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ENERGY RESOURCES AND POWER DEVELOPMENT IN CZECHOSLOVAKIA SINCE 1924

Les Ressources d'Energie et le Développement de la Production d'Energie en Tchécoslovaquie depuis 1924

Prepared by an ADVISORY COMMITTEE OF THE CZECHOSLOVAK NATIONAL COMMITTEE OF THE WORLD POWER CONFERENCE

SOLID FUELS—UTILIZATION OF LOWER-GRADE COAL

The coal produced in Czechoslovakia is of very varying quality. Most grades belong to various sorts of long-flame and gas coal which is, however, unsuitable for further treatment and is therefore used for combustion. Considerable quantities of coking coal of excellent quality, and of gas coal, are, however, available. These are also suited for the production of coke. For coking purposes, long-flame coal may be added to the coking coal. It may be said that Czechoslovakia is approaching an optimum of her technical and economical state; in other words, that all coal will become a raw material for further treatment, in order to obtain valuable by-products such as tar, ammonia, gas, etc., which form the basis of a large chemical industry. The quality of the coke produced in Czechoslovakia is well known; it is mostly consumed in the domestic metallurgical industry, only a small part being exported to European countries. The coke-oven plants mostly possess modern equipment, and the older oven batteries are being renovated by our own means and with Czechoslovak refractory materials. After further coke ovens, at present under construction, have been completed, only waste coal (slack) will be used for energy production, besides coke gas partly utilized in metallurgy and blast-furnace gas.

The chief fuels for heating in industry, households, and traction, are lower-grade coal, brown coal, and lignite. From the statistical tables it is evident that in Czechoslovakia, even before the Second World War, the production of brown coal was about 50% higher than the production of black coal. Taking the calorific value of brown coal as equal to two-thirds of that of black coal, the energy produced from the two kinds is equal. The importance of the utilization

of brown coal is thus evident. Some of the brown coal output goes to form the very good grades of hard brown coal, which in purity and value is not inferior to black coal. Before the war considerable quantities were exported. Nowadays it is used for domestic heating as it is economically worth while to transport it over considerable distances. But the bulk of the production is the ordinary brown coal, which is the most widely used fuel for all purposes. Its quality varies in respect of moisture and ash content; also the content of bitumen is quite different. Since the price of this brown coal varies considerably according to quality as well as calorific value, there has long been a tendency to utilize only the inferior grades. For this reason, the application of special boilers utilizing this lower-grade coal had spread in Czechoslovakia even before the Second World War. Different methods of improving coal by washing, drying, pressing into briquettes, and heat treatment were tried, but in the end a return is always made to the direct burning of raw coal on special grates or—more recently—to the use of pulverized coal and to boilers with slag tap furnaces. It must be emphasized, however, that most Czechoslovak brown coal is of higher quality—even in the raw and unimproved state—than other coals such as the well-known brown coal of Central Germany.

During the last decade remarkable developments have been made in the chemical treatment of brown coal for the production of synthetic fuels and of gas for long-distance distribution, which are still having an important influence on the Czechoslovak energy economy. Firstly, there is a trend towards the combustion of fuels of lower quality, resulting in a better utilization of the intermediate layers of ash containing brown coal; and secondly, there is a better utilization of lignite, the most inconvenient feature of which is the high percentage of water. Furthermore, brown coal is being replaced by semi-coke produced from it, a development which may be regarded as a real progress from the standpoint of energy economy. Efforts are being made to improve lower-grade brown coal and lignite by removing the ashes, drying, and pressing, and only a shortage of funds for investment purposes is obstructing a more accelerated development in this respect. Research work on these lines is very active, and it can be taken that, according to the country's economic plan, Czechoslovakia will occupy a high place as regards the economic utilization of the fuel produced within its territory.

WATER POWER

The natural conditions in Czechoslovakia are not favourable for the utilization of water power. The territory mostly consists of the upper basins of rivers with small and very variable flow, so that the usable energy is small, even where high heads are available.

The average annual precipitation (1876–1925) in the basin of the Labe (Elbe) is 687 mm. (27 in.), in Moravia 663 mm., and in Slovakia 806 mm., the average value for the whole country being 728 mm. (28·7 in.). The average precipitation in dry years is 537 mm. (21 in.). Rainfalls vary during the year, and the ratio of the minimum to the maximum flow varies from $\frac{1}{200}$ to $\frac{1}{250}$. It is therefore necessary to build expensive dams, with considerable storage capacity.

