

Coal in the western Pacific basin: an overview

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Abstract: Coal comprises about 50 percent of the conventional energy resources and about 70 percent of the fossil energy resources of the world. Asia contains about 50 to 70 percent of the total estimated coal resources of the world. The western Pacific basin of the Circum-Pacific Region contains about 20 percent of the world's total coal resources and is estimated to contain about 50 percent of the presently recoverable coal reserves of the world.

Coal supplies about 27 percent of the world's primary energy production and provides about 56 percent of the primary energy production of the western Pacific basin. Among the nations of the area, China, Australia, New Zealand, and Vietnam produce more coal than they consume. Japan, both Koreas, the Philippines and Thailand consume more coal than they produce. Within the area as a whole, coal production and consumption are both about 30 percent of the world totals. Between 1981 and 1990, primary energy consumption in the basin increased by about 150 percent, and coal consumption increased by almost 170 percent. Both energy and coal consumption are expected to increase over the next three decades as nations of the region expand their economies and focus on indigenous coal resources as a basic energy supply.

Within the western Pacific basin, the amount of information concerning coal resource potential ranges widely. Some nations (for example, Japan) place all their estimated coal resources in the proven-in-place reserve category, while others (for example, Malaysia) place only a few percent in that category. While estimates vary, depending on the philosophy and practices used, it is probable that, in many cases, the available coal database is inadequate for reliable resource assessment.

Increased exploration and development activities are needed to permit realistic and accurate evaluation of energy-planning options in the basin.

INTRODUCTION

Coal constitutes about 50 percent of the mineral energy resources of the world. Coal and nuclear energy combined constitute the bulk of the energy available to mankind in the near future (Fig. 1). Other energy forms, such as geothermal steam, water power, tidal energy, winds, organic wastes, plant energy, solar energy, geothermal hot rocks, heavy hydrogen and atmospheric electricity, range in potential from limited to vast but are decades removed from significant contribution to the world's energy budget (Moody, 1978).

WORLD ENERGY RESOURCES

The latest available data (Table 1) on world energy resources show essentially the same gross relationships as Figure 1, whether compared as percent of total resources or as heat units (Btu) (United Nations, 1991). In Table 1, coal, peat and uranium are shown both as proved-in-place quantities with an ill-defined recoverable component, and as total resource estimates. Petroleum (crude oil and natural gas liquids) is

shown only as reserves (recoverable amount unstated). Natural gas and oil shales and bituminous sands are shown as proved recoverable reserves. Hydraulic resources are shown in gross theoretical capability. Estimates of energy available from uranium range widely depending on assumptions regarding utilization technology. Shown here are assumptions of breeder reactor technology. Regardless of assumptions and qualifications, coal is the dominating energy resource.

WORLD COAL RESOURCES

Estimates of the total quantity of coal in the earth's crust range widely, depending on the amount and type of information available and on the economic and engineering restrictions accepted by the estimators. The estimates shown on Figure 2, which are in trillions of tons (teratonnes), display these effects. The 1913 estimate (International Geologic Congress, 1913) was the earliest reasonably successful attempt to produce country-by-country estimates that were comparable. Almost all subsequent estimates use similar methodology but

Table 1: World energy resources (Btu x 10¹⁸) (modified from United Nations, 1991).

	Total	Recoverable Component ¹
Coal	252.00	60.00
Peat	8.90	5.70
Petroleum	5.30	5.30
Oil Shale/Bituminous Sands	2.20	2.20
Natural Gas	3.94	3.94
Uranium	145.00	94.00
Hydraulic resources	0.10	0.10

¹Proved-in-place — coal, peat, and uranium.
 Proved recoverable — oil shale/bituminous sands, and natural gas.
 Reserves — petroleum.
 Gross theoretical capacity — hydraulic resources.

