential and Potential Transportation Costs: An Evaluation of the Concepts and Their Surface Patterns in the USSR. The Canadian Geographer 13, 3:216-236.
- Huzinec, G.A. 1977. A Reexamination of Soviet Industrial Location Theory. The Professional Geographer 29, 3:259-265.
- Kish, G. 1960. Economic Atlas of the Soviet Union. Ann Arbor: The University of Michigan Press.
- Kish, G. 1970. Economic Atlas of the Soviet Union. Ann Arbor: The University of Michigan Press.

- Koropecjy, I.S. 1970. Industrial Location in the U.S.S.R. During the Postwar Period. In Economic Performance and the Military Burden in the Soviet Union, Subcommittee on Foreign Economic Policy of the Joint Economic Committee, Congress of the United States, pp. 233-295. Washington, D.C.: U.S. Government Printing Office.
- Lewis, R.A. and Rowland, R.H. 1969. Urbanization in Russia and the U.S.S.R.: 1897-1966. Annals of the Association of American Geographers 59, 4:776-796.
- Lonsdale, R.E. 1961. Industrial Location Planning in the Soviet Union. The Professional Geographer 13, 6:11-15.
- Lukermann, F. and Porter, P.W. 1960. Gravity and Potential Models in Economic Geography. Annals of the Association of American Geographers 50, 4:493-504.
- Lydolph, P.E. 1977. Geography of the U.S.S.R. New York: John Wiley & Sons.
- Lydolph, P.E. 1979. Geography of the U.S.S.R., Topical Analysis. Elkhart, Wisconsin: Misty Valley Publishing.
- Lydolph, P.E., Johnson, R., Mintz, J., and Mills, M.E. 1978. Recent Population Trends in the U.S.S.R. Soviet Geography: Review and Translation 19, 8:505-539.
- Lydolph, P.E. and Pease, S.R. 1972. Changing Distributions of Population and Economic Activities in the U.S.S.R. Tijdschrift voor Economische en Sociale Geografie 63, 4:244-261.
- Lydolph, P.E. and Shabad, T. 1960. The Oil and Gas Industries in the U.S.S.R. Annals of the Association of American Geographers 50, 4: 461-486.
- Mikhailov, S. and Solovev, N. 1969. Small and Medium-Size Cities and the Location of Industry in the U.S.S.R. In Contemporary Soviet Economics, vol. 2, ed. M. Yanowitch, pp. 129-136. White Plains, New York: International Arts and Sciences Press, Inc.
- Mints, A.A. and Kakhanovskaya, T.G. 1974. An Attempt at a Quantitative Evaluation of the National Resource Potential of Regions in the U.S.S.R. Soviet Geography: Review and Translation 15, 9:554-565.
- Mints, A.A. 1976. A Predictive Hypothesis of Economic Development in the European Part of the U.S.S.R. Soviet Geography: Review and Translation 17, 1:1-27.
- Myakinenkov, V.M. 1975. Prospects of the Development of Production and Settlement in the Northern Yenisey Region. Soviet Geography: Review and Translation 16, 9:578-583.

- National Geographic Society. 1976. Soviet Union. Washington, D.C.: National Geographic Society.
- Rodgers, A. 1974. The Locational Dynamics of Soviet Industry. Annals of the Association of American Geographers 64, 2:226-240.
- Runova, T.G. 1976. The Location of the Natural Resource Potential of the U.S.S.R. in Relation to the Geography of Productive Forces. Soviet Geography: Review and Translation 17, 2:73-85.
- Shabad, T. 1961a. News Notes. Soviet Geography: Review and Translation 2, 1:76.
- Shabad, T. 1961b. News Notes. Soviet Geography: Review and Translation 2, 3:80-81.
- Shabad, T. 1969. Basic Industrial Resources of the U.S.S.R. New York: Columbia University Press.
- Shabad, T. 1978. News Notes. Soviet Geography: Review and Translation 19, 4:273-285.
- Shabad, T. 1979. News Notes. Soviet Geography: Review and Translation 20, 4:255-265.
- Stewart, J.Q. and Warntz, W. 1958. Macrogeography and Social Science. The Geographical Review 48, 2:167-184.
- Taaffe, E.J. and Gauthier, H.L. Jr. 1973. Geography of Transportation. Englewood Cliffs, N.J.: Prentice-Hall, Inc.
- Taaffe, R.N., and Kingsbury, R.C. 1965. An Atlas of Soviet Affairs. New York: Frederick A. Praeger.
- USSR Geological Ministry. 1966. USSR Railroads: Directions and Stations. Moscow: Central Board in Geology and Cartography.
- Yeates, M. 1974. An Introduction to Quantitative Analysis in Human Geography. New York: McGraw-Hill Book Company.
- Yonge, J.R. 1975. U.S.S.R. Railways. Exeter, England: The Quail Map Company.

APPENDICES

APPENDIX A  
DISTANCES TO COAL SOURCES

## DISTANCES TO 1960 COAL SOURCES IN 100 KM

|               | P  | E  | C  | H  | O  | D  | R  | A  | U  | K  | R  | O  | S  | A  | G  | E  | R  | I  | L  | V  | O  | V   | L   | Y   | P   | E  | R  | I  | R  | H  | M | S | E | R | O | N | S | K | A | N | O | V | E | A | B | M | K | O | Z | K | U | C | H | I | T | T | Y | A | M | A | R | H | A | K | E | I | A | G | A | N | S | E | R | A | F |
|---------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LENINGRAD     | 23 | 9  | 18 | 18 | 14 | 15 | 28 | 25 | 19 | 22 | 23 | 39 | 44 | 44 | 53 | 51 | 60 | 66 | 87 | 84 | 88 | 96  | 101 | 110 | 110 | 37 | 35 | 41 | 45 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| MURMANSK      | 25 | 19 | 28 | 30 | 26 | 27 | 39 | 35 | 25 | 28 | 29 | 45 | 51 | 51 | 59 | 57 | 66 | 72 | 92 | 90 | 94 | 102 | 107 | 116 | 116 | 41 | 41 | 52 | 56 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| PETROZAVODSK  | 24 | 10 | 19 | 21 | 18 | 19 | 30 | 26 | 21 | 24 | 26 | 41 | 46 | 47 | 56 | 53 | 62 | 68 | 89 | 86 | 90 | 98  | 103 | 113 | 113 | 37 | 37 | 43 | 47 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| NOVGOROD      | 23 | 7  | 16 | 17 | 13 | 14 | 27 | 23 | 20 | 23 | 24 | 39 | 44 | 45 | 54 | 51 | 61 | 66 | 87 | 84 | 88 | 96  | 102 | 111 | 111 | 35 | 36 | 40 | 44 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| VOLOGDA       | 17 | 7  | 16 | 16 | 18 | 16 | 27 | 21 | 13 | 16 | 17 | 33 | 38 | 38 | 47 | 45 | 54 | 60 | 80 | 77 | 81 | 90  | 95  | 104 | 104 | 29 | 29 | 37 | 41 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| ARKHANGELSK   | 19 | 13 | 22 | 23 | 25 | 22 | 33 | 27 | 18 | 21 | 23 | 38 | 43 | 44 | 53 | 50 | 60 | 65 | 86 | 83 | 87 | 95  | 100 | 110 | 110 | 34 | 34 | 44 | 48 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| SYKTYVKAR     | 10 | 16 | 25 | 25 | 27 | 25 | 36 | 26 | 14 | 17 | 18 | 34 | 38 | 39 | 48 | 46 | 55 | 60 | 81 | 78 | 82 | 90  | 96  | 105 | 105 | 29 | 30 | 43 | 47 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| MOSCOW        | 22 | 2  | 11 | 11 | 13 | 11 | 22 | 18 | 16 | 19 | 19 | 35 | 40 | 40 | 49 | 47 | 56 | 62 | 83 | 79 | 84 | 92  | 97  | 106 | 106 | 30 | 31 | 34 | 38 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| YAROSLAVL     | 19 | 5  | 14 | 14 | 16 | 13 | 24 | 19 | 14 | 17 | 18 | 34 | 38 | 39 | 48 | 45 | 55 | 60 | 81 | 78 | 82 | 90  | 96  | 105 | 105 | 29 | 30 | 35 | 39 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| VLADIMIR      | 22 | 4  | 13 | 13 | 15 | 14 | 24 | 17 | 14 | 17 | 18 | 34 | 39 | 39 | 48 | 46 | 56 | 61 | 81 | 78 | 82 | 91  | 96  | 105 | 105 | 29 | 30 | 33 | 37 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| IVANOVO       | 22 | 5  | 14 | 15 | 16 | 14 | 25 | 17 | 14 | 17 | 18 | 34 | 39 | 39 | 48 | 46 | 56 | 61 | 81 | 78 | 82 | 91  | 96  | 105 | 105 | 29 | 30 | 33 | 37 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| KALININ       | 23 | 4  | 13 | 13 | 15 | 12 | 23 | 19 | 17 | 20 | 21 | 37 | 42 | 43 | 52 | 49 | 58 | 64 | 85 | 82 | 86 | 94  | 99  | 109 | 109 | 32 | 33 | 36 | 40 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| KAZAN         | 24 | 1  | 12 | 11 | 12 | 9  | 23 | 19 | 18 | 21 | 21 | 37 | 41 | 42 | 51 | 48 | 58 | 63 | 84 | 81 | 85 | 93  | 99  | 108 | 108 | 32 | 33 | 34 | 38 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| KALUGA        | 24 | 1  | 12 | 11 | 12 | 9  | 23 | 19 | 18 | 21 | 21 | 37 | 41 | 42 | 51 | 48 | 58 | 63 | 84 | 81 | 85 | 93  | 99  | 108 | 108 | 32 | 33 | 34 | 38 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| KOSTROMA      | 21 | 6  | 15 | 15 | 18 | 15 | 26 | 19 | 13 | 16 | 17 | 33 | 37 | 38 | 47 | 44 | 54 | 59 | 80 | 77 | 81 | 89  | 95  | 104 | 104 | 28 | 29 | 35 | 39 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| RYAZAN        | 24 | 3  | 9  | 10 | 15 | 13 | 20 | 16 | 18 | 21 | 18 | 36 | 40 | 41 | 50 | 47 | 57 | 62 | 83 | 80 | 84 | 92  | 98  | 107 | 107 | 30 | 31 | 32 | 36 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| TULA          | 24 | 1  | 11 | 9  | 13 | 10 | 21 | 18 | 18 | 22 | 20 | 37 | 42 | 42 | 51 | 49 | 58 | 64 | 84 | 81 | 85 | 94  | 99  | 108 | 108 | 32 | 33 | 33 | 37 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| KAZAN         | 22 | 10 | 16 | 16 | 22 | 19 | 25 | 12 | 9  | 12 | 11 | 27 | 32 | 32 | 41 | 49 | 48 | 54 | 74 | 71 | 75 | 84  | 89  | 98  | 98  | 32 | 23 | 29 | 33 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| GORKIY        | 20 | 6  | 15 | 16 | 18 | 15 | 24 | 19 | 11 | 14 | 16 | 31 | 36 | 37 | 46 | 43 | 52 | 58 | 79 | 76 | 80 | 88  | 94  | 103 | 103 | 27 | 27 | 32 | 36 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| KIROV         | 14 | 11 | 20 | 20 | 22 | 20 | 31 | 26 | 19 | 10 | 11 | 27 | 31 | 32 | 41 | 39 | 48 | 53 | 74 | 71 | 75 | 83  | 89  | 98  | 98  | 22 | 23 | 26 | 30 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| YOSHKAR_DLA   | 24 | 11 | 17 | 17 | 22 | 19 | 25 | 12 | 10 | 13 | 13 | 28 | 33 | 34 | 43 | 40 | 49 | 55 | 76 | 73 | 77 | 83  | 91  | 100 | 100 | 24 | 24 | 28 | 32 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| SARANSK       | 23 | 8  | 12 | 12 | 20 | 16 | 23 | 12 | 13 | 16 | 14 | 31 | 36 | 36 | 46 | 43 | 52 | 57 | 79 | 76 | 80 | 88  | 93  | 102 | 102 | 26 | 27 | 28 | 32 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| CHEBOKSARY    | 23 | 9  | 15 | 15 | 20 | 17 | 25 | 12 | 10 | 13 | 13 | 29 | 33 | 34 | 43 | 40 | 49 | 55 | 76 | 73 | 77 | 85  | 91  | 100 | 100 | 24 | 24 | 29 | 33 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| ULYANOVSK     | 25 | 10 | 13 | 14 | 22 | 18 | 22 | 9  | 11 | 15 | 11 | 28 | 33 | 34 | 43 | 40 | 49 | 55 | 76 | 72 | 77 | 85  | 91  | 100 | 100 | 23 | 24 | 31 | 35 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| BELGROD       | 29 | 5  | 6  | 4  | 11 | 6  | 16 | 21 | 25 | 28 | 24 | 41 | 46 | 46 | 55 | 53 | 62 | 68 | 88 | 85 | 89 | 98  | 103 | 112 | 112 | 34 | 35 | 35 | 40 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| VORONEZH      | 27 | 5  | 6  | 6  | 13 | 8  | 16 | 18 | 21 | 24 | 20 | 37 | 42 | 43 | 52 | 49 | 58 | 64 | 85 | 82 | 86 | 94  | 99  | 108 | 108 | 30 | 31 | 32 | 36 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| KURSK         | 27 | 3  | 7  | 6  | 10 | 7  | 18 | 20 | 21 | 24 | 22 | 40 | 44 | 45 | 54 | 51 | 61 | 66 | 87 | 84 | 88 | 96  | 102 | 111 | 111 | 32 | 33 | 35 | 39 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| OREL          | 25 | 2  | 9  | 8  | 11 | 7  | 19 | 20 | 20 | 23 | 22 | 39 | 44 | 44 | 53 | 51 | 60 | 66 | 86 | 83 | 87 | 96  | 101 | 110 | 110 | 32 | 33 | 34 | 38 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| BRYANSK       | 25 | 3  | 9  | 8  | 10 | 7  | 20 | 21 | 20 | 23 | 23 | 39 | 44 | 44 | 53 | 51 | 60 | 66 | 86 | 83 | 87 | 96  | 101 | 110 | 110 | 32 | 33 | 34 | 38 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| LIPETSK       | 27 | 3  | 7  | 7  | 14 | 10 | 18 | 17 | 20 | 23 | 23 | 39 | 44 | 44 | 53 | 51 | 60 | 66 | 86 | 83 | 87 | 96  | 101 | 110 | 110 | 32 | 33 | 34 | 38 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| TAMBOV        | 26 | 4  | 8  | 8  | 16 | 12 | 19 | 15 | 18 | 21 | 17 | 35 | 39 | 40 | 49 | 46 | 55 | 61 | 82 | 79 | 83 | 93  | 99  | 108 | 108 | 30 | 31 | 31 | 35 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| ASTRAKHAN     | 34 | 6  | 10 | 11 | 19 | 14 | 21 | 12 | 15 | 18 | 14 | 31 | 36 | 37 | 46 | 43 | 52 | 58 | 79 | 76 | 80 | 88  | 93  | 102 | 102 | 24 | 25 | 28 | 32 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| VOLGOGRAD     | 32 | 10 | 13 | 13 | 23 | 18 | 22 | 8  | 15 | 15 | 10 | 27 | 32 | 33 | 42 | 39 | 48 | 57 | 83 | 80 | 84 | 93  | 98  | 107 | 107 | 29 | 29 | 30 | 34 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| KUYBYSHEV     | 27 | 10 | 13 | 13 | 23 | 18 | 22 | 8  | 15 | 15 | 10 | 27 | 32 | 33 | 42 | 39 | 48 | 57 | 83 | 80 | 84 | 93  | 98  | 107 | 107 | 29 | 29 | 30 | 34 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| SARATOV       | 28 | 7  | 9  | 11 | 19 | 15 | 18 | 12 | 16 | 19 | 14 | 31 | 36 | 37 | 46 | 43 | 52 | 58 | 79 | 76 | 80 | 88  | 93  | 102 | 102 | 24 | 25 | 28 | 32 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| ROSTOV        | 34 | 12 | 1  | 2  | 15 | 9  | 10 | 22 | 26 | 29 | 24 | 42 | 46 | 47 | 56 | 53 | 63 | 68 | 90 | 86 | 90 | 98  | 104 | 113 | 113 | 34 | 35 | 35 | 39 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| KRASNOVAR     | 37 | 15 | 5  | 6  | 19 | 13 | 9  | 24 | 28 | 31 | 26 | 43 | 48 | 49 | 58 | 55 | 64 | 70 | 91 | 88 | 92 | 100 | 105 | 114 | 114 | 36 | 36 | 34 | 38 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| STAVROPOL     | 38 | 16 | 5  | 6  | 19 | 13 | 9  | 24 | 28 | 31 | 26 | 44 | 49 | 49 | 58 | 55 | 65 | 70 | 91 | 88 | 92 | 100 | 106 | 115 | 115 | 36 | 37 | 34 | 38 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| MAKHACHKALA   | 40 | 20 | 10 | 11 | 24 | 18 | 11 | 25 | 29 | 32 | 27 | 44 | 49 | 49 | 58 | 55 | 65 | 71 | 92 | 89 | 93 | 101 | 106 | 115 | 115 | 35 | 35 | 26 | 30 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| NALCHIK       | 40 | 18 | 7  | 9  | 22 | 15 | 12 | 26 | 29 | 32 | 28 | 45 | 50 | 53 | 59 | 57 | 66 | 72 | 92 | 89 | 93 | 102 | 107 | 116 | 116 | 39 | 39 | 36 | 40 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| ORDZHONIKIDZE | 41 | 19 | 8  | 9  | 21 | 16 | 12 | 25 | 29 | 32 | 27 | 45 | 49 | 50 | 59 | 56 | 66 | 71 | 92 | 89 | 93 | 101 | 107 | 116 | 116 | 38 | 36 | 29 | 30 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| GROZNY        | 40 | 19 | 8  | 9  | 21 | 16 | 12 | 25 | 29 | 32 | 26 | 43 | 48 | 49 | 47 | 45 | 63 | 70 | 91 | 88 | 92 | 100 | 105 | 114 | 114 | 34 | 35 | 29 | 33 |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| KIEV          | 30 | 8  | 9  | 9  | 7  | 6  | 4  | 19 | 24 | 24 | 27 | 44 | 48 | 49 | 58 | 55 | 65 | 70 | 91 | 88 | 92 | 100 | 106 | 115 | 115 | 38 | 38 | 35 | 39 | 43 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

[illegible]

