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POWER SOURCES IN POLAND

AND THEIR UTILIZATION

PUBLISHED BY THE POLISH NATIONAL COMMITTEE
OF THE WORLD POWER CONFERENCE

WARSAW, 1931

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Drukarnia
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Wydawniczych
M. Arct S. A.
Warszawa

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PREFACE

The question of the available power reserves, with regard to the continuously increasing importance of mechanical energy and to the enormous progress of electrification, has now-a-days become a problem of almost the same importance as that of the technological raw materials, forming the basis of a rational policy in this field. The actuality of that question has been so great during recent years, that it has not only become an immence internal economical problem for the different countries, but it reached the rank of questions of great international importance. It was therefore rational that the World Power Conference considered the realization of a rational inventorisation of power reserves on a world-wide scale as one of its most important tasks. — Performing that task within the limits of its territorial activity, the Polish Power Committee, began as early as 1924 to register the power resources of its country, placing the results before the London World Power Conference in its report: „Resources d'énergie et leur exploitation en Pologne", in which the statistical data were followed by short explanations. The interest, which this report aroused, especially beyond the frontiers of Poland, induced the Polish Power Committee to elaborate a new enlarged edition of the publication of power sources in Poland, with maps indicating the distribution of these sources, as well as of the high tension lines; and it is this new edition, the title of which is „Power Sources in Poland and their Utilization", which is now launched into the World.

In this publication the following questions have been treated in a logical order: geological characteristics, methods of output, the quantity and the nature of Polish coal, the reserves and the exploitation of petroleum and of gas fields, of peat and wood,

which in the eastern parts of the country, situated far away from the coal centres, has also considerable importance as a fuel. A particular chapter has been devoted to water power. Wind power also has been taken into consideration. The second part of the book treats of the utilization of the power sources mentioned above, giving a short characteristic of transport by different means, describing the present state and the future possibilities of the development of the gas industry in Poland, as well as analyzing in a rather detailed manner the problem of the production and consumption of electrical energy. An important space has been reserved for the electrification of the country, as one of the most perfect forms of utilization of energy; statistical data reaching up to 1930, diagrams and electrification maps give a clear image of the present state and of the possibilities for further development. A short bibliography, comprising the most characteristical works about the Polish power sources, has been also added to the present publication. In giving this book for the use of all those, who are interested in the problem of power sources, the Polish Power Committee is convinced to have not only fulfilled its task as a member of the World Power Conference, but also to have rendered more accessible the materials illustrating this sphere of the economic life of Poland in an impartial way, contributing, perhaps, thereby to remove a great quantity of gaps and inexactitudes in foreign publications.

POLISH NATIONAL COMMITTEE
WORLD POWER CONFERENCE

POWER SOURCES

C O A L

GEOLOGICAL CHARACTERISTICS

By St. Czarnocki

All the ascertained coal resources of Poland are situated in the area known as the Polish Coal Basin (Polskie Zagłębie Węglowe) which constitutes the eastern part of the Polish-Silesian Basin. Of the total area of the Polish-Silesian Basin, which, within the limits defined by productive deposits, amounts to 5400 square kilometres:

Poland	possesses	3 880 sq. km.
Czechoslovakia	„	950 „ „
Germany	„	570 „ „

The Polish Coal Basin is divided into the four following districts:

1) Upper Silesia	2 180 sq. km.
2) Teshen Silesia.	200 „ „
3) The Cracow Basin	1 300 „ „
4) The Dombrowa Basin . . .	200 „ „
	3 880 sq. km.

From the geological point of view, the area of the Polish-Silesian Basin forms one complete whole.

The area of 3 880 square kilometres comprises, within the boundaries of Poland, the region in which the presence of coal deposits has actually been proved. The western and northern

boundaries of our Coal Basin are defined partly by the frontiers of the State and partly by the deposits underlying the productive coal measures. In respect to the eastern boundary, certain geological factors indicate the possibility of extending the Basin farther to the South East, beyond its present boundary. In the southern part of the Basin the productive coal measures are covered with a thick series of deposits known as Carpathian Flysch. A whole series of drillings sunk to 800—1000 meters failed to pierce this covering. The exact extension of our Basin to the South thus remains unknown.

The productive coal measures outcrop only in limited parts of the Polish Basin, whereas in the remainder of the area they are covered by a thicker or thinner layer of strata of more recent formation.

For practical purposes we shall divide our coal measures into three main groups: the Lower, which bears the name of „Brzeżna" (German: Randgruppe), the Middle or „Siodłowa" (German: Sattelgruppe) and the Upper, which is called „Łękowa" (German: Muldengruppe).

In the Dombrowa Basin the same groups have other local names. The Lower group is called „Podredenowa", the Middle is known as „Redenowa" and the Upper — as „Nadredenowa".

The total thickness of productive coal measures in the Polish Coal Basin decreases from West to East. In the West of our Basin it amounts to about 4 500 metres, whereas in the East, the corresponding figure falls to 2 700 metres.

The above mentioned main groups of coal measures are subdivided into several smaller groups.

Short characteristics of each of these groups are given in table I (see opposite page).

The productive coal measures are folded in the two following directions: 1) folds with general longitudinal trend with certain occasional deviations to NNE—SSW and 2) folds trending latitudinally with occasional deviations to WNW—ESE.

The folds of the first type are most strikingly expressed in the western part of the Basin, in the Rybnik area.

To the East of the Rybnik area the longitudinal folding plays a secondary part; the main folds have a trend which is approximately latitudinal.

TABLE I.

Thickness of Coal Measures.

GROUP	Total thickness in metres		Aggregate thickness of workable coal seams in metres		Quantity of workable seams in metres		Ratio of aggregate thickness of workable seams to total thickness of group in metres	
	West	East	West	East	West	East	West	East
Upper Group (Łękowa, „Nadredenowska")								
Chełm Series	118	118	1,4	1,4	1	1	1,6	1,2
Łaziska „	675	675	28,6	28,6	14	14	4,4	4,4
Orzesze „	1 700	716	25,0	7,8	17	3	1,7	1,1
Ruda „	585	255	38,0	4,3	20	3	6,5	1,7
Middle Group (Siodłowa, „Redenowska")	170	12	17,0	12,0	5	1	10,0	100,0
Lower Group (Brzeżna, „Podredenowska")								
Upper Series	750	905	16,0	8,0	14	8	2,1	0,9
Lower „	470		11,4		8		2,4	
(Upper part of this group is operated in the Rybnik district)								
Total of productive carbon . .	4 468	2 681	137,4	62,1	79	30	3,1	2,6

We shall now deal with the factors of geological nature which play the most important part from the point of view of the economics of coal mining, comparing the Polish Coal Basin with other Basins in Europe.

In respect to the thickness of seams, our Coal Basin distinguishes itself advantageously. In two groups, the „Middle" and the „Ruda" which at present give about 3/4 of our output, the majority of the available reserves lies in seams possessing a thickness of more than 2 metres, whereas in other large basins in Europe seams in excess of 2 metres are comparatively rare. It should be noted, however, that in the eastern part of our Basin where the „Middle" (Siodłowa) group thins out into one seam with a thickness varying from twelve to eighteen metres, such a great thickness of seam actually presents a certain disadvantage from the mining point of view.

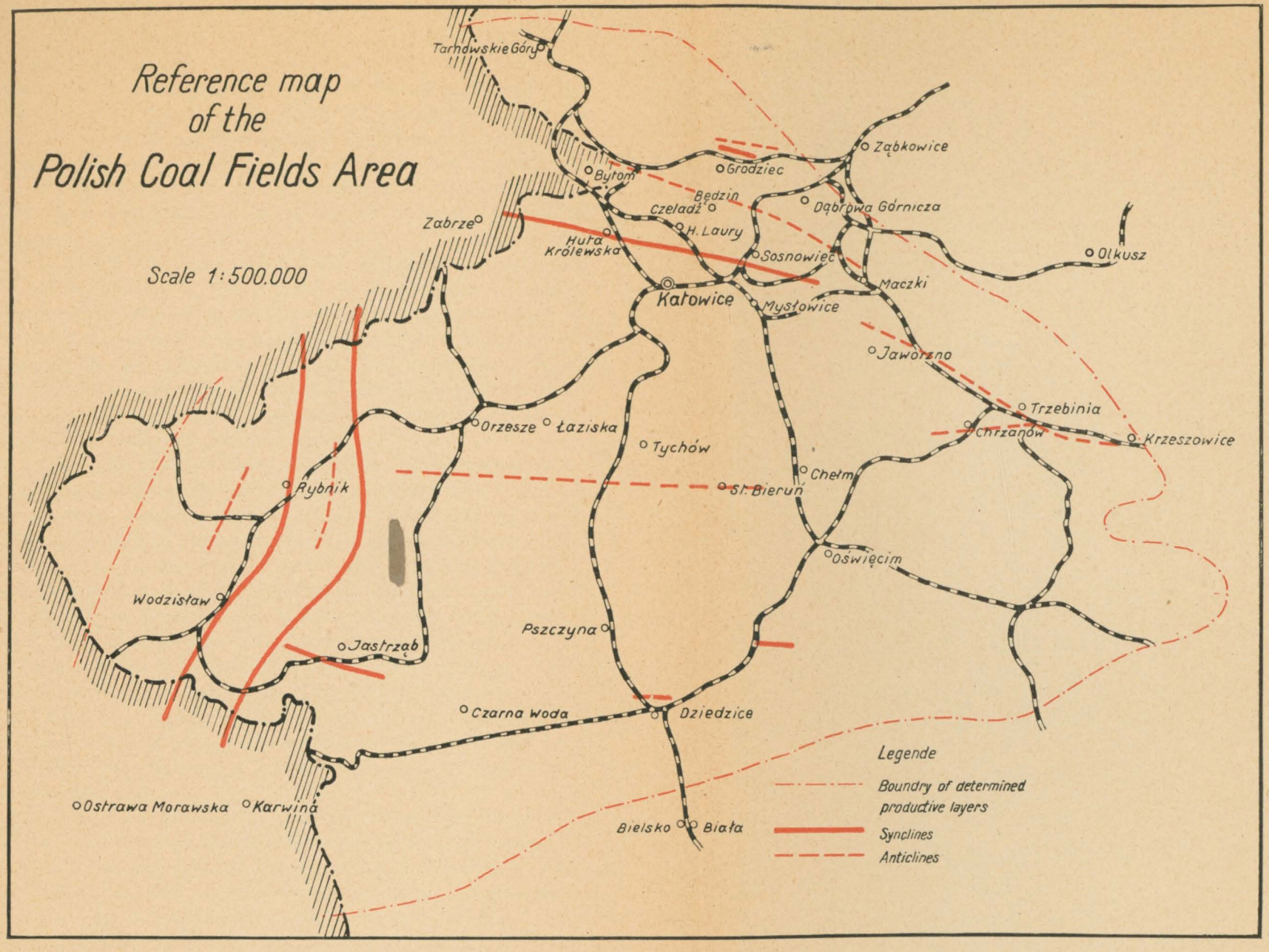
Another important factor is the ratio of the aggregate thicknesses of the workable seams to the total thickness of the productive coal measures. The higher this ratio (i. e. the less the thickness of the barren rocks), the more favourable are the mining conditions, as it is possible to avoid driving long cross cuts and easy to arrange ventilation and underground transport.

If in the Coal Basin we separate the „Middle" (Siodłowa) and „Ruda" groups from the whole cross section of the productive coal measures, we obtain in the western part of the Basin a series of strata with a total thickness of 755 metres, of which 55 metres is of workable coal seams, which makes up 7,3%. The aggregate thickness of the coal seams contained in these two groups therefore amounts to approximately 40% of the total thickness in the western part of the Basin.

To the East in the Dombrowa Basin geological conditions slightly deteriorate. The „Middle" (Siodłowa) group becomes one seam with a considerable thickness, while in the „Ruda" group the percentage of coal amounts to barely 1,7%. In any event, our coal deposits are in more favourable conditions than in other European Basins.

The „Middle" (Siodłowa) and „Ruda" groups form the basis of the present operations in the Coal Basins. They supply about 75% of the total output.

The third factor is the thickness of the coal measures' roof, or, in other words, those upper strata of more recent geolog-


Reference map
of the
Polish Coal Fields Area
Scale 1:500.000
Tarnowskie Góry
Zabrze
Bytom
Grodziec
Ząbkowice
Będzin
Czeladź
Dąbrowa Górnicza
H. Laury
Huta Królewska
Sosnowiec
Olkusz
Katowice
Mysłowice
Maczki
Jaworzno
Trzebinia
Chrzanów
Krzeszowice
Orzesze
Łaziska
Tychów
Chełm
Rybnik
St. Bieruń
Oświęcim
Wodzisław
Jastrząb
Pszczyna
Czarna Woda
Dziedzice
Ostrawa Morawska
Karwina
Bielsko
Biała
Legende
Boundry of determined productive layers
Synclines
Anticlines

ical formation which it is necessary to pierce in order to reach the coal. In this respect our Basin is not uniform. In a general way it may be divided into two areas: 1) the northern — approximately up to the latitude of Stary Bieruń — in which the productive coal deposits either oucrop or have a covering which does not exceed 100—150 metres and 2) the southern, in which the productive carbon only appears on the surface in the form of a few „islands" whereas, in the remainder of the area, it is covered by strata reaching up to several hundred metres in thickness.

The fourth important factor is the quality of the coal. Our coal belongs chiefly to the gas and gas-flamy types containing large quantities of volatile matter. Of coking coal, particularly of that which is suitable for the production of furnace coke, we have comparatively little. We have no steam coal or anthracite whatever. The three main types mentioned are not in any way connected with any particular group of seams and their occurrence is chiefly dependent on factors of tectonic nature.

In those parts of our Basin which have not undergone intensive folding and where the coal has thus retained a greater percentage of volatile matter, we have gas-flamy coal and partly gas coal. These territories are situated in the East and in the central area of the trough. In the West — in the area of intense folding in a longitudinal direction (the Rybnik area) and particularly there where longitudinal and latitudinal folds intersect — which occurs to the West of Królewska Huta, near Zabrze (Hindenburg), the coal belongs to the bituminous type and partly to the type suitable for coke production. Coal of a coking quality constitutes 6—7% of the total output and the greater part of the coke produced is not of a very high grade. Its chief disadvantage, particularly from the point of view of using it in large furnaces, is its lack of resistance to crushing.

In respect to its calorific value the Polish coal varies considerably. In this case also the influence of folding, tending to increase the calorific value of coal, is noticeable. However, we have some indications that in this respect the group of seams from which the coal is obtained also exerts a certain influence. It is very difficult to characterise the calorific values of coal from certain groups of the particular parts of the Coal Basin as, in the available analytical material, there is a whole series of factors

which render the preparation of a table difficult, i. e. lack of uniformity in laboratory methods and various methods of taking samples.

It should be pointed out, however, that the calorific value of all groups of seams generally decreases from West to East. In the West the figures for the „Middle" (Siodłowa) and „Rudzki" groups reach 7000 and 7700 calories; for the same groups in the eastern part of Silesia they amount to 6500 — 7000; in the Dombrowa Basin to 6000—6500 and finally in the Łaziska and Orzesk groups of the Cracow Basin to 5000 calories.

In computing our coal reserves we only take into consideration such seams as lend themselves to refilling on account of their thickness. As the minimum thickness of such seams we take 0,50 to 1 metre (for different groups of seams), as the maximum depth for computation we take 1000 meters.

TABLE II.

Reserves of Coal in units of 1 000 000 tons.

RESERVES	Actual *a*	Probable *b*	Possible *c*	Total *a+b+c*	%
Upper Silesia:					
Upper Group (Łękowa). . . .	4 703	34 918		39 621	
Middle „ (Siodłowa) . . .					
Lower „ (Brzeżna) . . .	585	4 675		5 260	
Total	5 288	39 593		44 881	72,6
Dombrowa Basin.					
Upper Group (Łękowa) . . .	130	120		250	
Middle „ (Siodłowa) . . .	210	500	190	900	
Lower „ (Brzeżna) . . .	160	280	610	1 050	
Total	500	900	800	2 200	3,6
Cracow Basin	8 200		6 000	14 200	23,0
Teshen Silesia			500	500	0,8
Total	5 788 + 8 200	40 493	7 300	61 781	100.0

We divide the reserves into the three following categories:

1) Actual reserves relating to the territories where deposits have been examined by means of mining operations.

2) Probable reserves on territories examined by a series of drillings.

3) Possible reserves which embrace territories where there is a complete lack of prospecting work or where we have a small number of occasional drillings spread over a large area.

The results of the computations effected on the above principles are shown in table II.

The geographical situation of our coal reserves is unfavourable. They are all centered in one basin which is situated right on the frontier of the State and a long way from waterways. In this respect Poland cedes precedence to other coal producing countries of Europe.

INDUSTRIAL CHARACTERISTICS

By Z. Rajdecki

From the industrial viewpoint, Polish coal may be divided into: 1) coke producing coal, 2) gas coal, 3) forge coal and 4) boiler coal.

At the coke plants many by-products are obtained such as: tar, naphthaline, crude benzol, ammonium sulphide, gas tar and coke gas.

In tar distilleries and benzol plants crude tar, crude benzol and other crude oils are made into marketable articles such as tar, crude and pure naphthaline, pirydine bases (C_5H_5N etc.), phenols and benzols of all kinds, concentrated ammonia, ammonium sulphide and other preparations. Coke is used for smelting purposes, as a fuel in iron, steel and metal foundries and for other purposes in the metallurgical industry.

Forge coal is suitable for factory forges. Polish coal is also a first class fuel for factories and for household use.

Polish coal is better than the corresponding quality of English coal in respect of ash and sulphur contents. In addition to this, and as a result of the smaller silica (SiO_2) and aluminium oxide (Al_2O_3) contents of the ash, fire bars do not get slag-clogged during combustion.

Thanks to its large oxygen and volatile contents, Polish coal burns with a long flame, which enables its theoretical calorific value to be utilised to a very high degree.

Other valuable properties which should be noted are: ease of ignition and resistance to atmospheric influences during storage.

With regard to compactness and hardness Polish coal is classed among the hardest qualities of coal with the exception of anthracite. This property enables a very wide variation of sizes in grading and long distance transport without crumbling.

This high degree of variation in sorting has a very important significance for the rational utilisation of coal for various industrial purposes.

The classification of Polish coal according to its quality, which was determined by the general Polish Coal Convention (Ogólno-Polska Konwencja Węglowa), depends on division into 6 classes for all sorts of coal, with the exception of dust, and into 4 classes for dust.

TABLE III.

Sizes of sorting grades.

	In Upper Silesia	In the Dombrowa and Cracow Basins
Large	above 70 mm	above 120 mm
Cobbles I and II	„ 45 „	„ 40 „
Nuts Ia	„ 30—80 „	
„ Ib	„ 25—45 „	„ 20—60 „
„ IIa	„ 15—40 „	
„ IIb	„ 15—30 „	„ 10—40 „
„ III		„ 5—25 „
Small coal	„ 10—30 „	„ 6—15 „
Slack	„ 5—20 „	„ 3—15 „
Dust	„ 0—15 „	„ 10— 0 „

The Polish Standards Committee (Polski Komitet Normalizacyjny) is preparing a scheme for the standardisation of the grading of Polish coal which fixes identical standard dimensions for such grading for all the collieries in the Polish Basin.

General conditions of exploitation. The favourable geological conditions of the Polish Basin, particularly the very considerable thickness of the coal seams, allow easy mining and favour an increase in the efficiency of the miners.

In 1928 the output in kilograms per workman per day in Poland amounted to 1 267, in Gr. Britain to 1 111, in Germany

(the Ruhr Basin) to 1 191, in Belgium to 554 and in Czechoslovakia to 1 016.

Besides, the expenditures for installations and consumption of the operation materials are less than in other Coal Basins in Europe.

Coal mining embraces 92 mining enterprises which own 103 mines. Of those mines two belong to the State Treasury, the remainder being private enterprises. French, German and Polish capitals take part in the private enterprises. Of the coal companies in the Silesian district eight, which are the owners of 38 collieries, have each an output of over 2 million tons annually; two with 6 mines have an output of about 2 million tons each; two with 4 mines from 1,2 to 1,3 million tons each; two with 5 mines about 1 million tons and the remainder, each owning one mine, from 500 000 to 3 000 tons annually.

In the Dombrowa district there are 9 Joint Stock Companies and 46 single enterprises which operate the so-called „surface

TABLE IV.

Output of Coal in Poland during the period 1913 — 1929 according to Mining Districts.