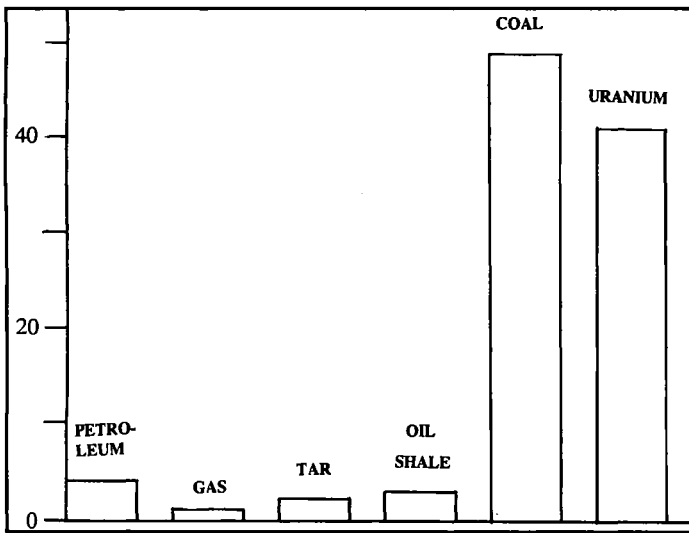


Figure 1. Mineral energy resources, in percent (Moody, 1978).

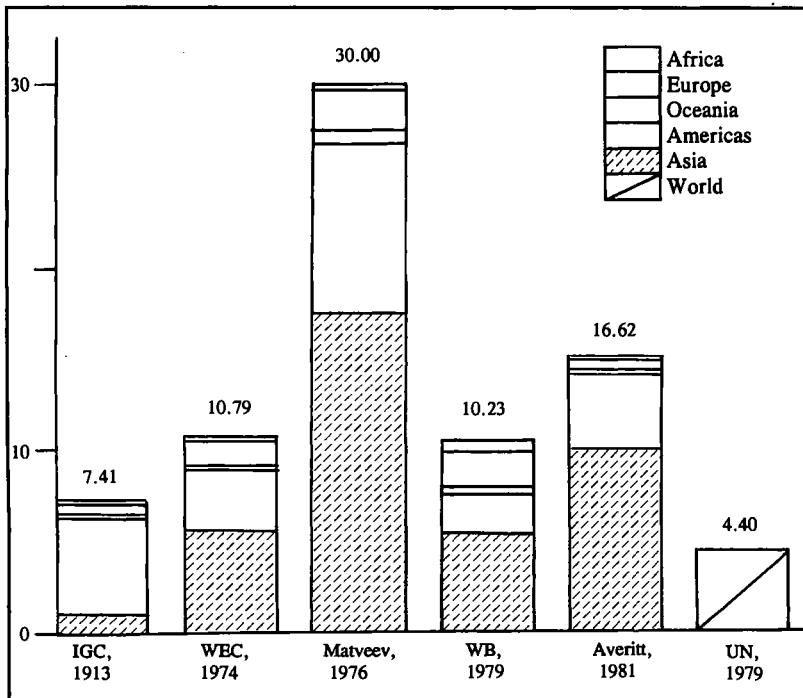


Figure 2. World coal resource estimates by continents, in teratonnes.

are based on more information. Some estimates, such as that of Matveev (1976), include geologic extension of data far beyond the engineering and economic restrictions commonly accepted. Some estimates, such as that of the United Nations (1989), are severely constricted by economic considerations.

Most of the same estimates shown on Figure 2 are shown on Table 2 in percentages. In all recent estimates, Asia contains about 50 to 70 percent of the estimated total coal resources of the world.

WORLD COAL RESERVES

After application of engineering and economic factors, recent estimates of the recoverable coal reserves of the world (Table 3) indicate that about 55 percent of the total is in the western Pacific basin (Energy Information Administration, 1992a, modified by authors). As used herein, the western Pacific basin includes the eastern part of Russia except in discussion of energy production and consumption where data are lacking.

WESTERN PACIFIC BASIN COAL RESERVES

The estimated recoverable coal reserves of the western Pacific basin (Table 4) differ between countries by several orders of magnitude. Part of the difference in estimated reserves is very real, but part is caused by lack of coal resource information with resulting inadequate assessment of resource potential.

WORLD ENERGY PRODUCTION AND CONSUMPTION

As expectable, the primary energy production of the world, by type (Table 5), closely resembles the primary energy consumption of the world. Coal and petroleum account for about 27 and 39 percent, respectively, of both production and consumption. Figure 3 provides a comparison of the world's primary energy production by source between the years 1973 and 1990. All energy sources show

Table 2: World coal resource estimates (by percent¹).