## DISTANCES TO 1960 COAL SOURCES IN 100 KM

|                  | P   | R   | U   | D   | G   | K   | C  | Y  | M  | S  | K  | E  | F  |
|------------------|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|
|                  | E   | A   | K   | N   | A   | U   | H  | A  | A  | A  | A  | A  | E  |
|                  | C   | O   | R   | O   | O   | S   | A  | B  | R  | K  | M  | A  | E  |
|                  | H   | S   | A   | E   | R   | P   | R  | A  | I  | H  | K  | I  | A  |
|                  | O   | T   | I   | P   | H   | E   | K  | R  | T  | A  | A  | A  | A  |
|                  | R   | U   | N   | V   | I   | R   | S  | U  | I  | K  | K  | K  | A  |
|                  | A   | V   | E   | Y   | A   | M   | O  | C  | E  | N  | A  | A  | N  |
|                  | 19  | 24  | 24  | 27  | 32  | 11  | 2  | 5  | 6  | 22 | 27 | 36 | 34 |
| PERM             | 19  | 24  | 24  | 27  | 32  | 11  | 2  | 5  | 6  | 22 | 27 | 36 | 34 |
| SVERDLOVSK       | 23  | 19  | 26  | 30  | 33  | 9   | 4  | 4  | 4  | 18 | 23 | 24 | 32 |
| CHELBYABINSK     | 26  | 20  | 25  | 33  | 37  | 32  | 7  | 8  | 8  | 17 | 22 | 23 | 31 |
| TYUMEN           | 27  | 22  | 29  | 34  | 31  | 36  | 12 | 7  | 6  | 15 | 20 | 20 | 29 |
| KURGAN           | 27  | 22  | 27  | 34  | 31  | 35  | 10 | 8  | 3  | 15 | 20 | 29 | 26 |
| QNSK             | 32  | 28  | 33  | 39  | 36  | 40  | 15 | 13 | 7  | 9  | 14 | 15 | 23 |
| NOVOSIBIRSK      | 39  | 34  | 39  | 46  | 43  | 46  | 22 | 19 | 14 | 3  | 8  | 17 | 15 |
| TOMSK            | 42  | 37  | 42  | 49  | 46  | 49  | 25 | 22 | 17 | 5  | 11 | 7  | 20 |
| BARNAUL          | 42  | 37  | 42  | 49  | 46  | 49  | 25 | 22 | 17 | 5  | 11 | 7  | 20 |
| KRASNOYARSK      | 46  | 42  | 46  | 53  | 50  | 54  | 29 | 27 | 22 | 7  | 1  | 6  | 9  |
| IRKUTSK          | 57  | 53  | 57  | 64  | 61  | 65  | 40 | 38 | 33 | 18 | 11 | 13 | 1  |
| CHITA            | 67  | 63  | 67  | 74  | 71  | 75  | 50 | 48 | 43 | 28 | 21 | 23 | 11 |
| ABAKAN           | 47  | 42  | 47  | 54  | 51  | 55  | 30 | 28 | 23 | 7  | 6  | 1  | 12 |
| KEMEROVO         | 41  | 37  | 42  | 49  | 46  | 49  | 25 | 22 | 17 | 1  | 7  | 17 | 15 |
| ULAN_UEDE        | 62  | 57  | 62  | 69  | 65  | 69  | 45 | 42 | 37 | 23 | 15 | 22 | 6  |
| VLADEVOSTOK      | 99  | 94  | 99  | 106 | 103 | 106 | 82 | 79 | 74 | 60 | 52 | 45 | 38 |
| KHABAROVSK       | 90  | 86  | 90  | 91  | 97  | 94  | 71 | 66 | 62 | 44 | 35 | 37 | 30 |
| BLAGOVESHCHENSK  | 85  | 80  | 85  | 92  | 89  | 93  | 48 | 46 | 41 | 35 | 32 | 24 | 17 |
| MAGADAN          | 102 | 97  | 102 | 109 | 106 | 109 | 85 | 82 | 77 | 63 | 56 | 46 | 48 |
| YAKUTSK          | 89  | 84  | 89  | 96  | 93  | 97  | 72 | 69 | 65 | 50 | 43 | 36 | 28 |
| PETROPALOVSK_KAM | 118 | 105 | 108 | 115 | 113 | 116 | 92 | 89 | 84 | 70 | 62 | 53 | 45 |
| GURVEY           | 40  | 23  | 25  | 30  | 33  | 30  | 33 | 20 | 19 | 13 | 30 | 35 | 36 |
| AKTYUBINSK       | 35  | 18  | 20  | 21  | 29  | 25  | 27 | 15 | 14 | 8  | 25 | 30 | 39 |
| URALSK           | 32  | 12  | 14  | 15  | 24  | 19  | 22 | 15 | 18 | 12 | 29 | 34 | 35 |
| KUSTANAY         | 28  | 23  | 26  | 31  | 34  | 31  | 34 | 30 | 9  | 9  | 2  | 18 | 23 |
| PETROPALOVSK     | 30  | 25  | 30  | 37  | 37  | 34  | 37 | 10 | 10 | 5  | 12 | 17 | 26 |
| KOKCHETAV        | 32  | 27  | 30  | 31  | 39  | 35  | 38 | 15 | 12 | 7  | 14 | 19 | 19 |
| TSELINGRAD       | 34  | 30  | 32  | 33  | 41  | 36  | 39 | 14 | 15 | 10 | 14 | 19 | 16 |
| KARACANDA        | 37  | 32  | 34  | 35  | 44  | 39  | 41 | 20 | 18 | 12 | 16 | 22 | 19 |
| KZYL_ORDA        | 44  | 27  | 29  | 30  | 39  | 34  | 24 | 24 | 17 | 31 | 37 | 34 | 46 |
| CHIMKENT         | 49  | 32  | 34  | 35  | 43  | 39  | 29 | 28 | 22 | 26 | 32 | 29 | 41 |
| OSHANBUL         | 51  | 34  | 36  | 37  | 45  | 41  | 33 | 31 | 31 | 24 | 30 | 36 | 46 |
| SEMPALATINSK     | 45  | 40  | 45  | 52  | 50  | 49  | 28 | 25 | 20 | 9  | 15 | 11 | 23 |
| PAVLODAR         | 39  | 34  | 36  | 37  | 46  | 41  | 49 | 22 | 20 | 14 | 9  | 15 | 12 |
| UST_KAMENOGORSK  | 46  | 41  | 46  | 53  | 42  | 52  | 29 | 27 | 22 | 10 | 15 | 13 | 24 |
| ALMA_ATA         | 48  | 39  | 42  | 44  | 51  | 47  | 39 | 31 | 28 | 23 | 19 | 25 | 21 |
| ASHKHABAD        | 50  | 29  | 21  | 24  | 36  | 30  | 16 | 42 | 42 | 35 | 41 | 47 | 44 |
| DUSHANBE         | 63  | 44  | 35  | 38  | 51  | 44  | 30 | 42 | 42 | 35 | 42 | 47 | 44 |
| TASHKENT         | 50  | 32  | 34  | 36  | 44  | 40  | 29 | 29 | 29 | 23 | 27 | 34 | 31 |
| FRUNZE           | 47  | 36  | 39  | 41  | 48  | 44  | 36 | 31 | 28 | 23 | 25 | 30 | 27 |
| ELISTA           | 40  | 18  | 7   | 9   | 22  | 16  | 11 | 27 | 31 | 34 | 30 | 46 | 51 |

[illegible]





APPENDIX B  
DISTANCES TO OIL SOURCES

## DISTANCES TO 1960 OIL SOURCES IN 100 KM

|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|--|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F | T |
|  | K | R | A | S | T | G | D | T | B | K | S | V | P | O | R | W | B | S | E | F |   |

## DISTANCES TO 1960 GIL SOURCES IN 100 KM

|                 | K  | R  | A  | S  | N  | O  | D  | R  | G  | D  | A  | G  | E  | S  | T  | A  | R  | K  | B  | U  | K   | S  | A  | R  | A | G | O | L | V | P | D | R | E | N | B | U | R | G | M | U | K | R | A | I | N | B | A | K | U | S | A | H | A | L | I | N | E | M | R | A | A | O | F | E | R | G | A | N | A | T | U | R | K | M | E | N |
|-----------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|----|----|----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ZAPOROZHYE      | 9  | 10 | 16 | 15 | 13 | 14 | 15 | 19 | 20 | 17 | 13 | 13 | 12 | 11 | 11 | 21 | 24 | 19 | 13 | 18 | 103 | 28 | 43 | 23 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| KHARKOV         | 27 | 24 | 29 | 25 | 23 | 20 | 21 | 25 | 26 | 23 | 19 | 10 | 11 | 11 | 27 | 21 | 24 | 15 | 12 | 19 | 100 | 25 | 40 | 24 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| LVIV            | 31 | 25 | 31 | 22 | 20 | 21 | 25 | 26 | 26 | 23 | 19 | 20 | 20 | 19 | 27 | 27 | 27 | 25 | 25 | 28 | 107 | 34 | 49 | 33 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| KISHINEV        | 23 | 23 | 29 | 27 | 24 | 26 | 20 | 21 | 21 | 20 | 17 | 18 | 20 | 19 | 29 | 29 | 29 | 25 | 25 | 25 | 109 | 34 | 49 | 30 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| TALLIN          | 24 | 20 | 26 | 24 | 27 | 29 | 23 | 24 | 24 | 23 | 20 | 17 | 18 | 20 | 21 | 21 | 21 | 23 | 35 | 35 | 102 | 34 | 48 | 40 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| VILNIUS         | 27 | 23 | 29 | 27 | 27 | 21 | 22 | 14 | 15 | 14 | 11 | 12 | 12 | 12 | 18 | 16 | 16 | 16 | 31 | 31 | 98  | 26 | 41 | 31 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| KALININGRAD     | 20 | 17 | 23 | 21 | 21 | 22 | 17 | 18 | 18 | 17 | 15 | 16 | 16 | 16 | 19 | 19 | 19 | 20 | 27 | 27 | 100 | 30 | 45 | 37 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| SMOLENSK        | 20 | 22 | 28 | 26 | 22 | 23 | 17 | 18 | 18 | 18 | 15 | 16 | 16 | 16 | 19 | 19 | 19 | 20 | 27 | 27 | 101 | 30 | 45 | 32 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| PSKOV           | 23 | 18 | 24 | 22 | 22 | 23 | 23 | 27 | 27 | 24 | 20 | 18 | 18 | 18 | 30 | 26 | 26 | 26 | 28 | 28 | 110 | 35 | 28 | 10 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| MINSK           | 40 | 11 | 13 | 11 | 11 | 9  | 23 | 24 | 24 | 21 | 16 | 17 | 17 | 17 | 27 | 23 | 23 | 23 | 30 | 30 | 107 | 29 | 23 | 5  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| TBILISI         | 38 | 12 | 7  | 5  | 5  | 4  | 23 | 24 | 24 | 21 | 16 | 17 | 17 | 17 | 27 | 23 | 23 | 23 | 32 | 32 | 113 | 31 | 30 | 12 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| BAKU            | 43 | 14 | 14 | 12 | 12 | 10 | 29 | 30 | 27 | 27 | 23 | 22 | 22 | 22 | 34 | 29 | 29 | 29 | 32 | 32 | 107 | 33 | 48 | 32 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| YEREVAN         | 28 | 18 | 24 | 22 | 21 | 22 | 23 | 24 | 24 | 21 | 18 | 19 | 19 | 19 | 26 | 23 | 23 | 23 | 3  | 3  | 106 | 36 | 50 | 34 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| LUTSK           | 27 | 17 | 23 | 21 | 21 | 22 | 22 | 23 | 23 | 20 | 17 | 18 | 18 | 18 | 25 | 22 | 22 | 22 | 26 | 26 | 110 | 36 | 50 | 34 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| ROVNO           | 31 | 20 | 26 | 24 | 24 | 25 | 25 | 26 | 26 | 24 | 21 | 22 | 22 | 22 | 29 | 26 | 26 | 26 | 2  | 2  | 109 | 35 | 50 | 33 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| UZNGOROD        | 30 | 20 | 26 | 24 | 24 | 25 | 24 | 24 | 24 | 22 | 18 | 19 | 19 | 19 | 28 | 24 | 24 | 24 | 1  | 1  | 107 | 33 | 48 | 32 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| IVANO_FRANKOVSK | 28 | 18 | 24 | 22 | 22 | 23 | 23 | 24 | 24 | 22 | 18 | 19 | 19 | 19 | 26 | 23 | 23 | 23 | 6  | 6  | 104 | 30 | 45 | 28 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| TERNOPOL        | 26 | 15 | 21 | 19 | 19 | 20 | 20 | 21 | 21 | 19 | 16 | 17 | 17 | 17 | 25 | 21 | 21 | 21 | 5  | 5  | 105 | 31 | 45 | 29 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| ZHITOMIR        | 27 | 15 | 21 | 19 | 19 | 21 | 21 | 22 | 22 | 19 | 16 | 17 | 17 | 17 | 25 | 21 | 21 | 21 | 5  | 5  | 106 | 32 | 47 | 30 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| VINHITSA        | 28 | 17 | 23 | 21 | 21 | 22 | 22 | 23 | 23 | 21 | 17 | 18 | 18 | 18 | 26 | 23 | 23 | 23 | 3  | 3  | 106 | 32 | 47 | 30 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| KHMELNITSKIY    | 31 | 19 | 25 | 23 | 23 | 24 | 24 | 25 | 25 | 23 | 20 | 21 | 21 | 21 | 28 | 25 | 25 | 25 | 2  | 2  | 109 | 35 | 49 | 35 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| CHEKHOVITSKY    | 23 | 13 | 19 | 17 | 17 | 18 | 18 | 19 | 19 | 17 | 13 | 14 | 14 | 14 | 21 | 19 | 19 | 19 | 8  | 8  | 101 | 28 | 43 | 27 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| CHEKHOVITSKY    | 23 | 12 | 18 | 16 | 16 | 17 | 17 | 18 | 18 | 15 | 11 | 12 | 12 | 12 | 21 | 17 | 17 | 17 | 11 | 11 | 101 | 26 | 41 | 24 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| SUNY            | 25 | 10 | 16 | 14 | 14 | 15 | 15 | 16 | 16 | 15 | 11 | 12 | 12 | 12 | 22 | 17 | 17 | 17 | 11 | 11 | 103 | 26 | 41 | 23 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| POLTAVA         | 26 | 12 | 18 | 16 | 16 | 18 | 18 | 20 | 21 | 18 | 15 | 16 | 16 | 16 | 23 | 20 | 20 | 20 | 9  | 9  | 104 | 30 | 44 | 26 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| CHEKASSY        | 27 | 13 | 19 | 17 | 17 | 18 | 18 | 21 | 21 | 18 | 15 | 16 | 16 | 16 | 24 | 20 | 20 | 20 | 8  | 8  | 104 | 30 | 45 | 26 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| KIROVOGRAD      | 29 | 10 | 20 | 18 | 18 | 18 | 18 | 24 | 24 | 21 | 17 | 18 | 18 | 18 | 27 | 23 | 23 | 23 | 8  | 8  | 107 | 33 | 48 | 26 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| ODESSA          | 29 | 7  | 16 | 14 | 14 | 15 | 15 | 22 | 22 | 19 | 16 | 17 | 17 | 17 | 27 | 21 | 21 | 21 | 11 | 11 | 105 | 31 | 45 | 23 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| NIKOLAYEV       | 29 | 7  | 15 | 13 | 13 | 14 | 14 | 22 | 22 | 19 | 15 | 15 | 15 | 15 | 27 | 21 | 21 | 21 | 11 | 11 | 105 | 30 | 45 | 23 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| KHERSON         | 29 | 7  | 15 | 13 | 13 | 14 | 14 | 22 | 22 | 19 | 15 | 15 | 15 | 15 | 27 | 21 | 21 | 21 | 14 | 14 | 106 | 32 | 46 | 22 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| SIMFEROPOL      | 31 | 6  | 14 | 14 | 14 | 14 | 14 | 23 | 23 | 20 | 17 | 18 | 18 | 18 | 27 | 22 | 22 | 22 | 12 | 12 | 102 | 27 | 42 | 22 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| ONEPROPETROVSK  | 26 | 8  | 11 | 9  | 9  | 10 | 10 | 17 | 17 | 16 | 12 | 12 | 12 | 12 | 22 | 17 | 17 | 17 | 15 | 15 | 101 | 26 | 41 | 20 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| DONETSK         | 27 | 6  | 11 | 9  | 9  | 10 | 10 | 17 | 17 | 16 | 12 | 12 | 12 | 12 | 22 | 17 | 17 | 17 | 15 | 15 | 101 | 26 | 41 | 20 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| VOROSHILOVGRAD  | 27 | 8  | 13 | 11 | 11 | 11 | 11 | 16 | 17 | 14 | 9  | 8  | 8  | 8  | 20 | 16 | 16 | 16 | 16 | 16 | 100 | 24 | 41 | 20 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| GRODNO          | 26 | 21 | 27 | 25 | 25 | 26 | 26 | 21 | 22 | 21 | 18 | 19 | 19 | 19 | 23 | 23 | 23 | 23 | 9  | 9  | 105 | 33 | 48 | 30 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| VITEBSK         | 22 | 18 | 24 | 22 | 22 | 23 | 23 | 16 | 17 | 14 | 13 | 14 | 14 | 14 | 20 | 17 | 17 | 17 | 12 | 12 | 100 | 28 | 42 | 29 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| MOGILEV         | 20 | 17 | 23 | 21 | 21 | 22 | 22 | 16 | 17 | 15 | 12 | 13 | 13 | 13 | 20 | 17 | 17 | 17 | 9  | 9  | 100 | 27 | 42 | 29 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| GOMEL           | 22 | 17 | 21 | 19 | 19 | 20 | 20 | 18 | 18 | 16 | 12 | 13 | 13 | 13 | 20 | 18 | 18 | 18 | 8  | 8  | 100 | 27 | 42 | 29 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| BREST           | 27 | 22 | 26 | 24 | 24 | 26 | 26 | 21 | 22 | 21 | 18 | 19 | 19 | 19 | 25 | 23 | 23 | 23 | 5  | 5  | 105 | 33 | 47 | 32 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| UFA             | 25 | 21 | 23 | 21 | 21 | 22 | 22 | 3  | 3  | 2  | 8  | 9  | 9  | 9  | 7  | 7  | 7  | 7  | 28 | 28 | 81  | 13 | 32 | 31 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| TZHEVSK         | 13 | 22 | 24 | 22 | 22 | 23 | 23 | 4  | 4  | 5  | 11 | 12 | 12 | 12 | 4  | 4  | 4  | 4  | 27 | 27 | 83  | 22 | 37 | 32 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| IRENBURG        | 26 | 19 | 20 | 18 | 18 | 18 | 18 | 7  | 7  | 6  | 8  | 9  | 9  | 9  | 14 | 14 | 14 | 14 | 29 | 29 | 85  | 9  | 24 | 27 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