Year	COAL DISTRICTS						Total	
	Dombrowa		Silesian		Cracow			
	thousands of tons	1913= =100	thousands of tons	1913= =100	thousands of tons	1913= =100	thousands of tons	1913= =100
1913	32 182	100,0	6 819	100,0	1 971	100,0	40 972	100,0
1914	27 588	85,7	4 540	66,6	1 727	87,7	33 855	82,6
1915	28 282	87,9	2 791	40,9	1 643	83,4	32 716	79,9
1916	31 624	98,3	5 212	76,4	1 848	93,7	38 684	94,4
1917	32 053	99,6	4 911	72,0	1 869	94,9	38 834	94,8
1918	29 777	92,5	4 499	66,0	1 575	79,9	35 851	87,5
1919	19 363	60,2	4 614	67,7	1 349	68,4	25 326	61,8
1920	24 443	76,0	4 874	71,5	1 385	70,3	30 702	74,9
1921	22 469	69,8	5 752	84,4	1 673	84,9	29 894	73,0
1922	25 591	79,5	7 055	103,5	1 986	100,8	34 631	84,5
1923	26 630	82,8	7 419	108,8	2 049	104,0	36 098	88,1
1924	23 871	74,2	6 585	96,6	1 824	92,6	32 280	78,8
1925	21 660	67,3	5 729	84,0	1 692	85,9	29 081	71,0
1926	26 165	81,3	7 226	106,0	2 356	119,6	35 747	87,3
1927	28 600	87,0	7 644	112,1	2 440	123,8	38 084	93,0
1928	30 448	94,6	7 635	112,0	2 533	128,6	40 616	99,1
1929	34 444	107,0	8 947	131,2	2 844	144,3	46 235	112,8

mines". The number of deep mines amounts to 24. Of the 9 companies referred to above, five have an annual output of about one million tons annually each and four of about half a million tons each.

The „surface mines" have an annual output of from five to eighty thousand tons.

The Cracow district has nine enterprises with seventeen mines. The annual output of these enterprises amounts to from one hundred thousand to one million tons. The capital invested in the coal mining industry amounts to about 667 million Zloties.

Output of coal. Poland's share in the World's output of coal in 1928 was 3,26% and its share in the European output about 7%. Thus, Poland took fourth place in Europe after Great Britain, Germany and France.

The table of the output of coal in Poland for the period 1913—1929 illustrates the changes which took place in output in figures and in the ratio to 1913 during which year the output reached its highest prewar figure.

The shares of the individual coal districts in the total output undergo minimal changes. In 1929 they were as follows;

Silesian Basin	74,5%
Dombrowa Basin	19,4%
Cracow Basin	6,1%

The increase in the marketing of coal during the period 1925—1929 amounted to 63,9%, or an average of 12,8% per annum. The home market increased by 11,7% and the export market by 15%.

The marketing of coal according to various grades and districts, together with the percentage share of each grade in each particular item for 1928 is given in tables V and VI.

The home market accounts for about 65% and the export market for about 35% of the whole market.

The above data show that Poland is a country which produces coal for its own requirements to a much greater extent than for export. The present consumption of coal in Poland amounts to about 0,9 tons per head per annum, or less than in other European countries.

As can be seen from Table VII, the main home consumers are the industries and the railways. The third place is taken by

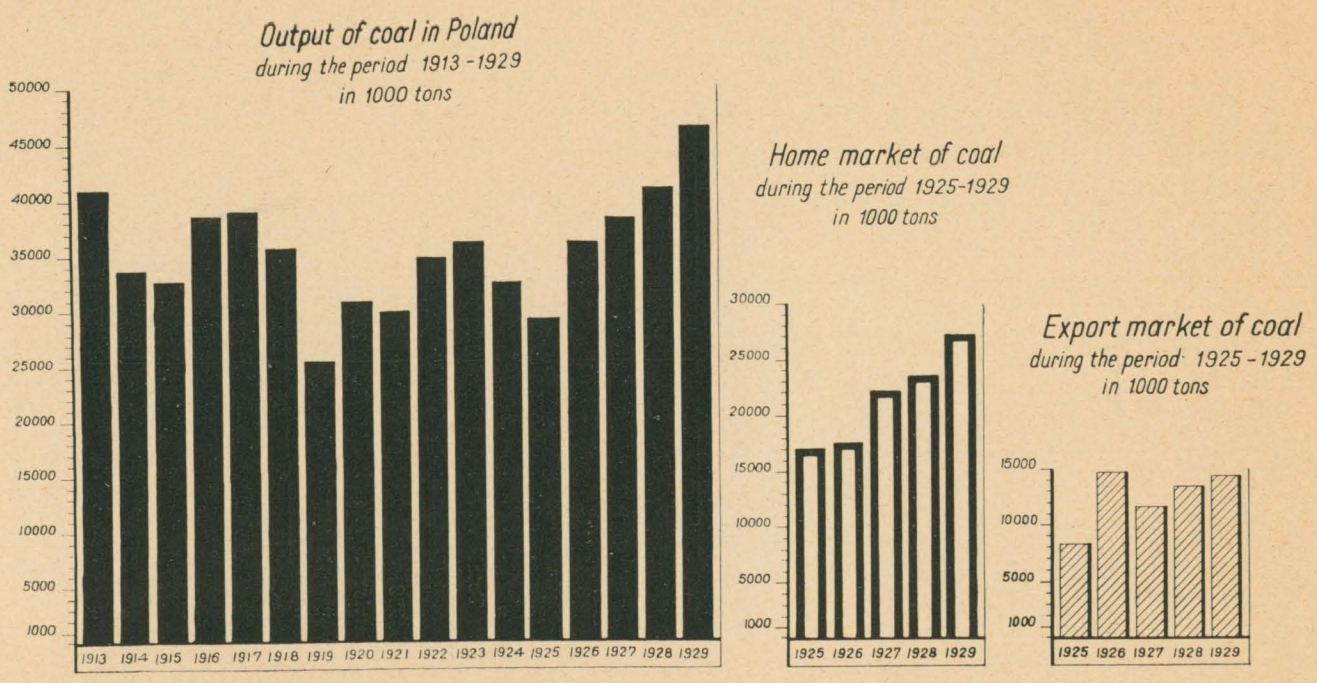

Output of coal in Poland
during the period 1913 - 1929
in 1000 tons
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
1000
1913 1914 1915 1916 1917 1918 1919 1920 1921 1922 1923 1924 1925 1926 1927 1928 1929
Home market of coal
during the period 1925-1929
in 1000 tons
30000
25000
20000
15000
10000
5000
1000
1925 1926 1927 1928 1929
Export market of coal
during the period 1925 - 1929
in 1000 tons
15000
10000
5000
1000
1925 1926 1927 1928 1929

Fig. 1.

TABLE V.

Marketing of coal in Poland during the period 1925 — 1929 according to Coal Districts.

	Home Market		Export Market		Total	
	thousands of tons	%	thousands of tons	%	thousands of tons	%
1925						
Silesian District	11 112	65,0	7 738	94,0	18 850	74,4
Dombrowa „	4 596	26,9	461	5,6	5 057	20,0
Cracow „	1 386	8,1	31	0,4	1 417	5,6
Total	17 094	100,0	8 230	100,0	25 324	100,0
%	—	67,5	—	32,5	—	100,0
1926						
Silesian District	11 900	67,4	11 998	81,6	23 898	73,9
Dombrowa „	4 140	23,5	2 312	15,7	6 452	19,9
Cracow „	1 602	9,1	397	2,7	1 999	6,2
Total	17 642	100,0	14 707	100,0	32,349	100,0
%	—	54,5	—	45,5	—	100,0
1927						
Silesian District	15 369	69,3	9 680	83,6	25 049	74,2
Dombrowa „	4 778	21,5	1 892	16,4	6 670	19,7
Cracow „	2 047	9,2	7	—	2 054	6,1
Total	22 194	100,0	11 579	100,0	33 773	100,0
%	—	65,7	—	34,3	—	100,0
1928						
Silesian District	16 734	71,1	11 297	84,2	28 031	75,7
Dombrowa „	4 673	19,7	2 100	15,7	6 773	18,5
Cracow „	2 154	9,2	10	0,1	2 164	5,8
Total	23 561	100,0	13,407	100,0	36 968	100,0
%	—	63,7	—	36,3	—	100,0
1929						
Silesian District	19 287	71,2	11 872	82,6	31 159	75,1
Dombrowa „	5 462	20,1	2 480	17,3	7 942	19,1
Cracow „	2 374	8,7	19	0,1	2 393	5,8
Total	27,123	100,0	14,371	100,0	41 494	100,0
%	—	65,4	—	34,6	—	100,0

TABLE VI.

Coal Statement for the Polish State Collieries for 1928, according to particular items and grades, in units of 1000 tons or percentages.

	Large	Cobbles I	Cobbles II	Nuts I a	Nuts I b	Nuts II	Small coal & slack	Small coal 0—70 mm	Small coal 0—35 mm	Dust	Slime	Slate	Ungraded	Unsorted	Total
Home market . .	3 928	3 604	1 096	1 604	891	1 202	1 718	1 154	704	6 810	—	268	48	534	23 561
	16,67%	*15,30%*	*4,65%*	*6,81%*	*3,78%*	*5,10%*	*7,29%*	*4,90%*	*2,99%*	*28,91%*	—	*1,14%*	*0,20%*	*2,26%*	*100,00%*
Export	2 901	2 766	1 132	1 990	665	790	1 130	1 014	164	514	—	—	35	305	13 406
	21,64%	*20,62%*	*8,44%*	*14,85%*	*4,96%*	*5,89%*	*8,43%*	*7,56%*	*1,23%*	*3,84%*	—	—	*0,26%*	*2,28%*	*100,00%*
Total market .	6 829	6 370	2 228	3 594	1 556	1 992	2 848	2 168	868	7 324	—	268	83	839	36 967
	18,47%	*17,23%*	*6,03%*	*9,73%*	*4,21%*	*5,39%*	*7,70%*	*5,86%*	*2,35%*	*19,81%*	—	*0,72%*	*0,23%*	*2,27%*	*100,00%*
Used by collieries: for technical purposes	63	18	13	25	11	24	25	32	26	2 457	168	280	2	55	3 199
	1,97%	*0,56%*	*0,40%*	*0,77%*	*0,34%*	*0,75%*	*0,79%*	*1,01%*	*0,82%*	*76,82%*	*5,25%*	*8,75%*	*0,05%*	*1,72%*	*100,00%*
for payments in kind	64	11	16	109	195	84	3	58	10	—	—	56	3	8	617
	10,50%	*1,80%*	*2,51%*	*17,79%*	*31,45%*	*13,51%*	*0,56%*	*9,33%*	*1,55%*	*0,10%*	—	*9,08%*	*0,48%*	*1,34%*	*100,00%*
Total used . .	127	29	29	134	206	108	28	90	36	2 457	168	336	5	63	3 816
	3,35%	*0,76%*	*0,74%*	*3,52%*	*5,37%*	*2,81%*	*0,75%*	*2,36%*	*0,94%*	*64,41%*	*4,40%*	*8,81%*	*0,12%*	*1,66%*	*100,00%*
Total deliveries.	6 956	6 399	2 357	3 728	1 762	2 100	2 876	2 258	904	9 781	168	604	88	902	40 783
	17.06%	*15,69%*	*5,53%*	*9,15%*	*4,31%*	*5,15%*	*7,05%*	*5,53%*	*2.22%*	*23,99%*	*0,41%*	*1,48%*	*0,22%*	*2,21%*	*100,00%*

household consumption (items „household consumption" and the majority of sundries).

Among the various branches of industry, first place in respect of coal consumption is taken by coke plants, which are followed by the metallurgical industry, cement factories and agriculture.

TABLE VII.

Home Coal Market according to Consumers.

No.	NATURE OF CONSUMER	Thousands of tons	%
	I. Industries.		
1	Metallurgical (Iron)	1 772	6,6
2	„ (Other metals)	1 060	3,9
3	Coke Plants	2 479	9,3
4	Briquette Factories	350	1,3
5	Gas Works	418	1,5
6	Mining (ore and other mines not having own coal)	169	0,6
7	Petroleum	232	0,9
8	Salt	177	0,7
9	Cement, pottery, brickfields and lime kilns	1 323	4,9
10	Manufacturing (metal and others)	230	0,8
11	Chemical	618	2,2
12	Tannery and manufacture of animal products	46	0,1
13	Agricultural (agricultural products, breweries, mills and distilleries)	1 143	4,2
14	Sugar factories	721	2,7
15	Paper mills	343	1,3
16	Textile	971	3,5
17	Other branches of industry	2 367	8,7
	Total for Industry	14 419	53,2
	II. Other Consumers.		
1	Railways	5 035	18,6
2	Shipping	10	—
3	Municipal institutions	722	2,7
4	Military institutions	325	1,2
5	State institutions	196	0,7
6	Household use	3 095	11,4
7	Sundries	3 321	12,2
	Total for other Consumers	12 704	46,8
	Total Home Market	27 123	100,0

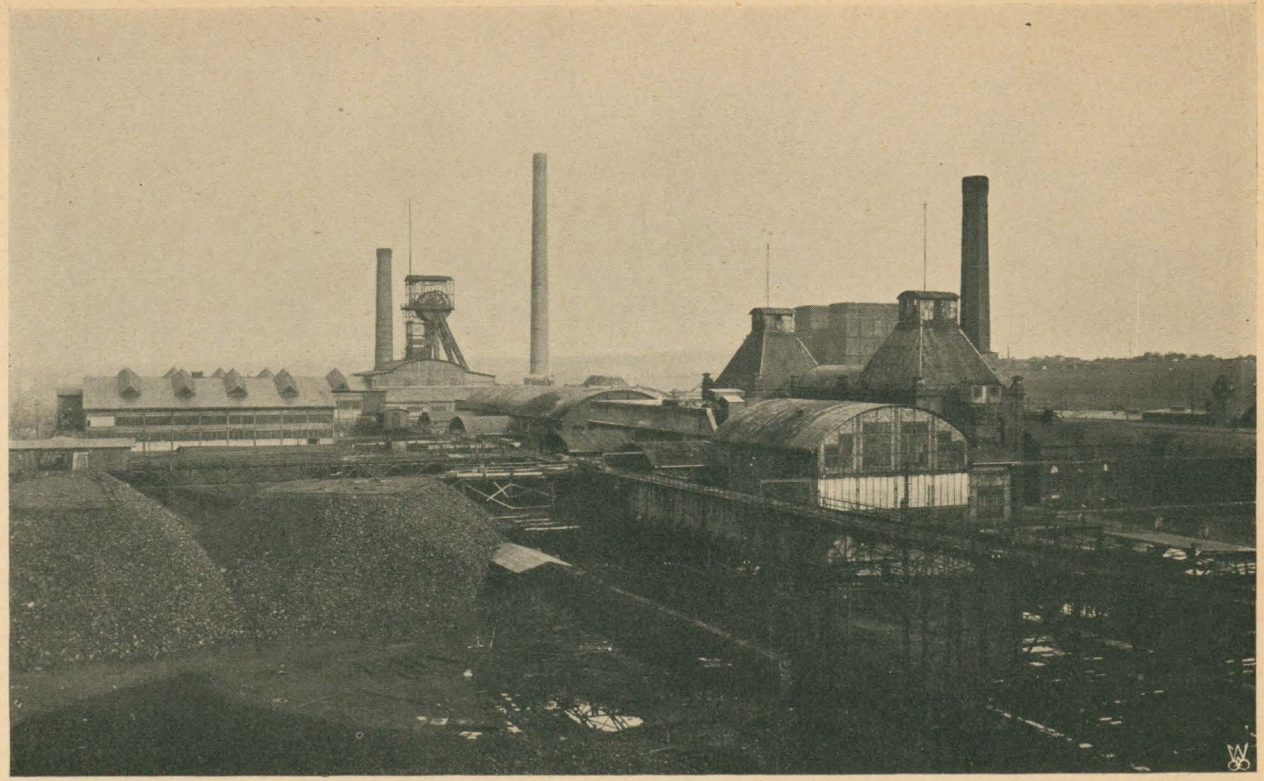


Fig. 2. General view of a colliery in the Polish Coal Basin.

TABLE VIII.

Development of export of Polish Coal according to main groups of markets for the period 1924 — 1929.

MARKET	1924		1925		1926		1927		1928		1929	
	thousands of tons	%	thousands of tons	%	thousands of tons	%	thousands of tons	%	thousands of tons	%	thousands of tons	%
A. PRE-WAR MARKETS.												
I. Germany	6 777	58.5	2 709	32,9	38	0,3	14	0,1	9	0,1	5	—
II. Other pre-war markets (Austria, Czechoslovakia, Hungary, Yougoslavia and Rumania).	4 358	37.8	4 300	52,3	4 344	29,5	4 616	39,9	5 275	39,4	5 357	37,1
B. NEW MARKETS.												
I. North Sea Markets	28	0.3	600	7,3	6 671	45,4	4 397	38,1	6 100	45,5	6 177	43,1
II. Remaining markets and coal for shipping	369	3.4	621	7,5	3 654	24,8	2 552	21,9	2 023	15,0	2 832	19,8
	11 532	100,0	8 230	100.0	14 707	100,0	11 579	100,0	13 407	100,0	14 371	100,0

Fig. 3. Breaking out of coal by means of a drilling machine.

TABLE IX.

Export of Polish Coal in 1929 according to Countries.

No.	COUNTRY	Thousands of tons	%
	A. PRE-WAR MARKET.		
1	Austria	3 196	22,4
2	Czechoslovakia	940	6,5
3	Hungary	927	6,4
4	Jugoslavia	161	1,1
5	Rumania	118	0,8
6	Russia	15	0,1
7	Germany	5	0,1
	Total	5 362	37,3
	B. POST-WAR MARKETS (NEW).		
	I. *North Sea Markets.*		
8	Sweden	2 595	18,2
9	Denmark	1 771	12,4
10	Norway	616	4,3
11	Latvia	583	4,1
12	Finland	437	3,0
13	Memel	84	0,6
14	Lithuania	79	0,5
15	Esthonia	12	—
	Total	6 177	43,1
	II. *Other Markets.*		
16	France	763	5,4
17	Italy	574	4,1
18	Switzerland	150	1,1
19	Holland	87	0,6
20	Brazil	70	0,4
21	Algeria	24	0,1
22	Iceland	19	0,1
23	Belgium	10	—
24	Tunis	2	—
	Total	1 699	11,8
	III. *Free City of Danzig and Coal for Shipping.*		
25	F. C. of Danzig	413	2,8
26	Coal for shipping	720	5,0
	Grand Total of Export	14 371	100,0

Export of coal. Tables VIII and IX illustrate the development of the export of coal from Poland according to export markets. Up to 1924 the greater part of this export (58,5%) went to Germany and practically the whole of the remainder to other pre-war markets, whereas the northern markets had an almost negligible share in the export. After the loss of the German market, the export coal trade was forced to penetrate other markets in order to maintain its development on the same level.

The northern countries, which were separated from Poland merely by the waters of the Baltic and the North Sea, and which had practically no coal deposits of their own, became the territories of expansion for Polish coal as the natural markets for the country.

If, however, we take into consideration the fact that the coal requirements of these northern markets which fall within the orbit of Polish export, amount to about 20 million tons per annum it ensues that Poland covers barely 30% of such requirements.

Outside these countries the penetration of distant oversea markets has already made certain progress and in this direction considerable possibilities of coal export have come to light. This matter, however, is closely connected with the development of the Polish ports and the Polish Mercantile Marine.

As shown in Table IX, the first place in the pre-war market was taken by Austria, which country was followed by Czechoslovakia, Hungary, Jugoslavia and Rumania. In the northern market the greatest export falls to Sweden, which is followed by Denmark and Norway and smaller quantities fall to Lotwa and Finland. In other markets the sea export to France and Italy takes first place; a start has been made with regard to Holland, Algiers and Brazil and with regard to overland export to Switzerland and other countries.

An important place in the market is taken by the Free City of Danzig (2,8%) and coal for shipping (5,0%).

An important part in the development of the export of Polish coal was played by the sea ports of the Free City of Danzig and Gdynia. Sea export, which has been continually increasing since 1925, brought about essential extensions to the old port of Danzig which previously had not been in a fit condition to deal with large transports of coal.

The building of the port of Gdynia which was begun in 1924, was practically finished in 1929.

TABLE X.

Transhipment of export coal at the Sea and River ports for the period 1925 — 1929.