The systematic utilization of water power in Czechoslovakia was promoted by the law for the systematic electrification of the country in 1919, which provided for the building of dams with public means. The law of national funds (1931) for making rivers navigable, for the construction of dams, and for the utilization

of water power, enabled the building of hydro-electric power plants to be accelerated.

Usable water power. The data on usable water power in Czechoslovakia vary to a great extent. According to the last approximate data, the maximum theoretically usable water power of the country amounts to 10^9 kWh., and 3,000 MW. It will be practicable to utilize 75% of the theoretical value.

From this total amount, about 40% belongs to the rivers Vltava and Váh. The power plants of these rivers will form a complete system, the Vltava plants working in the periods of maximum demand, with a utilization factor of 2,000 hr. while the Váh plants will have a utilization factor of 3,400 hr. This system, together with the steam plants in the brown coal fields of North Bohemia and the coal fields of Ostrava, are the pillars of the energy economy of Czechoslovakia.

Water power in energy economy. Until 1919, the water power utilization was limited to the direct driving of small factories. Only a small number of power plants supplying their immediate neighbourhood were built.

The publication of the above-mentioned laws in 1919 and 1931 made it possible to build larger power plants for supplying larger districts.

Energy production of water-power plants. In 1919, 85×10^6 kWh. from the total production of $1{,}161 \times 10^6$ kWh. (7·3%) was from water power. In 1930, the figure had increased to 270×10^6 kWh. from the total production of $2{,}993 \times 10^6$ kWh. (11%), and in 1948, 909×10^6 kWh. from $7{,}515 \times 10^6$ kWh. (12·1%).

According to the plan, the production of electrical energy in water-power plants will, in 1963, be 4·5 times higher than in 1948, and will amount to 20% of the total production. It is evident that water power can never supply more than a part of the total energy demand, but it will be an important factor in the energy economy, and will postpone the exhaustion of other energy resources, especially of coal. From this point of view great attention is being paid in the planned economy of Czechoslovakia to the more rapid building of water-power plants, especially in Slovakia, where water-power utilization is an essential condition for industrialization.

ELECTRICAL ENERGY

The production of electrical energy in Czechoslovakia is increasing a little more quickly than the volume of industrial production, as in other industrial countries. In the years 1924–37 economic fluctuations are also conspicuous in the production of electricity. The annual increase of production, until 1937, amounted to 6–7%; from 1934 to 1937 it was about 14%. The production per head increased from 125 kWh. in 1924 to 270 kWh. in 1937, an average increase of 8·6% in a year.

After the nationalization of energy production and distribution in 1945, the consumption of electricity increased very quickly. The annual increase in 1946 and 1947 was 16·8%, and the production per head 650 kWh., i.e., 146% more than in 1937. At the end of the 5-year plan the consumption should be 1,000 kWh. per head.

The growth of power plants and a new level of production is keeping pace with the growing production of electricity. The new demand of energy is being

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more and more nearly satisfied through the public supply system of Czechoslovak Energy Works (a national corporation). The contribution of industrial power plants in the whole production of electricity was 62% in 1937; by 1948 it had fallen to 57%; and at the end of the 5-year plan it will be only 30%. Before the Second World War the public electricity supply was produced by the public utility companies established on the basis of the law for systematic electrification, operating from 1919. Most of these companies were owned by the State, by municipalities, and by co-operative societies.

As already emphasized Czechoslovak energy economy is based chiefly on the coal fields. The big power plants are situated in the neighbourhood of the coal mines and make use of waste coal and lower-grade coal. In 1945 the power production in plants using coal from adjacent mines amounted to 48·6%; in plants remote from the mines the figure was 29·5%; in gas and petroleum plants it was 3·52%; and in hydro-electric plants it was 16·3%. By 1953, 62·6% of the production should be based on local fuels. Power plants consuming higher-grade coal are constructed as reserves and to meet maximum demand; in this connexion special mention may be made of the combined power and district-heating plants.

Development of district heating power plants. The steam sent into the distribution lines of district-heating plants increased by 60% during 1938–48. In the same period the length of the steam conduits increased by 80% and the production of electricity in the district-heating power plants by 67%. Great developments in combustion technique were called for to enable waste coal to be utilized. Boilers have been installed with an output of 150 tons per hour for fuels with ash content up to 50%; and boilers with an output of 220 tons per hr. are under construction. In the large power plants the standard pressure in the turbines is 80 atm., and for more than 15 years power plants have been working with Löffler boilers at a pressure of 120 atm. and a temperature of 500°C. (930°F.) and a very high thermal efficiency. In the large condensing plants turbo-generators of 25–32 MW. are used, and there are plants with units of 50 MW. capacity.