	IGC ² , 1913	WEC ³ , 1974	MATVEEV, 1976	WB ⁴ , 1979	AVERITT, 1981
Asia	17.5	52.5	57.5	53.0	67.0
North, Central and South America	69.0	28.0	32.5	28.0	26.0
Oceania	1.5	1.5	1.0	3.0	1.5
Europe	10.0	17.0	7.0	13.5	4.5
Africa	2.0	1.0	2.0	2.5	1.0

¹Rounded to 0.5 percent.
²International Geologic Congress.
³World Energy Conference.
⁴World Bank.

Table 3: Estimated recoverable coal reserves of the world (modified from Energy Information Administration, 1992a).

	Tonnes x 10 ⁶	Percent of Whole
Western Hemisphere	270	16
Europe and Western Part of the C.I.S. ¹	320	19
Africa, Middle East and India	120	7
Western Pacific Basin including eastern Russia	940	57
World Total	1,650	

¹Commonwealth of Independent States.

Table 4: Estimated recoverable coal reserves of the western Pacific basin (from Energy Information Administration, 1992a).

	10 ⁶ Tonnes	Percent of Total, Rounded
Australia	90,916	10
China (P.R.C.)	730,506	80
Indonesia	2,999	0.3
Japan	873	0.09
Korea, North	600	0.06
Korea, South	158	0.02
New Zealand	117	0.01
R.O.C. (Taiwan)	200	0.02
Russia, Eastern	96,375	10
Thailand	914	0.1
Vietnam	150	0.02
Total	923,808	

Table 5: World Primary Energy Production, by type, 1990 (Energy Information Administration, 1992a).

	10 ¹⁵ Btu	Percent of Total
Petroleum	136.25	39
Natural Gas	73.50	21
Coal	93.00	27
Hydroelectric Power	21.95	6
Nuclear Electric Power	20.35	6
World Total	345.05	99

increases in quantity produced, and consumed, as the world's energy demand increases.

WESTERN PACIFIC BASIN ENERGY PRODUCTION AND CONSUMPTION

Energy consumption in the western Pacific basin increased very substantially between 1981 and 1990 (Table 6). Coal consumption increased the most, followed by petroleum. In the western Pacific basin, coal provides about 56 percent of the primary energy production of the region while accounting for about 46 percent of the consumption. In contrast, petroleum supplies about 24 percent of the primary energy production of the region while accounting for about 37 percent of the consumptive demand (Tables 7 and 8).

The countries of the western Pacific basin consumed more energy than they produced in 1990 — about 67 quadrillion Btu consumed versus about 53 quadrillion Btu produced. In terms of energy

(Btu), all sources remained almost static in the ratio of production versus consumption, except petroleum. More than twice as much petroleum was consumed in the region as was produced.

For countries — Australia, China, New Zealand and Vietnam — produced more energy than they consumed and five countries — Japan, both Koreas, Philippines and Thailand — consumed more than they produced (Energy Information Administration, 1992a).

WESTERN PACIFIC BASIN COAL RESOURCES

As previously shown graphically, the known coal resources of the world are not equally distributed. More than 2,000 different coal "areas" and "occurrences" have been identified in various resource studies. Figure 4 shows only part of the known or reported coal areas of the world but does illustrate the widespread distribution of coal around

the world while highlighting the principal coal-bearing regions.

The western Pacific basin has been adequately blessed with coal resources. A list of the 20 countries with the most reported estimated resources (Table 9) includes 4 of the countries of the western Pacific basin. Classification of known coal resource areas

on the basis of estimated total quantity indicates that 8 of the 24 coal areas presently included in the top three estimated resource categories are in the western Pacific basin (Table 10 and Fig. 5).