Year	Danzig		Gdynia		River Ports		Total	
	thousands of tons	%	thousands of tons	%	thousands of tons	%	thousands of tons	%
1925	608	94,1	38	5,9	—	—	646	100
1926	3 048	80,0	380	10,0	382	10,0	3 810	100
1927	4 053	79,6	881	17,3	154	3,1	5 088	100
1928	5 494	75,5	1 766	24,5	9	—	7 269	100
1929	5 329	68,2	2 448	31,3	39	0,5	7 816	100

Table X illustrates the development of the shipping of coal from the ports of Danzig and Gdynia and the river ports (chiefly Tczew).

These shipments increased from 3,8 million tons in 1926 to 7,8% million tons in 1929.

Productive capacity of the coal industry. Owing to intensive competition, particularly in foreign markets, the Polish coal mining industry was forced to reduce production costs to the lowest possible level. Technical improvements and organisation of labour in Polish collieries brought about a very considerable increase in the output of work per working day, which greatly exceeded the pre-war output despite the fact that the working day had been reduced from 10 to 8 hours. Thus, the output capacity of Polish collieries with their present equipment has increased in comparison with the pre-war output.

According to the statement of the State Enquiry Committee (Państwowa Komisja Ankietowa), the output of Polish collieries in 1913, when conditions in the coal industry were excellent, amounted to only 73% of the output capacity of shafts and 60% of the capacity of the sorting equipment. Since that time the output capacity of shafts as well as of sorting equipment has increased as a result of the opening and expansion of new collieries and the output for 1929 increased by 7% in comparison with the output of 1913, so that the present Polish coal mining industry

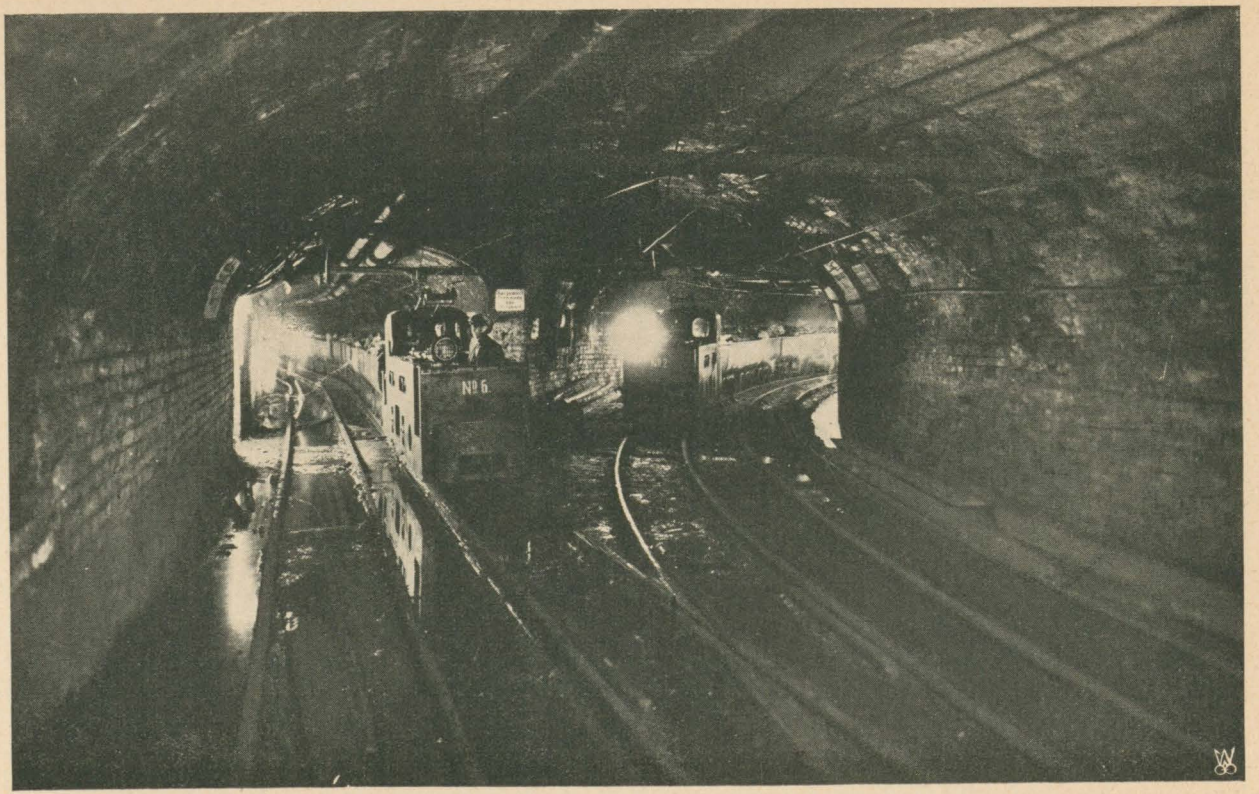


Fig. 4. Electric locomotives with overhead trollies transporting the coal on the underground gallery of a colliery.

exploits merely slightly more than 70% of its actual productive capacity, which, with the present technical conditions of the collieries, may be defined at about 60 million tons par annum.

TECHNICAL EQUIPMENT AND EXPLOITATION METHODS

By Z. Rajdecki

Polish collieries stand on a very high level with regard to technical equipment.

The breaking out of coal has been made mechanical. From the moment of the introduction of compressed air as a driving force, drilling machines both percussive and rotary for the making of shot holes were applied. In addition to these, electrically driven drills and cutting tools are frequently used.

The amount of the above mentioned mechanical means of breaking out coal, owned by the Polish coal industry, is about 9 000 drills and 200 cutters as well as about 600 hammers for breaking up coal.

The systems of refilling the coal galleries applied in the Polish Coal Basin vary in accordance with the features of the seam, its minimum thickness, grade and the properties of the surrounding rocks etc.

In the refilling of thick coal seams the most widely applied system is that of sand and water injection. This is effected as follows. The empty space which remains after the extraction of the coal is filled with a mixture of sand and water, after which the water flows off through filter dams and the remaining sand fills the gallery up tightly. This system has very valuable advantages as it makes it possible to extract the coal completely, prevents fires, resulting from spontaneous combustion of coal, and to a great extent protects the surface of the earth from falling in owing to settling.

The removal of coal from the place where it is broken out to the main galleries, is effected by trucks or endless chains of buckets. The driving motors of these chains are powered by compressed air or electricity. The collieries own more than 100 kilometres of such chains and about 3000 motors for the same. In

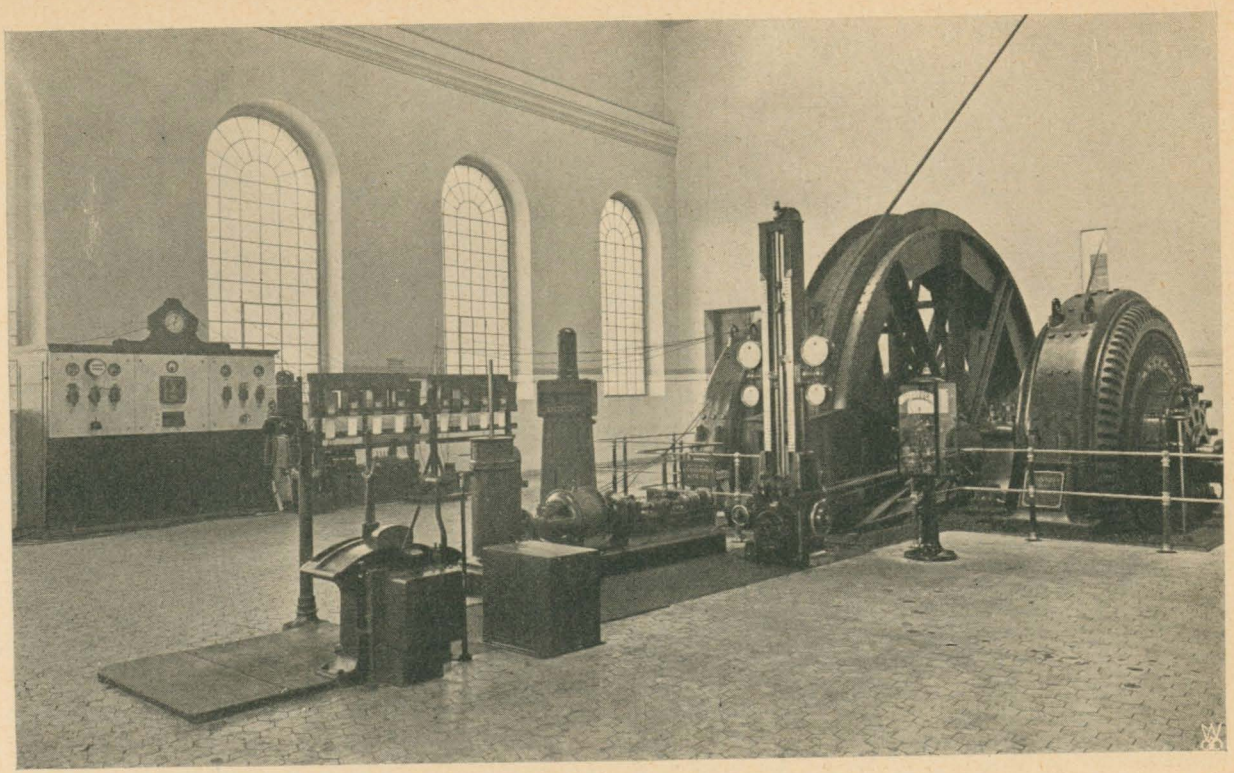


Fig. 5. Electric winding machine.

addition to these chains, windlasses with compressed air or electric drive are also used on inclined galleries. The collieries own about 3000 of these. Transport on horizontal underground roads has been made mechanical by means of endless cables.

During recent years, locomotives driven by internal combustion engines, compressed air or electricity, have been competing with transport by endless cables. In mines where explosive gases exist, locomotives driven by compressed air are chiefly employed and in some instances locomotives driven from electric accumulators are used. In mines which are free from explosive gas, electric locomotives with overhead trollies are coming into use more and more (direct current of 250 volts and a capacity of 30—60 HP). The total number of locomotives in all the collieries amounts to about 800.

In winding at the main shafts two storied cages are being used more and more. These cages are arranged so as to empty both storeys simultaneously with the object of better exploitation of the shafts. In addition to this the last few years have seen the increasing installation of automatic apparatus at pit heads for the self acting traffic of trucks. Out of considerations of safety and economy of energy, electricity is replacing steam engines for winding. For shafts up to 800 metres the Ward-Leonard electric drive is chiefly used and ordinary three phase motors are used for shafts of more than 800 metres. The capacity of a single winding apparatus amounts to from 300 to 1000 kW.

Electrically driven fans are used for ventilating the mines. Motors for large ventilating units have direct drive and medium units have belt drive. In order to regulate speed without loss of power, three phase motors are fitted with an auxiliary commutator set of alternating or direct current. The capacity of the motors runs up to 1000 HP.

In pumping out the mines, in which the inflow generally amounts to from 5—10 cubic metres per minute (it sometimes, but very rarely, reaches 30—40 cubic metres per minute), high speed centrifugal pumps with electric motors are used almost exclusively.

When deepening shafts, hanging shaft pumps with electrical drive are used in units up to 1000 HP. These take up sectionally barely 1,5 × 1,5 metres and can be easily raised and lowered without the necessity of unscrewing and screwing up hot steam-pipes, as for instance in the case of steam-driven pumps.

Fig. 6. Interior of a sorting department.

TABLE XI.

Installed capacity of motors in Polish Collieries according to Mining Districts.

TYPE OF ENGINE	Silesian District		Dombrowa District		Cracow District		Total		%
	Steam HP	Electric HP	Steam HP	Electric HP	Steam HP	Electric HP	Steam HP	Electric HP	Electrified
Pumps	18 995	126 729	16 653	29 596	6 973	12 805	42 621	169 130	80
Hoists	76 325	31 748	11 373	9 023	4 516	1 189	92 214	41 960	31
Compressors	73 276	37 290	2 577	5 342	5 180	3 892	81 033	46 524	36
Fans	1 943	11 932	70	2 354	—	981	2 013	15 267	88
Other	29 076	122 209	5 665	8 250	852	1 822	35 593	132 281	79
Total . . .	199 615	329 908	36 338	54 565	17 521	20 689	253 474	405 162	—
Percentage electrified . . .	62,3		60,0		54,1		61,5		

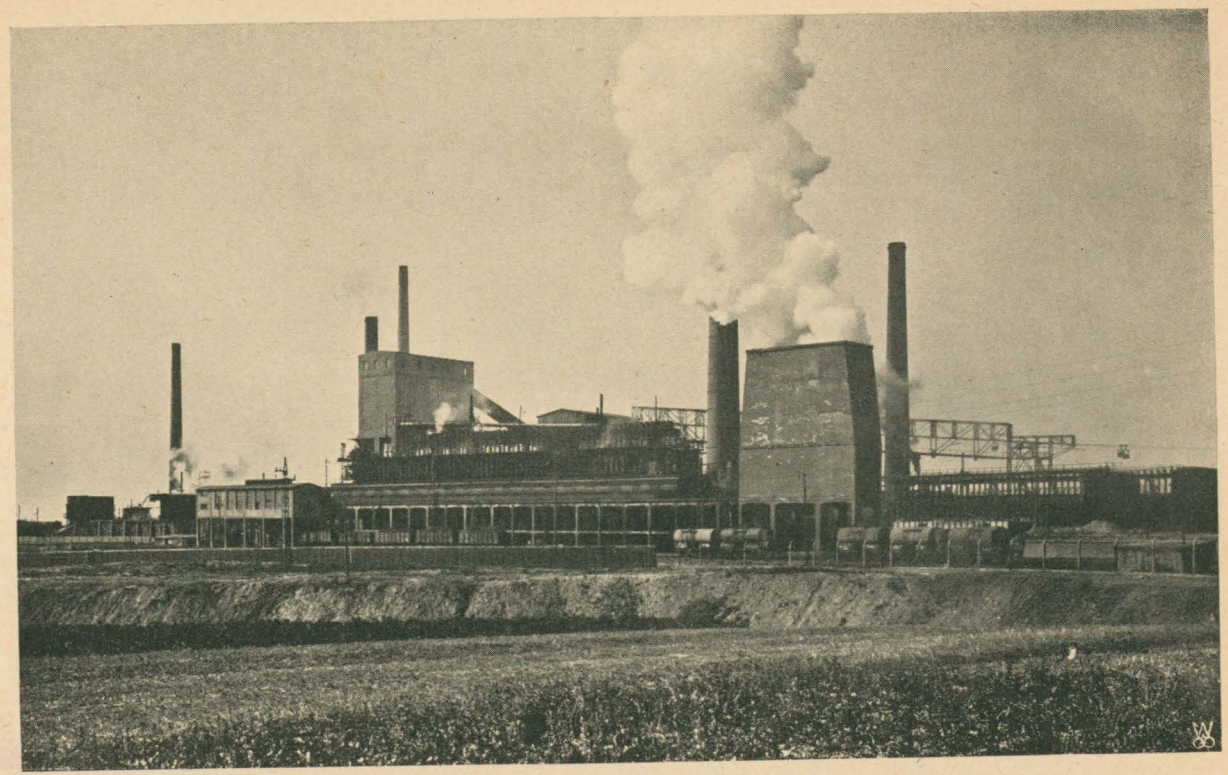


Fig. 7. General view of a coke plant in the Polish Coal Basin.

For auxiliary pumping a series of smaller, easily portable centrifugal or suction pumps with electric drive are employed.

In the application of air drive an electric motor is used for the operation of the compressor. Units with an output of less than 8 000 cubic metres (air 800 HP) are of the piston type and are driven by low speed motors (300 RPM) synchronous or induction of the open type. Units in excess of this output are applied almost exclusively as turbo-compressors which are driven by steam turbines, providing they are near the boilerhouse, or by electric motors with 3000 RPM at greater distances from the central boiler house. Larger units have an output of 25 000 cubic metres (or a capacity of 2 500 HP).

Polish collieries mostly generate the current they require in their own power plants which are installed with a large reserve of energy producing capacity. Three phase alternating (50 cycles per sec.) current is universally used. Tensions vary, being most frequently 3000 V, more rarely 2000 and 500 and recently 5000 V.

Further manufacturing of coal. In the sphere of manufactures from coal, the Polish coal industry possesses plants for the preparation of briquettes, coke, distillates of tar and benzol.

The production of briquettes from coal in Poland is embraced by 5 factories and amounts to about 300 000 tons per annum of which, in 1928, 4% was exported and the remainder used in the country chiefly for the requirements of the railways.

The manufacture of coke in Poland is concentrated exclusively in the Silesian district which is the only one in possession of coal of a good coking quality.

TABLE XII.

Production, Home and Export Markets for Coke in Poland during the period 1924 — 1929.

YEAR	Number of enterprises in operation	Output in thousands of tons	Total sales in thousands of tons	Home market in thousands of tons	Export in thousands of tons
1924	9	950	953	787	166
1925	9	964	910	803	107
1926	9	1 113	1 095	953	142
1927	9	1 402	1 496	1 337	159
1928	9	1 668	1 663	1 471	192
1929	9	1 858	1 840	1 639	191

Table XII gives the production of coke in Poland together with the home and export markets. The production of coke depends mainly on the development of the iron foundry industry, which is the chief consumer.

Since 1926 a continual increase in the production of coke in conjunction with the increase in the output of iron foundries has been noticeable. The coke export is accounted for chiefly by Austria, the Free City of Danzig, Hungary and Rumania.

The main products of the coke plants constitute coke in lumps, small coke, grains and fine dust.

Among the by-products received in coke plants are crude tar, pitch, tar oils, naphthalene, crude benzol and its derivatives and ammonium sulphide.

The majority of these products such as crude tar, crude benzol and naphthalene go, as raw materials, to special factories to be transformed into their more costly derivatives. Pitch is chiefly used in the production of briquettes from coal and in the manufacture of roofing felt, tar oils chiefly in enterprises for the impregnation of wood and ammonium sulphide as an artificial fertiliser.

TABLE XIII.

Output of By-products in Manufacture of Coke during the period 1924 — 1928.

Products	1924	1925	1926	1927	1928
	Output in tons	Output in tons	Output in tons	Output in tons	Output in tons
Crude Tar	40 272	44 712	51 948	66 472	80 438
Pitch	11 424	6 744	7 704	10 024	12 185
Tar oils	7 500	3 888	4 212	5 605	6 734
Naphthalene	732	864	1 080	1 033	—
Crude Benzol	10 752	12 396	14 436	18 125	21 141
Ammonium Sulphide	12 708	14 544	17 004	22 558	36 722

The actual increase in the production of these substances corresponds to the requirements brought about by the development of the chemical industry in Poland.

There are three tar distilleries and benzol plants in Poland. They convert tar, benzol and other crude oils into prepared tar, condensed tar, tar oils of every kind (without benzol), pitch, pure naphthaline, pirydine bases, phenol and other preparations.

BROWN COAL

By St. Czarnocki

DEPOSITS OF BROWN COAL

From the geological point of view our deposits of brown coal (Lignite) may be subdivided into:

1) Coal in mesozoic formations,

2) Coal in layers of triassic formation.

Deposits of mesozoic coal are available in two areas: 1) in the neighbourhood of Zawiercie and 2) in the neighbourhood of Starachowice and Ostrowiec.

In the Zawiercie area there is actually only one layer fit for operation, its thickness usually varying from 0,60 to 1,20 m.

The deposits of brown coal in this area extend in the shape of two wide belts from North West to South Eeast.

The average calorific value of damp coal from all collieries in said area amounts to 4 478 calories, whereas that of dried coal to 5 441 calories. The proportion of ashes varies from 9,93% to 23,70%.

The second area of mesozoic brown coals is found in the belt of liassic formation, along the south-eastern slope of the Świętokrzyskie („Holy Cross") Mountains.

The coal in this area invariably consists of thin irregular layers and usually the thickness of one only of these exceeds 0,30 m; the maximum thickness of the layer approximates 0,90 m.

Triassic coal is available in two extensive areas: the north-western, or Poznań—Kujawy area, and the south-eastern or Little Poland (Galician) area.

The north-western area comprises almost the entire Voivodeship *) of Poznań, a considerable part of Pommerania, protruding in its southern extension into the Voivodeships of Warsaw and Lodz.

The greatest importance, from a practical point of view, is attributed to a group of coal deposits which German geologist term the „Basic" group and which is located in the uppermost part of the local miocenic formation. It sometimes consists of several layers of an aggregate thickness of up to 9 metres, though usually there is only one thicker layer of an average thickness of 2—3 metres.

The calorific value of this coal is relatively high, dry coal yielding more than 4 500 calories, frequently exceeding 5 000 calories.

The technical mining conditions are exceedingly difficult, owing mainly to the presence of coal dust not only in the layers covering the coal deposits, but sometimes also in layers immediately below them.