The capacity of power plants has the following index: 1937, 100; 1948, 150; 1953, 200. The development of distribution lines is in similar ratio. The standardization of distribution voltages long ago has made possible this extensive electrification of the country, especially in rural districts. The power plants are connected together by a system of 100 kV. lines, and 220 kV. lines are under construction for the interconnexion of water-power systems and large energy-producing centres in coal fields.

The length of high-voltage lines has increased by 28% since 1937. The percentage of municipalities having electric supply has risen from 60% in 1938 to 83% in 1948.

By 1948 the utilization factor had increased by 24% over the figure for 1937. The specific heat consumption is decreasing systematically; the average value for the whole republic was 7,500 kcal. per kWh. in 1939; 5,200 kcal. per kWh. in 1948; and at the end of the 5-year plan it should be 4,300 kcal. per kWh.

Czechoslovakia has important sources of thermal energy, chiefly using waste coal; 40% of this energy is derived from brown coal and lignite, and 60% from black coal. If power plants could have been run at the efficiency which they have recently attained, the entire output of coal would permit a consumption of energy per head about ten times as high as at present.

There is parallel working between the Czechoslovak and the Polish power plants, a co-operation which will be developed further by the construction of 220 kV. lines. Electrical energy produced in thermal power stations in Czechoslovakia and Poland can conveniently complement the energy produced by hydro-electric plants in countries such as Austria.

GAS

After the First World War there were over 80 gas works in Czechoslovakia, all carbonization plants. They were mostly municipal undertakings and were only of local importance. This development continued until the Second World War, when the long-distance pressure lines were laid which inter-linked the carbonization plants and supplied neighbouring towns. In North Bohemia the first pressure gas works utilizing brown coal was put into operation. Eventually gas was distributed through pressure lines totalling over 300 km. (186 miles) in length over all the surrounding industrial districts.

The establishment of the Czechoslovak Energy Works for the production and distribution of both gas and electricity formed the basis of the plan for energy supply to the whole country. The construction of long-distance pipe lines was begun on a large scale for the distribution of gas from brown coal, as well as coke-oven gas, and has been carried out to a small extent for the coal gas. This system makes possible a considerable development in the consumption of gas both in industry and in private houses. In addition, the utilization of natural gas is also increasing. Over the years 1925–35 the average annual increase in the amount of gas distributed was 5·6%; for the years 1935–45 the corresponding figure was 4%; and during 1946–8 it was 14·1%.

The carbonization plants are working with maximum capacity; but the relative importance of their production is decreasing, as the quantity of gas supplied by coke ovens and brown coal works is increasing, as well as the use of natural gas, as indicated by Table I.

TABLE I.—Development of gas supply

	1948 %	1950 %
Gas from carbonizing plants	71·7	52·7
Coke-oven gas	9·5	21·2
Brown-coal gas	18·4	22·3
Natural gas	0·4	3·8

This development will keep pace with the construction of long-distance gas lines, in accordance with the plan for the whole country. Under this scheme further large districts will be supplied with gas, and the country's gas undertakings will form a key industry, supplying energy to important industrial centres and numbers of people.

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Čábelka (water power); Ing. Dr. Jaroslav Ibler (electrical energy); Ing. Dr. Rudolf Riedl (gas); J. Wisinger (statistical data); and Ing. Josef Cenek (editorial arrangement).

Summary

The principal source of energy in Czechoslovakia is coal: black coal, brown coal, and lignite. The water-power resources cover only a small part of the energy required, and in the future this proportion will not change essentially. A constant tendency towards the use of lower-grade coal is noticeable, and this is causing developments in furnaces of special design. This paper deals with the data and characteristic features of solid fuels, water power, electrical energy, and gas in Czechoslovakia.

Résumé

Les Ressources d'Energie et le Développement de la Production d'Energie en Tchécoslovaquie depuis 1924. La base principale de l'énergie en Tchécoslovaquie est le charbon: c'est a dire houille, lignite noir et lignite. Seulement une petite partie de l'énergie demandée peut être livrée par les usines hydrauliques et dans l'avenir cette proportion ne changera pas essentiellement. Une tendence constante vers l'utilisation du charbon de basse qualité est remarquée et ceci influence le développement de constructions spéciales des chaudières. Dans le présent rapport des indications caractéristiques pour la Tchécoslovaquie en ce qui concerne les combustibles solides, les forces hydrauliques, l'énergie électrique et le gaz sont données.