Credible estimates of total resources are necessary for long-range planning and understanding of energy budget options. However,

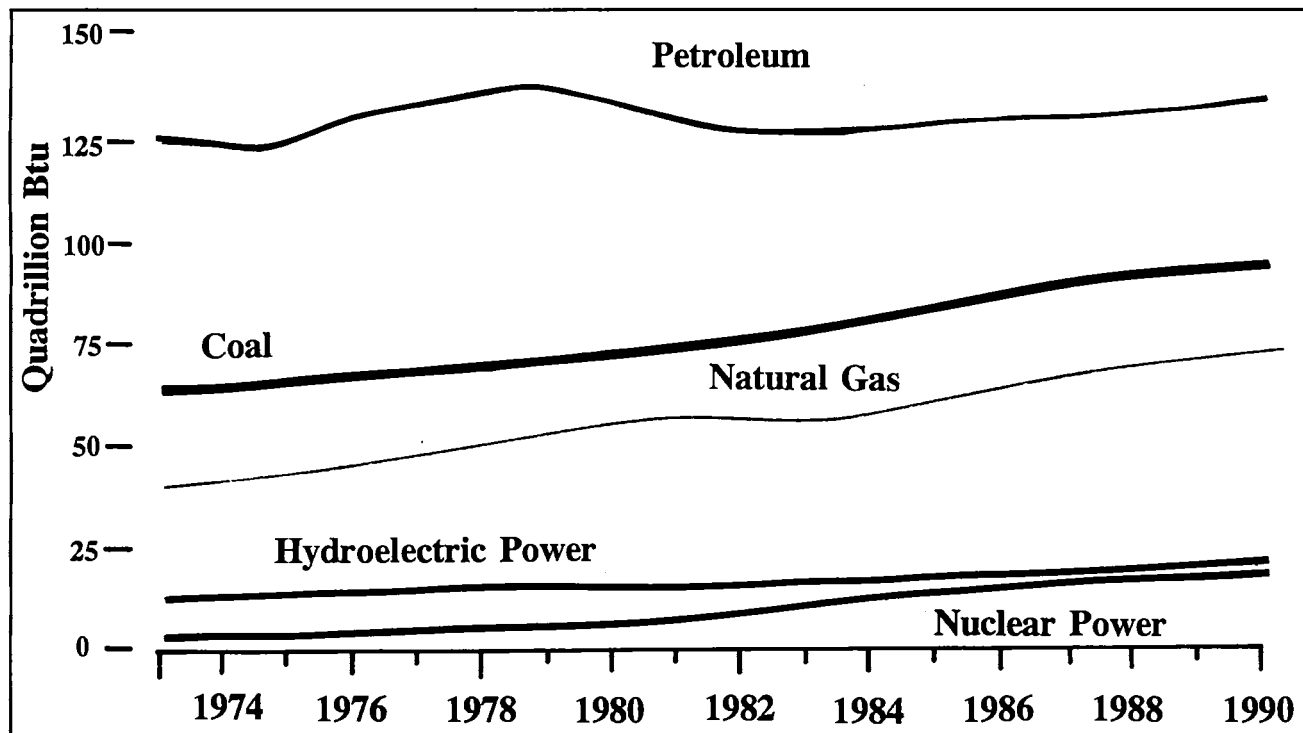


Figure 3. World primary energy production by source, 1973-1990 (modified from EIA, 1992b).