Towards the South East these coal deposits issue into the area of the Voivodeships of Warsaw and Lodz, right up to the environments of Warsaw and Żyrardów, though the depths in this district already exceed 100 metres.

Areas situated farther West may rely on coal deposits at a depth of less than 100 metres. This contention was justified a few years ago by the discovery of brown coal at Regny near Koluszki, where coal with a thickness of layer of up to 8 metres was found at a depth of 50—60 metres.

The deposits of miocenic brown coal in the Galician (Little Poland) area may, in respect of nature, be divided into the following two groups:

1) the Carpathian group, comprising deposits associated with the Carpathian range and its foreland, and

2) the Podolian group, where the deposits are located already in the so-called Podolian stratum.

The Carpathian coal, with a very few exceptions, is marked by its high calorific value, greater uniformity of deposits, whereas the thickness is invariably smaller than in the case of the Podolian deposits.

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*) Largest administrative division in Poland.

In the western part of the Carpathian area there are a few isolated islands of coal yielding miocenic formations.

Farther East, in the Carpathian foreland, areas of brown coal are available in the neighbourhood of Kołomyja. This coal is of fairly good quality, with an average calorific value of 4250 calories.

A considerable part of the area is occupied by deposits of brown coal associated with the so-called Podolian stratum. In this instance, one layer has been determined, suitable for operation, of a thickness of 1—3 metres.

The quality of coal in the western part of this area is inferior to that in the Carpathian foreland, yielding on average 3 100 calories. In the north-eastern part, — in Volhynia — coal is found with a calorific value of 3 100—5 200 calories.

In respect of the Poznań area, together with the adjacent part of Pommerania, which represents the most prospected area, German specialists, before the war, quoted the following figures: determined available resources — 29 700 000 tons, whereas the estimated available resources including Eastern Prussia and Silesia, exceed 1 milliard tons.

A great handicap in the development of the operation of brown coal deposits is presented by the difficult mining conditions. The irregular nature of the deposits renders it impossible to rationalize the organization of collieries and to concentrate operation on a larger scale in one colliery.

EXPLOITATION OF BROWN COAL

The exploitation of brown coal in Poland has never reached any appreciable level, due to the unfavourable conditions attending it and to the competition of black coal. Before the war, the output did not exceed 200 000 tons per annum.

During the war and the years immediately succeeding it, the difficulties in the mining and transport of black coal brought about a temporary increase in the number of brown coal mines and in the output of the latter. The maximum figure was reached in 1921 when the aggregate output of 18 collieries amounted to 270 415 tons. Practically the entire surplus in output was provided by collieries located in the central Voivodeships, where the number of

collieries during that time increased from 5 to 12, and the rate of output by 50%.

As the re-conditioning of the partly destroyed black coal mines in the Dombrowa Coal District progressed, and subsequently, after the incorporation of Silesia, the sales and output of brown coal rapidly decreased, it became necessary to close down not only those new collieries which were founded during the war, but even old ones. The colleries in Great Poland and Little Poland (Galicia) were abandoned entirely, whereas in the central Voivodeships 3 collieries, in the Zawiercie district, maintained their existence, supplying coal to the local chemical industry and also for the requirements of the local population.

The fluctuation in the output of brown coal is represented in table XIV.

TABLE XIV.

Exploitation of brown coal in Poland according to districts.

Voivodeships	Central		Western		Southern		Total	
Year	No. of collieries	Output in tons	No. of collieries	Output in tons	No. of collieries	Output in tons	No. of collieries	Output in tons
1913	5	155 081	—	—	3	37 407	8	192 488
1920	11	238 017	—	—	3	10 460	14	248 477
1921	11	227 748	4	31 434	3	11 233	18	270 415
1922	12	182 896	2	32 629	3	4 458	17	219 983
1923	12	150 019	1	17 099	2	3 916	15	171 034
1924	6	73 003	1	10 560	2	4 475	9	88 038
1925	3	56 577	1	3 407	1	5 691	5	65 675
1926	3	74 716	—	—	1	1 310	4	76 026
1927	3	115 871	—	—	—	—	3	115 871
1928	3	110 967	—	—	—	—	3	110 967
1929	3	74 321	—	—	—	—	3	74 321

The brown coal deposits in Great Poland and in the neighbouring central Voivodeships have excellent prospects for future extensive development, particularly in respect of meeting the requirements of the chemical industry and of electric plants.

At present the output of brown coal in Poland represents a mere 0,25% of the output of black coal.

CRUDE OIL

THE POLISH OIL FIELDS

By St. Czarnocki

The oil fields of Poland are located at the foot of the Carpathian Mountain Range and constitute the north-western extension of the Rumanian oil fields.

The Polish oil fields may be allocated to two individual areas, i. e. the Carpathian range and the Carpathian foreland.

The majority of the oil deposits known and exploited is located in the first area, whereas in respect of the second, there are so far only certain indications of the presence of oil there.

The occurence of oil in the Carpathians is closely associated with the important series of strata known as the Carpathian Flysch, this latter term applying to formations of usually thin stratified deposits of sandstone, slate and schist. From a stratigraphical point of view, this series comprises strata commencing from the chalk layers at the bottom and terminating at the extreme oligocene at the top.

Oil deposits suitable for exploitation are met with in the bukled strata, commonly known as „saddles". These saddles run alongside of the Carpathian range.

The occurrence of oil in commercial quantities begins in the West, near Limanowa, and extends right down to the Rumanian frontier, in the form of a series of more or less parallel belts, varying in length from a few to some score kilometres.

Occasional oil deposits are found to the West of Limanowa and right up to the Czechoslovakian frontier, yet none of these have so far proved sufficiently attractive for exploitation.

There are two distinct oil belts in the Carpathians, i. e. the „inner", which comprises the deposits lying within the inner system of the Carpathian range, and the „outer" representing deposits occurring at the actual orographic boundary of the Carpathians, that is to say, at the boundary of the Carpathian foreland.

The deposits of the inner belt are found almost exclusively in the western part of our oil fields, in the mining district of Jaslo. Farther East, we meet with merely an insignificant occurrence of oil in this belt. The main oil-yielding levels of the inner belt occur in the eocene and the so-called Krosno oligocene formations. In tectonic respect, we here come across comparatively regular saddles which are extremely narrow and long. Sometimes a whole series of saddles occurs alongside one and the same line.

A characteristic feature of the oil deposits in this belt is the extremely low average output of wells, amounting to approx. 0,3 tons per diem. This output, though small, is steady, and one well may be operated for a period of from 15 to 20 years. The depth of the wells, in general, is not very considerable, hardly ever exceeding 800 metres, and it is only in a very few areas that wells of a depth of more than 1000 metres may be found.

These characteristic features of this particular belt have influenced the adoption of a system of exploitation based on a large number of shallow wells.

The outer belt comprises practically all the oil deposits of the central Drohobycz district and the eastern Stanislawów district.

Oil deposits are available here at all levels of the Carpathian Flysch. The main role, however, is played by the sandstone layers beneath the menilite series (Boryslaw sandstone), or by layers located within said series.

The tectonic features here are more complicated than in the belt previously referred to, there often being two saddles (folds) superposed one upon the other, and frequently inclined towards the North. The lower fold, which bears the name of the „synclinal element" generally contains the productive oil levels.

The necessity of having to penetrate through the upper fold in order to reach the synclinal element containing the oil level calls for the sinking of deep wells. The depth of certain of the wells in the Boryslaw district already reaches 2000 metres. The

output of the wells in this outer belt is less steady and of comparatively shorter duration.

The Carpathian foreland consists of a generally flat surface between the Carpathians and the so-called Podolian Plain. It represents a belt, some tens of kilometres wide, which begins at the Rumanian frontier in the East and terminates at the valley of the river Vistula in the North-West. Miocene formations in the form of a potential series of shale, sand, sandstone and laminae, play the dominating role in the geological structure of this foreland.

The existence of oil deposits is heralded by the appearance of natural gas, particularly prominent in the Daszawa district. Drillings undertaken on several sites have resulted in oil being struck, though so far in negligible quantity. The fact of special attention having been devoted to this foreland, was prompted by analogous precedents in neighbouring Rumania and in the Caucasian oil fields.

The majority of oil deposits in these areas is not connected with the mountain range, but with the foreland. Although geological conditions in our foreland are divergent to some extent, and there is no so strongly developed pliocene stratum available as in Rumania and the Caucasus, where it contains a considerable part of the oil deposits, yet we are led to anticipate that important oil deposits are available in the Carpathian foreland.

Oil prospecting in the Carpathian forelands is rendered more difficult than in Rumania or the Caucasus, owing to tectonic motion having ceased here earlier than in the latter countries, and for this reason, our tectonic structure has become concealed beneath a strongly developed series of junior formations. This greatly increases the difficulty of selecting sites suitable for the sinking of pioneer wells. Under these circumstances, geophysical methods may become of paramount importance.

Apart from the Carpathians and their foreland, there is yet another district in respect of which hopes are entertained as to oil deposits. This is the salt-yielding area in Great Poland and the Kujawy district. These latter areas appear to be a continuation of the salt-producing province of Hannover in Germany, where oil is available in the so-called „salt pillars" of the calcareous rock of the Zechstein era, and is being exploited. In our salt pillars, and in their vicinity, traces of bituminous substance have sometimes

been discovered. Thus, it is not unlikely that deposits of the Hannoverian species are available in the said districts.

Last, but not least mention must be made of the presence of oil at Wojcza in the southern part of the Voivodeship of Kielce. The occurrence of oil there is associated with calcareous formations. Up to the present these local traces of oil were being associated with the Carpathian foreland, but at the present moment it appears more likely that we have to deal with a south-eastern extension of the Great Poland—Kujawy belt, referred to above, and that the Wojcza oil is in a certain association with some likely deposits of salt of the Zechstein era. The prospecting at Wojcza has only recently been started.

Computation of the resources of the oil fields is much more complicated than in the case of other useful minerals, because we have to deal with a liquid and thus movable mineral, which commonly appears in conjunction with gas and water, and saturates rocks in a most irregular manner dependant upon factors of a geological nature which it is often difficult to grasp. Thus, it is impossible to adopt the usual method of computing the resources by volume, and in this instance computations would of necessity have to be based on the capacity of oil-containing rocks in any particular area.

Oil deposits, however, have a specific property of which we might take advantage for the purpose of estimating their resources. Namely, the output of any particular mining unit, such as a well shaft, depends on the natural conditions of the formation, and particularly on the latter's richness. This renders it possible to estimate the resources in any such formation according to the results obtained from the exploitation thereof.

The aggregate output of oil in Poland is concentrated in the Carpathian area. Output during recent years has been decreasing, though slowly. The decline in the output affects, primarily, our main oil district, i. e. that of Boryslaw. This area takes precedence not only because of its total output which at present represents about 70% of the aggregate output for the whole of Poland, but also by reason of the average output of the wells. The figure for Boryslaw at present is about 1 200 tons per annum, whereas that for all the remaining oil districts amounts to only approx. 115 tons per annum.

The gradual exhaustion of the Boryslaw deposits is substan-

tially confirmed by the decline in the average output of the wells, which as recently as in 1921 amounted to as much as 2 800 tons per annum.

This decline continues in spite of the fact that the aggregate figure of metres drilled has been maintained at a practically uniform level during recent years. The development of drillings is impeded by the constantly increasing average depth of new wells.

Certain hopes are at present being entertained in respect of the southern part of the area to the South of Mraźnica, where it is possible that some new oil fields are still available, although they are not thought to be particularly extensive.

All other areas, as a total, in comparison with Boryslaw, show a very limited, though relatively steady average rate of output per well. These territories are likely to maintain, or even slightly increase, their present output, but yet they do not offer facilities for industrial expansion on a larger scale.

Thus, it becomes essential to take up intensive prospecting work, with a view to discovering new, so far unknown, oil fields.

OIL WELL DRILLING AND OPERATION

By T. Regula

Oil Well Drilling.

The only method by which crude oil is so far being obtained in Poland is drilling. Mechanical drilling, adopted for the first time in 1869, was carried out mainly by free-drop method, and in certain instances by rope method, the latter being adopted from Pensylvania. In 1884 McGarvey introduced the Canadian system to Poland which quickly came into general favour, maintaining its popularity up to the present moment. About 1898 flush systems were being tried, however with little success. In 1902 the genial idea of Mr. Wolski was adopted, consisting of a hydraulic ram, having a water turbine fitted immediately above the drilling bit, near the bottom of the shaft, the water being supplied to it by means of small feed pipes from a pump erected on the surface; but this method, for no ostensible reason, soon passed into oblivion.

At present dry ramming methods are used almost exclusively, namely:

a) the Canadian rod method,
b) the Pansylvanian rope method and
c) a combined rod and rope method.

Recently tendencies are being displayed towards adopting the „Rotary" system.

The Canadian method, using rigid rods, ranks among the dry ramming methods, i. e. such ones by which the crushed rock is periodically lifted out from the bottom of the shaft by means of a bailing scoop. The Canadian rig (fig. 1) consists of a shaft on which the lever of the oscillator and 3 belt pulleys are fitted, one of the latter being connected by means of a belt with the pulley of the driving motor, the two other being connected, by means of

Fig. 1. Canadian rig. Two steam driven hoists for swabbing.

belt clutches actuated by the pressing of small rolls, with two drums of which one serves for the lowering and raising of the drilling tackle, as well as for raising and lowering of weights and pipes, and the other for bailing. The drilling tower is constructed of timber and is approximately 20 metres high. The drilling tackle consists of a bit, usually of the eccentric type, a weight, link jar and steel rods or ropes in length of 11,5 metres. The lift of the oscillator varies from 30 to 50 cm, the number of revolutions from 25—60 per minute. In order to render it possible to drill a circular aperture by a comparatively narrow bit, the entire drilling tackle is being twisted during the drilling process, rotating the drilling rods on the shaft.

The pipes used are almost invariably of steel, seamless, downward of 24″ in diameter and from 5 to 11 mm thick, according to the depth of the well and the properties of the soil. One column of pipes traverses a depth of from some tens to some hundreds of metres, according to the difficulties presented by underground water and layers which are often considerably inclined and consist of alternating thin laminae of varying hardness.

The Canadian method was used in Poland almost exclusively until 1923, the depth of the shafts varying from some tenths to two thousand odd metres. At present said system is still in use, mainly outside the Boryslaw district, although both at Rypne and at Bitków, as well as in the vinicity of Krosno it is being ousted by the combined rod and rope system. It may safely be assumed that out of 205 shafts in the course of drilling in Poland at the end of 1929, more than one half was being drilled by the the Canadian method.

In the Pensylvanian rope method, the cardinal difference consists in that a steel rope is used instead of drilling rods. The drilling tackle is similar as in the Canadian type, but the bit is symmetrical, high and thick, taking up an appreciable part of the section of the aperture, and the weight is very heavy. Similarly as in the case of the Canadian method, the drilling tackle usually operates at a slow drop, the rotary motion of the working part in the shaft being obtained by twisting the drilling rope. The rig is constructed in such a manner that the main shaft, in addition to the lever, contains a double pulley connected with the engine pulley and, by means af a crossed manilla rope drive, with the winding drum on which the steel drilling rope is wound (fig. 2 and 3).

This system has been tried in Poland before the war, but did not adapt itself. It was not until 1923 that the rope drilling method was applied, practically simultaneously at Boryslaw and at Bitków, with equipment imported from the United States, and until the end of 1929 some tens of shafts were drilled, considerable progress in drilling being experienced. Thus, for instance, whereas at Mraźnica it took four years and more to drill a shaft 1 500 metres deep by the Canadian method, the time taken by the Pensylvanian method amounts to from one to two years.

Yet at present only a few wells are being drilled by this latter method. The disadvantages of this method, as well as the availability of considerable supplies of other equipment, prompted the

Polish engineer to combine the advantages provided by the rigid drilling method with the efficiency of the rope method, and thus the combined rope and rod system came into existence, commonly described in Poland as the „combined" or „Polish" system.

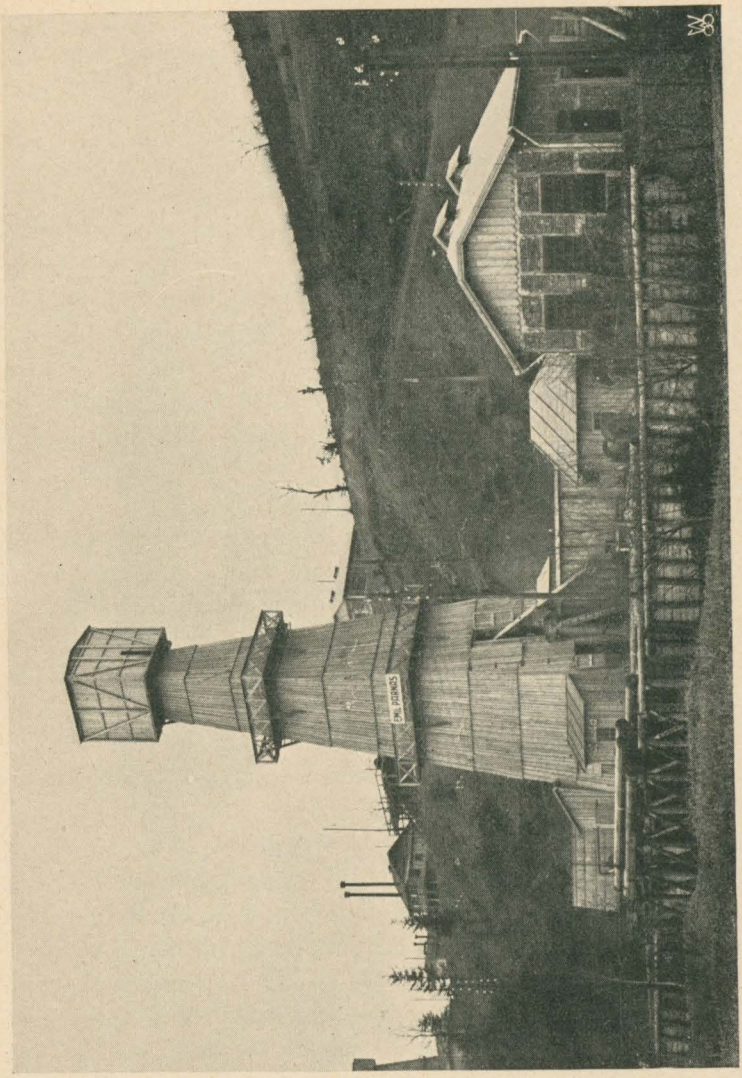

Fig. 2. Electrically driven Pensylvanian rope rig.
All parts of the equipment manufactured in Poland of Polish material.

The combined rope and rod rig (see figures 4 and 5) is more convenient than the Pensylvanian one, as it enables the changing over from rope drilling to rod drilling, which is of importance

in the event of likely swerving in the aperture of the shaft, and enables the carrying of drilling tackle on rods for which purpose the latter are more suitable than ropes. So far no particular type of combined rig has been standarized, practically each firm finding its individual solution. Recently the Scientific Management Section of the Association of Polish Engineers of the Oil Industry has put forward a scheme of a normal combined rig which combines the advantages of all those in use. The principle of the combined rig is to leave the winding drum for the drilling rope within the drilling tower, and to fit the lifting drum for the rods above the lever shaft. The drilling tackle used is similar to that used for rope drilling or Canadian drilling, the bits being symmetrical or being excentrical and heavy.

This system is in use practically in all deep shafts throughout the Polish oil fields, and the results reached are comparatively more satisfactory than those with the Pensylvanian system, to say nothing of the Canadian method, and hopes are entertained that it will replace the latter also in the case of shallow drillings in the oil fields.

The „Rotary" system comprises the use of a normal mud-flush device for dense loam which has a most beneficial effect on the sides of the shaft by clogging up cracks and preventing the collapse of the sides on to the bottom of the shaft. The rotary motion of the bit is obtained through the revolving of the tackle which consists of strong rinsing pipes. By means of this system it is possible to drill considerable areas, several hundreds of metres at a time, without having to sink pipes, thus eliminating the necessity of constant change in the size of pipes which results in considerable economy in drilling.

The motive power for drilling is supplied in the majority of cases by single cylinder steam engines of a nominal power of 40 HP. They are used for all of the ramming methods. During recent years electric motors have come into use, of a capacity, dependant on the depth of the shaft, of from 50 to 150 HP, and in the case of rope drilling even up to as much as 250 HP. The number of electric motors installed in the Polish oil industry for drilling purposes is approx. 25, and at present almost entirely in the Borysław district. Internal combustion engines are also being used, such as single and two cylinder Diesel engines of 65—80 HP, further gas engines of 80 HP, as well as the explosion-type petrol and crude

oil engines. Internal combustion engines are readily used particularly in the case of pioneer shafts, where it is difficult to procure the necessary motive power and where the transport of coal is too expensive.