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The total length of navigable waterways in Yugoslavia amounts to about 2,100 km. (1,300 miles).

II. POWER SOURCES

1. Solid Fuels: (a) Mineral coal. Mineral coal deposits are found in the northern and eastern parts of Serbia, between the rivers Mlava and Pek, then from Dobra on the Danube to Vrska Cuka and Bela Palanka; further in north-eastern Bosnia (in the Majevica mountains) and in Istra. The total amount of such coal is not large; probable deposits are estimated at about 100×10^6 tons, the calorific value of this coal being about 6,000–7,000 kcal. per kg. (10,800 to 12,600 B.Th.U.per lb.).

(b) Brown coal. Considerable quantities of brown coal of tertiary formation are found throughout the country. The largest basins of this kind of coal are in Slovenia, in middle Bosnia, and in Serbia. Its calorific value is from 4,000 to 5,000 kcal. per kg. (7,200 to 9,000 B.Th.U. per lb.). The total probable quantities of brown coal have been estimated at 2×10^9 tons.

(c) Lignite. The largest deposits are those of lignite, the average calorific value of which is about 2,200 kcal. per kg. (3,960 B.Th.U. per lb.). The probable deposits have been estimated at 10×10^9 tons. The principal lignite deposits are in western Slovenia (to the north of Ljubljana—the lignite basin of Velenj), in northern Croatia (the lignite basin of Zagorje), in north-eastern Bosnia (the largest in the country: estimated deposits, $4{,}000 \times 10^6$ tons), in eastern Serbia (Kolubara basin), and in south Serbia (Kosovo basin).

(d) Peat. There are also deposits of peat in Yugoslavia, which lie in the basins of the Sava and the Danube. But the best known are the Ljubljana Barje peat deposits, in the Ljubljana district, covering a surface of about 11,000 hectares (42·5 sq. miles). However, peat deposits are of no special importance in Yugoslavia and have not yet been exploited.

(e) Wood. Forests cover 7,441,000 hectares (28,700 sq. miles), or 29% of the whole territory of Yugoslavia, making 0·47 hectare of forest per capita. The total actual value of wood in mass, calculating the volume of trees measured while growing, with bark, was estimated in 1938 at 825×10^6 cu. m., while the annual increase of timber in all kinds of forest was estimated at about 15×10^6 cu. m., that is, about 2·00 cu. m. annually per hectare of forest-covered area. The total consumption of wood for heating in Yugoslavia before the war was about 12×10^6 cu. m. per annum.

(f) Oil shales and other solid fuels. The most important deposits of oil shales in Yugoslavia are in eastern Serbia and in Dalmatia.

The essential characteristic of oil derived from shales in eastern Serbia is its richness in paraffin, its small percentage of light petrol, and its relatively small contents of acid ingredients (phenol) and of sulphur.

Oil shale deposits in eastern Serbia are in the basins of the rivers Morava and Timok. These deposits, as well as those in Dalmatia (north of Split), have not yet been sufficiently investigated, and at present it is not possible to evaluate either their quantity or their quality. Casual distillation tests show that the proportion of oil is over 20%.

2. Liquid fuels: crude petroleum. According to the latest investigations, three vast oil-containing areas have been ascertained up to the present time. One of these is in northern Croatia and extends from the Hungarian frontier as far as

ENERGY RESOURCES AND POWER DEVELOPMENTS

Ressources et Développements de l'Energie

By Ing. JERKO JERIC
Engineer in the Ministry of Electrification, Zagreb

YUGOSLAV COMMITTEE

I. INTRODUCTION

Before World War II, Yugoslavia occupied an area of 248,900 sq. km. (96,000 sq. miles), and after the peace agreement with Italy in 1947, when the Istra province was united to this country, the total area of Yugoslavia increased to 256,600 sq. km. (99,300 sq. miles). Yugoslavia is mainly a mountainous country, 70% of its surface being mountains, and only 30% lowland.

Pre-war Yugoslavia was predominantly an agricultural country, about 77% of its population being engaged in agriculture, forestry, and fishing. After the war considerable changes occurred in the occupations of the population due to the increased employment in mining and industry, which resulted from the changed political and economic conditions of post-war Yugoslavia. According to the census of March 15, 1948, the population of Yugoslavia was 15,752,000. Over 58% of the Yugoslav territory is tillable soil.

There are in Yugoslavia 1,851 streams of at least 10 km. length. Rivers flow into the Black, the Ægean, and the Adriatic seas. Table I shows the areas of the principal slopes in Yugoslavia.