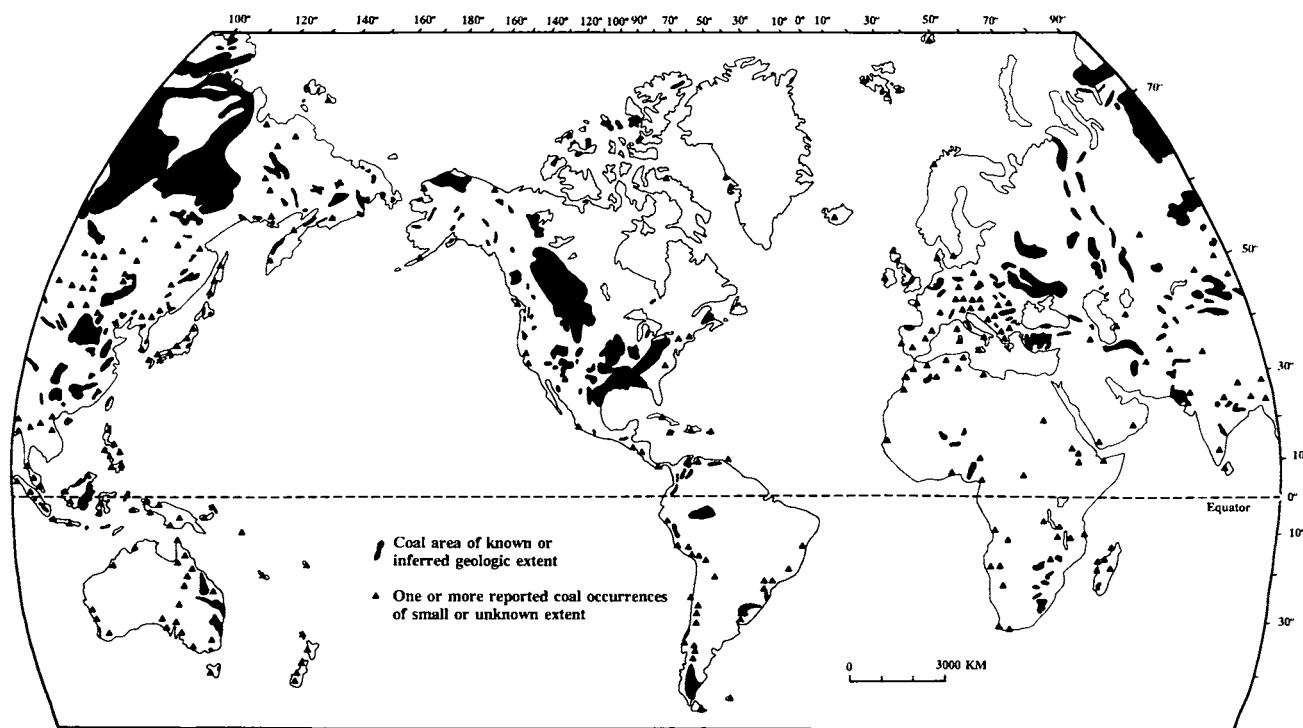


Figure 4. Global coal distribution.

Table 6: Primary energy consumption, western Pacific basin, by type, 1981-1986-1990¹ (Energy Information Administration, 1992a).

	10 ¹⁵ Btu			Ratio 1990/81
	1981	1986	1990	
Petroleum	20.41	20.25	25.15	1.23
Natural Gas	2.39	3.83	4.71	1.97
Coal	18.37	24.69	30.86	1.68
Hydroelectric Power	2.38	3.00	3.45	1.45
Nuclear Electric Power	1.10	2.23	2.78	2.35
Total	44.65	54.00	66.95	1.50

¹Eastern Russia omitted for lack of data.

Table 7: Primary energy production, western Pacific basin, by type, 1990¹ (Energy Information Administration, 1992a).

	10 ¹⁵ Btu	Percent of Total
Petroleum	12.39	24
Natural Gas	4.54	9
Coal	29.39	56
Hydroelectric Power	3.45	7
Nuclear Electric Power	2.78	5
Total	52.55	101

¹Eastern Russia omitted for lack of data.

Table 8: Primary energy consumption, western Pacific basin, by type, 1990¹ (Energy Information Administration, 1992a).

	10 ¹⁵ Btu	Percent of Total
Petroleum	25.15	38
Natural Gas	4.71	7
Coal	30.86	46
Hydroelectric Power	3.45	5
Nuclear Electric Power	2.78	4
Total	66.95	100

¹Eastern Russia omitted for lack of data.

Table 9: Twenty countries with most reported estimated resources (World Energy Conference, 1983) (In millions of tonnes) (In bold — countries of western Pacific basin).

1)	USSR (former)	4,405,900 ¹
2)	USA	1,570,262
3)	China	1,566,500
4)	Australia	785,226
5)	Germany	285,400
6)	Great Britain	190,000
7)	Poland	184,000
8)	South Africa	129,100
9)	India	115,402
10)	Botswana	107,000
11)	Canada	63,000
12)	Mongolia	24,000
13)	Brazil	23,000
14)	Yugoslavia	21,367
15)	Czechoslovakia	20,090
16)	Indonesia	16,615
17)	Belgium	16,085
18)	Venezuela	15,367
19)	New Zealand	13,385
20)	Colombia	10,063

¹At least one-half in eastern Russia.