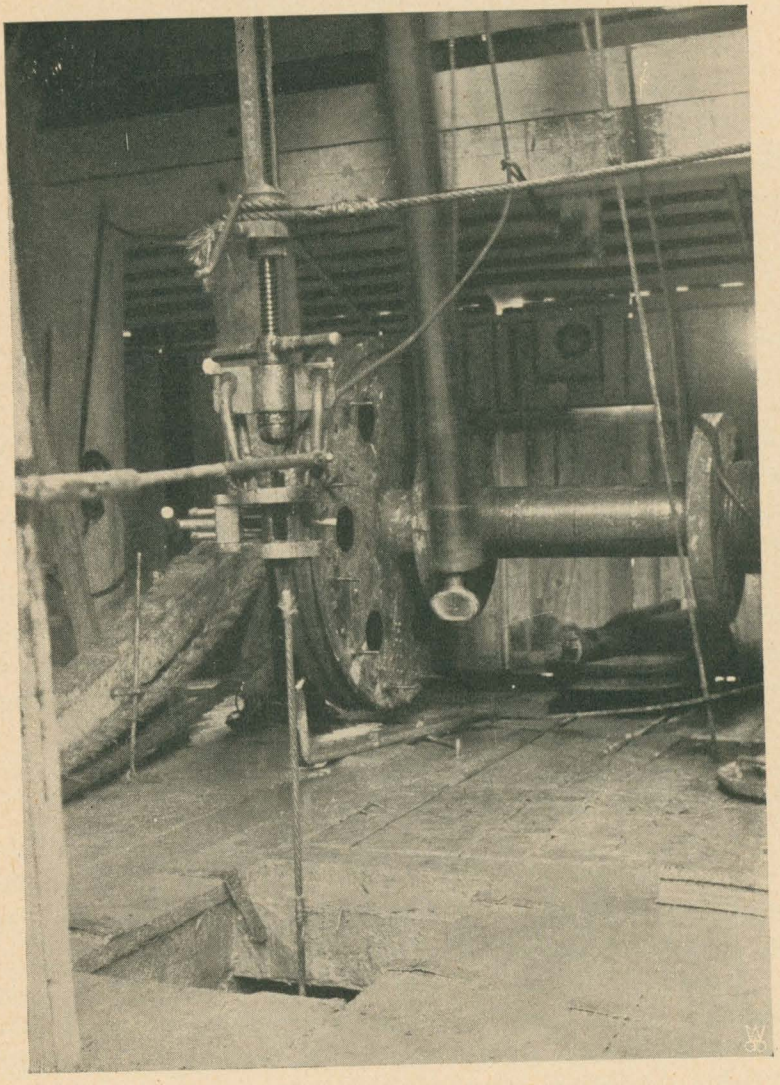

Fig. 3. Interior of a Pensylvanian rope rig. View showing the rope chuck, bailing scoops and drilling drum with grooved wheel.

Oil Well Operation.

Oil struck in a layer, provided it does not issue forth under the influence of gas contained in the layer, must be brought to the surface by the following methods:

a) bailing,
b) swabbing,
c) pumping,
d) gas or compressed air pressure.

Bailing is carried out by the sinking to the bottom of the shaft into the oil vein of a bailing scoop, i. e. of a pipe of several metres length fitted with a bottom valve secured by means of a rope to the drum of the bailing rig or a specially erected hoist.

Swabbing is effected by the sinking into the pipes to the bottom of the shaft of a swabbing device, or piston, fitted with a ball valve and tightened by means of a rubber ring in the pipes, the entire quantity of oil depositing above it being then raised to the surface; during the upward motion suction occurs at the bottom of the shaft, increasing the flow of gas and oil from the oil vein. In addition to the ordinary pistons, pump pistons are also in use which combine the principles of pumping and ordinary swabbing.

The capacity of the steam engines and electric motors varies within wide limits, from 80 to 400 HP, according to the speed of piston required and to the output of the well. The speed of the piston during the upward motion amounts to from 2 to 8 metres per second.

Swabbing is the most prevalent method of raising oil from the deep wells of the Boryslaw district, ever since 1905.

At the end of 1929 the number of wells swabbed in all the Polish oil districts amounted to over 400, whereof 305 in the Boryslaw district alone. Of that number, approx. 50 wells were served by electric motors, the balance by steam engines.

Pumping is effected by means of special suction pumps, the prototype of which are the common water well pumps; in the case of the normal type Jarecki pumps working in the Polish oil fields, the bottom valve is in the shape of a piston which can at any moment be extracted, after previous lifting out of the pump piston.

The shafts may be pumped singly, from the swinging-lever, or in groups of several or ten odd at a time from one distributing gear. In shallow shafts yielding oil without paraffin, pumping which

Fig. 4. Combined „Polish" rope and rod rig with steam drive.

is the oldest operating method in Poland — gives excellent results and still continues to be in use at some 1850 wells in all the Polish oil fields.

Of the total number of 1870 wells operated by pumping, some 300, mainly at Bitków, Potok, Rypne and Wańkowa, use electric drive, the majority being driven by gas engines, whereas drive by steam engines is only used in a few isolated cases.

The easiest operating method is by means of compressed gas. This represents a self-acting operation dependent upon an adequate output of gas issuing from the oil vein, corresponding to the output of oil. In order to prevent undue escape of gas from the oil vein, the gas is throttled by means of the working gas pressure. In the event that the available quantity of gas is inadequate for self-action, a column of small pump pipes is sunk into the drilling pipes, fitted at the bottom end with an expansion piece in the form of a funnel of a diameter slightly less than that of the drilling pipes. Whereas previously the gas was inadequate for self-acting operation, the aforesaid device renders it fit for emulgating a small column of liquid in the pumping pipes and for carrying it to the surface.

The proper operation of oil by means of compressed gas or air is effected by introducing the compressed medium (gas or air) by means of drilling pipes to the bottom of the shaft below the funnel-shaped end of the pumping pipes, where it causes an action similar to that of a natural funnel. By adopting, instead of a funnel, suitable jets, known as nipples (Wolski and W. Łozinski nipples) the efficiency of the aforesaid arrangement is considerably improved.

Such jets have been adopted in several of the Bitków wells more than 1200 m deep, with good results, compressed air having been used as a medium. Jets cannot be used in wells where the pressure of the oil layer is low, nor in the winning of highly paraffinous oils.

The depth of wells in the more important oil well districts in Poland is as follows:

Borysław (shallow oil deposits) . .	200— 500 m
Boryslaw (deep oil deposits) . . .	900—2000 „
Bitków	500—1500 „
Rypne	500—1000 „
Jaslo District, average	200— 700 „
Isolated wells at Równe and Rogi . .	1100 „
Jaszczew gas saddle, Męcinka — Winnica — Sądkowa	800—1000 „

Separation of gases from oil. Almost invariably oil brought to the surface is accompanied by natural gas in quantities varying from decimal fractions of a cubic metre to several tens of cubic metres per minute. These gases are absorbed and dissolved

by the oil, according to pressure, the heavier hydro-carbons being more readily absorbed than the lighter ones. This explains the abundance of Methane (CH_4) which, being the least heavy of all, is less readily absorbed, and only in a negligible quantity.

Fig. 5. Combined „Polish" rope and rod rig. Electrically driven hoist for swabbing.

In order to separate the gas from the crude oil, they are jointly conducted from a header within the well, fitted on the flow pipes, to a gas separator located immediately alongside of the well. This separator consists of a steel container, in the shape of a cylinder of 1 m in diameter and from 3 to 4 m high, the bottom being fitted with an outlet for the oil which flows by its own gravity,

whereas the cover is fitted with a suitable outlet for the gas. The gas and oil inlet is provided in the separator casing, approx. 0,5 m above the bottom. Inside the separator there are sectional partitions made of thin steel sheets, counter opposed to each other. The bottom outlet immersed in oil acts as a syphon check for the separator.

The gas, mixed with oil, passes from the header to the separator which lies on a lower level and is under constant suction produced by compressors or blowers, is here separated from the oil in such a manner that the oil falls to the bottom, due to its gravity, and thence passes into an oil tank, whereas the gas, being lighter, escapes by the outlet at the top, and any atomized particles of oil, still contained in the gas, as well as solid impurities, adhere to the partitions and, by forming larger drops, flow to the bottom.

Impurities in the crude oil and their removing. Water and brine of varying concentration, which frequently accompany oil in the vein, are raised to the surface simultaneously with the latter, irrespective of the method of operation. The oil is also frequently contaminated by such substances as loam, sand, etc.

As it is commonly known, such contamination is very much detrimental to the conversion of crude oil at the refineries, and therefore must be withdrawn before the crude oil will be refined.

The first method originally adopted in Poland for resolving emulsions, was the heating it by steam (either directly, or in coils) for several hours to a higher temperature in wooden or steel tanks. The contents of the tanks were then left undisturbed for several days, so as to enable the impurities to settle, whereafter the water and solid substances were drained off by means of a valve in the bottom of the tank, whereas the intermediate layers, containing insufficiently purified oil, were drained into special containers for repeated heating, only the top layers, containing pure oil, being drained into the storage tanks.

Rationalization of the scouring of crude oil has been considerably advanced by the „Metan" apparatus operating on the basis of a system devised by Prof. Mościcki. It consists of two cylindrical containers to which emulsion is driven under pressure. In the first container the emulsion driven in from the bottom is heated, meeting a coil containing outgoing scoured oil, whereafter it is heated by means of a steam coil to a temperature of

130 — 160° C. The oil, practically entirely rid of water, next passes into the second container fitted with a series of partitions and plates, on which it deposits the balance of water and residual matter, and through an outlet at the top passes into the coil of the first container in which it transfers its heat to the entering emulsion. This apparatus is manufactured in one size only, for an output of 25 — 35 railway cisterns per month.

The only disadvantage of this apparatus is that the steel steam coils rapidly erode under the influence of brine, which necessitates frequent replacement and repairs.

The sharpless type hyper-centrifugals were introduced into Boryslaw for trial purposes; in these the emulsion, at a temperature of 40—60° C, flows through a rapidly revolving drum, at up to 17 000 r. p. m., which ejects the water together with the mud and heavy impurities, whereas the purified oil is drained off from the intermediate layer. This method is quite suitable for a not particularly consistent emulsion which contains no solid substances. In applying it at Boryslaw, Phenol was added which enabled the most consistent emulsions to be resolved at comparatively reasonable cost.

Besides, a comparatively frequently used method is that of resolving the emulsion by means of several reactives, as for instance Phenol, and by heating this mixture. The best results seem to be obtainable by Mr. Geritz' patented method of this category.

ECONOMIC FEATURES OF THE OIL INDUSTRY IN POLAND

By Dr. St. Bartoszewicz

Oil wells exist in more than seventy localities in the Carpathian foreland, with a total number of 11 000 workmen employed in that industry. The largest oil field is that of Boryslaw with the neighbouring communities of Tustanowice and Mraźnica, in the Drohobycz district, which at present, in spite of its gradual exhaustion, produces more than 70% of the total output of crude oil in Poland.

In order to properly illustrate the present state of the crude

oil output, we must subdivide same according to the following districts:

1) the Boryslaw district (communities of Boryslaw, Tustanowice and Mraźnica),

2) the Drohobycz mining district, exclusive of the Boryslaw area,

3) the Stanislawów mining district, which comprises the most south-eastern fields, adjacent to the Rumanian frontier, and

4) the Jaslo mining district, embracing mines located to the West, along the Carpathian range.

The following table illustrates the output of these districts since 1925:

Output of crude oil (in tons).

YEAR.	Drohobycz		Jaslo	Stanislawów	Total
	Boryslaw area	Other localities.			
1925	622 250	75 106	64 778	49 795	811 929
1926	603 250	75 850	70 329	46 658	796 087
1927	530 680	78 512	72 661	40 743	722 596
1928	541 588	82 339	76 281	42 788	742 996
1929	474 825	80 838	73 611	45 415	674 689

The decline in the output during recent years may be attributed almost solely to the exhaustion of the richest oil fields in the Boryslaw area.

In order to maintain output, the number of drillings ought to have been increased, yet the decreasing remunerability of existing wells, and also the restricted exploitation areas at Boryslaw, rendered such course impossible. Towards the end of last year, however, drilling operations were revived in the southern part of Mraźnica, with a view to preventing a more violent decrease in the output of this wealthy oil field, pending the discovery of other more productive oil deposits.

With a view to locating such new oil deposits, some twenty wells are being drilled, on sites scattered over areas which have not been previously operated at all, or on the extensions of areas previously exploited and located farther away from previous ones. These drillings resulted in the striking of natural gas or oil at a small rate of output at some of the wells, without however striking more productive deposits.

The aggregate drilling operations from 1925 onwards, are represented by the following table:

State of oil wells.

Y E A R	1925	1926	1927	1928	1929
In course of drilling and operation . .	106	138	131	121	116
Wells yielding oil during drilling . . .	88	66	78	56	48
Total, in course of drilling	194	204	209	177	164
Number of wells subjected to fishing .	48	42	37	37	33
No. of wells swabbed	298	313	359	398	421
„ „ „ pumped	1529	1606	1724	1861	1978
„ „ „ being rigged	38	52	59	61	66
„ „ „ with natural flow . . .	24	21	21	17	21
„ „ „ yielding exclusively gas .	149	158	150	119	128
„ „ „ dismantled, refitted, etc. .	—	—	10	20	34
TOTAL . . .	2280	2398	2569	2690	2845

In spite of the fact that the number of wells drilled has been decreasing ever since 1928, the aggregate depth drilled is being maintained at the rate of approx. 100 000 metres p. a., which goes to prove the progress made by engineering in the speed of drilling during recent years, particularly in the case of the deep wells in the Boryslaw area.

The following table illustrates the average annual output of the Polish wells:

Average annual rate of output per well.

YEAR	For the whole of Poland	Boryslaw area only	Other localities
1925	419 tons	—	—
1926	391 „	1 497 tons	120 tons
1927	331 „	1 255 „	109 „
1928	319 „	1 140 „	108 „
1929	273 „	979 „	101 „

The average rate of output of the Polish oil wells is declining as a result of the exhaustion of wells in the Boryslaw area, but, nevertheless, it still exceeds that of the wells in the United States of America.

The crude oil, after having been struck, raised to the surface and scoured, is pumped into storage tanks from which it is next

distributed for treatment to refineries, either by pipelines or by rail, in tank waggons.

The whole output of crude oil is treated in home refineries; Poland has not been importing any crude oil from abroad for the past thirty years, nor has it been exporting any during the past few years. The refineries are in a position to deal with an output at least 40% in excess of the present one. At the moment there are 29 refineries in operation in Poland, of which number 16 are small and work only occasionally, when the opportunity is favourable. The number of workmen employed in the refineries at the end of 1929 was approx. 4 500.

The quantity of crude oil treated in Polish refineries during the past few years, and the quantities of products obtained therefrom, are shown in the following table:

Output of oil products in tons.

	1925	1926	1927	1928	1929
QUANTITY OF CRUDE OIL TREATED . . .	715 130	780 769	681 697	725 370	656 143
PRODUCTS OBTAINED:					
Petrol	96 570	93 240	90 283	97 008	101 723
Kerosene	202 760	233 596	203 508	216 826	188 383
Gas oil and fuel oil . . .	116 610	155 170	115 568	130 758	122 447
Lubricating oil	128 340	103 379	94 029	108 370	99 016
Paraffin	33 960	39 615	36 790	40 140	35 778
Candles	1 330	578	643	89	206
Asphalt	12 570	17 291	18 386	20 234	20 212
Coke	10 760	10 800	8 887	10 236	11 351
Vaseline, solid lubricants and Naphthene soap .	1 780	2 749	2 487	2 986	2 712
Semi-products & sundries .	43 170	53 546	47 715	37 390	12 891
TOTAL . . .	647 850	709 964	618 294	664 037	594 719

In compliance with the requirements of the home market, certain changes have occurred in the treatment of crude oil; as will be observed from the above table, the output of petrol, in spite of a decrease in the quantity of crude oil treated, has increased, which is due to technical improvements which reduce the evaporation-escape of the more volatile hydro-carbons, to the adoption of „cracking" equipment in two of the larger refineries, by means of

which petrol is being obtained from gas oil, and, finally, to the production of gasoline, by liquifying natural gas.

The following tables represent the home consumption and the exports of Polish oil products:

Home consumption of oil products, in tons.

	1925	1926	1927	1928	1929
Petrol	32 006	33 157	50 465	69 405	89 587
Kerosene	128 072	135 556	149 374	147 895	153 903
Gas oil and fuel oil	26 101	24 100	46 041	55 396	68 644
Lubricants	47 395	64 463	62 482	62 205	62 790
Paraffin	8 538	7 346	15 091	5 619	9 471
Candles	1 101	620	261	71	33
Asphalt	2 471	7 563	6 938	7 104	8 677
Coke	2 662	2 717	2 049	1 369	2 342
Vaseline, solid lubricants & Naphthene soap	1 706	2 517	2 471	2 665	2 404
Semi-products & sundries	23 180	23 255	22 540	21 479	16 971
TOTAL	234 032	309 294	357 712	373 208	413 922

Export of oil products, in tons.

	1925	1926	1927	1928	1929
Petrol *)	66 537	77 689	62 186	61 758	43 930
Kerosene	73 629	108 745	49 403	41 436	57 173
Gas oil and fuel oil	80 889	143 669	58 404	62 034	61 431
Lubricants	55 479	54 673	42 258	35 868	41 031
Paraffin	23 625	31 460	22 575	34 434	26 779
Candles	61	138	306	121	204
Asphalt	3 936	15 490	12 531	6 542	7 651
Coke	7 313	9 489	8 084	8 058	6 925
Vaseline, solid lubricants & Naphthene soap	171	135	174	229	282
Semi-products & sundries	22 356	18 255	14 481	9 997	3 363
TOTAL	333 996	459 743	270 402	260 477	248 768
*) In addition to which the following quantities of gasoline were exported	1 127	834	1 133	860	514

The home consumption during the five years under review increased by approx. 50%, the greatest progress being made by

petrol, the consumption of which increased at the rate of approx. 30% p. a., closely followed by kerosene and fuel oil.

The export of oil products is bound to decrease proportionately to the increase of home consumption and the decrease in the output of crude oil. Yet, under the most unfavourable conditions during the past year, it amounted to as much as 248 768 tons, or approx. 40% of the total output.

The export of oil products, as allocated to individual countries, is shown in the following table:

Export of oil products to individual countries.

	1925	1926	1927	1928	1929
Austria	33 813	49 763	32 256	35 934	34 378
Czechoslovakia	112 397	115 721	101 234	92 011	63 609
Danzig	69 916	178 710	63 343	66 606	79 583
Denmark	1 063	2 289	2 714	2 882	2 452
France	4 984	13 570	6 647	10 047	11 149
Germany	66 115	24 837	20 760	17 061	19 282
Great Britain	1 115	1 857	220	89	151
Greece	193	50	471	334	522
Hungary	5 498	9 327	4 955	4 153	3 469
Italy	2 129	5 465	3 787	3 662	4 169
Latvia	2 178	6 489	4 211	5 599	4 266
Lithuania	427	3 767	3 522	2 380	899
Rumania	1 850	1 915	1 316	658	327
Sweden	140	3 163	3 505	2 217	3 084
Swizerland	29 943	39 168	18 781	14 269	16 687
Yougoslavia	1 067	1 354	1 530	1 708	3 238
Other countries	1 168	2 298	1 150	867	1 503
Total	333 996	459 743	270 402	260 477	248 768

NATURAL GAS IN POLAND

By Z. Wrangel

The utilization of natural gas for boiler fuel at the oil wells dates as far back as 1894, although the over-production of oil during the period of 1906—1910 did not render it possible to put natural gas to greater use. Since, however, the prices of oil began to rise, the utilization of natural gas considerably improved.

Even as recently as in 1921 the quantity of crude oil consumed as fuel in Boryslaw amounted to 50 000 tons, representing 7% of the aggregate output of oil. At present, as a result of nationalized fuel economy, and the adoption of natural gas for fuel, the consumption of crude oil for this purpose in Boryslaw in 1929 amounted to approx. 2600 tons.