TABLE I.—Areas of principal slopes

Slope	*Area of slope, sq. km.*
Black Sea	174,200
Adriatic Sea	37,700
Ægean Sea	23,900
Rocky barren land	16,700
Separate (closed) slopes	4,100
Total	256,600

5. Survey of power resources. Table II represents a survey of the power resources in Yugoslavia for solid fuels, wood, and water power, but excluding the deposits of liquid and gaseous fuels, such as crude petroleum and natural gas, as well as oil shales, the deposits of which are now being investigated.

In calculations relating to wood and water power, the period of 100 years has been taken, in view of the fact that for this period the existing coal deposit would be sufficient even if consumption should increase many times (about 10 times). It may be mentioned further that the equivalent of water energy is taken as 1 kWh.=5,000 cal.

All these data are only approximate, and precise information will be available only when the investigations and measurements are nearing completion. Such investigations are now in progress.

III. PRODUCTION, IMPORT, EXPORT, AND CONSUMPTION

Tables III to VII show the figures for the years 1928, 1937, 1946, and 1948 covering production, import, export, and consumption of solid, liquid, and gaseous fuels, as well as the production of electric energy. Table VIII gives data for wood fuel in 1938; and Table IX shows the balance of energy consumption in Yugoslavia in various years. Table X shows how the demand for electrical power is distributed among various industries.

TABLE III.—Survey of production and consumption of coal

Year	*Mineral coal, tons* $\times 10^3$				*Brown coal, tons* $\times 10^3$			
	Production	*Import*	*Export*	*Consumption*	*Production*	*Import*	*Export*	*Consumption*
1928	353·9	313·8	—	671·7	3,653·4	35·9	50·3	3,602·0
1937	427·4	188·8	—	616·8	3,544·3	0·9	83·9	3,506·6
1946	756·5	115·5	—	872·0	3,809·0	—	47·6	3,761·4
1948	951·0	134·1	108·5	977·6	6,348·0	19·0	254·9	6,112·1

Year	*Lignite, tons* $\times 10^3$				*Total coal, tons* $\times 10^3$			
	Production	*Import*	*Export*	*Consumption*	*Production*	*Import*	*Export*	*Consumption*
1928	1,043·3	—	2·6	1,048·1	5,050·6	349·7	52·9	5,321·9
1937	1,030·7	—	74·7	1,016·1	5,002·4	163·1	84·1	5,139·5
1946	2,244·2	—	12·7	2,231·5	6,809·7	115·5	60·3	6,846·9
1948	3,490·0	—	1·7	3,488·3	10,789·0	153·1	365·1	10,578·0

TABLE IV.—Survey of production and consumption of coke

Year	*Coke, tons* $\times 10^3$			
	Production	*Import*	*Export*	*Consumption*
1928	17·4	172·2	0·2	191·4
1937	21·8	222·4	—	244·2
1946	22·0*	160·7	—	180·7
1948	28·4	444·2	—	472·6

* Approximately

the Sava river, another is in north-eastern Bosnia, and the third is in eastern Vojvodina. There are also indications of oil in other places.

3. Gaseous fuels: (a) Natural gas. In the Yugoslav petroleum basins, natural gas is also to be found in great quantities. The largest deposits found hitherto are in middle Croatia, east of Zagreb, and in Medjumurje.

This gas is almost pure methane with a calorific value of 8,300–8,400 kcal. per kg. (14,900–15,100 B.Th.U. per lb.). It is found at a depth of 600–800 m. (1,970–2,620 ft.) under pressures of from 20 to 42 atm. There are no definite figures yet as to the quantities of gas, but indications show that they are considerable. At present investigations are being made in this direction.

(b) Manufactured gas. There are gas works in the larger communities and towns in Yugoslavia, gas being consumed in households for cooking and water heating, and also by craftsmen and in industry. The production of manufactured gas in the local gas works amounted in 1928 to $10{\cdot}4 \times 10^6$ cu. m. (367×10^6 cu. ft.), and in 1938 to $14{\cdot}1 \times 10^6$ cu. m. (494×10^6 cu. ft.).

Besides some other by-products, about 17,000 to 22,000 tons of coke are being produced in gas works.

4. Water power. Studies of the water-power resources of Yugoslavia after World War II show that the data in the various world statistics relating to water power in Yugoslavia, based on the temporary registration of water power of the country as a kingdom in 1921, have been much under-estimated. A compilation of water power cadastral data is now being made; but on the basis of the latest estimates it may already be stated that the theoretical water power of FPR (Federal People's Republic) Yugoslavia at mean water amounts to about 14×10^6 kW., and it is estimated that to-day the power capable of being economically developed amounts to about 9×10^6 kW., with about 45×10^9 kWh. per annum.