## DISTANCES TO 1960 OIL SOURCES IN 100 KM

|   | K   | R   | A   | S   | S   | T   | G   | D   | T  | B  | K  | U  | S  | V  | O  | R  | E  | N   | M   | H   | A   | L   | I   | N | S | E | F | T |
|---|-----|-----|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|---|---|---|---|---|
| N | 14  | 26  | 27  | 28  | 28  | 28  | 26  | 27  | 4  | 5  | 7  | 11 | 12 | 12 | 12 | 9  | 13 | 29  | 30  | 81  | 19  | 34  | 35  | U |   |   |   |   |
| O | 18  | 27  | 28  | 29  | 29  | 29  | 26  | 27  | 9  | 8  | 11 | 14 | 15 | 15 | 15 | 4  | 13 | 32  | 32  | 77  | 15  | 30  | 37  | R |   |   |   |   |
| D | 20  | 26  | 27  | 28  | 28  | 28  | 26  | 27  | 8  | 6  | 9  | 12 | 13 | 13 | 13 | 6  | 10 | 33  | 31  | 76  | 13  | 28  | 36  | K |   |   |   |   |
| M | 21  | 31  | 31  | 33  | 33  | 33  | 31  | 31  | 12 | 11 | 14 | 17 | 18 | 18 | 18 | 7  | 16 | 36  | 35  | 74  | 18  | 33  | 40  | R |   |   |   |   |
| I | 21  | 29  | 30  | 30  | 30  | 30  | 28  | 29  | 10 | 13 | 11 | 14 | 15 | 15 | 15 | 7  | 13 | 36  | 33  | 74  | 156 | 30  | 38  | K |   |   |   |   |
| E | 27  | 34  | 36  | 36  | 36  | 36  | 34  | 35  | 15 | 13 | 17 | 20 | 21 | 21 | 21 | 13 | 18 | 41  | 39  | 68  | 21  | 30  | 41  | E |   |   |   |   |
|   | 33  | 40  | 42  | 42  | 42  | 42  | 40  | 41  | 21 | 20 | 24 | 27 | 28 | 28 | 28 | 19 | 25 | 48  | 45  | 62  | 27  | 32  | 44  | M |   |   |   |   |
|   | 36  | 43  | 45  | 45  | 45  | 45  | 43  | 44  | 24 | 23 | 26 | 29 | 30 | 30 | 30 | 22 | 27 | 51  | 48  | 60  | 30  | 35  | 46  | E |   |   |   |   |
|   | 36  | 43  | 45  | 45  | 45  | 45  | 43  | 44  | 24 | 23 | 26 | 29 | 30 | 30 | 30 | 22 | 28 | 50  | 47  | 65  | 30  | 30  | 42  | N |   |   |   |   |
|   | 40  | 48  | 50  | 50  | 50  | 50  | 48  | 49  | 29 | 28 | 31 | 34 | 35 | 35 | 35 | 27 | 32 | 55  | 53  | 54  | 35  | 39  | 51  | A |   |   |   |   |
|   | 51  | 59  | 61  | 61  | 61  | 61  | 59  | 60  | 40 | 39 | 42 | 45 | 46 | 46 | 46 | 38 | 43 | 66  | 63  | 43  | 47  | 49  | 61  | H |   |   |   |   |
|   | 61  | 69  | 71  | 71  | 71  | 71  | 69  | 70  | 50 | 49 | 52 | 55 | 56 | 56 | 56 | 48 | 53 | 76  | 74  | 33  | 36  | 36  | 48  | A |   |   |   |   |
|   | 61  | 69  | 71  | 71  | 71  | 71  | 69  | 70  | 50 | 49 | 52 | 55 | 56 | 56 | 56 | 48 | 53 | 76  | 74  | 33  | 36  | 36  | 48  | A |   |   |   |   |
|   | 41  | 49  | 51  | 51  | 51  | 51  | 49  | 49  | 30 | 29 | 32 | 35 | 36 | 36 | 36 | 27 | 33 | 56  | 52  | 61  | 30  | 34  | 45  | E |   |   |   |   |
|   | 36  | 43  | 45  | 45  | 45  | 45  | 43  | 44  | 24 | 23 | 26 | 29 | 30 | 30 | 30 | 22 | 27 | 51  | 48  | 62  | 30  | 34  | 45  | E |   |   |   |   |
|   | 56  | 63  | 65  | 65  | 65  | 65  | 63  | 64  | 44 | 43 | 46 | 49 | 50 | 50 | 50 | 42 | 48 | 71  | 68  | 39  | 50  | 54  | 66  | A |   |   |   |   |
|   | 93  | 100 | 102 | 102 | 102 | 102 | 100 | 101 | 81 | 80 | 83 | 86 | 87 | 87 | 87 | 79 | 85 | 108 | 105 | 87  | 91  | 91  | 103 | A |   |   |   |   |
|   | 85  | 92  | 94  | 94  | 94  | 94  | 92  | 93  | 73 | 72 | 75 | 78 | 79 | 79 | 79 | 71 | 76 | 99  | 97  | 10  | 79  | 83  | 95  | R |   |   |   |   |
|   | 79  | 87  | 89  | 89  | 89  | 89  | 87  | 88  | 68 | 67 | 70 | 73 | 74 | 74 | 74 | 65 | 71 | 94  | 91  | 18  | 74  | 78  | 89  | R |   |   |   |   |
|   | 96  | 103 | 105 | 105 | 105 | 105 | 103 | 104 | 85 | 84 | 87 | 90 | 91 | 91 | 91 | 82 | 88 | 111 | 108 | 14  | 90  | 94  | 106 | A |   |   |   |   |
|   | 100 | 108 | 110 | 110 | 110 | 110 | 108 | 108 | 89 | 88 | 91 | 94 | 95 | 95 | 95 | 86 | 92 | 115 | 112 | 8   | 94  | 99  | 110 | E |   |   |   |   |
|   | 83  | 91  | 93  | 93  | 93  | 93  | 91  | 92  | 72 | 71 | 74 | 77 | 78 | 78 | 78 | 69 | 75 | 98  | 95  | 33  | 78  | 82  | 93  | E |   |   |   |   |
|   | 113 | 110 | 112 | 112 | 112 | 112 | 110 | 111 | 91 | 90 | 93 | 96 | 97 | 97 | 97 | 89 | 94 | 118 | 115 | 10  | 97  | 101 | 113 | A |   |   |   |   |
|   | 35  | 27  | 27  | 27  | 27  | 27  | 25  | 26  | 15 | 14 | 17 | 15 | 16 | 16 | 16 | 19 | 11 | 36  | 29  | 89  | 1   | 26  | 34  | R |   |   |   |   |
|   | 29  | 22  | 22  | 22  | 22  | 22  | 20  | 20  | 9  | 8  | 11 | 10 | 11 | 11 | 11 | 14 | 5  | 31  | 24  | 84  | 6   | 22  | 29  | K |   |   |   |   |
|   | 26  | 16  | 16  | 16  | 16  | 16  | 14  | 15  | 9  | 8  | 8  | 4  | 5  | 5  | 5  | 16 | 5  | 25  | 19  | 88  | 11  | 25  | 24  | R |   |   |   |   |
|   | 23  | 28  | 28  | 28  | 28  | 28  | 26  | 27  | 10 | 9  | 12 | 15 | 16 | 16 | 16 | 9  | 10 | 37  | 31  | 77  | 13  | 27  | 36  | E |   |   |   |   |
|   | 24  | 31  | 33  | 33  | 33  | 33  | 31  | 32  | 12 | 11 | 14 | 17 | 18 | 18 | 18 | 10 | 16 | 40  | 36  | 71  | 18  | 27  | 39  | A |   |   |   |   |
|   | 26  | 33  | 32  | 32  | 32  | 32  | 30  | 31  | 14 | 13 | 16 | 19 | 20 | 20 | 20 | 12 | 14 | 41  | 35  | 73  | 17  | 25  | 37  | E |   |   |   |   |
|   | 29  | 33  | 34  | 34  | 34  | 34  | 32  | 32  | 17 | 16 | 18 | 21 | 22 | 22 | 22 | 15 | 16 | 43  | 36  | 73  | 18  | 22  | 34  | A |   |   |   |   |
|   | 31  | 36  | 36  | 36  | 36  | 36  | 34  | 35  | 19 | 18 | 21 | 24 | 25 | 25 | 25 | 17 | 18 | 45  | 36  | 75  | 21  | 20  | 31  | N |   |   |   |   |
|   | 39  | 31  | 31  | 31  | 31  | 31  | 29  | 30  | 18 | 17 | 20 | 21 | 22 | 22 | 22 | 23 | 16 | 40  | 27  | 90  | 16  | 10  | 22  | E |   |   |   |   |
|   | 43  | 36  | 31  | 31  | 31  | 31  | 29  | 35  | 23 | 22 | 25 | 24 | 28 | 28 | 28 | 25 | 20 | 45  | 24  | 86  | 20  | 7   | 19  | R |   |   |   |   |
|   | 46  | 38  | 33  | 33  | 33  | 33  | 31  | 37  | 25 | 24 | 27 | 26 | 27 | 27 | 27 | 30 | 23 | 47  | 26  | 83  | 23  | 9   | 21  | A |   |   |   |   |
|   | 39  | 47  | 48  | 48  | 48  | 48  | 46  | 45  | 28 | 27 | 30 | 33 | 34 | 34 | 34 | 25 | 29 | 56  | 41  | 68  | 32  | 25  | 37  | E |   |   |   |   |
|   | 33  | 38  | 43  | 43  | 43  | 43  | 41  | 37  | 22 | 21 | 23 | 26 | 27 | 27 | 27 | 19 | 20 | 47  | 46  | 68  | 23  | 29  | 41  | A |   |   |   |   |
|   | 40  | 39  | 49  | 49  | 49  | 49  | 47  | 48  | 29 | 28 | 31 | 34 | 35 | 35 | 35 | 26 | 30 | 48  | 45  | 69  | 24  | 29  | 40  | N |   |   |   |   |
|   | 42  | 43  | 39  | 39  | 39  | 39  | 37  | 35  | 31 | 30 | 33 | 33 | 33 | 33 | 33 | 28 | 27 | 53  | 31  | 79  | 27  | 15  | 27  | E |   |   |   |   |
|   | 44  | 20  | 16  | 16  | 16  | 16  | 14  | 12  | 37 | 36 | 26 | 22 | 23 | 23 | 23 | 33 | 28 | 38  | 9   | 101 | 33  | 18  | 4   | A |   |   |   |   |
|   | 57  | 34  | 30  | 30  | 30  | 30  | 28  | 27  | 37 | 36 | 26 | 22 | 22 | 22 | 22 | 37 | 42 | 52  | 23  | 101 | 33  | 15  | 18  | E |   |   |   |   |
|   | 44  | 33  | 29  | 29  | 29  | 29  | 27  | 25  | 25 | 24 | 23 | 25 | 26 | 26 | 26 | 29 | 20 | 46  | 21  | 88  | 21  | 5   | 17  | R |   |   |   |   |
|   | 42  | 40  | 36  | 36  | 36  | 36  | 34  | 32  | 28 | 27 | 27 | 29 | 30 | 30 | 30 | 28 | 24 | 50  | 29  | 84  | 12  | 12  | 24  | A |   |   |   |   |
|   | 34  | 11  | 11  | 11  | 11  | 11  | 9   | 9   | 21 | 22 | 19 | 14 | 13 | 13 | 13 | 25 | 21 | 23  | 14  | 105 | 29  | 41  | 19  | E |   |   |   |   |

2003

|              | K  | S  | D  | I  | B  | K  | V  | O  | D  | R  | E  | C  | H  | A  | T  | M  | E  | S   | S   | A   | F  | T  |
|--------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|-----|-----|----|----|
| N            | R  | -T | G  | A  | A  | U  | S  | A  | R  | E  | N  | U  | R  | A  | L  | I  | U  | S   | A   | H   | E  | R  |
| O            | A  | V  | Z  | T  | S  | Y  | A  | L  | O  | P  | B  | U  | K  | R  | A  | K  | Z  | A   | M   | A   | N  | R  |
| D            | N  | R  | M  | G  | H  | S  | T  | C  | B  | U  | M  | K  | R  | A  | L  | I  | E  | A   | H   | A   | N  | R  |
| E            | I  | L  | A  | N  | I  | F  | D  | D  | S  | M  | P  | A  | I  | A  | O  | S  | S  | N   | I   | A   | R  | R  |
| LENINGRAD    | 17 | 23 | 29 | 27 | 17 | 18 | 15 | 16 | 17 | 19 | 17 | 9  | 16 | 14 | 31 | 28 | 33 | 98  | 27  | 35  | 45 | 36 |
| MURMANSK     | 20 | 33 | 39 | 37 | 28 | 29 | 26 | 27 | 23 | 30 | 28 | 21 | 28 | 26 | 42 | 34 | 39 | 104 | 35  | 45  | 56 | 47 |
| PETROZAVODSK | 19 | 24 | 30 | 28 | 19 | 17 | 14 | 18 | 19 | 21 | 20 | 13 | 20 | 13 | 33 | 30 | 35 | 100 | 28  | 36  | 47 | 38 |
| NNVGOROD     | 18 | 21 | 27 | 25 | 16 | 17 | 14 | 15 | 18 | 18 | 17 | 16 | 13 | 30 | 29 | 34 | 98 | 25  | 33  | 44  | 35 |    |
| VOLOGDA      | 9  | 21 | 27 | 25 | 12 | 13 | 14 | 15 | 11 | 16 | 15 | 11 | 20 | 14 | 30 | 25 | 27 | 92  | 27  | 35  | 41 | 33 |
| ARKHANGELSK  | 13 | 27 | 32 | 30 | 19 | 20 | 20 | 21 | 16 | 22 | 21 | 18 | 26 | 23 | 36 | 28 | 33 | 97  | 31  | 39  | 47 | 41 |
| SYKTYVKAR    | 4  | 30 | 34 | 32 | 17 | 18 | 20 | 21 | 12 | 22 | 12 | 20 | 29 | 23 | 36 | 28 | 33 | 93  | 31  | 39  | 47 | 41 |
| MOSCOW       | 16 | 16 | 22 | 20 | 10 | 11 | 11 | 10 | 14 | 13 | 12 | 6  | 16 | 9  | 25 | 24 | 29 | 95  | 20  | 28  | 38 | 30 |
| YAROSLAVL    | 13 | 19 | 25 | 23 | 24 | 10 | 11 | 11 | 12 | 13 | 12 | 9  | 18 | 12 | 27 | 23 | 28 | 93  | 22  | 30  | 39 | 32 |
| VLADIMIR     | 16 | 18 | 24 | 22 | 23 | 8  | 9  | 9  | 10 | 11 | 11 | 8  | 18 | 11 | 26 | 23 | 28 | 98  | 21  | 29  | 37 | 31 |
| IVANOVNO     | 16 | 19 | 25 | 23 | 24 | 9  | 10 | 10 | 11 | 12 | 11 | 10 | 19 | 12 | 28 | 23 | 28 | 93  | 21  | 29  | 37 | 32 |
| KALININ      | 18 | 18 | 24 | 22 | 12 | 13 | 12 | 10 | 11 | 15 | 14 | 9  | 15 | 10 | 26 | 26 | 31 | 96  | 21  | 29  | 43 | 31 |
| KALUGA       | 18 | 17 | 22 | 20 | 12 | 13 | 11 | 9  | 10 | 16 | 13 | 14 | 5  | 14 | 8  | 25 | 26 | 96  | 20  | 28  | 38 | 30 |
| KOSTROMA     | 15 | 20 | 25 | 23 | 24 | 10 | 11 | 11 | 12 | 13 | 11 | 11 | 12 | 13 | 28 | 22 | 27 | 92  | 23  | 31  | 39 | 33 |
| KRYAZAN      | 18 | 14 | 20 | 18 | 20 | 10 | 11 | 9  | 10 | 14 | 11 | 12 | 19 | 9  | 23 | 25 | 30 | 94  | 19  | 26  | 36 | 28 |
| TULA         | 18 | 15 | 21 | 19 | 20 | 12 | 13 | 10 | 7  | 16 | 12 | 14 | 6  | 15 | 17 | 23 | 16 | 96  | 18  | 26  | 37 | 29 |
| KAZAN        | 16 | 19 | 21 | 19 | 20 | 2  | 4  | 5  | 7  | 8  | 7  | 4  | 15 | 24 | 17 | 23 | 16 | 86  | 18  | 26  | 37 | 28 |
| GORKIY       | 14 | 20 | 22 | 20 | 21 | 6  | 7  | 8  | 9  | 10 | 10 | 9  | 11 | 20 | 13 | 25 | 21 | 90  | 19  | 27  | 36 | 33 |
| KIROV        | 8  | 25 | 27 | 25 | 25 | 9  | 10 | 13 | 13 | 14 | 5  | 15 | 25 | 18 | 29 | 16 | 21 | 86  | 24  | 32  | 40 | 34 |
| YOSHKAR_OLA  | 18 | 20 | 21 | 19 | 20 | 4  | 5  | 6  | 8  | 9  | 8  | 5  | 15 | 24 | 18 | 24 | 18 | 87  | 19  | 27  | 34 | 29 |
| SARANSK      | 17 | 17 | 19 | 17 | 18 | 7  | 8  | 5  | 6  | 11 | 7  | 8  | 13 | 21 | 21 | 20 | 25 | 90  | 15  | 24  | 32 | 26 |
| CHEBOKSARY   | 17 | 19 | 21 | 19 | 20 | 4  | 5  | 6  | 7  | 8  | 8  | 5  | 13 | 22 | 15 | 24 | 18 | 87  | 16  | 24  | 33 | 29 |
| ULYANOVSK    | 19 | 16 | 18 | 16 | 17 | 3  | 4  | 5  | 6  | 10 | 5  | 6  | 15 | 24 | 14 | 21 | 19 | 87  | 15  | 23  | 35 | 26 |
| VERGOROD     | 23 | 10 | 16 | 14 | 16 | 16 | 13 | 10 | 6  | 7  | 19 | 12 | 15 | 7  | 5  | 19 | 32 | 96  | 17  | 25  | 40 | 24 |
| VRGONEZH     | 22 | 10 | 16 | 14 | 16 | 13 | 13 | 10 | 6  | 7  | 19 | 12 | 15 | 7  | 5  | 19 | 32 | 96  | 17  | 25  | 40 | 24 |
| KURSK        | 21 | 12 | 18 | 16 | 17 | 15 | 15 | 12 | 9  | 10 | 14 | 17 | 5  | 12 | 3  | 21 | 30 | 98  | 17  | 25  | 39 | 26 |
| OREL         | 20 | 13 | 20 | 18 | 19 | 14 | 15 | 12 | 8  | 9  | 14 | 16 | 4  | 13 | 5  | 22 | 28 | 98  | 18  | 26  | 38 | 27 |
| BRVANSK      | 20 | 14 | 20 | 18 | 19 | 14 | 15 | 12 | 8  | 9  | 18 | 15 | 3  | 12 | 5  | 23 | 28 | 98  | 19  | 27  | 39 | 28 |
| LIPETSK      | 21 | 12 | 18 | 16 | 17 | 12 | 12 | 9  | 6  | 7  | 18 | 11 | 15 | 7  | 6  | 20 | 27 | 95  | 15  | 23  | 35 | 25 |
| TAMBOV       | 21 | 13 | 18 | 16 | 18 | 10 | 10 | 7  | 6  | 5  | 16 | 9  | 13 | 9  | 17 | 8  | 22 | 94  | 15  | 23  | 34 | 27 |
| YEYZA        | 19 | 15 | 19 | 17 | 18 | 7  | 7  | 4  | 4  | 5  | 13 | 6  | 9  | 12 | 10 | 22 | 27 | 90  | 14  | 22  | 32 | 17 |
| ASHKRAHAN    | 29 | 11 | 7  | 5  | 6  | 13 | 10 | 7  | 8  | 18 | 12 | 18 | 15 | 14 | 9  | 22 | 30 | 92  | 4   | 11  | 22 | 14 |
| ASTRAGHAN    | 26 | 7  | 11 | 9  | 10 | 10 | 9  | 4  | 3  | 15 | 11 | 18 | 20 | 14 | 9  | 25 | 30 | 95  | 9   | 16  | 34 | 19 |
| KUYBISHEV    | 22 | 16 | 18 | 16 | 17 | 3  | 3  | 1  | 4  | 5  | 7  | 12 | 15 | 12 | 15 | 21 | 24 | 86  | 10  | 18  | 28 | 26 |
| SARATOV      | 22 | 12 | 14 | 12 | 12 | 7  | 7  | 4  | 1  | 11 | 6  | 11 | 16 | 12 | 12 | 16 | 23 | 90  | 11  | 19  | 30 | 21 |
| ROSTOV       | 28 | 4  | 9  | 6  | 8  | 17 | 17 | 14 | 12 | 9  | 20 | 16 | 20 | 11 | 17 | 13 | 38 | 100 | 14  | 22  | 39 | 18 |
| KRASNODAR    | 32 | 1  | 9  | 6  | 8  | 18 | 19 | 16 | 12 | 22 | 18 | 22 | 17 | 11 | 12 | 35 | 40 | 102 | 15  | 23  | 38 | 17 |
| STAVROPOL    | 32 | 3  | 9  | 6  | 8  | 19 | 19 | 16 | 12 | 11 | 23 | 18 | 23 | 17 | 11 | 12 | 35 | 40  | 102 | 15  | 23 | 38 |
| MAKHACHKALA  | 34 | 8  | 4  | 2  | 1  | 19 | 20 | 17 | 13 | 13 | 23 | 19 | 23 | 20 | 16 | 14 | 4  | 32  | 37  | 103 | 10 | 18 |
| NALCHIK      | 35 | 5  | 4  | 2  | 1  | 19 | 20 | 18 | 13 | 13 | 24 | 20 | 24 | 18 | 23 | 16 | 7  | 38  | 104 | 11  | 19 | 34 |
| OROZHNIKIDZE | 35 | 5  | 3  | 1  | 3  | 19 | 20 | 17 | 13 | 14 | 24 | 19 | 24 | 19 | 24 | 15 | 5  | 37  | 103 | 10  | 18 | 30 |
| GRZNYNY      | 34 | 7  | 2  | 1  | 7  | 18 | 19 | 16 | 12 | 12 | 23 | 18 | 22 | 19 | 75 | 15 | 2  | 36  | 102 | 9   | 17 | 28 |
| IGEVY        | 25 | 13 | 19 | 17 | 18 | 19 | 20 | 17 | 14 | 15 | 22 | 19 | 20 | 3  | 7  | 27 | 31 | 103 | 21  | 29  | 43 | 27 |