The output of natural gas in Poland during recent years was as follows, in thousand m^3:

Mining district	1925	1926	1927	1928	1929
Drohobycz	332 859	344 723	331 744	353 271	375 141
Jaslo	63 740	57 946	45 536	44 063	49 138
Stanislawów.	138 411	78 697	76 859	62 152	43 006
TOTAL . . .	535 010	481 366	454 139	459 486	467 285

The output of the individual areas and wells shows considerable fluctuations, as will be appreciated from the following table representing figures for December 1929:

Mining District	Locality	Average m^3/min.	Monthly output in thous. m^3	Number of wells in operation
Drohobycz	Boryslaw	503,0	22 446	411
	Daszawa-Gelsendorf	225,3	10 059	7
	Others	28,1	1 251	542
Jaslo	Męcinka-Sądkowa	126,6	5 649	19
Stanislawów	Bitków	84,6	3 585	79
	Others	11,3	504	9
		978,9	43 494	1 067

GAS FIELDS

Boryslaw fields. The first place is, thus, held by the Boryslaw fields (Boryslaw—Tustanowice—Mraźnica), which yield over 50% of the total output of natural gas.

The main gas area in the Boryslaw fields is at Mraźnica, with 217,8 m^3 per minute, next follows Tustanowice with 175,8 m^3 and Boryslaw with 109,4 m^3.

The output of natural gas in the Boryslaw fields emanates in its majority from wells simultaneously yielding oil.

The total number of wells in the Boryslaw fields yielding natural gas at present amounts to 411, whereof:

in Boryslaw 135
„ Tustanowice . . . 194
„ Mraźnica 82

The first natural gas trunk line from Tustanowice to the Refineries of the „Galicia" Co. at Drohobycz (10 kilometres) was erected in 1911, a second line being erected in 1912 to the State Refinery at Drohobycz (approx. 13 km).

As to the utilisation of natural gas, its greater portion is used entirely in the production of gasoline, the remaining quantity being totally utilized for acting the drive of drilling equipment.

Daszawa fields. Close connection, by means of a gas trunk line, exists between Boryslaw and Drohobycz on the one side and the highly productive and extensive gas fields at Daszawa-

Gelsendorf, situated North-East of the city of Stryj, in miocenic formations, on the other side.

The gas fields of Daszawa, discovered in 1921/1924, are among the most productive and most promising ones. In 1924, at a depth

Fig. 1. Escape of gas at a well in the Daszawa fields.

of 736 metres, the main gas vein was struck, from which all further wells, subsequently drilled, obtain their supply. The escape of gas at this well (see fig. 1) was so terrific that at the time it could not be harnessed by means of the available equipment, and only

a month later a sufficiently strong valve could be erected to harness the gas.

At a pressure of 30 Ats. the output of this well amounted to 77 m^3/min. Even at the present moment, after more than 5 years of operation, this well yields, on average, approx. 50 m^3/min.

Among some characteristic features tending to prove the presence of enormous resources of natural gas, is the fact of remarkable constancy of pressure in a neighbouring well, viz. „Daszawa I", where gas was struck in 1925 at a comparatively small depth. This well, after having been harnessed, showed for a considerable time a pressure of approx. 60 Ats. in spite of its closeness (250 metres) to the originally drilled well.

At a third well „Książe Pole I" the initial output of gas reached in 1927 at a depth of 666 metres amounted to approx. 50 m^3/min. The fact that this well is some $2^1/_2$ kilometres away from the previously drilled wells is indicative of the extensive area of this gas field.

Subsequently, in Daszawa-Gelsendorf a further 6 wells were completed during 1928—1929 at depths of from 438 to 778 metres.

The following figures represent the gas output of Daszawa, in thous. m^3:

1923	659
1924	5 624
1925	45 550
1926	51 527
1927	51 894
1928	66 149

Full use of the Daszawa output will probably be rendered possible by the gas trunk line recently erected by the Gazolina Co. from Daszawa to Lwów.

K r o s n o — J a s l o f i e l d s. Third rank, in respect of output of natural gas, is occupied by the Krosno—Jaslo gas fields in western Galicia, the total output of which at present amounts to approx. 127 m^3/min.

Gas is available at Krościenko in oil yielding wells. The boundary of the gas area proper commences at Potok. Wells situated to the West (community of Jaszczew, Męcinka, Bialkówka and Brzezinka) produce exclusively gas.

The first gas well was drilled in 1896, but the issuing gas was so powerful that it could not be put to any use under the condi-

tions prevailing at that time. The development of the natural gas industry only commenced with the erection of the Iwonicz—Gorlice trunk pipe line which was erected in 1916 and which distributes gas throughout the district.

The most western gas wells are situated at Sobniów, to the West of the communities of Dobrucowa and Sądkowa, and at Roztoka.

The output of the wells in the Krosno gas area reached 150 m^3/min. and more, the average output of one well reaching the highest figure in 1919 (85 m^3), but subsequently began to fall rapidly (33 m^3 in 1921 and 12.3 m^3 in 1923).

However, even at present, other wells with a considerable output are being opened up, thus for instance at the end of 1927 the well „Gaz V" at a depth of 1154 m yielded gas at a rate of up to 25 m^3/min.

Bitków fields. In the Bitków fields natural gas is yielded both at the so-called „old well" and the „Dział" area, and also in the so-called „Gas area", situated more to the North.

Gas at the „old well" and the „Dział" area is operated simultaneously with oil. The quantity of gas struck here was comparatively insignificant (from 4 to 6 m^3/min) so that it was easy to harness and to put it to use as fuel at the wells.

The position in respect of the northern gas fields is different. Four wells were opened up there in 1924, viz.: „Olej Skalny" 6 and 8, „Nafta 1" and „Dąbrowa 134" with an aggregate output of gas of 200 m^3/min which, however, due to the difficulties in harnessing same and putting it to use, was for a long time allowed to escape.

On the basis of drillings carried out, 4—5 individual gas layers per 100 metres of menilite schist drilled were determined.

In view of the situation which arose at that time, the mining authorities were forced to prohibit the completion of newly commenced wells in this gas area. In 1925, the wells nearing completion were closed up and the output of gas harnessed, thus preventing further waste of this valuable fuel.

Besides Bitków, we must also refer to Piaseczna, where the „Laszcz" well in July 1927 yielded 200 m^3/min of gas, thereby proclaiming extensive resources of natural gas in this newly discovered field.

Chemical composition of natural gas

The following table gives the chemical analysis of natural gas from the more important gas areas: *)

Locality	CH_4	C_4H_{2n+2}	CO_2	O_2	CO	N_2	H_2
Boryslaw . .	60,6 – 70,7	27,8 – 38,2	0,4 – 1,5	0,5 – 2,1	0 – 0,4	0, – 3,4	—
Krasno-Jaslo .	63,9	96,8	0 – 1,9	0 – 7,4	–	1,3 – 28,7	—
Bitków . . .	85,2 – 85,9	5,3 – 9,8	3,3 – 3,8	0,9 – 1,9	–	0,1 – 3,8	—

As will be seen from the above table, the combustible part of natural gas consists almost entirely of hydrocarbons. In addition to the latter, the combustible part also contains, in small proportion, carbonic oxyde, whereas hydrogen is altogether absent. The non-combustible components consist of: carbon dioxyde, oxygen and nitrogen.

The Daszawa gas, thus, consists almost entirely of methane, which constitutes approx. 99%.

As to helium, this element has been detected in almost all of the sub-Carpathian natural gases. The proportion of helium, according to tests carried out, is comparatively insignificant and in no case does it exceed 0,03%, increasing at a regular rate from West to East.

Calorific value of natural gas

Natural gas is an ideal fuel, due to its purity and the uniform temperature it maintains during combustion. The calorific value of gas depends, as it is known, on its chemical composition. The calorific value of the gas in the western gas fields (Krosno—Jaslo) amounts to approx. 8 000 calories per m^3, whereas that of Daszawa exceeds 9 000 calories, and that of Boryslaw — 11 000 calories.

GAS TRUNK LINES

In 1919 a Decree was issued vesting in the Government the exclusive right of erecting gas trunk lines. In the same year the Government proceeded to erect a gas trunk line in the Jaslo district,

*) According to Dr. Kling and L. Suchowiak.

of a length of 30 kilometres and, by purchasing private gas pipe lines, formed a system in Western Galicia known as the „State gas trunk line Iwonicz—Gorlice", of a total length of 66 kilometres.

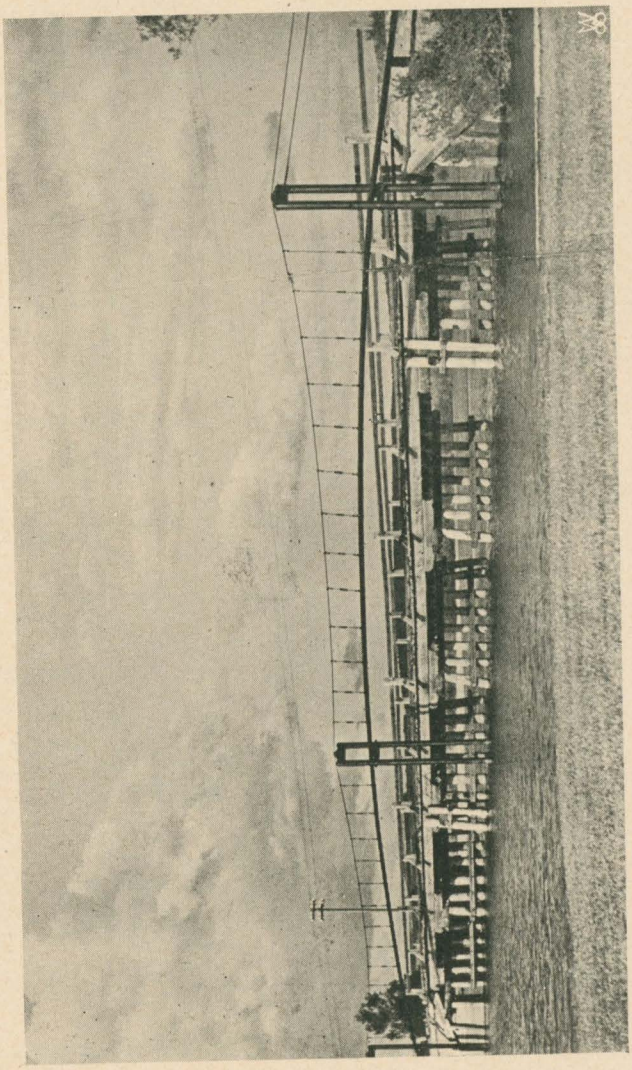

Fig. 2. Suspension bridge for the gas trunk line crossing the river Dniestr.

As an immediate consequence thereof, glass, brick, distilling and other industries began to develop in recent years in the neighbourhood of Krosno and Jaslo, and simultaneously gas has been introduced as boiler fuel in neighbouring oil refineries, as well as

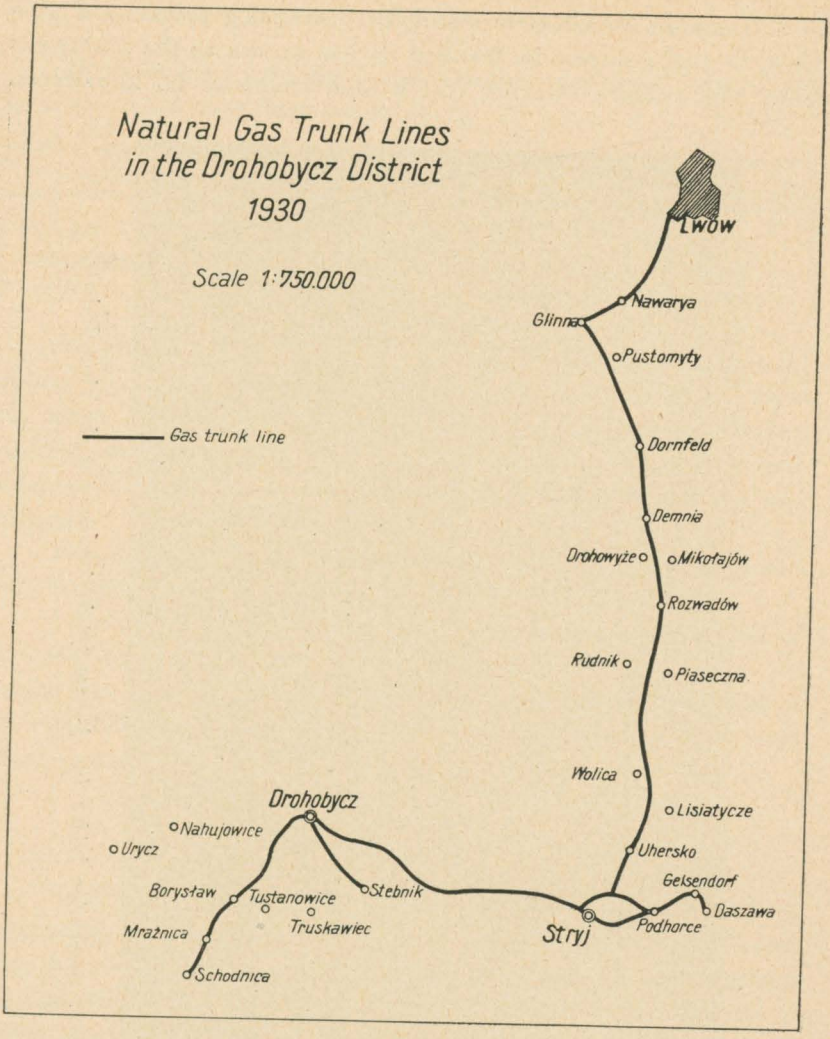

Fig. 3. Natural Gas Trunk Lines in the Drohobycz District.

for heating and lighting purposes in towns (Krosno, Jaslo, Jedlicze).

The distribution of natural gas in December 1929 (at a total rate of output of 126,6 m^3/min.) was as follows:

supplied to sundry consumers . . .	101,4	m^3/min.
own requirements of the wells . .	15,0	„
loss	10,2	„

The more important consumers at the present time are:

oil refineries	70,7	m^3/min.
cities	11,1	„
glass factories	6,7	„

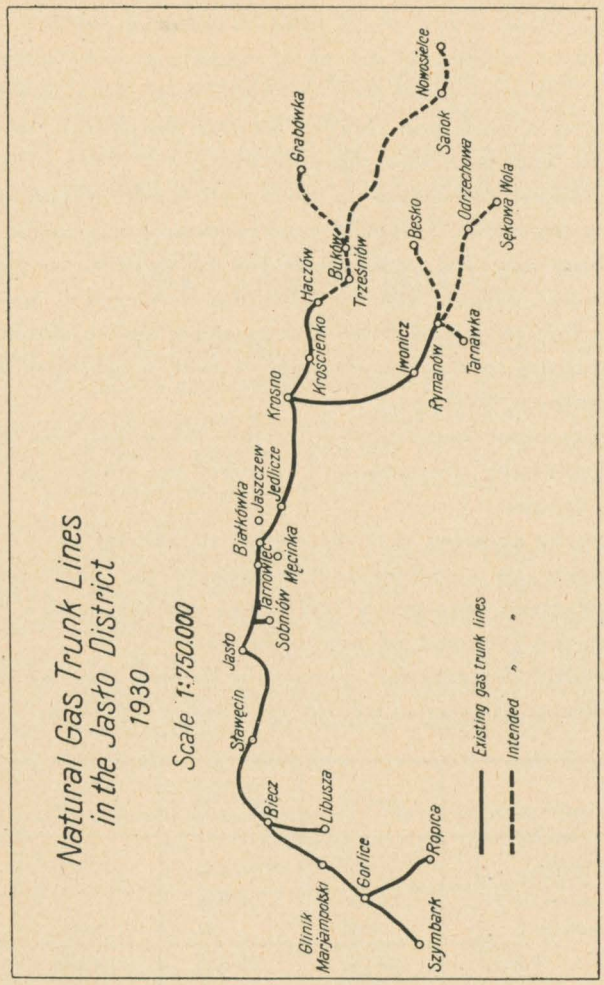

Fig. 4. Natural Gas Trunk Lines in the Jaslo District.

In 1923 a private Company known as the „Inter-urban gas lines" erected a 7″ pipe line from Daszawa to Stryj, and later on, in 1924, another 7″ gas pipe line was erected from Stryj to Drohobycz.

In addition to these lines, a further line from Daszawa to Drohobycz was erected in 1928 by the State Petroleum Refineries „Polmin".

The largest gas trunk line in Poland at present is that from Daszawa via Stryj to Lwów, of a total length of approx. 90 kilometres which was carried out in 1929 by the „Gazolina" Co. under a concession granted to it by the Polish Government *).

The pipes, welded by means of water-gas, were subjected to a hydraulic pressure of 60 Ats. The individual pipes had a length of 5—6 metres each and, before leaving the works, had been welded into lengths of two pipes each.

The greatest difficulties in the erection of the gas line were met in crossing rivers. A special construction of suspension bridges on steel ropes was used to overcome the difficulties (see fig. 2).

The route selected for the pipe line rendered it possible to supply gas fuel to the adjacent lime quarries and to distribute gas to such localities to which the supply of coal is awkward, owing to lack of transport facilities.

An agreement concluded with the Municipal Gas Plant at Lwów provides for the supply of natural gas, to be mixed with ordinary coal gas.

It must be assumed that the supply of natural gas to the city will constitute an excellent factor towards the development of existing industrial enterprises (refineries, glass factories, etc.), as well as for the founding of new industries.

In the Drohobycz mining district the balance sheet of the operation of natural gas was as follows (December 1929), in thous. m^3:

	Output	Supplied to sundry consumers	Used at the wells	Loss
Boryslaw district . .	22 446	10 535	11 752	159
Daszawa-Gelsendorf .	10 059	10 056	3	—
Other localities . . .	1 251	24	1 227	—
Total. .	33 756	20 615	12 982	159

In the Stanislawów mining district the difficult conditions which ensued from the excessive output of the wells in the so-

*) M. Wieleżyński: „Natural Gas at Daszawa" published in No. 18 of the journal „Przemysł Naftowy" (Oil Industry) in 1929.

called „gas district" and the lack of adequate market facilities resulted in the slackening of drilling. Out of an output of 4 089 000 m^3 per month in the eastern part of this gas district (localities: Bitków, Pasieczna and Dźwiniacz) the supply to sundry consumers amounted to only 762 000 m^3 (mostly to other oil wells and ozokerite mines), 2 916 000 m^3 were used for own requirements, whereas 411 000 m^3 are represented by loss and waste escape.

The erection of gas trunk lines to Stanislawów, Kalusz and Kolomyja would create a new and extensive market for gas fuel and would considerably promote the development of the gas industry in the gas field which nature has so lavishly favoured.

THE GASOLINE INDUSTRY

The value of the Polish natural gas is considerably enhanced by the fact that in numerous instances the so-called humid gas is capable of yielding gasoline, i. e. light petrol of a specific gravity of 0,660 — 0,710. A patent taken out by Mr. W. Wolski in 1898 for the production of gasoline from gas was the first patent of its kind in the world.

The gasoline industry was inaugurated before the war by the „Gazolina" Co., but not before 1924 did it commence to make enormous progress. Suffice it to say that at present the gasoline industry has an output representing 1/3 of the total output of petrol obtained in refineries by the distilling of crude oil.

The development of the gasoline industry in Poland is represented in the following table:

Year	Quantity od gas dealt with in thous. m^3	Quantity of gasoline obtained in tons
1914	3 585	463
1921	5 265	661
1923	8 850	795
1924	42 376	3 435
1925	116 249	9 793
1926	188 141	18 044
1927	248 415	27 794
1928	259 205	31 855
1929	277 083	34 504

The total number of gasoline plants in Poland at present amounts to 21. The largest number is situated at Boryslaw (15), two plants each are at Schodnica and Bitków, and one each at Drohobycz (at the „Galicia" Co.'s refineries) and at Rypne.