TABLE II.—Survey of power resources of Yugoslavia (excluding crude petroleum, natural gas, and oil shales)

Origin of energy	*Heating power kcal. per kg.*	*Quantities*			
		Original state		*Converted at 7,000 kcal. per kg.*	
		Unit of measure	*Quantity*	*Quantity, tons* $\times 10^6$	*Per capita tons*
Mineral coal . . .	6,500	tons $\times 10^6$	100	93	
Brown coal . . .	4,000	tons $\times 10^6$	2,000	1,140	
Lignite	2,200	tons $\times 10^6$	10,000	3,140	
Total . .		tons $\times 10^6$	12,100	4,373	277
Fire wood* Increase . . .	3,200	cu. m. $\times 10^6$	750	200	12·7
Water power† . .	5,000	kWh. $\times 10^9$	4,500	3,214	203·5
Grand total	—	—	—	7,741	493·2

* Annual increase of wood, 15×10^6 cu. m., of which 50% is fire wood
† Annual capacity of water power, 45×10^9 kWh.

TABLE V.—Survey of production and consumption of crude petroleum

Year	Crude petroleum, tons × 10^3			
	Production	Import*	Export	Consumption
1928	—	* 104·3	—	104·3
1937	0·5	102·0	—	102·5
1946	23·0	42·5	—	65·5
1948	36·3	240·3	—	276·6

* Crude petroleum together with its derivatives

TABLE VI.—Survey of production and consumption of gaseous fuels

Year	Natural gas, cu. m. × 10^3			Manufactured gas, cu. m. × 10^3			Total, cu. m. × 10^3
	Production	Import	Export	Production	Import	Export	
1928	930·4	—	—	11,401·5	—	—	12,331·9
1937	1,840·9	—	—	14,187·6	—	—	16,028·5
1946	5,554·9	—	—	4,549·6	—	—	10,104·5
1948	6,015·4	—	—	15,335·0	—	—	21,350·4

TABLE VII.—Survey of production of electrical energy

Year	Thermal electric plants, kWh. × 10^6	Hydro-electric plants, kWh. × 10^6	Total, kWh. × 10^6
1928	390	260	650
1937	462	450	912
1946	674	470	1,144*
1948	1,094†	1,075‡	2,169

* Plants over 500 kWh. † Power of plants, 273·7 MW. ‡ Power of plants, 346 MW.

TABLE VIII.—Timber statistics for 1938 (used also as reference figures for post-war years)

Production, cu. m. × 10^6		Imports, cu. m. × 10^6		Exports		Consumption	
Total	Fuel	Total	Fuel	Total	Fuel	Total	Fuel
22·69	12·84	0·0074	0·0034	1·68	0·19	20·49	11·17

The production of denatured alcohol in 1948 amounted to 20,577 tons, of which 120,000 tons were exported

TABLE IX.—Balance of energy consumption in FPR Yugoslavia

Item No.	Fuel	Heating power, kcal. per kg.	Quantities									
			Original condition					Converted at 7,000 kcal. per kg.				
			Unit of measurement	1928	1937	1946	1948	Unit of measurement	1928	1937	1946	1948
1	Mineral coal	6,500	tons × 10^3	672	617	872	978	tons × 10^3	624	574	810	908
2	Brown coal	4,000	,,	3,602	3,507	3,761	6,112	,,	2,060	2,000	2,150	3,495
3	Lignite	2,200	,,	1,048	1,016	2,232	3,488	,,	327	319	702	1,096
4	Totals, 1–3	—	,,	5,322	5,140	6,865	10,578	,,	3,011	2,893	3,662	5,499
5	Coke	7,000	tons × 10^3	192	244	181	473	,,	192	244	181	473
6	Fire wood	3,200	cu.m. × 10^3	11,000	11,175	11,000	11,000	,,	3,020	3,070	3,020	3,020
7	Crude petroleum	1,000	tons × 10^3	104	103	43	240	,,	149	147	62	343
8	Natural gas	8,400*	cu.m. × 10^3	930	1,841	5,555	6,015	,,	1	2	6	6·5
9	Manufactured gas	3,800†	,,	11,401	14,188	4,550	15,335	,,	6	8	2·4	8·7
10	Water power	5,000	kWh. × 10^6	260	450	470	1,075	,,	186	322	335	770
11	Totals, 5–10	—	—	—	—	—	—	,,	3,479	3,599	3,606·4	4,621·2
12	Totals, 4+11	—	—	—	—	—	—	,,	6,490	6,492	7,268·4	10,120·2

* In kcal. per cu. m. † At thermal equivalent 1 kWh. = 5,000 kcal.