| DISTANCES TO 1970 OIL SOURCES IN 100 KM |                 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |     |    |    |    |    |
|-----------------------------------------|-----------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|-----|----|----|----|----|
|                                         |                 | K  | S  | G  | D  | T  | Θ  | K  | V  | O  | R  | E  | U  | D  | B  | P  | E  | E  | S  | S   | S   | E  | U  | F  | T  |
|                                         |                 | R  | A  | A  | A  | S  | A  | U  | S  | A  | R  | C  | M  | N  | A  | A  | A  | A  | A  | A   | A   | M  | Z  | E  | U  |
|                                         |                 | A  | V  | O  | G  | E  | H  | B  | O  | L  | H  | K  | M  | N  | K  | R  | R  | R  | H  | H   | H   | B  | E  | R  | U  |
|                                         |                 | N  | O  | R  | Z  | S  | S  | S  | S  | G  | K  | K  | R  | D  | R  | E  | E  | E  | A  | A   | A   | A  | N  | E  | U  |
|                                         |                 | D  | O  | P  | N  | T  | H  | H  | D  | O  | S  | T  | U  | B  | B  | I  | I  | I  | L  | L   | L   | B  | O  | K  | U  |
|                                         |                 | R  | O  | P  | A  | A  | A  | A  | A  | O  | R  | A  | A  | R  | R  | A  | A  | A  | T  | T   | T   | A  | O  | K  | U  |
|                                         |                 | I  | L  | L  | N  | R  | R  | R  | V  | D  | V  | R  | G  | G  | V  | M  | N  | U  | O  | O   | O   | S  | S  | E  | U  |
| Y                                       | ZAPOROZHYE      | 27 | 9  | 15 | 13 | 14 | 19 | 20 | 17 | 13 | 12 | 24 | 19 | 23 | 9  | 13 | 4  | 18 | 35 | 40  | 103 | 18 | 26 | 43 | 23 |
| O                                       | KHARKOV         | 24 | 10 | 16 | 15 | 16 | 16 | 16 | 13 | 10 | 11 | 21 | 15 | 23 | 6  | 12 | 9  | 19 | 31 | 36  | 100 | 17 | 25 | 40 | 24 |
| D                                       | LVIV            | 29 | 19 | 25 | 24 | 24 | 25 | 23 | 23 | 19 | 20 | 27 | 25 | 25 | 7  | 1  | 2  | 28 | 43 | 107 | 17  | 35 | 49 | 30 |    |
|                                         | KISHINEV        | 31 | 16 | 22 | 20 | 21 | 25 | 26 | 23 | 19 | 19 | 29 | 25 | 27 | 10 | 5  | 8  | 25 | 39 | 44  | 109 | 25 | 35 | 48 | 30 |
|                                         | TALLIN          | 21 | 25 | 31 | 29 | 31 | 20 | 21 | 21 | 19 | 20 | 22 | 22 | 22 | 12 | 17 | 16 | 35 | 32 | 37  | 102 | 30 | 38 | 48 | 40 |
|                                         | RIGA            | 23 | 39 | 27 | 28 | 19 | 20 | 20 | 20 | 17 | 18 | 22 | 22 | 21 | 8  | 13 | 14 | 32 | 33 | 38  | 103 | 28 | 36 | 47 | 37 |
|                                         | VILNIUS         | 24 | 20 | 26 | 24 | 26 | 20 | 21 | 20 | 17 | 18 | 22 | 22 | 21 | 5  | 9  | 10 | 29 | 34 | 39  | 103 | 27 | 35 | 47 | 34 |
|                                         | KALININGRAD     | 27 | 23 | 29 | 27 | 29 | 23 | 24 | 23 | 20 | 21 | 26 | 25 | 25 | 8  | 13 | 13 | 32 | 42 | 47  | 107 | 30 | 38 | 50 | 37 |
|                                         | SHOLENSK        | 20 | 17 | 23 | 21 | 22 | 14 | 15 | 14 | 11 | 12 | 18 | 16 | 16 | 4  | 11 | 9  | 26 | 28 | 33  | 98  | 22 | 30 | 41 | 31 |
|                                         | PSKOV           | 20 | 22 | 28 | 26 | 28 | 17 | 18 | 17 | 15 | 16 | 19 | 19 | 19 | 3  | 8  | 14 | 32 | 30 | 35  | 100 | 27 | 35 | 45 | 37 |
|                                         | MINSK           | 23 | 18 | 24 | 22 | 23 | 17 | 18 | 17 | 15 | 16 | 21 | 20 | 19 | 3  | 9  | 8  | 27 | 32 | 37  | 101 | 25 | 33 | 45 | 32 |
|                                         | TBILISI         | 40 | 11 | 13 | 11 | 9  | 26 | 27 | 24 | 20 | 18 | 30 | 26 | 30 | 23 | 28 | 19 | 5  | 41 | 46  | 110 | 19 | 27 | 28 | 10 |
|                                         | BAKU            | 38 | 12 | 17 | 5  | 4  | 23 | 24 | 21 | 16 | 17 | 27 | 27 | 27 | 24 | 30 | 20 | 1  | 35 | 40  | 107 | 13 | 21 | 23 | 5  |
|                                         | YEREVAN         | 43 | 14 | 15 | 10 | 10 | 24 | 30 | 27 | 23 | 22 | 34 | 29 | 34 | 27 | 32 | 22 | 7  | 42 | 47  | 113 | 20 | 28 | 30 | 12 |
|                                         | ROVNO           | 27 | 17 | 23 | 21 | 22 | 22 | 23 | 21 | 18 | 19 | 26 | 23 | 24 | 6  | 3  | 8  | 27 | 36 | 41  | 107 | 26 | 34 | 48 | 32 |
|                                         | UZMGOROD        | 31 | 20 | 26 | 24 | 25 | 25 | 26 | 24 | 21 | 22 | 29 | 26 | 26 | 9  | 2  | 10 | 29 | 40 | 45  | 110 | 28 | 36 | 50 | 34 |
|                                         | IVANO-FRANKOVSK | 30 | 20 | 26 | 24 | 25 | 24 | 25 | 24 | 20 | 21 | 28 | 26 | 27 | 8  | 1  | 9  | 29 | 39 | 44  | 109 | 28 | 36 | 50 | 33 |
|                                         | TERNOPOL        | 28 | 18 | 24 | 23 | 23 | 23 | 24 | 22 | 18 | 19 | 26 | 24 | 24 | 6  | 2  | 9  | 27 | 37 | 41  | 107 | 26 | 34 | 48 | 32 |
|                                         | ZHITOMIR        | 26 | 15 | 21 | 19 | 20 | 20 | 21 | 19 | 15 | 16 | 24 | 21 | 22 | 4  | 6  | 5  | 24 | 35 | 39  | 104 | 24 | 31 | 45 | 28 |
|                                         | VINNITSA        | 27 | 15 | 21 | 19 | 21 | 21 | 22 | 19 | 16 | 17 | 25 | 21 | 22 | 5  | 5  | 5  | 24 | 35 | 40  | 105 | 24 | 32 | 45 | 29 |
|                                         | KHMELNITSKIY    | 28 | 17 | 23 | 21 | 22 | 22 | 23 | 21 | 17 | 18 | 26 | 23 | 24 | 6  | 3  | 7  | 26 | 36 | 41  | 106 | 25 | 33 | 47 | 30 |
|                                         | CHERNOVYSTY     | 31 | 19 | 25 | 23 | 24 | 24 | 25 | 23 | 20 | 21 | 28 | 25 | 26 | 9  | 2  | 11 | 28 | 39 | 44  | 109 | 28 | 35 | 49 | 35 |
|                                         | CHERNIGOV       | 23 | 13 | 19 | 17 | 18 | 19 | 19 | 17 | 13 | 14 | 21 | 19 | 19 | 1  | 8  | 2  | 23 | 32 | 37  | 101 | 22 | 30 | 43 | 27 |
|                                         | SUNY            | 23 | 12 | 18 | 16 | 17 | 17 | 18 | 15 | 11 | 12 | 21 | 17 | 19 | 4  | 11 | 1  | 20 | 31 | 36  | 101 | 19 | 27 | 41 | 24 |
|                                         | POLTAVA         | 25 | 10 | 16 | 14 | 15 | 18 | 18 | 15 | 11 | 12 | 22 | 17 | 21 | 5  | 11 | 1  | 19 | 33 | 38  | 103 | 18 | 27 | 41 | 23 |
|                                         | CHEKKA          | 26 | 12 | 18 | 16 | 18 | 20 | 21 | 18 | 15 | 16 | 23 | 20 | 21 | 5  | 9  | 2  | 21 | 34 | 39  | 104 | 21 | 29 | 44 | 26 |
|                                         | CHEKKA          | 26 | 12 | 18 | 16 | 18 | 20 | 21 | 18 | 15 | 16 | 23 | 20 | 21 | 5  | 9  | 2  | 21 | 34 | 39  | 104 | 21 | 29 | 44 | 26 |
|                                         | KIROVOGRAD      | 27 | 13 | 19 | 17 | 18 | 21 | 21 | 18 | 15 | 16 | 24 | 20 | 22 | 6  | 8  | 6  | 22 | 38 | 43  | 107 | 24 | 32 | 48 | 26 |
|                                         | ODESSA          | 29 | 10 | 20 | 18 | 18 | 24 | 24 | 21 | 17 | 18 | 27 | 21 | 25 | 8  | 11 | 4  | 19 | 37 | 42  | 105 | 21 | 29 | 45 | 23 |
|                                         | NIKOLAYEV       | 29 | 7  | 16 | 14 | 15 | 22 | 22 | 19 | 16 | 15 | 27 | 21 | 25 | 8  | 11 | 4  | 19 | 37 | 42  | 105 | 21 | 29 | 45 | 23 |
|                                         | KHMERSON        | 29 | 7  | 16 | 14 | 15 | 22 | 22 | 19 | 16 | 15 | 27 | 21 | 25 | 8  | 11 | 4  | 19 | 37 | 42  | 105 | 21 | 29 | 45 | 23 |
|                                         | STAFEROPOL      | 31 | 6  | 14 | 13 | 14 | 22 | 22 | 20 | 15 | 15 | 27 | 21 | 25 | 8  | 11 | 4  | 19 | 37 | 42  | 105 | 21 | 29 | 45 | 23 |
|                                         | DNEPRPETROVSK   | 26 | 8  | 15 | 13 | 14 | 19 | 19 | 16 | 12 | 12 | 24 | 18 | 22 | 7  | 12 | 3  | 18 | 34 | 39  | 102 | 18 | 26 | 42 | 22 |
|                                         | ODNETSK         | 27 | 6  | 11 | 9  | 10 | 17 | 17 | 15 | 11 | 10 | 22 | 17 | 20 | 9  | 15 | 5  | 15 | 33 | 37  | 101 | 15 | 23 | 41 | 20 |
|                                         | VOVNOSHILOVGRAD | 27 | 6  | 11 | 9  | 10 | 17 | 17 | 15 | 11 | 10 | 22 | 17 | 20 | 9  | 15 | 5  | 15 | 33 | 37  | 101 | 15 | 23 | 41 | 20 |
|                                         | GRONDO          | 26 | 21 | 27 | 25 | 26 | 21 | 22 | 21 | 18 | 19 | 25 | 23 | 23 | 6  | 9  | 11 | 30 | 35 | 40  | 105 | 28 | 35 | 48 | 35 |
|                                         | VITEBSK         | 22 | 18 | 24 | 22 | 23 | 16 | 17 | 14 | 13 | 14 | 19 | 16 | 17 | 4  | 12 | 8  | 27 | 30 | 35  | 100 | 23 | 31 | 42 | 30 |
|                                         | MOSTLEV         | 20 | 17 | 23 | 21 | 22 | 16 | 17 | 15 | 12 | 13 | 20 | 17 | 18 | 2  | 9  | 7  | 26 | 30 | 35  | 100 | 22 | 30 | 43 | 29 |
|                                         | GOMEL           | 22 | 17 | 21 | 19 | 20 | 18 | 16 | 12 | 13 | 13 | 20 | 18 | 18 | 2  | 9  | 7  | 26 | 30 | 35  | 100 | 22 | 30 | 43 | 29 |
|                                         | NEST            | 27 | 22 | 26 | 24 | 26 | 21 | 22 | 21 | 18 | 19 | 25 | 21 | 23 | 5  | 5  | 9  | 28 | 31 | 36  | 100 | 22 | 30 | 43 | 29 |
|                                         | UFA             | 25 | 21 | 23 | 21 | 22 | 3  | 5  | 8  | 11 | 12 | 4  | 7  | 10 | 21 | 28 | 20 | 26 | 13 | 18  | 83  | 13 | 19 | 32 | 31 |
|                                         | IZHEVSK         | 13 | 22 | 24 | 22 | 23 | 4  | 5  | 8  | 11 | 12 | 4  | 7  | 10 | 21 | 28 | 20 | 26 | 13 | 18  | 83  | 13 | 19 | 32 | 31 |
|                                         | GREYBURG        | 26 | 19 | 20 | 18 | 18 | 7  | 6  | 4  | 8  | 9  | 14 | 2  | 17 | 20 | 29 | 20 | 27 | 14 | 23  | 85  | 9  | 17 | 24 | 27 |

### DISTANCES TO 1970 OIL SOURCES IN 100 KM

[illegible]

[illegible]