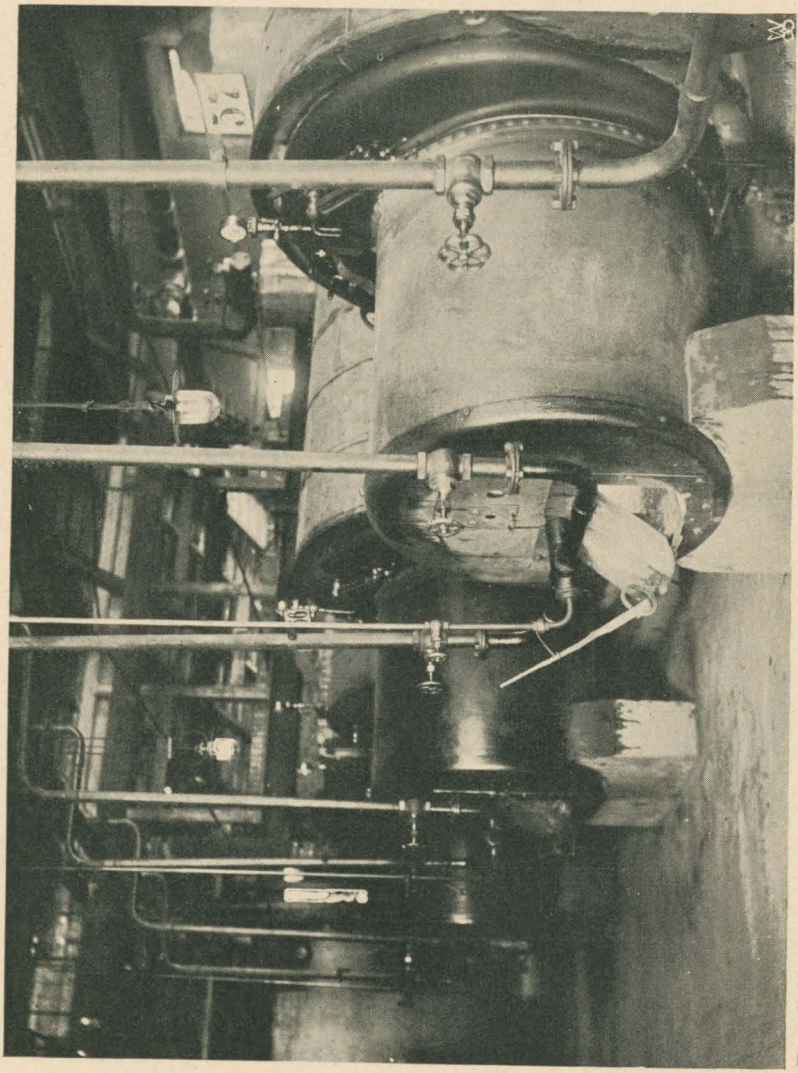

Fig. 5. Interior of the boiler house with a battery of Cornish type boilers using natural gas fuel.

The majority of Polish gasoline plants work on the coal method. This method depends on the absorption of gas by so-called active coal and the extraction of the gasoline, so absorbed, from

the coal by means of water steam, the coal after each extraction of gasoline being dried by air.

In addition to this method, the so-called „oil" and „compression" methods are also used.

The latest achievement of the Polish gasoline industry is the manufacture of „Gazol", which constitutes a mixture of fluid butylene and propylene. One cubic metre of „Gazol" has a heating value of approx. 25 000 calories.

PEAT

By Prof. St. Turczynowicz

The peat bogs in Poland constitute over 8% of the aggregate area of the country, occupying approximately 3 000 000 hectares. The compilation of a general register of peat works, initiated 10 years ago, is not completed yet; the area of peat bogs examined for purpose of guidance only amounts to approximately 1 000 000 hectares, whereas the area of those thoroughly surveyed amounts to roughly 300 000 hectares.

The geographical allocation of peat bogs in Poland is not uniform. The largest peat bog areas are located in the Voivodeships *) of Polesie (38%), Nowogródek and Bialystok (11%), Vilno and Volhynia (10%). The Voivodeships with a medium percentage of peat bogs (5 — 10%) are: Poznań, Pommerania, Lublin and Lwów. In the remaining Voivodeships, the percentage of peat bogs is less than 5%.

The peat bogs in Poland are partly located in watersheds, though the majority lie in the valleys of the rivers Prypeć, Narew and Bug, with their tributaries, the Noteć, Odra, Brda, etc. The location of peat bogs along the rivers influences their chemical composition and physical properties. Thus, presumably, approx. 95% thereof are lowmoor bogs, and only some 5% highmoor. The highmoor peat bogs are located mainly in the Voivodeships of Vilno, Nowogródek, the north-eastern part of the Voivodeship of Polesie, in Pommerania and along the foot of the Carpathian range. In other districts of the country they are only met with sporadically.

*) The largest administrative division in Poland.

As regards the size of individual peat bogs, they often extend over some hundreds of square kilometres. The number of peat bogs of more than 1 000 hectares each is approx. 70, representing an aggregate area of some 1 200 000 hectares.

The medium sized peat bogs (from 200 to 1 000 hectares each) represent an aggregate area of presumably some 1 000 000 hectares, the balance, i. e. approximately 800 000 hectares, consists of smaller peat bogs of from a few up to 200 hectares. These latter, though occupying the relatively smallest area, are exceedingly numerous, due to which they play an important role in the economic life of the country. The thickness of the layers of peat in Poland varies from some tens of centimetres up to ten odd metres. The deepest peat bog so far thoroughly surveyed is near the village of Strutyń in the Voivodeship of Stanislawów; this is a highmoor peat bog of 220 hectares, with a depth of 15 metres.

According to the survey and statistics of Dr. S. Olszewski, the average depth of peat bogs surveyed is approximately 2,5 metres. Considering, however, that the survey was being carried out mainly in respect of the larger peat bogs, as to which there were certain assumptions or tangible informations that they were suitable for exploitation, it must be anticipated that those peat bogs which have not yet been surveyed will not be quite so deep, so that the average depth of the peat layers in Poland ought to be estimated at a figure not exceeding some 1,5 metres.

On the basis of above figures, the resources of crude peat in Poland may be computed at approximately 45 000 000 000 cubic metres, which could yield more than 6 000 000 000 tons of fuel peat. This also includes the socalled „concealed" peat bogs, that is to say such as are covered by a more or less thick layer of mineral soil.

It is obvious, however, that certain of these peat bogs may be of considerable value for industrial fuel purposes, as in respect of the degree of humification and of specific gravity they might considerably surpass the more recent peat bogs lying at the surface. Some 30 of such concealed peat bogs have so far been determined, some of them with a depth of up to 5 metres.

The value of our peat for industrial fuel purposes, as a rule, is not particularly high. The proportion of highmoor and lowmoor peat bogs (5% and 95% respectively) in itself shows that the quantity of peat with a small content of ashes is not considerable.

The average content of ashes in Polish peat may be fixed at between 10% and 15%. The calorific value of Polish peat, dried to the extent of 25% moisture, is estimated at 3200 to 3300 calories, although peat is also available of a calorific value (at 25% moisture) of up to 3900 calories.

As regards chemical composition, Polish peat in certain respects differs from the peat of Western Europe. Thus, primarily, in respect of calcium content, Poland has enormous peat bog areas in the Voivodeships of Vilno, Nowogródek and Polesie, in which lowmoor peat (phragmitetum, caricetum, cariceto-hypnetum) contains a mere 0,57 to 2,30% of calcium oxide, whereas in Germany, Professor Fleischer allocates to lowmoor peat bogs only such peat which contains more than 2,5% CaO.

The next component, in respect of which certain of our peat differs from others, is Nitrogen. There are numerous peat bogs in Poland with peat containing more than 3% Nitrogen (3,2 to 3,87%), which renders it possible to obtain, as a by-product, Ammonium Sulphate.

The winning of peat in Poland is at present restricted almost exclusively to the meeting of local requirements. Owing to the purely local character of exploitation and consumption of peat, as well as in view of the enormous number of peat bogs dispersed all over the country, it is impossible to quote even approximate figures as to the annual output of peat and the number of localities where exploitation proceds.

The term of „local requirements" must, however, be construed as applying not only to household fuel, but also to fuel for industrial enterprises, such as brick-kilns, sugar factories, distilleries and even electric plants, etc.

Apart from the utilisation of peat for fuel purposes, there is also a small number of factories in Poland for the manufacture of blocks, insulating sheets, etc. from peat.

TIMBER

By Professor A. Schwarz

The aggregate area of forest land in Poland, according to the statistics of the Ministry of Agriculture, amounts to 8 969 388 ha. Relatively to the entire area of the country, amounting to 38 869 000 ha., with a population of more than 30 millions, the area of forests in Poland represents 23%, which works out at a rate of approx. 0,30 ha. per capita of population.

It must be pointed out that the Polish forests have been greatly devastated by the belligerent armies during the Great War (1914 — 1918), so that the aforesaid area actually represents forest land rather than forests; this latter, in effect, is the minor portion, in spite of the most strenuous efforts to re-tree the waste areas.

In comparison to the average proportion of the forests in other European countries which amounts to 28%, that in Poland is less by 5%.

A very characteristic feature, which at the same time is most important in respect of the opportunities of exploitation of the forests, is that the forests in Poland are spread all over the country, though in a most irregular manner and, invariably, in those parts of the country which are most densely populated and in a stare of the greatest industrial development, the forest areas are relatively small.

The allocation of forests in respect of the individual Voivodeships *) is shown in the following table:

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*) The largest administrative division in Poland.

Voivodeship of:	Areas of forest in hectares			Forest density	
	State owned	other than State owned	Total	relatively to the respective area, %	per capita of population, in hectares
Warsaw	109 701	232 955	342 656	12	0,10
Lodz	75 449	199 117	274 566	14	0,11
Kielce	246 227	379 366	625 593	24	0,23
Lublin	88 348	558 345	646 693	21	0,29
Bialystok	502 103	169 777	671 880	21	0,48
Total for the Central Voivodeships.	1 021 828	1 539 560	2 561 388	19	0,21
Vilno	205 637	511 680	717 317	25	0,28
Nowogródek	168 380	398 338	566 718	25	0,64
Polesie	385 630	914 137	1 299 767	31	1,67
Volhynia	213 367	573 766	787 133	26	0,50
Total for the Eastern Voivodeships	973 014	2 397 921	3 370 935	27	0,76
Poznań	227 383	262 470	489 853	18	0,22
Pommerania	318 740	79 548	398 288	24	0,40
Silesia	9 673	133 822	143 495	34	0,12
Total for the Western Voivodeships	575 796	475 840	1 031 636	21	0,24
Cracow	21 993	385 734	407 667	23	0,19
Lwów	27 509	650 357	677 866	25	0,23
Stanisławów	260 592	385 004	645 956	35	0,45
Tarnopol	—	273 940	273 940	16	0,18
Total for the Southern Voivodeships	310 394	1 695 035	2 005 429	25	
Grand Total for the whole of Poland	2 861 032	6 108 456	8 969 388	23	0,31

The forests in the aforesaid districts form more or less concentrated areas. There are 17 important concentrated forest areas in Poland, the largest of these being: 1) the so-called virgin forest of Międzyrzecze, of an area of 49 175 ha. (state owned), 2) the so-called Nalibocka and Wiszniewska virgin forest, of 42 019 ha. (state owned), 3) The Grodno virgin forest, of 104 129 ha. (state owned), 4) The Augustów virgin forest, of 107 653 ha. (state

owned), 5) The Knyszyn virgin forest, of 58 202 ha. (state owned), 6) The Bialowieża virgin forest, of 142 926 ha. (state owned), and the smaller Kozienicka, Holy Cross, Carpathian and Tuchola virgin forests.

The Polish forests contain various species of trees, the proportion of the more important varieties being as follows: pine 60%, red fir 12%, common fir 3%, oak 5%, other deciduous varietis 20%, whereof 10% beech. Thus, the aggregate forest area of Poland consists in 75% of coniferous trees and in 25% of deciduous trees.

The output of timber by Polish forests is not uniform. The rate of output under rational forestry policy, should correspond to the rate of increment in timber. The annual rate of increase in Poland per hectare amounts to 2,85 m^3 in respect of State owned forests and to 1,82 m^3 in the case of privately owned forests. The approximate annual increase in timber for the entire forest area of Poland, should thus amount to:

in respect of State owned forests	2 861 032 ha × 2,85 m^3 = approx. 9 000 000 m^3
in respect of privately owned forests	6 108 356 ha × 1,82 m^3 = approx. 11 000 000 m^3
Total, in round figures	20 000 000 m^3

Actually, however, the output of timber in Poland was considerably greater, particularly in privately owned forests, due to various factors, such as, for instance, the necessity of felling trees attacked by the Pannolis Flamea, the increased demand for timber in the country for repairing war damages, the increased export of timber abroad in order to maintain the trade balance.

The exports of timber from Poland in 1927 were as follows:

Firewood	156 998	tons,	representing	261 663 m^3
Pulp wood	1 272 902	„	„	2 121 503 „
Pit props	1 099 205	„	„	1 832 008 „
Logs (for saw mills and building purposes)	1 451 679	„	„	2 419 460 „
Boards	2 004 222	„	„	3 340 370 „
Sleepers	228 768	„	„	107 488 „
Telegraph poles	64 493	„	„	381 480 „
Barrel staves	37 691	„	„	62 818 „
Sundries	1 835	„	„	3 058 „
Furniture	6 084	„	„	10 140 „
Veneer and plywood	22 888	„	„	38 110 „
Chemical products (paper, cellulose)	25 051	„	„	41 751 „
Total	6 371 916	tons	representing	10 619 659 m^3

Considering that the home demand for timber amounts to approx. 20 000 000 m^3 per annum, it will be appreciated that the exports were maintained at the expense of excessive output

The normal annual output (approx. 20 000 000 m^3) consists of industrial timber to the extent of approx. 52%, and of firewood to the extent of approx. 48%, or approx. 10 400 000 m^3 and 9 600 000 m^3 respectively.

In order to compute the power equivalent, the above quantity of firewood of 9 600 000 m^3, as well as a certain proportion of the industrial timber, namely such as is worked-up in the country and which provides a certain amount of waste suitable for fuel purposes, i. e. contributing towards the generation of power, should be taken into consideration.

The dominating factor in this respect are the saw mills, whose annual consumption amounts to approx. 7 000 000 m^3 of logs *). In the course of sawing-up this quantity of timber, waste to the extent of approx. 20% is obtained in the form of saw-dust and shavings, which, converted into cubic metres, represent approx. 1 400 000 m^3. Other mechanical woodworking industries do not come into consideration, as relatively insignificant consumers.

By totalling up the two figures specified above, i. e. 9 600 000 m^3 of firewood and 1 400 000 m^3 of waste, we arrive at a figure of 11 000 000 m^3 of timber constituting a source for generating power.

Considering that the majority of timber consumed in Poland is pine, a cubic metre of which, after drying, weights approximately 600 kilograms, the corresponding weight in respect of the above total will amount to $11\,000\,000 \times 0{,}6 = 6\,600\,000$ tons of timber, representing a calorific value of approx. 18 000 000 calories, which represents an equivalent of about 3 000 000 tons of coal.

In order to render the description of the timber industry in Poland complete, it may me added that the number of saw mills in operation in the country *) amounts to 1687, equipped with 3 355 frames. Further, Poland has 3 cellulose factories, 26 wood pulp mills, 10 match factories, 117 furniture factories and 24 parquet flooring factories.

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*) W. Barański. „Kwestja drzewna w Polsce" („The Timber Problem in Poland").

*) According to the Report of the State Inquiry Commission.

WATER POWER

By H. Herbich

A thorough appreciation of available water power resources in Poland, as well as of the opportunities towards their utilization, is considerably handicapped owing to the inadequacy of data compiled as to the main factors on which computations of water power could be based, namely, the rate of flow and head on the rivers.

The collecting of these data so as to prepare the inventory of undeveloped resources of water power and the statistics of developed power is the task of a special Board, namely the Central Hydrographical Bureau, Ministry of Public Works.

The principles adopted by this Bureau for the purpose of compiling the statistics of water power in Poland are based on the standards fixed by the Polish National Committee, World Power Conference, which, in their turn, comply with the recommendations of the International Advisory Committee on rating of rivers. These latter fix: 1) the head which is to be taken into consideration in computing water power, 2) the methods for determining characteristic values and periodic rates of flow, specifying periods in respect of which such rates of flow are to be determined, 3) the efficiency factor applicable in computing capacity, and 4) the values for minimum heads and power per km of river flow, constituting the extreme limit below which the utilization of water power should be dispensed with.

The rotation, in which the compilation of river statistics is being carried out, has been determined according to general classification, commencing with rivers with the largest resources of water power. The survey which has been going on for several

years has so far resulted in the classification of the basin of the rivers Dunajec, San and Stryj; the data collected in respect of the former two have been published, the publication comprising the hydrometrical survey and power estimates.

It appears from the rough characteristics of Polish rivers that the most important, in respect of water power resources, are the basins of the Upper Vistula, Prut and Dniester, the tributaries of which drain the slopes of the Carpathian Mountain range. These rivers are conspicuous, primarily for their considerable slopes and for being located in the sphere of heavy rainfall, as a result of which the volumes of flow and the specific power value, in spite of the comparatively small area, are quite considerable. They are followed by the rivers draining the hills in the Pommeranian Lake District which rank among the larger ones and present special facilities for exploitation. These rivers have an abundance of water equalized by the lakes, as well as concentrated heads rendered possible by the reduction of the length of flow. Similar features accompany the rivers in the Niemen and Wilja basins.

The aggregate value of water power in Poland, computed on the basis of mean annual flow, amounts to approximately 3 700 000 HP, which works out at the rate of approximately 10 HP per square kilometre and at approximately 0,13 HP per capita of population. This amount of power available corresponds to 16,2 milliard kWh per annum.

In respect of the possibility of economical utilization the water power resources are divided into 4 categories. The first (Table I) comprises rivers whose specific power per kilometre of flow as a rule exceeds 200 HP and whose slope is more than 0,5 $^{0}/_{00}$. There are 46 such rivers in Poland. There are, however, certain sectors on some of these rivers with slopes of less than 0,5$^{0}/_{00}$, and of less than 200 HP/km power, yet, in view of the possibility of reducing the length of flow, or in view of certain other features rendering their exploitation favourable, it was deemed necessary to include them in the first category. The water power resources in this category, which is undeniably fit for rational exploitation, amount to 1 320 000 HP, equivalent to approximately 5,76 milliard kWh per annum. By adopting partial equalising of the discharge by means of storage reservoirs, the aforesaid figures would be increased to 1,7 million HP of installed capacity and to 6,6 milliard kWh of annual output.

Converting the figure of all available sources of power to the equivalent average value of black coal (of 6000 calories), and assuming that the ultimate effective power value per 1 kg of coal

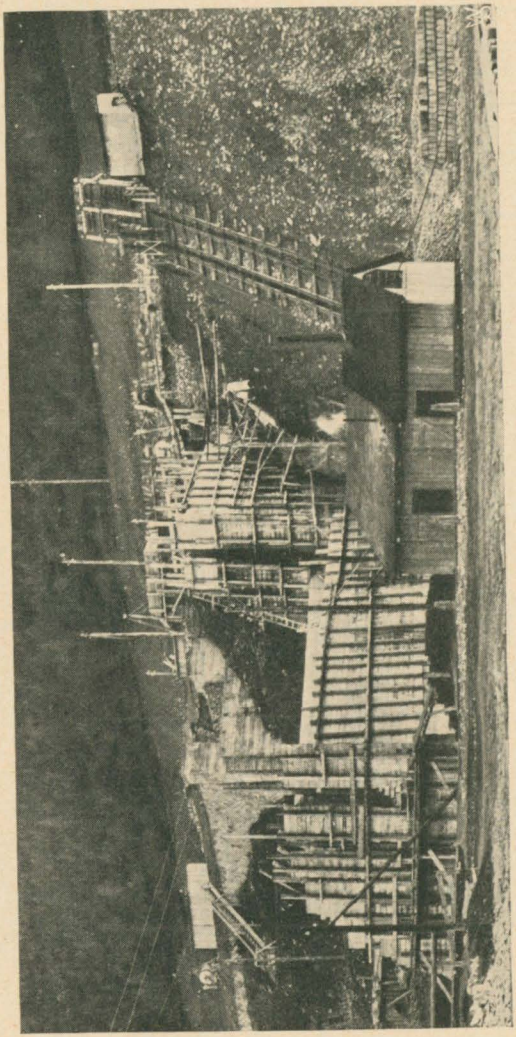


Fig. 1. Hydro-electric plant „Porąbka". Right hand bank sector of the dam under construction from the inlet end.

is equal to 0,735 kWh of water power, we arrive at a figure of 9,2 million tons of coal as constituting the equivalent of water power available. The water power resources of Poland, estimated

TABLE I.

Water power resources — first category.