Table 10: Group classification of world coal areas (underline — coal areas in western Pacific basin).

Group 1 — More than 500 billion tonnes	
<u>Lena Basin</u> ¹	Upper Amazon Basin ¹
<u>Tunguska Basin</u> ¹	Appalachian Basin ¹
<u>Taimyr Basin</u> ¹	Northern Alaska Area ²
<u>Kansko-Achinsk Basin</u> ¹	Great Plains Province ³
Kuznetsk Basin ¹	<u>Ordos Basin-Taiyuan Region</u> ⁴
Group 2 — 200 to 500 billion tonnes	
Lower Rhine-Westphalian Basin ¹	Gulf Coast Province ³
Donetsk Basin ¹	Guasare Region ⁵
Penchora Basin ¹	Magallanes Region(?) ⁶
Eastern Region, Interior Province ¹	<u>Sechwan Basin</u> (?) ⁷
Group 3 — 500 million to 200 billion tonnes	
Western Region, Interior Province ³	
Witbank Basin ⁷	
South Sind Region(?) ⁶	
Saar-Lorraine Basin ⁷	
<u>Clarence-Moreton-Surat Province</u> (?) ⁷	
<u>Sydney-Gunnedah</u> ⁷	
¹ Matveev (1976a, 1976b) ² Stricker (1991) ³ Wood and Bour (1988) ⁴ Grossling (1981) and Landis (personal commun.) ⁵ Matveev (1972) and Weaver (personal commun.) ⁶ Landis (personal commun.) ⁷ Matveev (1972)	

predictions of reserves — which may be defined as the part of total resources which could be economically recovered at the time of determination considering environmental, legal, and technologic constraints — are necessary for near-future utilization planning. Table 11 shows a comparison of the reported coal resources of the countries of the western Pacific basin with the reported proved-in-place reserves of the same countries. Also shown are the same comparisons for the western Pacific basin as a whole, and for the world.

25 percent of the estimated coal resources of the western Pacific basin and 23 percent of the world's estimated coal resources are categorized as proved. Four of the countries listed in Table 11 place their total estimated resources in the proved

category; the other eight countries place from 72 percent to less than 1 percent of their estimated resources in the proved category. While the cited relationships may be real for a few of the western Pacific basin countries, in most cases the reported reserves are either too large or too small compared to the estimated resources. Estimates based largely on economic, technologic and societal understanding and predictive extensions thereof.

While much is known about the coal resources of the western Pacific basin, much remains to be learned. The areal size and/or resource potential of several coal areas shown on the map (Fig. 5) were not recognized until recently; for example, the Ordos basin and nearby areas in northern China, and many other areas require much more exploration

to allow realistic assessment of their coal resource potential. Examples of the latter are Kalimantan, Irian Jaya, and some, most, or all of the known and reported coal areas of Sumatra, eastern Indonesia, Malaysia, Thailand, Philippines, parts of easternmost Russia, and the southern, western and northernmost parts of China.

Some coal areas that cannot be realistically evaluated at this time will prove to be of large future resource and utilization potential. Many other areas of smaller resource potential will prove to be of considerable economic importance because of strategic location, particular utilization capability or societal need, political requirements, or environmental advantages.

SUMMARY AND CONCLUSIONS

The world has massive, and growing, needs for energy and only coal among the fossil fuels is well-positioned to satisfy future energy needs.

The consumption of energy by most of the nations of the western Pacific basin will increase even faster than the world as a whole.

Even if coal only satisfies the same percentage of future energy needs as at present, the quantity of coal needed, both worldwide and in the western Pacific basin, must increase substantially.

The known coal resource potential of the western Pacific basin is very large and will increase as geologic understanding is advanced.