## DISTANCES TO 1975 OIL SOURCES IN 100 KM

|   | K  | S  | G  | D  | T  | A  | H  | K  | V  | O  | R  | E  | U  | D  | R  | E  | U  | R  | W  | E   | S   | S  | A   | S  | E  | U  | F  | T |
|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|-----|----|-----|----|----|----|----|---|
| N | 27 | 9  | 15 | 13 | 14 | 19 | 20 | 17 | 13 | 12 | 19 | 23 | 19 | 23 | 9  | 13 | 6  | 12 | 9  | 18  | 35  | 40 | 103 | 18 | 26 | 43 | 23 |   |
| O | 24 | 10 | 16 | 14 | 15 | 16 | 16 | 13 | 10 | 11 | 21 | 15 | 19 | 25 | 7  | 1  | 9  | 28 | 38 | 44  | 109 | 25 | 35  | 49 | 30 | 24 |    |   |
| D | 29 | 19 | 25 | 23 | 24 | 25 | 26 | 23 | 19 | 19 | 29 | 25 | 27 | 25 | 10 | 6  | 8  | 25 | 39 | 44  | 109 | 25 | 35  | 49 | 30 | 33 |    |   |
| O | 31 | 16 | 22 | 20 | 21 | 25 | 26 | 23 | 19 | 20 | 29 | 25 | 27 | 25 | 10 | 6  | 8  | 25 | 39 | 44  | 109 | 25 | 35  | 49 | 30 | 33 |    |   |
| E | 21 | 23 | 31 | 29 | 31 | 20 | 21 | 21 | 19 | 20 | 21 | 23 | 22 | 22 | 12 | 17 | 16 | 35 | 32 | 37  | 102 | 30 | 38  | 48 | 40 | 30 |    |   |
|   | 23 | 23 | 29 | 27 | 28 | 19 | 20 | 20 | 17 | 18 | 22 | 22 | 21 | 21 | 8  | 13 | 14 | 32 | 33 | 38  | 103 | 28 | 36  | 47 | 37 | 37 |    |   |
|   | 24 | 20 | 26 | 24 | 26 | 20 | 21 | 20 | 17 | 18 | 23 | 22 | 21 | 21 | 5  | 9  | 10 | 29 | 34 | 39  | 103 | 27 | 35  | 47 | 34 | 34 |    |   |
|   | 27 | 23 | 29 | 27 | 29 | 23 | 24 | 23 | 20 | 21 | 26 | 25 | 25 | 25 | 8  | 13 | 13 | 32 | 37 | 42  | 107 | 30 | 38  | 50 | 37 | 37 |    |   |
|   | 20 | 22 | 28 | 26 | 28 | 17 | 18 | 17 | 15 | 16 | 19 | 19 | 19 | 19 | 3  | 14 | 13 | 32 | 30 | 35  | 100 | 27 | 35  | 45 | 37 | 37 |    |   |
|   | 23 | 18 | 24 | 22 | 23 | 17 | 18 | 18 | 15 | 16 | 21 | 20 | 19 | 3  | 9  | 8  | 27 | 32 | 37 | 101 | 25  | 33 | 45  | 32 | 32 | 32 |    |   |
|   | 40 | 11 | 13 | 11 | 9  | 26 | 27 | 24 | 20 | 18 | 30 | 26 | 30 | 23 | 28 | 19 | 5  | 41 | 46 | 110 | 19  | 27 | 28  | 10 | 10 | 10 | 10 |   |
|   | 43 | 14 | 14 | 12 | 10 | 29 | 30 | 27 | 23 | 22 | 34 | 29 | 34 | 27 | 32 | 22 | 7  | 42 | 47 | 113 | 20  | 28 | 30  | 12 | 12 | 12 | 12 |   |
|   | 28 | 18 | 24 | 22 | 23 | 23 | 24 | 21 | 18 | 17 | 26 | 23 | 24 | 24 | 6  | 3  | 8  | 27 | 36 | 41  | 107 | 26 | 34  | 48 | 32 | 32 | 32 |   |
|   | 31 | 20 | 26 | 24 | 25 | 25 | 26 | 24 | 21 | 22 | 29 | 26 | 26 | 26 | 8  | 1  | 9  | 29 | 39 | 44  | 109 | 28 | 36  | 50 | 34 | 34 | 34 |   |
|   | 27 | 17 | 23 | 21 | 22 | 23 | 20 | 17 | 18 | 25 | 22 | 23 | 24 | 24 | 9  | 2  | 10 | 29 | 40 | 45  | 110 | 28 | 36  | 50 | 33 | 33 | 33 |   |
|   | 30 | 20 | 26 | 24 | 25 | 24 | 25 | 24 | 20 | 19 | 26 | 24 | 24 | 24 | 6  | 2  | 9  | 27 | 37 | 41  | 107 | 26 | 34  | 48 | 32 | 32 | 32 |   |
|   | 28 | 18 | 24 | 22 | 23 | 23 | 24 | 21 | 15 | 16 | 24 | 21 | 22 | 22 | 5  | 5  | 5  | 24 | 35 | 39  | 104 | 24 | 31  | 45 | 28 | 28 | 28 |   |
|   | 26 | 15 | 21 | 19 | 20 | 20 | 21 | 19 | 15 | 16 | 24 | 21 | 22 | 22 | 5  | 5  | 5  | 24 | 35 | 40  | 105 | 24 | 32  | 45 | 29 | 29 | 29 |   |
|   | 27 | 15 | 21 | 19 | 21 | 21 | 22 | 19 | 16 | 17 | 25 | 21 | 22 | 22 | 5  | 5  | 5  | 24 | 35 | 40  | 105 | 24 | 32  | 45 | 29 | 29 | 29 |   |
|   | 28 | 17 | 23 | 21 | 22 | 22 | 23 | 21 | 17 | 18 | 26 | 23 | 24 | 24 | 6  | 3  | 7  | 26 | 36 | 41  | 106 | 25 | 33  | 47 | 30 | 30 | 30 |   |
|   | 31 | 19 | 25 | 23 | 24 | 24 | 25 | 23 | 20 | 21 | 28 | 25 | 26 | 26 | 9  | 2  | 11 | 28 | 39 | 44  | 109 | 28 | 35  | 49 | 35 | 35 | 35 |   |
|   | 23 | 13 | 19 | 17 | 18 | 18 | 19 | 13 | 14 | 12 | 21 | 19 | 19 | 19 | 1  | 8  | 2  | 23 | 32 | 37  | 101 | 22 | 30  | 43 | 27 | 27 | 27 |   |
|   | 23 | 12 | 18 | 16 | 17 | 17 | 18 | 15 | 11 | 12 | 21 | 17 | 19 | 19 | 4  | 11 | 1  | 20 | 31 | 36  | 101 | 19 | 27  | 41 | 24 | 24 | 24 |   |
|   | 25 | 10 | 16 | 14 | 15 | 18 | 18 | 15 | 11 | 12 | 22 | 17 | 21 | 21 | 5  | 11 | 1  | 19 | 33 | 38  | 103 | 18 | 26  | 41 | 23 | 23 | 23 |   |
|   | 26 | 12 | 18 | 16 | 18 | 20 | 21 | 18 | 15 | 16 | 24 | 20 | 22 | 22 | 5  | 9  | 2  | 21 | 34 | 39  | 104 | 21 | 29  | 44 | 26 | 26 | 26 |   |
|   | 27 | 13 | 19 | 17 | 18 | 21 | 21 | 18 | 15 | 16 | 24 | 20 | 22 | 22 | 6  | 8  | 3  | 22 | 35 | 40  | 104 | 21 | 29  | 45 | 25 | 25 | 25 |   |
|   | 29 | 10 | 20 | 18 | 18 | 24 | 24 | 21 | 17 | 18 | 27 | 23 | 25 | 25 | 8  | 6  | 6  | 22 | 36 | 43  | 107 | 24 | 32  | 48 | 26 | 26 | 26 |   |
|   | 29 | 7  | 16 | 14 | 15 | 22 | 22 | 19 | 16 | 15 | 27 | 21 | 25 | 25 | 8  | 11 | 4  | 19 | 37 | 42  | 105 | 21 | 29  | 45 | 23 | 23 | 23 |   |
|   | 29 | 7  | 15 | 13 | 14 | 22 | 22 | 19 | 15 | 15 | 27 | 21 | 25 | 25 | 8  | 11 | 4  | 18 | 37 | 42  | 105 | 21 | 29  | 45 | 23 | 23 | 23 |   |
|   | 31 | 6  | 14 | 13 | 13 | 23 | 23 | 20 | 17 | 16 | 27 | 22 | 26 | 26 | 12 | 14 | 7  | 17 | 38 | 43  | 106 | 21 | 29  | 46 | 22 | 22 | 22 |   |
|   | 26 | 8  | 15 | 13 | 14 | 19 | 19 | 16 | 12 | 12 | 24 | 18 | 22 | 22 | 7  | 12 | 3  | 14 | 34 | 39  | 102 | 18 | 26  | 42 | 22 | 22 | 22 |   |
|   | 27 | 6  | 11 | 9  | 10 | 17 | 19 | 15 | 11 | 10 | 22 | 17 | 20 | 20 | 9  | 15 | 5  | 15 | 33 | 37  | 101 | 15 | 23  | 41 | 20 | 20 | 20 |   |
|   | 27 | 8  | 13 | 11 | 11 | 16 | 17 | 14 | 9  | 8  | 20 | 16 | 19 | 19 | 9  | 16 | 6  | 16 | 32 | 37  | 100 | 14 | 22  | 41 | 20 | 20 | 20 |   |
|   | 26 | 21 | 27 | 25 | 26 | 21 | 22 | 21 | 18 | 15 | 25 | 23 | 23 | 23 | 6  | 9  | 11 | 30 | 35 | 40  | 105 | 28 | 36  | 48 | 35 | 35 | 35 |   |
|   | 22 | 18 | 24 | 22 | 23 | 16 | 17 | 14 | 13 | 14 | 19 | 16 | 17 | 17 | 4  | 12 | 8  | 27 | 30 | 35  | 100 | 23 | 31  | 47 | 30 | 30 | 30 |   |
|   | 20 | 17 | 23 | 21 | 22 | 16 | 17 | 15 | 12 | 13 | 20 | 17 | 18 | 2  | 9  | 7  | 26 | 30 | 35 | 102 | 22  | 30 | 43  | 29 | 29 | 29 | 29 |   |
|   | 22 | 17 | 21 | 19 | 20 | 17 | 18 | 16 | 12 | 13 | 20 | 18 | 18 | 18 | 1  | 8  | 5  | 24 | 31 | 36  | 100 | 22 | 30  | 42 | 29 | 29 | 29 |   |
|   | 27 | 22 | 26 | 24 | 26 | 21 | 22 | 21 | 18 | 19 | 25 | 23 | 23 | 23 | 5  | 9  | 9  | 29 | 35 | 40  | 105 | 27 | 35  | 47 | 32 | 32 | 32 |   |
|   | 25 | 21 | 23 | 21 | 22 | 3  | 2  | 5  | 3  | 9  | 7  | 10 | 10 | 10 | 21 | 28 | 20 | 26 | 13 | 18  | 81  | 13 | 19  | 32 | 31 | 31 | 31 |   |
|   | 13 | 22 | 24 | 22 | 23 | 4  | 5  | 8  | 1  | 12 | 4  | 10 | 1  | 1  | 18 | 27 | 21 | 27 | 13 | 18  | 83  | 21 | 29  | 37 | 32 | 32 | 32 |   |
|   | 26 | 19 | 20 | 18 | 18 | 7  | 6  | 4  | 8  | 9  | 14 | 2  | 12 | 12 | 20 | 29 | 20 | 22 | 18 | 23  | 85  | 9  | 17  | 24 | 24 | 24 | 24 |   |

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IVANCFRANKOVSK

TERNOPOL

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VINNYTSA

KHMELNITSKIY

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| DISTANCES TO 1975 OIL SOURCES IN 100 KM |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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APPENDIX C  
DISTANCES TO GAS SOURCES

## DISTANCES TO 1960 GAS SOURCES IN 100 KM

| NODE           | KRASNOBR | STAVROPOL | GRUZY | TATAR | BASHKIR | SARATOV | VOLGOGRD | DASHAVA | FUKPAIN |
|----------------|----------|-----------|-------|-------|---------|---------|----------|---------|---------|
| LENINGRAD      | 18       | 20        | 24    | 28    | 30      | 15      | 17       | 21      | 16      |
| NOVGOROD       | 16       | 14        | 22    | 26    | 23      | 13      | 15       | 19      | 14      |
| MOSCOW         | 11       | 13        | 17    | 21    | 23      | 8       | 10       | 14      | 9       |
| KALININ        | 13       | 15        | 19    | 24    | 26      | 10      | 12       | 16      | 11      |
| KALUGA         | 12       | 14        | 18    | 23    | 25      | 10      | 12       | 13      | 8       |
| RYAZAN         | 12       | 14        | 18    | 19    | 21      | 6       | 8        | 16      | 11      |
| TULA           | 9        | 11        | 15    | 22    | 24      | 9       | 11       | 15      | 7       |
| KAZAN          | 29       | 31        | 35    | 3     | 5       | 10      | 12       | 32      | 25      |
| GORKY          | 27       | 27        | 31    | 6     | 8       | 7       | 9        | 29      | 22      |
| SARANSK        | 22       | 24        | 28    | 7     | 11      | 4       | 6        | 26      | 19      |
| CHELOKSA       | 27       | 29        | 33    | 4     | 6       | 9       | 11       | 30      | 24      |
| BELGOROD       | 9        | 11        | 16    | 29    | 31      | 16      | 18       | 15      | 4       |
| VORONEZH       | 6        | 8         | 13    | 25    | 27      | 12      | 14       | 18      | 4       |
| KURSK          | 11       | 13        | 17    | 28    | 30      | 15      | 17       | 14      | 5       |
| OPEL           | 13       | 15        | 19    | 26    | 28      | 14      | 17       | 12      | 6       |
| ORYANSK        | 14       | 16        | 20    | 25    | 27      | 12      | 14       | 11      | 6       |
| PENZA          | 21       | 23        | 27    | 10    | 12      | 2       | 4        | 25      | 18      |
| VOLGOGRAD      | 22       | 24        | 28    | 16    | 18      | 4       | 2        | 26      | 19      |
| SARATOV        | 18       | 20        | 24    | 13    | 15      | 1       | 2        | 22      | 15      |
| ROSTOV         | 1        | 3         | 8     | 29    | 31      | 16      | 18       | 24      | 8       |
| KRASNOVAR      | 1        | 5         | 10    | 31    | 33      | 19      | 21       | 25      | 11      |
| STAVROPOL      | 4        | 1         | 4     | 32    | 34      | 20      | 22       | 27      | 13      |
| ORDZHONIKIDZE  | 9        | 4         | 2     | 36    | 38      | 24      | 26       | 27      | 13      |
| GRUZY          | 9        | 4         | 1     | 36    | 38      | 24      | 26       | 27      | 13      |
| KIEV           | 19       | 21        | 25    | 36    | 38      | 17      | 19       | 6       | 12      |
| KHARKOV        | 8        | 10        | 14    | 29    | 30      | 15      | 16       | 16      | 1       |
| LYOV           | 24       | 26        | 30    | 36    | 38      | 23      | 25       | 1       | 18      |
| TALLIN         | 21       | 23        | 27    | 31    | 33      | 18      | 20       | 24      | 19      |
| MINSK          | 31       | 33        | 37    | 43    | 45      | 30      | 32       | 7       | 25      |
| TERNOPOL       | 22       | 24        | 28    | 33    | 35      | 20      | 22       | 2       | 15      |
| ZHITOMIR       | 21       | 23        | 27    | 32    | 34      | 19      | 21       | 5       | 13      |
| VINNITSA       | 22       | 24        | 28    | 33    | 35      | 20      | 22       | 5       | 14      |
| CHERNOBYL      | 10       | 12        | 16    | 29    | 31      | 17      | 18       | 14      | 2       |
| VOROSHILOVGRAD | 3        | 4         | 9     | 28    | 30      | 15      | 17       | 21      | 6       |
| OREST          | 28       | 30        | 34    | 40    | 42      | 27      | 29       | 4       | 22      |
| UFA            | 32       | 34        | 38    | 3     | 3       | 16      | 18       | 34      | 33      |



|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |    |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|----|----|
| N | O | D | E | K | S | G | T | A | R | K | J | C | V | E | P | B | D | U | G | B | Z | L | A | C | H | I | A | G | A | K  | 31 |
|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |    |
| O | O | M | I | A | V | O | O | Z | S | H | D | P | O | R | F | K | S | K | R | A | A | Z | L | A | C | H | I | A | G | A  | 47 |
|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |    |
| D | D | H | I | R | P | Y | Y | F | I | K | H | D | G | R | R | U | H | R | R | A | Z | L | A | C | H | I | A | G | A | 48 |    |
|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    | 41 |
| E | E | M | I | R | P | Y | Y | F | I | K | H | D | G | R | R | U | H | R | R | A | Z | L | A | C | H | I | A | G | A | 46 |    |
|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    | 39 |
| S | S | M | I | R | P | Y | Y | F | I | K | H | D | G | R | R | U | H | R | R | A | Z | L | A | C | H | I | A | G | A | 42 |    |
|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    | 34 |
| M | M | I | R | P | Y | Y | F | I | K | H | D | P | O | R | F | K | S | K | R | A | Z | L | A | C | H | I | A | G | A | 41 |    |
|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    | 34 |
| I | I | M | I | R | P | Y | Y | F | I | K | H | D | G | R | R | U | H | R | R | A | Z | L | A | C | H | I | A | G | A | 41 |    |
|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    | 34 |
| S | S | M | I | R | P | Y | Y | F | I | K | H | D | G | R | R | U | H | R | R | A | Z | L | A | C | H | I | A | G | A | 32 |    |
|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    | 32 |
| M | M | I | R | P | Y | Y | F | I | K | H | D | P | O | R | F | K | S | K | R | A | Z | L | A | C | H | I | A | G | A | 31 |    |
|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    | 32 |
| I | I | M | I | R | P | Y | Y | F | I | K | H | D | G | R | R | U | H | R | R | A | Z | L | A | C | H | I | A | G | A | 31 |    |
|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    | 32 |
| S | S | M | I | R | P | Y | Y | F | I | K | H | D | G | R | R | U | H | R | R | A | Z | L | A | C | H | I | A | G | A | 31 |    |
|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    | 32 |
| M | M | I | R | P | Y | Y | F | I | K | H | D | P | O | R | F | K | S | K | R | A | Z | L | A | C | H | I | A | G | A | 31 |    |
|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    | 32 |
| I | I | M |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |    |

[illegible]