TABLE XII.—Number of electrical plants, total installed capacities, and classification of electrical plants according to purpose and type of driving power in 1918 *and* 1938

Year	1918					1938				
Total number of electrical plants	223					790				
Total installed capacities, MW.	215					495				
Average installed capacity per electric plant, MW.	0·955					0·625				
Classification of electric plants according to purpose										
	No.	*%*	*Installed capacity, MW.*	*%*	*Average installed capacity per electric plant, MW.*	*No.*	*%*	*Installed capacity, MW.*	*%*	*Average installed capacity per electric plant, MW.*
Public electric plants	90	40·4	80	37·2	0·890	300	38·0	200	40·4	0·665
"Mixed" electric plants*	28	12·5	27	12·6	0·965	71	9·0	118	23·8	1,660
Industrial electric plants	105	47·1	108	50·2	1·030	419	53·0	177	35·8	0·420
Classification of electric plants according to type of driving power										
	No.	*%*	*Installed capacity, MW.*	*%*	*Average installed capacity per electric plant, MW.*	*No.*	*%*	*Installed capacity, MW.*	*%*	*Average installed capacity per electric plant, MW.*
Hydro-electric plants	—	—	—	—	—	168	21·6	160	32·3	0·952
Steam-power electric plants	—	—	—	—	—	306	38·6	208	42·0	0·680
Diesel-electric plants	—	—	—	—	—	140	17·6	25	5·1	0·179
Electric plants with suction gas engines	—	—	—	—	—	56	7·1	4	0·8	0·071
Electric plants with other prime movers	—	—	—	—	—	120	15·1	98	19·8	0·816

* Electric plants, supplying a part of the current produced for public use

TABLE X.—Power demand, number of industrial establishments, and working places

Kind of industry	*Power demand*		*No. of industrial establish-ments*	*kW. per industrial establish-ment*	*No. of working places*	*kW. per working place*
	kW.	*%*				
1. Extracting and binding materials	16,800	6·64	96	175·0	12,426	1·35
2. Metallurgical	23,050	9·10	43	535·0	15,514	1·48
3. Metal works	13,130	5·18	283	46·5	42,668	0·31
4. Ceramics and glass	9,100	3·59	234	38·9	17,355	0·52
5. Wood	31,600	12·50	622	50·8	42,020	0·75
6. Paper (including printing works)	9,270	3·66	139	66·6	11,095	0·84
7. Chemical	41,250	16·30	241	171·3	16,040	2·58
8. Foodstuffs and agriculture	72,650	28·60	1,374	52·8	42,676	1·70
9. Textiles	28,800	11·39	491	58·6	75,046	0·38
10. Leather and furs	6,490	2·56	109	59·5	14,025	0·46
11. Others	1,210	0·48	18	67·2	3,808	0·32
Total	253,350	100·00	3,650	69·5	292,673	0·87

IV. DEVELOPMENT OF ENERGY IN FPR YUGOSLAVIA

1. Period between the two World Wars. Table X shows the data on the power demand in various branches of Yugoslav industry in 1938. Moreover, in order to give a more precise insight into the conditions of the Yugoslav industry and an estimate as to the degree of industrialization of pre-war Yugoslavia, the table also contains some other characteristic data concerning the power used in various branches of industry.

As regards the consumption of coal produced in Yugoslavia, in 1937 industry occupied the first place with an approximate consumption of 50% of the total production, followed by the railways and shipping, with over 40%. Domestic heating amounted to less than 4%, because of the almost exclusive use of wood fuel for this purpose.

The economics of the electrical industry, as one of the important factors in the development of energy and, in general, of the economics of every country, did not show, in the period between the two World Wars even approximately the increase which could be achieved when the power available in the country is considered.

Table XI outlines the achievements in the production of electrical energy in the period between the two World Wars.

TABLE XI.—Production of electrical energy in 1918, 1931, *and* 1937

Year	*No. of inhabitants, millions*	*Production in kWh.* $\times 10^6$			*Per capita, kWh.*	*Index per capita*
		Hydro-electric	*Thermal*	*Total*		
1918	11·50	285	165	450	39	100
1931	14·00	291·5	493·5	785	56	143
1937	15·28	450	462	912	60	154

From Table XI it is evident that the average annual increase in the consumption of electrical energy in pre-war Yugoslavia was about 5%, while the specific consumption per capita averaged 2·7% only.