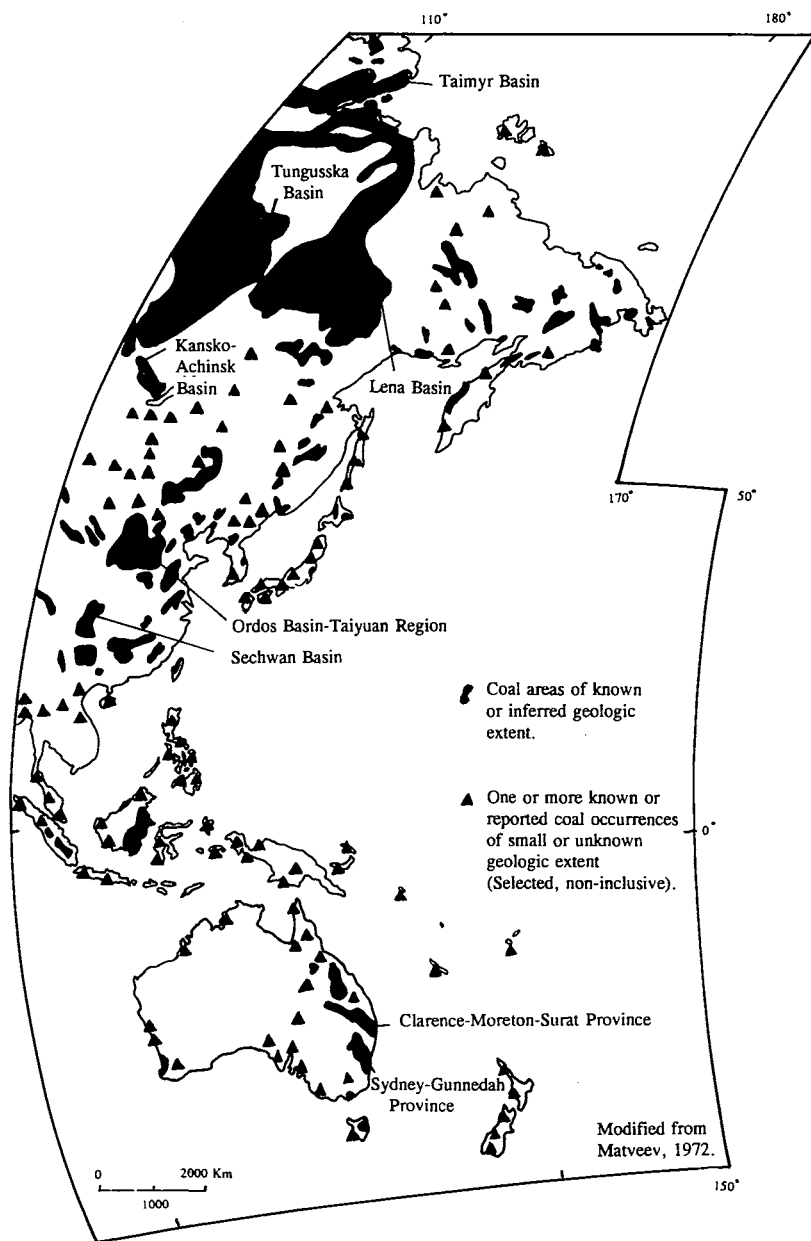


Figure 5. Coal distribution — Eastern Asia and Oceania.

Table 11: Proved-in-place reserves versus total estimated resources, countries in western Pacific basin (from United Nations, 1991, except as indicated).

	Reserves (10 ⁵ tonnes)	Resources (10 ⁶ tonnes)	Ratio Reserves/Resources
Australia	95,940	799,940	0.12
China	770,600	1,076,400	0.72
Indonesia	16,000 ¹	29,000	0.55
Japan	8,523	8,523	1.00
Korea, North	2,300	7,200	0.32
Korea, South	200	1,577	0.13
Malaysia	4	657	< 0.01
New Zealand	1,882	8,602	0.22
Philippines	170	170	1.00
Russia, Eastern	114,800	2,194,800	0.52
Thailand	1,663	1,663	1.00
Vietnam	300	300	1.00
Total – western Pacific basin	1,012,382	4,128,832	0.25
Total – World	2,412,654	10,404,821	0.23

¹Directorate of Coal, 1991.

Determination of the utilization potential of the basin's coal resources for the betterment of mankind will require large amounts of exploration, development and technologic, environmental and societal studies.

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