## DISTANCES TO 1975 GAS SOURCES IN 100 KM

|  | K  | R  | A  | S  | G  | T  | B  | K  | V  | S  | O  | D  | E  | P  | B  | G  | A  | N  | U  | K  | M  | O  | R |
|--|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|
|  | A  | A  | V  | A  | R  | A  | A  | U  | S  | A  | L  | A  | U  | U  | A  | A  | C  | A  | A  | U  | U  | A  | E |
|  | N  | N  | R  | R  | R  | T  | S  | Y  | R  | R  | G  | H  | K  | K  | H  | Z  | H  | D  | Z  | M  | A  | B  | N |
|  | O  | O  | P  | P  | O  | A  | H  | B  | A  | A  | O  | S  | R  | R  | K  | A  | A  | A  | E  | A  | A  | R  | B |
|  | M  | M  | L  | L  | Y  | R  | K  | Y  | V  | V  | U  | V  | A  | A  | U  | A  | I  | M  | A  | G  | A  | Y  | G |
|  | I  | I  | R  | R  | R  | R  | R  | R  | R  | R  | R  | R  | R  | R  | R  | R  | R  | R  | R  | R  | R  | R  | R |
|  | 18 | 13 | 15 | 19 | 16 | 16 | 18 | 17 | 13 | 15 | 15 | 10 | 8  | 28 | 32 | 33 | 30 | 34 | 26 | 31 | 35 | 21 |   |
|  | 21 | 16 | 18 | 22 | 19 | 21 | 21 | 21 | 16 | 18 | 24 | 29 | 10 | 31 | 35 | 36 | 33 | 34 | 29 | 34 | 38 | 24 |   |
|  | 36 | 11 | 6  | 3  | 31 | 31 | 31 | 24 | 20 | 22 | 36 | 5  | 23 | 45 | 41 | 39 | 36 | 41 | 32 | 37 | 41 | 28 |   |
|  | 41 | 15 | 11 | 8  | 36 | 37 | 37 | 29 | 25 | 27 | 41 | 1  | 28 | 50 | 46 | 44 | 41 | 56 | 37 | 42 | 45 | 33 |   |
|  | 39 | 14 | 9  | 6  | 34 | 36 | 36 | 30 | 26 | 28 | 39 | 6  | 26 | 48 | 47 | 45 | 42 | 54 | 38 | 43 | 47 | 34 |   |
|  | 27 | 18 | 20 | 24 | 25 | 27 | 25 | 25 | 21 | 23 | 30 | 31 | 3  | 13 | 37 | 42 | 40 | 43 | 33 | 38 | 42 | 29 |   |
|  | 31 | 18 | 20 | 24 | 29 | 31 | 25 | 24 | 20 | 23 | 34 | 31 | 3  | 13 | 39 | 42 | 40 | 49 | 33 | 38 | 42 | 29 |   |
|  | 31 | 17 | 19 | 23 | 28 | 30 | 24 | 24 | 20 | 22 | 33 | 30 | 1  | 12 | 42 | 41 | 39 | 48 | 32 | 37 | 41 | 28 |   |
|  | 31 | 16 | 18 | 22 | 27 | 29 | 23 | 19 | 15 | 18 | 30 | 27 | 1  | 12 | 41 | 39 | 35 | 47 | 31 | 36 | 40 | 27 |   |
|  | 31 | 16 | 18 | 20 | 25 | 27 | 20 | 15 | 17 | 18 | 30 | 27 | 2  | 9  | 37 | 35 | 32 | 45 | 28 | 33 | 37 | 24 |   |
|  | 30 | 14 | 16 | 20 | 25 | 27 | 20 | 15 | 17 | 18 | 28 | 25 | 5  | 6  | 37 | 36 | 31 | 43 | 27 | 32 | 36 | 23 |   |
|  | 28 | 12 | 14 | 18 | 23 | 25 | 19 | 15 | 17 | 18 | 28 | 25 | 5  | 7  | 38 | 37 | 35 | 44 | 28 | 33 | 37 | 24 |   |
|  | 29 | 13 | 15 | 19 | 24 | 26 | 20 | 20 | 16 | 18 | 29 | 26 | 5  | 7  | 38 | 37 | 35 | 44 | 28 | 33 | 37 | 24 |   |
|  | 29 | 13 | 15 | 19 | 24 | 26 | 20 | 20 | 16 | 18 | 29 | 26 | 5  | 7  | 38 | 37 | 35 | 44 | 28 | 33 | 37 | 24 |   |
|  | 32 | 17 | 19 | 23 | 28 | 30 | 24 | 24 | 20 | 22 | 33 | 30 | 3  | 8  | 38 | 37 | 35 | 44 | 28 | 33 | 37 | 24 |   |
|  | 32 | 17 | 19 | 23 | 28 | 30 | 24 | 24 | 20 | 22 | 33 | 30 | 3  | 8  | 38 | 37 | 35 | 44 | 28 | 33 | 37 | 24 |   |
|  | 12 | 14 | 18 | 19 | 21 | 19 | 15 | 17 | 15 | 17 | 24 | 25 | 8  | 6  | 33 | 35 | 32 | 39 | 28 | 33 | 37 | 23 |   |
|  | 24 | 12 | 14 | 18 | 19 | 21 | 19 | 15 | 17 | 15 | 24 | 25 | 8  | 6  | 33 | 35 | 32 | 39 | 28 | 33 | 37 | 23 |   |
|  | 30 | 8  | 10 | 14 | 23 | 23 | 15 | 11 | 13 | 12 | 28 | 21 | 10 | 3  | 37 | 32 | 30 | 43 | 23 | 28 | 32 | 19 |   |
|  | 29 | 7  | 9  | 13 | 22 | 22 | 14 | 10 | 12 | 12 | 27 | 20 | 9  | 1  | 36 | 31 | 29 | 42 | 22 | 27 | 31 | 18 |   |
|  | 29 | 7  | 9  | 13 | 22 | 22 | 14 | 10 | 12 | 12 | 27 | 20 | 9  | 1  | 36 | 31 | 29 | 42 | 22 | 27 | 31 | 18 |   |
|  | 32 | 10 | 12 | 16 | 25 | 25 | 17 | 13 | 15 | 15 | 30 | 23 | 8  | 4  | 40 | 35 | 32 | 45 | 25 | 30 | 34 | 21 |   |
|  | 33 | 11 | 13 | 17 | 26 | 26 | 18 | 14 | 16 | 16 | 31 | 24 | 16 | 6  | 40 | 35 | 32 | 45 | 25 | 30 | 34 | 21 |   |
|  | 32 | 10 | 12 | 16 | 25 | 25 | 17 | 13 | 15 | 15 | 30 | 23 | 15 | 5  | 39 | 34 | 32 | 45 | 25 | 30 | 34 | 21 |   |
|  | 32 | 10 | 12 | 16 | 25 | 25 | 17 | 13 | 15 | 15 | 30 | 23 | 15 | 5  | 39 | 34 | 32 | 45 | 25 | 30 | 34 | 21 |   |
|  | 29 | 7  | 9  | 13 | 22 | 22 | 14 | 10 | 12 | 12 | 27 | 20 | 15 | 2  | 36 | 31 | 29 | 42 | 22 | 27 | 31 | 18 |   |
|  | 29 | 7  | 9  | 13 | 22 | 22 | 14 | 10 | 12 | 12 | 27 | 20 | 15 | 2  | 36 | 31 | 29 | 42 | 22 | 27 | 31 | 18 |   |
|  | 29 | 4  | 5  | 9  | 21 | 21 | 13 | 13 | 9  | 11 | 26 | 16 | 13 | 2  | 35 | 30 | 28 | 44 | 21 | 26 | 30 | 17 |   |
|  | 26 | 3  | 4  | 9  | 21 | 21 | 13 | 13 | 9  | 11 | 26 | 16 | 13 | 2  | 35 | 30 | 28 | 44 | 21 | 26 | 30 | 17 |   |
|  | 25 | 20 | 22 | 26 | 23 | 25 | 24 | 24 | 20 | 22 | 28 | 33 | 7  | 15 | 35 | 39 | 40 | 41 | 33 | 38 | 42 | 28 |   |
|  | 25 | 20 | 22 | 26 | 23 | 25 | 24 | 24 | 20 | 22 | 28 | 33 | 7  | 15 | 35 | 39 | 40 | 41 | 33 | 38 | 42 | 28 |   |
|  | 20 | 15 | 17 | 21 | 18 | 20 | 19 | 19 | 15 | 17 | 23 | 28 | 10 | 10 | 32 | 34 | 35 | 40 | 28 | 33 | 37 | 23 |   |
|  | 20 | 15 | 17 | 21 | 18 | 20 | 19 | 19 | 15 | 17 | 23 | 28 | 10 | 10 | 32 | 34 | 35 | 40 | 28 | 33 | 37 | 23 |   |
|  | 25 | 13 | 15 | 19 | 20 | 22 | 20 | 20 | 16 | 18 | 25 | 26 | 10 | 8  | 34 | 36 | 36 | 40 | 29 | 34 | 38 | 24 |   |
|  | 24 | 20 | 22 | 26 | 23 | 25 | 25 | 24 | 20 | 22 | 28 | 32 | 4  | 14 | 34 | 36 | 36 | 40 | 33 | 38 | 42 | 28 |   |
|  | 24 | 20 | 22 | 26 | 23 | 25 | 25 | 24 | 20 | 22 | 28 | 32 | 4  | 14 | 34 | 36 | 36 | 40 | 33 | 38 | 42 | 28 |   |
|  | 26 | 24 | 26 | 30 | 3  | 3  | 3  | 8  | 12 | 14 | 8  | 37 | 29 | 21 | 17 | 13 | 22 | 19 | 23 | 21 | 26 | 4  |   |
|  | 26 | 24 | 26 | 30 | 3  | 3  | 3  | 8  | 12 | 14 | 8  | 37 | 29 | 21 | 17 | 13 | 22 | 19 | 23 | 21 | 26 | 4  |   |
|  | 31 | 19 | 21 | 25 | 5  | 4  | 4  | 12 | 16 | 18 | 2  | 39 | 28 | 24 | 12 | 19 | 28 | 25 | 18 | 25 | 30 | 7  |   |
|  | 31 | 19 | 21 | 25 | 5  | 4  | 4  | 12 | 16 | 18 | 2  | 39 | 28 | 24 | 12 | 19 | 28 | 25 | 18 | 25 | 30 | 7  |   |
|  | 28 | 28 | 30 | 34 | 5  | 7  | 14 | 14 | 18 | 20 | 1  | 41 | 31 | 27 | 9  | 18 | 28 | 25 | 15 | 29 | 34 | 10 |   |
|  | 28 | 28 | 30 | 34 | 5  | 7  | 14 | 14 | 18 | 20 | 1  | 41 | 31 | 27 | 9  | 18 | 28 | 25 | 15 | 29 | 34 | 10 |   |
|  | 34 | 30 | 32 | 36 | 11 | 10 | 10 | 14 | 18 | 20 | 6  | 43 | 36 | 27 | 11 | 13 | 22 | 19 | 15 | 29 | 34 | 10 |   |
|  | 34 | 30 | 32 | 36 | 11 | 10 | 10 | 14 | 18 | 20 | 6  | 43 | 36 | 27 | 11 | 13 | 22 | 19 | 15 | 29 | 34 | 10 |   |
|  | 33 | 28 | 30 | 34 | 10 | 8  | 12 | 12 | 16 | 18 | 8  | 41 | 34 | 25 | 11 | 11 | 20 | 17 | 17 | 27 | 32 | 8  |   |
|  | 33 | 28 | 30 | 34 | 10 | 8  | 12 | 12 | 16 | 18 | 8  | 41 | 34 | 25 | 11 | 11 | 20 | 17 | 17 | 27 | 32 | 8  |   |
|  | 31 | 19 | 21 | 25 | 12 | 10 | 14 | 18 | 20 | 15 | 43 | 36 | 26 | 18 | 7  | 15 | 12 | 24 | 22 | 27 | 17 | 10 |   |
|  | 35 | 30 | 32 | 36 | 12 | 10 | 14 | 18 | 20 | 15 | 43 | 36 | 26 | 18 | 7  | 15 | 12 | 24 | 22 | 27 | 17 | 10 |   |
|  | 32 | 28 | 30 | 34 | 10 | 7  | 12 | 16 | 18 | 13 | 41 | 34 | 24 | 16 | 11 | 20 | 17 | 22 | 27 | 32 | 22 | 8  |   |
|  | 32 | 28 | 30 | 34 | 10 | 7  | 12 | 16 | 18 | 13 | 41 | 34 | 24 | 16 | 11 | 20 | 17 | 22 | 27 | 32 | 22 | 8  |   |
|  | 53 | 40 | 42 | 46 | 34 | 37 | 31 | 31 | 29 | 31 | 37 | 54 | 46 | 38 | 18 | 9  | 12 | 46 | 22 | 27 | 17 | 32 |   |
|  | 53 | 40 | 42 | 46 | 34 | 37 | 31 | 31 | 29 | 31 | 37 | 54 | 46 | 38 | 18 | 9  | 12 | 46 | 22 | 27 | 17 | 32 |   |
|  | 55 | 42 | 44 | 49 | 36 | 35 | 33 | 33 | 31 | 33 | 39 | 56 | 48 | 40 | 42 | 20 | 13 | 48 | 23 | 28 | 17 | 33 |   |
|  | 55 | 42 | 44 | 49 | 36 | 35 | 33 | 33 | 31 | 33 | 39 | 56 | 48 | 40 | 42 | 20 | 13 | 48 | 23 | 28 | 17 | 33 |   |
|  | 59 | 46 | 48 | 52 | 40 | 38 | 37 | 35 | 37 | 34 | 34 | 51 | 43 | 35 | 37 | 15 | 12 | 52 | 26 | 31 | 21 | 36 |   |
|  | 59 | 46 | 48 | 52 | 40 | 38 | 37 | 35 | 37 | 34 | 34 | 51 | 43 | 35 | 37 | 15 | 12 | 52 | 26 | 31 | 21 | 36 |   |
|  | 50 | 37 | 39 | 43 | 31 | 29 | 28 | 26 | 28 | 26 | 28 | 51 | 43 | 35 | 37 | 15 | 12 | 52 | 26 | 31 | 21 | 36 |   |
|  | 50 | 37 | 39 | 43 | 31 | 29 | 28 | 26 | 28 | 26 | 28 | 51 | 43 | 35 | 37 | 15 | 12 | 52 | 26 | 31 | 21 | 36 |   |
|  | 51 | 38 | 40 | 44 | 32 | 30 | 29 | 29 | 27 | 29 | 35 | 52 | 44 | 36 | 38 | 16 | 7  | 10 | 19 | 25 | 15 | 30 |   |



APPENDIX D

COAL, OIL, AND NATURAL GAS POTENTIAL INDICES BASED ON  
DISTANCE AND TRANSPORT COSTS

## COAL, OIL, AND GAS POTENTIAL INDICES BASED ON DISTANCE

| MODE         | CP60 | OP60 | GP60 | CP70 | OP70 | GP70 | CP75 | OP75 | GP75 |
|--------------|------|------|------|------|------|------|------|------|------|
| LENINGRAD    | 17   | 11   | 2    | 18   | 25   | 11   | 19   | 32   | 14   |
| MURMANSK     | 11   | 7    | 0    | 12   | 17   | 0    | 13   | 22   | 0    |
| PETROZAVODSK | 15   | 10   | 0    | 16   | 23   | 0    | 17   | 29   | 0    |
| NOVGOROD     | 19   | 11   | 3    | 19   | 27   | 12   | 20   | 33   | 16   |
| VOLOGDA      | 20   | 14   | 0    | 21   | 33   | 12   | 22   | 41   | 17   |
| ARKHANGELSK  | 14   | 10   | 0    | 16   | 23   | 0    | 17   | 29   | 0    |
| SYKTYVKAR    | 15   | 10   | 0    | 17   | 26   | 9    | 19   | 35   | 15   |
| MOSCOW       | 30   | 17   | 4    | 31   | 38   | 17   | 31   | 47   | 21   |
| YAROSLAVL    | 22   | 16   | 0    | 23   | 37   | 13   | 24   | 46   | 18   |
| VLADIMIR     | 23   | 20   | 0    | 25   | 44   | 15   | 26   | 52   | 19   |
| IVANOVO      | 21   | 18   | 0    | 23   | 41   | 14   | 23   | 49   | 19   |
| KALININ      | 23   | 15   | 3    | 24   | 34   | 14   | 25   | 41   | 19   |
| KALUGA       | 38   | 15   | 4    | 37   | 35   | 17   | 37   | 43   | 21   |
| KOSTROMA     | 21   | 16   | 0    | 22   | 37   | 13   | 23   | 46   | 18   |
| RYAZAN       | 28   | 18   | 4    | 30   | 40   | 15   | 31   | 48   | 20   |
| TULA         | 41   | 16   | 4    | 40   | 37   | 19   | 40   | 44   | 23   |
| KAZAN        | 20   | 53   | 3    | 22   | 113  | 13   | 23   | 126  | 19   |
| GORKIY       | 21   | 24   | 3    | 22   | 53   | 14   | 23   | 63   | 19   |
| KIROV        | 19   | 17   | 0    | 21   | 41   | 0    | 22   | 53   | 0    |
| YOSHKAR_OLA  | 19   | 33   | 0    | 21   | 71   | 12   | 22   | 83   | 18   |
| SARANSK      | 23   | 26   | 3    | 25   | 54   | 12   | 26   | 64   | 19   |
| CHEBOKSARY   | 21   | 34   | 3    | 23   | 72   | 13   | 24   | 83   | 19   |
| ULYANOVSK    | 21   | 47   | 0    | 23   | 96   | 0    | 25   | 108  | 0    |
| BELGOROD     | 46   | 13   | 8    | 50   | 37   | 40   | 51   | 43   | 50   |
| VORONEZH     | 36   | 16   | 6    | 39   | 38   | 27   | 40   | 45   | 33   |
| KURSK        | 37   | 14   | 5    | 40   | 36   | 25   | 41   | 43   | 30   |
| OREL         | 34   | 14   | 4    | 36   | 35   | 21   | 36   | 42   | 26   |
| BRYANSK      | 31   | 14   | 4    | 33   | 34   | 19   | 34   | 42   | 24   |
| LIPETSK      | 35   | 17   | 0    | 37   | 39   | 20   | 37   | 46   | 25   |
| TAMBOV       | 31   | 20   | 0    | 33   | 44   | 14   | 33   | 52   | 18   |
| PENZA        | 25   | 28   | 4    | 27   | 58   | 14   | 28   | 67   | 21   |
| ASTRAKHAN    | 21   | 19   | 0    | 25   | 43   | 1    | 26   | 49   | 1    |
| VOLGOGRAD    | 36   | 22   | 4    | 39   | 46   | 13   | 40   | 53   | 21   |
| KUYBYSHEV    | 22   | 72   | 1    | 24   | 139  | 14   | 26   | 154  | 26   |
| SARATOV      | 25   | 37   | 7    | 27   | 69   | 18   | 28   | 79   | 26   |
| ROSTOV       | 98   | 16   | 12   | 104  | 36   | 55   | 105  | 40   | 42   |
| KRASNOGAR    | 33   | 23   | 10   | 35   | 39   | 46   | 37   | 44   | 32   |
| STAVROPOL    | 33   | 16   | 13   | 36   | 34   | 40   | 37   | 38   | 36   |
| MAKHACHKALA  | 20   | 20   | 0    | 22   | 51   | 2    | 23   | 49   | 1    |
| DALCHIK      | 24   | 18   | 0    | 26   | 45   | 21   | 27   | 44   | 22   |
| GROZHNKIDZE  | 24   | 20   | 5    | 26   | 60   | 22   | 27   | 51   | 24   |
| GROZNY       | 22   | 22   | 5    | 24   | 65   | 22   | 25   | 56   | 23   |
| KIEV         | 30   | 11   | 3    | 33   | 34   | 25   | 34   | 41   | 30   |
| ZAPOROZHYE   | 55   | 12   | 0    | 60   | 30   | 29   | 61   | 35   | 36   |
| KHARKOV      | 56   | 14   | 14   | 62   | 37   | 70   | 62   | 44   | 87   |
| LVOV         | 21   | 12   | 8    | 29   | 25   | 25   | 31   | 29   | 23   |
| KISHINEV     | 21   | 9    | 0    | 23   | 22   | 14   | 24   | 26   | 18   |
| TALLIN       | 15   | 9    | 2    | 17   | 22   | 9    | 17   | 28   | 13   |
| RIGA         | 16   | 10   | 0    | 18   | 23   | 8    | 19   | 29   | 12   |
| VILNIUS      | 18   | 10   | 0    | 20   | 24   | 10   | 21   | 30   | 14   |
| KALININGRAD  | 15   | 9    | 0    | 17   | 20   | 0    | 18   | 26   | 0    |
| SMOLENSK     | 24   | 13   | 0    | 26   | 31   | 16   | 27   | 39   | 20   |
| PSKOV        | 17   | 11   | 0    | 19   | 25   | 0    | 20   | 32   | 0    |
| MINSK        | 21   | 11   | 2    | 23   | 28   | 10   | 24   | 35   | 17   |
| TBILISI      | 17   | 14   | 1    | 19   | 27   | 16   | 20   | 31   | 19   |
| BAKU         | 16   | 36   | 7    | 18   | 58   | 16   | 19   | 58   | 24   |