Table XII gives further data concerning the number of electrical plants, the installed capacity, and the purpose and kind; it also includes figures, derived from these data, relating to the average capacity of the power installed in the different electrical plants.

These figures show that from 1918 to 1938 the number of electrical plants increased considerably—about 3·5 times—but that the installed capacity increased only 2·3 times, proving that in the period between the two World Wars the development of electric economics in Yugoslavia progressed on lines totally opposite to those of most other European and overseas countries. Instead of concentration of power in large and powerful energy-producing plants, decentralization took place in pre-war Yugoslavia, and unprofitable electrical plants of small size were erected locally.

Further, of the 168 hydro-electric plants existing in 1938, with a total installed capacity of 160 MW., two alone had an installed capacity of 104 MW. (65% of the total). In the remaining 166 plants, only 56 MW. were installed, so that the average installed capacity per electric plant hardly amounted to 0·34 MW. This applied also to steam-operated power plants, and still more to electrical plants using other kinds of prime movers.

According to Table XII, the water power in Yugoslavia has lately been estimated at 9,000,000 kW., but only 160,000 kW., or about 1·78%, had been utilized before World War II.

All these data on the utilization of energy resources in pre-war Yugoslavia clearly indicate the technical backwardness of the country, in spite of favourable economic conditions. Under such conditions, electrification was of limited scope and concerned only restricted areas, mostly in the vicinity of the larger towns and mining districts. This also explains why, in pre-war Yugoslavia, the highest voltage was limited to 80 kV., which was used for a single transmission line supplying northern Slovenia with electrical energy from the Fala hydro-electric plant on the Drava river.

Of a total of 4,645 municipalities which existed in Yugoslavia in 1938, only 713 (that is, 15%) were supplied with electricity, while the number of inhabitants who had been using electricity amounted to about 4,200,000, or about 27% of the then total population.

2. Post-war period up to 1948. After the end of hostilities in 1945, reconstruction work was begun energetically, and in a relatively short time (by the end of 1946) property and plant destroyed or damaged by the war was again put into working condition in all principal branches of industry (railways, coal and other mines, smelting works for iron, copper, lead, etc.). The beginning of the year 1947 was an important turning point in the economic life of the whole country. The government brought in the 5-year economic plan for the period 1947–51. The basic tasks in this 5-year plan are: to rationalize the existing coal mines and to open new ones; to raise the coal and coke production from 6,068,000 tons in 1949 to 16,500,000 tons in 1951, or by 272%; of crude petroleum from 1,000 tons to 450,000 tons in 1951, or by 450 times; to begin the exploitation of oil shales and constantly to increase their production; to rationalize the consumption of coal in communications and in industry; to reduce the present quotas

of coal consumption considerably; to ensure a change-over to the consumption of lignite dust and small-grained brown and mineral coal; to eliminate the use of wood as an industrial and a domestic fuel by replacing it with coal of suitable quality; and to erect plants for the treatment of lignite, to enable it to be used as fuel and as raw material for the chemical industry.

As regards electric power economics, the 5-year plan sets forth the following goals:—

(1) To increase the production of electrical energy from $1{\cdot}1 \times 10^9$ kWh. in 1939 to $4{\cdot}35 \times 10^9$ kWh. in 1951; to increase the production of cheap electrical energy by the construction of hydro-electric plants incorporating the latest achievements of modern technique; to begin the construction of some hydro-electric plants which will start working after 1951.

(2) To erect thermal plants with condensation to serve as supplementary plants, based principally on waste coal and on coal not fit for transportation; to carry out the utilization of waste heat and waste gases in metallurgical and large industrial plants.

(3) In cases where large quantities of heat are needed for manufacturing processes, to erect thermal plants in which suitably treated fuels could be utilized.

(4) To build up the electrical industry and carry out the electrification of the country.

Summary

The report gives a survey of the state of power resources in Yugoslavia, based on present-day knowledge. It also shows the development of power economics during the period from 1924 to 1948 inclusive, supported by statistics covering the production and consumption of natural fuels, of water power, and of electrical energy.

Résumé

Ressources et Développements de l'Energie. Le rapport fournit une étude de l'état des ressources d'énergie en Yougoslavie, basée sur les données connues usqu'à présent. Il montre aussi le développement de l'économie générale de l'énergie depuis 1924 jusqu'en 1948, avec les données qui se rapportent au développement de la production et de la consommation des combustibles naturels, de l'énergie hydraulique et de l'énergie électrique.

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