## COAL, OIL, AND GAS POTENTIAL INDICES BASED ON DISTANCE

| MODE              | CP60 | OP60 | GP60 | CP70 | OP70 | GP70 | CP75 | OP75 | GP75 |
|-------------------|------|------|------|------|------|------|------|------|------|
| YEREVAN           | 14   | 11   | 1    | 15   | 23   | 12   | 16   | 27   | 15   |
| LUTSK             | 21   | 10   | 0    | 26   | 24   | 15   | 27   | 29   | 16   |
| ROVNO             | 22   | 10   | 0    | 27   | 25   | 15   | 29   | 31   | 16   |
| JZHGOROD          | 18   | 10   | 0    | 21   | 22   | 25   | 22   | 26   | 22   |
| IVANO_FRANKOVSK   | 19   | 11   | 0    | 23   | 25   | 25   | 25   | 29   | 22   |
| TERNOPOL          | 21   | 10   | 5    | 26   | 24   | 20   | 27   | 29   | 21   |
| ZHITOMIR          | 25   | 11   | 3    | 28   | 27   | 20   | 29   | 33   | 23   |
| VINNITSA          | 23   | 10   | 3    | 26   | 26   | 18   | 29   | 32   | 21   |
| KHMELVITSKIY      | 22   | 10   | 0    | 25   | 25   | 19   | 27   | 30   | 21   |
| CHERNOVSTY        | 19   | 10   | 0    | 22   | 22   | 15   | 23   | 27   | 17   |
| CHERNIGOV         | 28   | 12   | 0    | 30   | 38   | 19   | 31   | 49   | 23   |
| SUMY              | 34   | 13   | 0    | 37   | 44   | 30   | 38   | 50   | 36   |
| POLTAVA           | 46   | 13   | 0    | 50   | 43   | 69   | 51   | 49   | 86   |
| CHEPKASSY         | 40   | 11   | 0    | 43   | 32   | 24   | 44   | 38   | 29   |
| KIPOVOGRAD        | 32   | 11   | 0    | 34   | 29   | 0    | 35   | 35   | 0    |
| ODESSA            | 24   | 10   | 0    | 27   | 24   | 18   | 28   | 29   | 22   |
| NIKOLAYEV         | 32   | 11   | 0    | 35   | 28   | 20   | 36   | 33   | 25   |
| CHERSON           | 32   | 11   | 0    | 35   | 28   | 20   | 36   | 33   | 25   |
| SIMFEROPOL        | 31   | 11   | 0    | 34   | 26   | 0    | 35   | 30   | 0    |
| CHERPOPETROVSK    | 56   | 12   | 8    | 61   | 32   | 40   | 62   | 37   | 49   |
| CHORTITSK         | 150  | 14   | 0    | 163  | 33   | 45   | 154  | 39   | 51   |
| VOROSHILOVGRAD    | 163  | 14   | 7    | 175  | 33   | 49   | 176  | 39   | 54   |
| GRONNO            | 17   | 9    | 0    | 19   | 23   | 10   | 20   | 28   | 14   |
| VITBSK            | 22   | 12   | 0    | 24   | 29   | 0    | 24   | 37   | 18   |
| MOGILEV           | 24   | 12   | 0    | 26   | 31   | 0    | 27   | 40   | 18   |
| GOMEL             | 26   | 12   | 0    | 28   | 34   | 16   | 29   | 45   | 19   |
| BREST             | 19   | 10   | 3    | 23   | 24   | 13   | 24   | 30   | 15   |
| UFA               | 20   | 51   | 2    | 22   | 102  | 11   | 24   | 116  | 22   |
| IZHEVSK           | 20   | 32   | 0    | 21   | 72   | 12   | 22   | 89   | 20   |
| ORENBURG          | 18   | 29   | 1    | 21   | 61   | 2    | 22   | 74   | 40   |
| PERM              | 24   | 35   | 0    | 24   | 89   | 11   | 25   | 112  | 17   |
| SVERDLOVSK        | 23   | 18   | 0    | 24   | 45   | 9    | 26   | 64   | 16   |
| CHELJABINSK       | 29   | 21   | 0    | 30   | 49   | 9    | 32   | 64   | 18   |
| TYUMEN            | 19   | 14   | 0    | 22   | 37   | 0    | 24   | 58   | 0    |
| KURGAN            | 22   | 17   | 0    | 25   | 40   | 0    | 27   | 59   | 0    |
| OMSK              | 21   | 12   | 0    | 25   | 28   | 0    | 29   | 44   | 0    |
| NOVOSIBIRSK       | 34   | 8    | 0    | 43   | 20   | 0    | 51   | 40   | 0    |
| TOMSK             | 33   | 7    | 0    | 42   | 18   | 0    | 49   | 47   | 0    |
| BARNAUL           | 25   | 8    | 0    | 31   | 18   | 0    | 37   | 33   | 0    |
| KRASNOYARSK       | 24   | 6    | 0    | 32   | 15   | 0    | 40   | 31   | 0    |
| IRKUTSK           | 23   | 5    | 0    | 26   | 11   | 0    | 26   | 20   | 0    |
| CHITA             | 12   | 4    | 0    | 14   | 9    | 0    | 17   | 15   | 0    |
| ABAKAN            | 22   | 6    | 0    | 28   | 15   | 0    | 32   | 27   | 0    |
| KEMEROVO          | 79   | 7    | 0    | 100  | 18   | 0    | 119  | 38   | 0    |
| ULAN_UBE          | 12   | 4    | 0    | 14   | 10   | 0    | 16   | 17   | 0    |
| VLADIVOSTOK       | 10   | 3    | 0    | 13   | 6    | 0    | 14   | 9    | 0    |
| KHABAROVSK        | 7    | 3    | 0    | 8    | 7    | 0    | 9    | 10   | 0    |
| BLAGOVESHCHENSK   | 8    | 3    | 0    | 9    | 7    | 0    | 10   | 11   | 0    |
| YUZHNO_SAKHALINSK | 7    | 2    | 0    | 8    | 6    | 0    | 9    | 9    | 0    |
| MAGADAN           | 5    | 3    | 0    | 6    | 6    | 0    | 7    | 9    | 0    |
| YAKUTSK           | 7    | 3    | 0    | 8    | 7    | 0    | 9    | 10   | 0    |
| PETROPAVLOVSK_KAM | 5    | 2    | 0    | 6    | 6    | 0    | 6    | 8    | 0    |
| GUR'YEV           | 14   | 14   | 0    | 22   | 39   | 11   | 23   | 48   | 20   |
| AKTYUBINSK        | 18   | 19   | 0    | 20   | 44   | 9    | 22   | 55   | 18   |
| URALSK            | 20   | 22   | 0    | 22   | 46   | 0    | 23   | 56   | 0    |
| KUSTANAY          | 23   | 17   | 0    | 25   | 38   | 9    | 27   | 51   | 17   |

## COAL, OIL, AND GAS POTENTIAL INDICES BASED ON DISTANCE

| NODE            | CP60 | OP60 | GP60 | CP70 | OP70 | GP70 | CP75 | GP75 | GP75 |
|-----------------|------|------|------|------|------|------|------|------|------|
| PETROPAVLOVSK   | 21   | 14   | 0    | 25   | 33   | 0    | 29   | 47   | 0    |
| KOKCHETAV       | 23   | 12   | 0    | 25   | 29   | 0    | 29   | 42   | 0    |
| TSELINOGRAD     | 24   | 11   | 0    | 32   | 25   | 0    | 39   | 36   | 0    |
| KAPAGANDA       | 37   | 10   | 0    | 49   | 23   | 0    | 58   | 32   | 0    |
| KZYL_ORDA       | 13   | 11   | 0    | 15   | 24   | 0    | 17   | 31   | 0    |
| CHIMKENT        | 14   | 9    | 0    | 16   | 20   | 9    | 18   | 27   | 15   |
| QZHAMBUL        | 13   | 8    | 0    | 16   | 19   | 8    | 19   | 25   | 14   |
| SEMIPALATINSK   | 17   | 7    | 0    | 21   | 16   | 0    | 25   | 25   | 0    |
| PAVLODAR        | 24   | 8    | 0    | 38   | 20   | 0    | 54   | 32   | 0    |
| UST_KAMENOGORSK | 17   | 7    | 0    | 21   | 16   | 0    | 25   | 24   | 0    |
| ALMA_ATA        | 13   | 7    | 0    | 16   | 16   | 7    | 18   | 22   | 12   |
| ASHKHBAD        | 12   | 11   | 0    | 14   | 24   | 0    | 15   | 29   | 19   |
| QUSHANBE        | 9    | 7    | 0    | 11   | 15   | 1    | 12   | 19   | 18   |
| TASHKENT        | 14   | 9    | 0    | 17   | 20   | 10   | 19   | 26   | 16   |
| FRUNZE          | 12   | 8    | 0    | 15   | 17   | 8    | 17   | 24   | 13   |
| NORILSK         | 2    | 0    | 0    | 2    | 0    | 0    | 2    | 0    | 1    |
| ELISTA          | 24   | 13   | 0    | 26   | 28   | 0    | 27   | 32   | 0    |

## COAL, OIL, AND GAS POTENTIAL INDICES BASED ON TRANSPORT COSTS

| NOOE          | CP60 | OP60 | GP60 | CP70 | OP70 | GP70 | CP75 | OP75 | GP75 |
|---------------|------|------|------|------|------|------|------|------|------|
| LENINGRAD     | 3    | 11   | 1    | 4    | 25   | 3    | 4    | 32   | 4    |
| MURMANSK      | 2    | 7    | 0    | 2    | 17   | 0    | 3    | 22   | 0    |
| PETROZAVODSK  | 3    | 10   | 0    | 3    | 23   | 0    | 3    | 29   | 0    |
| NOVGOROD      | 4    | 11   | 1    | 4    | 27   | 3    | 4    | 33   | 4    |
| VOLOGDA       | 4    | 14   | 0    | 4    | 33   | 3    | 4    | 41   | 4    |
| ARKHANGELSK   | 3    | 10   | 0    | 3    | 23   | 0    | 3    | 29   | 0    |
| SYKTYVKAR     | 3    | 10   | 0    | 3    | 26   | 2    | 4    | 35   | 4    |
| MOSCOW        | 6    | 17   | 1    | 6    | 39   | 4    | 6    | 47   | 5    |
| YAROSLAVL     | 4    | 16   | 0    | 5    | 37   | 3    | 5    | 46   | 5    |
| VLADIMIR      | 5    | 20   | 0    | 5    | 44   | 4    | 5    | 52   | 5    |
| IVANOVO       | 4    | 18   | 0    | 5    | 41   | 4    | 5    | 49   | 5    |
| KALININ       | 5    | 15   | 1    | 5    | 34   | 4    | 5    | 41   | 5    |
| KALUGA        | 9    | 15   | 1    | 7    | 35   | 4    | 7    | 42   | 5    |
| KOSTROMA      | 4    | 16   | 0    | 4    | 37   | 3    | 5    | 40   | 5    |
| RYAZAN        | 6    | 18   | 1    | 6    | 40   | 4    | 6    | 48   | 5    |
| TULA          | 8    | 16   | 1    | 8    | 37   | 5    | 8    | 44   | 6    |
| KAZAN         | 4    | 53   | 1    | 4    | 113  | 3    | 5    | 126  | 5    |
| GORKIY        | 4    | 24   | 1    | 4    | 53   | 4    | 5    | 63   | 5    |
| KIROV         | 4    | 17   | 0    | 4    | 41   | 0    | 4    | 53   | 0    |
| YOSHKAR_OLA   | 4    | 33   | 0    | 4    | 71   | 3    | 4    | 83   | 5    |
| SARANSK       | 5    | 26   | 1    | 5    | 54   | 3    | 5    | 64   | 5    |
| CHEKOKSARY    | 4    | 34   | 1    | 5    | 72   | 3    | 5    | 83   | 5    |
| ULYANDVSK     | 4    | 47   | 0    | 5    | 96   | 0    | 5    | 108  | 0    |
| BELGOROD      | 9    | 13   | 2    | 10   | 37   | 10   | 10   | 43   | 13   |
| VORONEZH      | 7    | 16   | 2    | 8    | 38   | 7    | 8    | 45   | 8    |
| KURSK         | 7    | 14   | 1    | 8    | 36   | 6    | 8    | 43   | 8    |
| OREL          | 7    | 14   | 1    | 7    | 35   | 5    | 7    | 42   | 7    |
| BRVANSK       | 6    | 14   | 1    | 7    | 34   | 5    | 7    | 42   | 6    |
| LIPETSK       | 7    | 17   | 0    | 7    | 39   | 5    | 7    | 46   | 6    |
| TAMBOV        | 6    | 20   | 0    | 7    | 44   | 4    | 7    | 52   | 5    |
| PFENZA        | 5    | 28   | 1    | 5    | 58   | 4    | 6    | 67   | 5    |
| ASTRAKHAN     | 4    | 19   | 0    | 5    | 43   | 0    | 5    | 49   | 0    |
| VOLGOGRAD     | 7    | 22   | 1    | 8    | 46   | 3    | 8    | 53   | 5    |
| KUYBYSHEV     | 4    | 72   | 0    | 5    | 139  | 4    | 5    | 154  | 7    |
| SARATOV       | 5    | 37   | 2    | 5    | 69   | 5    | 6    | 79   | 7    |
| POSTOV        | 20   | 16   | 3    | 21   | 36   | 14   | 21   | 40   | 11   |
| KRASNOGAR     | 7    | 23   | 3    | 7    | 39   | 12   | 7    | 44   | 8    |
| STAVROPOL     | 7    | 16   | 3    | 7    | 34   | 10   | 7    | 38   | 5    |
| MAKHACHKALA   | 4    | 20   | 0    | 4    | 51   | 1    | 5    | 49   | 0    |
| NALCHIK       | 5    | 18   | 0    | 5    | 45   | 5    | 5    | 44   | 6    |
| UROZHONIKIDZE | 5    | 20   | 1    | 5    | 60   | 6    | 5    | 51   | 6    |
| GROZNY        | 4    | 22   | 1    | 5    | 65   | 6    | 5    | 56   | 6    |
| KIEV          | 6    | 11   | 1    | 7    | 34   | 6    | 7    | 41   | 8    |
| ZAPOROZHYE    | 11   | 12   | 0    | 12   | 30   | 7    | 12   | 35   | 9    |
| KHARKOV       | 11   | 14   | 4    | 12   | 37   | 18   | 12   | 44   | 22   |
| LVOV          | 4    | 12   | 2    | 6    | 25   | 6    | 6    | 29   | 6    |
| KISHINEV      | 4    | 9    | 0    | 5    | 22   | 4    | 5    | 26   | 5    |
| TALLIN        | 3    | 9    | 1    | 3    | 22   | 2    | 3    | 28   | 3    |
| RIGA          | 3    | 10   | 0    | 4    | 23   | 2    | 4    | 29   | 3    |
| VILNIUS       | 4    | 10   | 0    | 4    | 24   | 3    | 4    | 30   | 4    |
| KALININGRAD   | 3    | 9    | 0    | 3    | 20   | 0    | 4    | 26   | 0    |
| SMOLENSK      | 5    | 13   | 0    | 5    | 31   | 4    | 5    | 39   | 5    |
| PSKOV         | 3    | 11   | 0    | 4    | 25   | 0    | 4    | 32   | 0    |
| MINSK         | 4    | 11   | 1    | 5    | 28   | 3    | 5    | 35   | 4    |
| TBILISI       | 3    | 14   | 0    | 4    | 27   | 4    | 4    | 31   | 5    |
| BAKU          | 3    | 36   | 2    | 4    | 3    | 4    | 4    | 58   | 6    |

## COAL, OIL, AND GAS POTENTIAL INDICES BASED ON TRANSPORT COSTS

| CODE              | CP60 | OP60 | GP60 | CP70 | OP70 | GP70 | CP75 | OP75 | GP75 |
|-------------------|------|------|------|------|------|------|------|------|------|
| YEREVAN           | 3    | 11   | 0    | 3    | 23   | 3    | 3    | 27   | 4    |
| LUTSK             | 4    | 10   | 0    | 5    | 24   | 4    | 5    | 29   | 4    |
| ROVNO             | 4    | 10   | 0    | 5    | 25   | 4    | 4    | 31   | 4    |
| UZHGOROD          | 4    | 10   | 0    | 4    | 22   | 6    | 4    | 26   | 5    |
| IVANO-FRANKOVSK   | 4    | 11   | 0    | 5    | 25   | 6    | 5    | 28   | 6    |
| TERNOPOL          | 4    | 10   | 1    | 5    | 24   | 5    | 5    | 29   | 5    |
| ZHITOMIR          | 5    | 11   | 1    | 6    | 27   | 5    | 6    | 33   | 5    |
| VINITSA           | 5    | 10   | 1    | 5    | 26   | 5    | 6    | 32   | 5    |
| KHMEVNITSKIY      | 4    | 10   | 0    | 5    | 25   | 5    | 5    | 30   | 5    |
| CHEPNOVSTY        | 4    | 10   | 0    | 4    | 22   | 4    | 5    | 27   | 4    |
| CHEPNOV           | 6    | 12   | 0    | 6    | 38   | 5    | 5    | 49   | 6    |
| SUMY              | 7    | 13   | 0    | 7    | 44   | 8    | 8    | 50   | 0    |
| POLTAVA           | 9    | 13   | 0    | 10   | 43   | 17   | 10   | 49   | 22   |
| CHEKASSY          | 8    | 11   | 0    | 9    | 32   | 6    | 9    | 38   | 7    |
| KIROVOGRAD        | 6    | 11   | 0    | 7    | 29   | 0    | 7    | 35   | 0    |
| ODESSA            | 5    | 10   | 0    | 5    | 24   | 5    | 6    | 29   | 6    |
| NIKOLAYEV         | 6    | 11   | 0    | 7    | 28   | 5    | 7    | 33   | 6    |
| KHERSON           | 6    | 11   | 0    | 7    | 28   | 5    | 7    | 33   | 6    |
| SIMFEROPOL        | 6    | 11   | 0    | 7    | 26   | 0    | 7    | 30   | 0    |
| DNEPROPETROVSK    | 11   | 12   | 2    | 12   | 32   | 10   | 12   | 37   | 12   |
| DONETSK           | 30   | 14   | 0    | 33   | 33   | 11   | 33   | 39   | 13   |
| VOPOSHILOVGRAD    | 33   | 14   | 2    | 35   | 33   | 12   | 35   | 39   | 14   |
| GRADNO            | 3    | 9    | 0    | 4    | 23   | 3    | 4    | 28   | 4    |
| VITEBSK           | 4    | 12   | 0    | 5    | 29   | 0    | 5    | 37   | 5    |
| MOGILEV           | 5    | 12   | 0    | 5    | 31   | 0    | 5    | 40   | 5    |
| SMOL              | 5    | 12   | 0    | 6    | 34   | 4    | 6    | 45   | 5    |
| ROST              | 4    | 10   | 1    | 5    | 24   | 3    | 5    | 30   | 4    |
| JFA               | 4    | 51   | 1    | 4    | 102  | 3    | 5    | 116  | 6    |
| IZHEVSK           | 4    | 32   | 0    | 4    | 72   | 3    | 4    | 89   | 5    |
| TRENBURG          | 4    | 29   | 0    | 4    | 61   | 1    | 4    | 74   | 0    |
| PERM              | 5    | 35   | 0    | 5    | 89   | 3    | 5    | 112  | 4    |
| SVEPDLOVSK        | 5    | 18   | 0    | 5    | 45   | 2    | 5    | 64   | 4    |
| CHEL'YABINSK      | 6    | 21   | 0    | 6    | 49   | 2    | 6    | 64   | 5    |
| TYUMEN            | 4    | 14   | 0    | 4    | 37   | 0    | 5    | 58   | 0    |
| KURGAN            | 4    | 17   | 0    | 5    | 40   | 0    | 5    | 59   | 0    |
| OMSK              | 4    | 12   | 0    | 5    | 28   | 0    | 6    | 44   | 0    |
| NOVOSIBIRSK       | 7    | 6    | 0    | 9    | 20   | 0    | 10   | 40   | 0    |
| TOMSK             | 7    | 7    | 0    | 8    | 18   | 0    | 10   | 47   | 0    |
| BARNUL            | 5    | 8    | 0    | 6    | 18   | 0    | 7    | 33   | 0    |
| KRASNOYARSK       | 5    | 6    | 0    | 6    | 15   | 0    | 9    | 31   | 0    |
| IRKUTSK           | 5    | 5    | 0    | 5    | 11   | 0    | 5    | 20   | 0    |
| CHITA             | 2    | 4    | 0    | 3    | 9    | 0    | 3    | 15   | 0    |
| IRAKAN            | 4    | 6    | 0    | 6    | 15   | 0    | 5    | 27   | 0    |
| KEMEROVO          | 16   | 7    | 0    | 20   | 19   | 0    | 24   | 38   | 0    |
| ULAN-UDE          | 2    | 4    | 0    | 3    | 10   | 0    | 3    | 17   | 0    |
| VLADIVOSTOK       | 2    | 3    | 0    | 3    | 6    | 0    | 3    | 9    | 0    |
| KHABAROVSK        | 1    | 3    | 0    | 2    | 7    | 0    | 2    | 10   | 0    |
| ALAGOVESHCHENSK   | 2    | 3    | 0    | 2    | 7    | 0    | 2    | 11   | 0    |
| YUZHNO-SAKHALINSK | 1    | 2    | 0    | 2    | 6    | 0    | 2    | 9    | 0    |
| MAGADAN           | 1    | 3    | 0    | 1    | 6    | 0    | 1    | 9    | 0    |
| YAKUTSK           | 1    | 3    | 0    | 2    | 7    | 0    | 2    | 10   | 0    |
| PETROPAVLOVSK_KAM | 1    | 2    | 0    | 1    | 6    | 0    | 1    | 8    | 0    |
| GUR'YEV           | 3    | 14   | 0    | 4    | 39   | 3    | 5    | 48   | 5    |
| IKTYUBINSK        | 4    | 19   | 0    | 4    | 44   | 2    | 4    | 55   | 5    |
| URALSK            | 4    | 22   | 0    | 4    | 46   | 0    | 5    | 56   | 0    |
| KUSTANAY          | 5    | 17   | 0    | 5    | 38   | 2    | 5    | 51   | 4    |

## COAL, OIL, AND GAS POTENTIAL INDICES BASED ON TRANSPORT COSTS

| NODE            | CP60 | OP60 | GP60 | CP70 | OP70 | GP70 | CP75 | OP75 | GP77 |
|-----------------|------|------|------|------|------|------|------|------|------|
| PETROPAVLOVSK   | 4    | 14   | 0    | 5    | 33   | 0    | 6    | 47   | 0    |
| KOKCHETAV       | 4    | 12   | 0    | 5    | 29   | 0    | 6    | 42   | 0    |
| TSELINGRAD      | 5    | 11   | 0    | 6    | 25   | 0    | 8    | 36   | 0    |
| KARAGANDA       | 7    | 10   | 0    | 10   | 23   | 0    | 12   | 32   | 0    |
| KZYL_ORDA       | 3    | 11   | 0    | 3    | 24   | 0    | 3    | 31   | 0    |
| CHIMKENT        | 3    | 9    | 0    | 3    | 20   | 2    | 4    | 27   | 4    |
| OZHAMBUL        | 3    | 9    | 0    | 3    | 19   | 2    | 4    | 25   | 4    |
| SEMIPALATINSK   | 3    | 7    | 0    | 4    | 16   | 0    | 5    | 25   | 0    |
| PAVLODAR        | 5    | 9    | 0    | 8    | 20   | 0    | 11   | 32   | 0    |
| JST_KAMENOGORSK | 3    | 7    | 0    | 4    | 16   | 0    | 5    | 24   | 0    |
| ALMA_ATA        | 3    | 7    | 0    | 3    | 16   | 2    | 4    | 22   | 3    |
| ASHKHABAD       | 2    | 11   | 0    | 3    | 24   | 0    | 3    | 29   | 5    |
| DUSHANBE        | 2    | 7    | 0    | 2    | 15   | 0    | 2    | 19   | 5    |
| TASHKENT        | 3    | 9    | 0    | 3    | 20   | 3    | 4    | 26   | 4    |
| FRUNZE          | 2    | 8    | 0    | 3    | 17   | 2    | 3    | 24   | 3    |
| NURILSK         | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| FLISTA          | 5    | 13   | 0    | 5    | 28   | 0    | 5    | 32   | 0    |

APPENDIX E  
URBAN POPULATION DATA

## SOVIET URBAN POPULATION AND GROWTH RATES

| NODE          | POP59 <sup>a</sup> | POP70 <sup>a</sup> | POP79 <sup>a</sup> | GROWTH1 <sup>b</sup> | GROWTH2 <sup>c</sup> |
|---------------|--------------------|--------------------|--------------------|----------------------|----------------------|
| LENINGRAD     | 3003               | 3550               | 4073               | 19                   | 15                   |
| MURMANSK      | 222                | 309                | 381                | 39                   | 23                   |
| PETROZAVOOSK  | 141                | 192                | 234                | 37                   | 22                   |
| NOVGOROD      | 61                 | 128                | 186                | 111                  | 45                   |
| VOLOGDA       | 139                | 178                | 237                | 28                   | 33                   |
| ARKHANGELSK   | 258                | 343                | 385                | 33                   | 12                   |
| SYKTYVKAR     | 69                 | 125                | 171                | 82                   | 37                   |
| MOSCOW        | 6009               | 6942               | 7831               | 16                   | 13                   |
| YAROSLAVL     | 407                | 517                | 597                | 27                   | 15                   |
| VLADIMIR      | 154                | 234                | 296                | 52                   | 26                   |
| IVANOV        | 335                | 419                | 465                | 25                   | 11                   |
| KALININ       | 261                | 345                | 412                | 32                   | 19                   |
| KALUGA        | 134                | 211                | 265                | 57                   | 26                   |
| KOSTROMA      | 172                | 223                | 255                | 30                   | 14                   |
| RYAZAN        | 214                | 351                | 453                | 64                   | 29                   |
| TULA          | 351                | 462                | 514                | 32                   | 11                   |
| KAZAN         | 667                | 869                | 993                | 30                   | 14                   |
| GORKIY        | 941                | 1170               | 1344               | 24                   | 15                   |
| KIROV         | 252                | 332                | 390                | 32                   | 17                   |
| YOSHKA_OLA    | 89                 | 166                | 201                | 87                   | 21                   |
| SARANSK       | 91                 | 191                | 263                | 109                  | 38                   |
| CHEBCKSARY    | 104                | 216                | 308                | 104                  | 43                   |
| ULYANOVSK     | 206                | 351                | 464                | 70                   | 32                   |
| BELGOROD      | 72                 | 151                | 240                | 109                  | 59                   |
| VORONEZH      | 407                | 660                | 783                | 48                   | 19                   |
| KURSK         | 205                | 284                | 375                | 39                   | 32                   |
| OREL          | 150                | 232                | 305                | 55                   | 31                   |
| BRYANSK       | 207                | 318                | 394                | 53                   | 24                   |
| LIPETSK       | 157                | 290                | 396                | 85                   | 37                   |
| TAMBOV        | 172                | 230                | 270                | 33                   | 17                   |
| PENZA         | 255                | 374                | 483                | 46                   | 26                   |
| ASTRAKHAN     | 305                | 410                | 461                | 34                   | 12                   |
| VOLGOGRAD     | 591                | 818                | 929                | 38                   | 14                   |
| KUYBYSHEV     | 806                | 1045               | 1216               | 30                   | 16                   |
| SARATOV       | 579                | 757                | 856                | 31                   | 13                   |
| ROSTOV        | 600                | 789                | 934                | 32                   | 18                   |
| KRASNOGAR     | 313                | 464                | 560                | 48                   | 21                   |
| STAVROPOL     | 141                | 198                | 258                | 41                   | 30                   |
| MAKHACHKALA   | 119                | 186                | 250                | 56                   | 35                   |
| NALCHIK       | 88                 | 146                | 207                | 66                   | 42                   |
| ORDZHONIKIDZE | 164                | 236                | 279                | 44                   | 18                   |
| GROZNY        | 250                | 341                | 375                | 37                   | 10                   |
| KIEV          | 1110               | 1632               | 2144               | 47                   | 31                   |
| ZAPOROZHIE    | 449                | 658                | 781                | 46                   | 19                   |
| KHARKOV       | 953                | 1223               | 1444               | 28                   | 18                   |
| LVOV          | 411                | 553                | 667                | 35                   | 21                   |
| KISHINEV      | 216                | 357                | 503                | 65                   | 41                   |
| TALLIN        | 282                | 363                | 430                | 29                   | 19                   |
| RIGA          | 580                | 732                | 835                | 26                   | 14                   |
| VILNIUS       | 236                | 372                | 481                | 58                   | 29                   |
| KALININGRAD   | 204                | 297                | 355                | 46                   | 20                   |
| SMOLENSK      | 147                | 211                | 276                | 43                   | 31                   |
| PSKOV         | 81                 | 127                | 176                | 56                   | 39                   |
| MINSK         | 509                | 907                | 1262               | 78                   | 39                   |
| TBILISI       | 703                | 889                | 1066               | 27                   | 20                   |
| BAKU          | 643                | 852                | 1022               | 33                   | 20                   |

## SOVIET URBAN POPULATION AND GROWTH RATES

| NODE              | POP59 | POP70 | POP79 | GROWTH1 | GROWTH2 |
|-------------------|-------|-------|-------|---------|---------|
| YEREVAN           | 493   | 767   | 1019  | 55      | 33      |
| LUTSK             | 56    | 94    | 137   | 69      | 46      |
| ROVNO             | 56    | 116   | 179   | 106     | 55      |
| UZHGOROD          | 47    | 65    | 91    | 36      | 41      |
| IVANO_FRANKOVSK   | 66    | 105   | 150   | 58      | 43      |
| TERNOPOL          | 52    | 85    | 144   | 62      | 70      |
| ZHITOMIR          | 106   | 161   | 244   | 52      | 52      |
| VINNITSA          | 122   | 212   | 313   | 74      | 48      |
| KHMELNITSKIY      | 62    | 113   | 172   | 81      | 52      |
| CHERNOVSTY        | 152   | 187   | 218   | 23      | 17      |
| CHEMNIGOV         | 90    | 159   | 238   | 77      | 50      |
| SUMY              | 98    | 159   | 223   | 62      | 43      |
| POLTAVA           | 143   | 220   | 279   | 54      | 27      |
| CHEKASSY          | 85    | 158   | 228   | 97      | 44      |
| KIROVOGRAD        | 132   | 189   | 237   | 43      | 26      |
| ODESSA            | 664   | 892   | 1046  | 34      | 17      |
| NIKOLAYEV         | 251   | 362   | 441   | 41      | 22      |
| KHERSON           | 158   | 261   | 319   | 65      | 22      |
| SIMFEROPOL        | 186   | 249   | 302   | 34      | 21      |
| DNEPROPETROVSK    | 691   | 904   | 1066  | 30      | 18      |
| DONETSK           | 708   | 879   | 1021  | 24      | 16      |
| VOROSHILOVGRAD    | 275   | 383   | 463   | 39      | 21      |
| GRODNO            | 73    | 132   | 195   | 82      | 47      |
| VITEBSK           | 148   | 231   | 297   | 56      | 29      |
| MOGILEV           | 122   | 202   | 290   | 66      | 43      |
| GOMEL             | 168   | 272   | 383   | 62      | 41      |
| BREST             | 74    | 122   | 177   | 65      | 46      |
| UFA               | 547   | 771   | 969   | 41      | 26      |
| IZHEVSK           | 285   | 422   | 549   | 48      | 30      |
| ORENBURG          | 267   | 344   | 459   | 29      | 33      |
| PERM              | 629   | 850   | 999   | 35      | 17      |
| SVERDLOVSK        | 779   | 1025  | 1211  | 32      | 18      |
| CHELYABINSK       | 689   | 875   | 1031  | 27      | 18      |
| TYUMEN            | 150   | 269   | 359   | 79      | 34      |
| KURGAN            | 146   | 244   | 310   | 67      | 27      |
| OMSK              | 581   | 821   | 1014  | 41      | 23      |
| NOVOSIBIRSK       | 885   | 1161  | 1312  | 31      | 13      |
| TOMSK             | 249   | 338   | 421   | 36      | 24      |
| BARNAUL           | 303   | 439   | 533   | 45      | 21      |
| KRASNOYARSK       | 412   | 648   | 796   | 57      | 23      |
| IRKUTSK           | 366   | 451   | 550   | 23      | 22      |
| CHITA             | 172   | 241   | 302   | 40      | 25      |
| ABAKAN            | 56    | 90    | 128   | 60      | 42      |
| KEMEROVO          | 289   | 385   | 471   | 33      | 22      |
| ULAN_UBE          | 174   | 254   | 300   | 45      | 18      |
| VLADIVOSTOK       | 291   | 441   | 550   | 52      | 25      |
| KHABAROVSK        | 323   | 436   | 528   | 35      | 21      |
| BLAGOVESHCHENSK   | 94    | 128   | 172   | 36      | 35      |
| YUZHNO_SAKHALINSK | 86    | 106   | 140   | 24      | 32      |
| MAGADAN           | 62    | 92    | 122   | 48      | 32      |
| YAKUTSK           | 74    | 108   | 152   | 45      | 41      |
| PETROPAVLOVSK_KAM | 86    | 154   | 215   | 80      | 40      |
| GURYEV            | 79    | 114   | 130   | 45      | 14      |
| AKTYUBINSK        | 97    | 150   | 191   | 55      | 27      |
| URALSK            | 99    | 134   | 167   | 36      | 24      |
| KUSTANAY          | 86    | 123   | 164   | 43      | 33      |

## SOVIET URBAN POPULATION AND GROWTH RATES

| NODE            | POP59 | POP70 | POP79 | GROWTH1 | GROWTH2 |
|-----------------|-------|-------|-------|---------|---------|
| PETROPAVLOVSK   | 131   | 173   | 207   | 32      | 20      |
| KOKCHETAV       | 53    | 81    | 103   | 52      | 29      |
| TSELINOGRAD     | 99    | 180   | 234   | 82      | 30      |
| KARAGANDA       | 383   | 523   | 572   | 37      | 9       |
| KZYL_ORDA       | 66    | 122   | 156   | 86      | 27      |
| CHIMKENT        | 153   | 247   | 321   | 61      | 30      |
| DZHAMBUL        | 113   | 187   | 264   | 65      | 41      |
| SEMIPALATINSK   | 156   | 236   | 283   | 51      | 20      |
| PAVLODAR        | 90    | 187   | 273   | 108     | 46      |
| UST_KAMENOGORSK | 150   | 230   | 274   | 53      | 19      |
| ALMA_ATA        | 456   | 733   | 910   | 60      | 24      |
| ASHKHABAD       | 170   | 253   | 312   | 49      | 23      |
| DUSHANBE        | 227   | 374   | 493   | 65      | 32      |
| TASHKENT        | 927   | 1385  | 1779  | 49      | 28      |
| FRUNZE          | 220   | 431   | 533   | 96      | 24      |
| NORILSK         | 118   | 135   | 180   | 14      | 33      |
| ELISTAD         | .     | .     | .     | .       | .       |

<sup>a</sup>Population in 1959, 1970, and 1979

<sup>b</sup>Percent increase 1959-1970

<sup>c</sup>Percent increase 1970-1979.

<sup>d</sup>Data not available.

Source: Data compiled by Shabad in Bond and Lydolph (1979).