Item	River	Stretch		Length in km	Head		Rated capacity at mean rate of flow and 75 per cent efficiency		Average output per annum
		from	to		Gross, m	‰	HP	HP	kWh
1	Vistula	mouth of Przemsza	mouth of Dunajec	160	54	0,34	53 220	332	233 000 000
2	Sola	mouth of Rajcza	Oświęcim	76	268	3,54	25 610	339	113 200 000
3	Skawa	mouth of Biala	Zator	52	155	2,99	15 410	297	66 500 000
4	Skawica	source	mouth	22	364	16,30	8 260	368	34 750 000
5	Raba	mouth of Mszana	mouth of Stradomka	53	179	3,39	15 330	290	67 100 000
6	Dunajec	Nowy Targ	Żabno	184	406	2,22	139 250	755	615 800 000
7	Bialy Dunajec	Zakopane	Nowy Targ	25	223	9,05	10 220	413	47 700 000
8	Bystry, Olcza, Sucha Woda			24	1366	56,92	6 570	274	31 590 000
9	Czarny Dunajec	Kościelisko	Nowy Targ	47	446	9,48	15 290	325	55 500 000
10	Bialka	Morskie Oko	mouth	40	872	21,70	17 440	434	74 300 000
11	Roztoka	Pięć Stawów	mouth	5,4	644	119,20	2 900	537	12 500 000
12	Poprad	Leluchów	Stary Sącz	62	177,5	2,86	28 620	462	134 000 000
13	Roztoka	source	Rytro	9	874	95,00	1 750	190	7 500 000
14	San	Tarnawa	Przemyśl	250	455	1,82	81 020	324	351 800 000
15	Solinka	Cisna	Solina	31	176	5,60	7 910	251	36 500 000
	Total for the Carpathian basin of the Vistula						428 800		1 881 740 000
16	Dniestr	Lomna	mouth of Strypa	251	311	1,24	124 800	497	547 000 000
17	Stryj	Matków	mouth	197	415	2,10	127 360	646	566 700 000
18	Opór	Slawsko	mouth	41	206	5,07	27 940	688	121 900 000
19	Orawa	Koziowa	mouth	12	124	10,33	2 840	229	12 000 000
20	Świca	source	mouth	97	754	7,78	43 910	453	192 500 000
21	Mizunka	source	mouth	45	421	9,35	11 450	254	50 000 000
22	Lomnica	source	mouth	118	877	7,43	67 700	573	287 000 000

23	Czeczwa	source	mouth	53	455	8,60	13 240	250	56 000 000
24	Bystrzyca	source	mouth	101	638	6,32	46 530	461	197 100 000
25	„ Solotwińska.	source	mouth	78	718	9,26	27 300	352	116 500 000
	Total for the Carpathian basin of the Dniestr . .						493 070		2 146 700 000
26	Prut	source	frontier	158	750	4,70	74 860	473	320 000 000
27	Czeremosz	mouth of Sarata	mouth	146	870	5,96	119 770	820	521 900 000
28	„ Czarny .	source	mouth	91	915	10,10	35 400	389	149 000 000
	Total for the basin of the Prut . . .						230 030		990 900 000
	Aggregate total for Carpathian Rivers						1 151 900		5 019 340 000
29	Drwęca	mouth of Rypienica	junction with Vistula	65	29	0,45	6 520	100	30 500 000
30	Brda	lake Kosobudy	junction with Vistula	130	90	0,69	19 880	153	92 700 000
31	Czarna Woda . . .	mouth of St. Potok	junction with Vistula	54	58	1,07	6 060	112	28 250 000
32	Wierzyca	mouth of Piesienica	junction with Jonka	23	45	1,91	3 050	130	14 230 000
	Total for Pommeranian Rivers . . .						35 510		165 680 000
33	Niemen	mouth of Lebioda	mouth of Szczara	28	10	0,36	9 500	339	44 000 000
34	Wilja	mouth of Serwecz	frontier	186	77	0,42	65 100	350	291 200 000
35	Żejmiana	mouth of Mera	mouth	22	23	1,05	3 550	161	16 000 000
36	Wilejka	Wilejka	mouth	13	48	3,70	2 200	169	9 600 000
	Total for the Vilna District Rivers. .						80 350		360 800 000
37	Wieprz	Kijany	mouth	39	20	0,51	8 770	224	38 500 000
38	Pilica.	mouth of Czarna	Osupów	56	33,5	0,60	11 710	209	51 300 000
39	Strypa	Leszczańce	mouth	25	91	3,60	6 750	264	30 000 000
40	Seret	Bucniów	mouth	151	157	1,00	23 250	153	100 000 000
	Total for the remaining area of Poland.						50 480		219 800 000
	Grand Total for Poland						1 318 240		5 765 620 000

over a period of 1000 years, represent 12,6% of the total of all power sources.

Water power, according to the nature of the work to which it is to be adapted in the individual provinces, may be divided into two categories.

The first category comprises the Carpathian rivers of Little Poland (Galicia) on which the head is considerable, and offering opportunities for the construction of large retention reservoirs. These, due to the mountainous nature of the valleys, ought to be intended for covering peak loads, at a small number of hours of work during the year at total installed capacity. The construction of retention reservoirs for this category of mountain rivers is all the more advisable due to the fact that these rivers are marked by a most irregular rate of flow, the divergence between the rate of flow at high and low water being very considerable. The construction of retention reservoirs in the aforesaid districts will be of great benefit to the navigation on the lower sectors of the rivers, extending the time at which navigation is possible and minimizing the danger of floods. From the point of view of national interests, considerable economy may be achieved, as a result of the fact that, due to the balancing of the rate of flow, the regulation of rivers may in many instances be dispensed with altogether, or the cost of usual maintenance of regulation and safety arrangements may be considerably reduced.

The second category comprises the rivers of Pommerania, Great Poland and the Vilno district which, due to a lesser head and to a more uniform rate of flow, regulated by numerous natural reservoirs in the form of lakes, provide a higher annual rate of output. These rivers may be utilized to advantage for covering the middle part of the load curve, and, at a higher rate of flow, even the basic load.

The investigations initiated by the Ministry of Public Works as to the opportunities for rational cooperations of thermal and hydro-electric plants in Pommerania have proved that the natural reservoirs of Pommerania provide a most efficient means for regulating the output.

The survey has been carried out in respect of 11 rivers, the more important of these being: the Brda, Czarna Woda, Wierzyca and Radunia. The majority of these rivers does not comply with the requirements set for inclusion into the first power category

(owing to the capacities being less than 200 HP and the slopes lower than 0,5 $^{0}/_{00}$) though having been found to be eminently useful in consequence of the uniformity in the rate of flow, com-

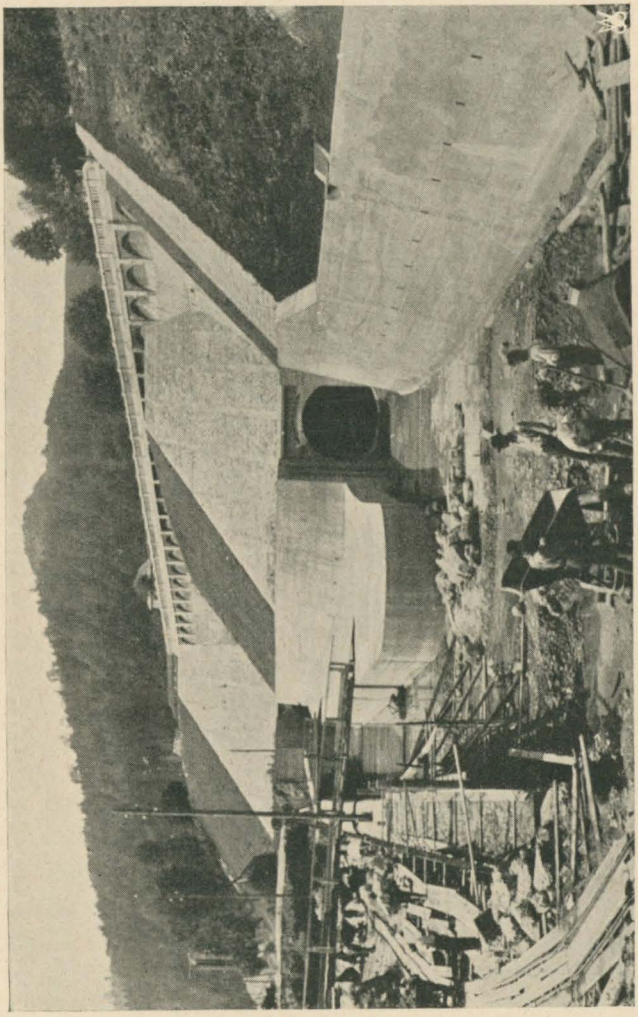


Fig. 2. Hydro-electric plant „Porąbka". Outlet canals of the tunnel (under construction).

patibility between the periodic rate of output and the consumption of energy, as well as of many other advantageous operation factors.

The capacity of these rivers, computed at mean rate of flow, amounts to approximately 37 000 kW and the output to 327 million kWh. The capacity of the available reservoirs amounts to

122 million m^3 which, at simultaneous discharge, yield 19,4 million kWh, which at 28,6 million kWh required for balancing the annual energy, represents a 67,8% degree of balancing. By utilizing the whole of the available water power of Pommerania and by constructing retention reservoirs in order to adjust the annual, weekly and daily fluctuations in output to the demand for energy, which is quite feasible, the whole of the demand for energy estimated for 1945 may be satisfied. Computations have proved that the curve of demand may be adjusted to the curve of output to such an extent that the loss would amount to a mere 2,8%, relatively to the aggregate output, which represents a very high utility factor in respect of the rivers and the balancing of the rate of flow.

An analysis of operation expenses, however, tends to advocate that the water power of Pommerania ought not to be relied upon for meeting the total demand for energy, but only for the purpose of cooperation with thermal electric plants and only to the extent of covering the centre of the load curve.

Similar conditions prevail in the case of the water power of the Vilno district, in which the area of lakes constituing accumulators of power, regulating the rate of flow and extending the duration of the spring floods and the effect of the summer rainfall, amounts to 70 000 hectares.

Table II specifies the hydro-electric plants so far contemplated. The total installed capacity of the contemplated plants amounts to 822 230 HP and the aggregate output to 2,55 milliard kWh.

The most important and interesting hydro-plants at the moment are those contemplated in Pommerania, the Vilno district and on the river Dunajec in Western Little Poland (Galicia).

The number of hydro-plants now in course of construction (Table III) is 8, for an aggregate installed capacity of 24 583 HP and an aggregate output of 66,18 million kWh. The largest of these is the hydro-electric plant at P o r ą b k a on the river Sola (figs. 1 and 2). This plant is to have a retention tank of 15,2 million m^3 capacity at maximum level, and 15,2 million kWh at a level 4,5 metres below the maximum. The difference in volume of 17 million m^3 of water is to constitute the normal working reserve which, at an average level of 19,3 metres above the tail race, will provide an accumulation of working reserve of

700 000 kWh. The six-month rate of flow equalised by the reservoir will amount to 18,2 m^3/sec. The plant, however, will be suit-

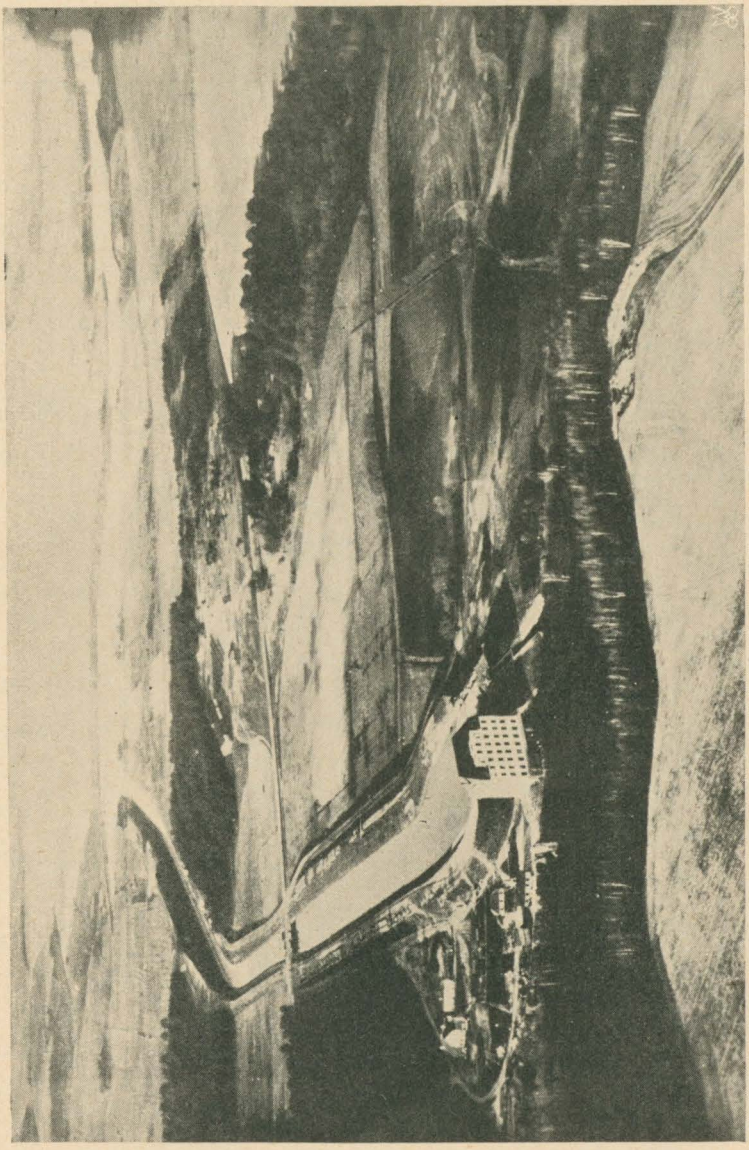


Fig. 3. Hydro-electric plant „Gródek". Bird's eye view.

able for dealing with three times that rate of flow, i. e. with 54,6 m^3/sec., the efficiency of the three vertical high speed turbines

TABLE II.

Hydro-plants contemplated.

Item	Site of hydro-plants	Number of plants	Installed capacity HP	Average annual output kWh	Capacity of reservoir in cub. metres
1	On the water-way of the upper Vistula . . .	7	42 000	189 200 000	—
2	On the Sola below Porąbka and Lękawka .	3	12 000	53 000 000	8 690 000
3	On the Skawa at Sucha and Skawica. . . .	2	11 700	24 580 000	9 020 000
4	On the Bialy (White) Dunajec	10	17 905	68 730 000	211 960
5	On the Czarny (Black) Dunajec	6	14 100	43 580 000	5 923 000
6	On the Dunajec down to Czorsztyn and Bialka.	7	21 000	108 085 000	—
7	On the Dunajec at Krościenko	1	54 000	155 000 000	66 000 000
8	On the Dunajec at Jazowsko	1	48 000	145 000 000	4 000 000
9	On the Dunajec at Marcinkowice.	1	45 000	194 000 000	—
10	On the Dunajec at Rożnów.	1	90 000	165 000 000	136 000 000
11	On the Dunajec below Rożnów	3	49 300	221 500 000	2 500 000
12	On the Poprad at Barcice.	1	2 800	8 100 000	—
13	On the San above Solina.	3	73 400	154 600 000	65 000 000
14	On the San between Solina und Lukawica .	4	50 400	98 800 000	135 100 000
15	On the Dniestr at Uniż .	1	29 000	130 000 000	—
16	On the Stryj with Opór and Rybnik	4	58 880	169 000 000	25 000 000
17	On the Lomnica above Perehińsko	2	50 100	112 392 000	50 420 000
18	On the Prut at Delatyn.	1	33 000	55 000 000	—
19	On the Brda	4	30 400	58 200 000	—
20	On the Czarna Woda .	2	2 900	8 200 000	4 000 000
21	On the Drwęca and Wel.	2	2 845	5 500 000	—
22	On the Radunia . . .	1	4 500	8 000 000	—
23	On the Wilja above Vilno and Wilejka. . .	6	32 300	138 600 000	—
24	On the Wilja below Vilno and Żejmiana . .	4	29 700	128 300 000	—
25	On the Bug-Warsaw water-way	3	17 000	102 575 000	—
	Total . . .	80	822 230	2544 942 000	511 864 960

to be installed being 0,88, consuming 18 m^3/sek., the capacity of reaching its highest during the summer months, i. e. 3,68 mill-

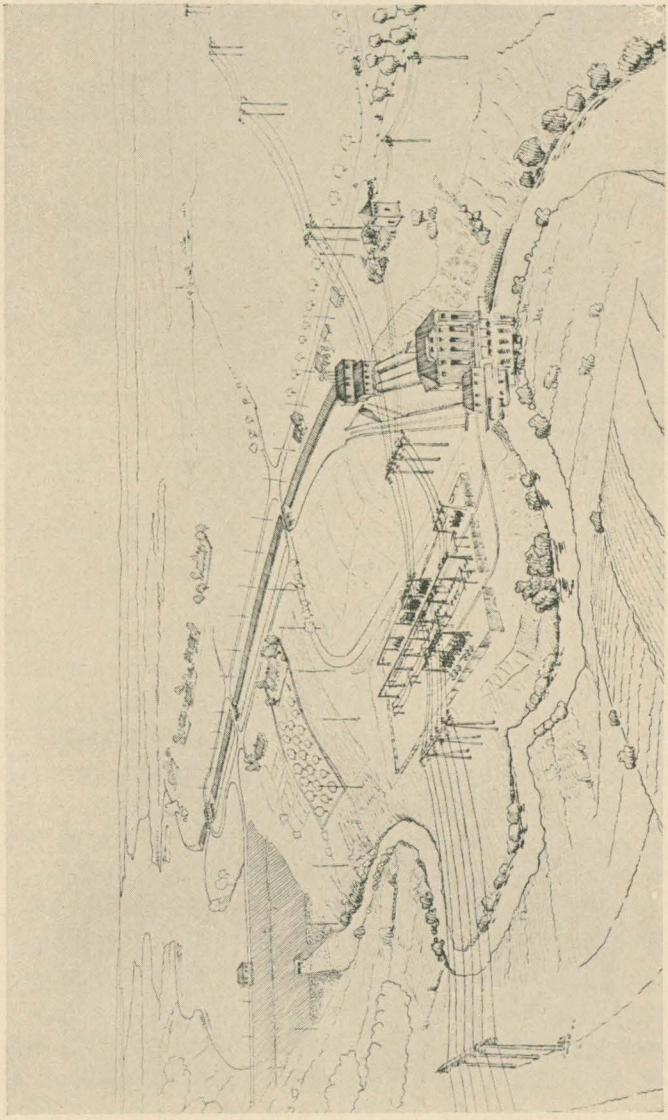


Fig. 4. Bird's eye view of the „Żur" electric plant.

ion kWh. The cost of accumulation per 1 m^3 of water is estimated at 0,49 Zloties, and the cost per 1 HP installed at 500 Zloties.

TABLE III.

Hydro-plants in course of construction.

Item	Voivodeship of	Locality	River	Installed Capacity HP	Annual output kWh	Capacity of reservoir in cub. metres
1	Cracow. . .	Bialy (White) Dunajec	Bialy Dunajec	640	2 800 000	—
2	„ . . .	Porąbka	Sola	14 700	27 280 000	32 200 000
3	Lwów . . .	Myczkowce	San	6 000	22 000 000	400 000
4	Stanislawów .	Jamny	Prut	180	900 000	—
5	„ .	Szeparowce	„	163	800 000	—
6	Vilno . . .	Grzegorzewo	Waka	2 000	8 600 000	—
7	„ . . .	Landwarowo	Lake of Troki	400	2 300 000	—
8	„ . . .	Orniany	Dubinka	500	1 500 000	—
		Total . .		24 583	66 180 000	

Of the hydro-electric plants recently put into operation, those of the Pommeranian Electric Plant at Gródek and Żur deserve special mention. Both plants are installed on the Czarna Woda river.

The Gródek Plant (fig. 3) consists of 3 turbo-generator units, namely 2 with vertical Francis turbines (300 r. p. m.) of 1750 HP rated capacity, and one with a Francis turbine (375 r. p. m.) of 2130 HP rated capacity, the total rated capacity being 5630 HP. The full capacity of the reservoir amounts to approximately 6 000 000 m^3, the surface to approximately 100 hectares and the useful capacity to approximately 300 000 m^3 at a useful layer of 0,3 metres. The net head amounts, on average, to 17,8 metres. The actual annual output of the plant, since the date of its being put into operation steadily increases, as will be seen from the following figures: in 1925 — 3,533 million kWh, in 1926 — 6,211 million kWh in 1927 — 9,886 million kWh, in 1928 — 12,434 million kWh and in 1929 — 11,961 million kWh. each turbine being 4 900 HP, or a total of 14 700 HP. The average annual output, at a turbine efficiency of 0,88 and a generator efficiency of 0,95, will amount to 27,28 million kWh. The rate of output will be at its lowest in winter, namely 1 million kWh, The cost of construction per 1 kW amounted to approx. 1000 Zloties and the cost of output per 1 kWh to approx. 0,25 Zloties.

The Żur Plant (figs. 4—6) was erected in record time (from autumm 1928 until the end of 1929) and is a typically peak

plant, the time of use of full installed capacity being 1800 hours p. a. The plant consists of two vertical Kaplan turbines

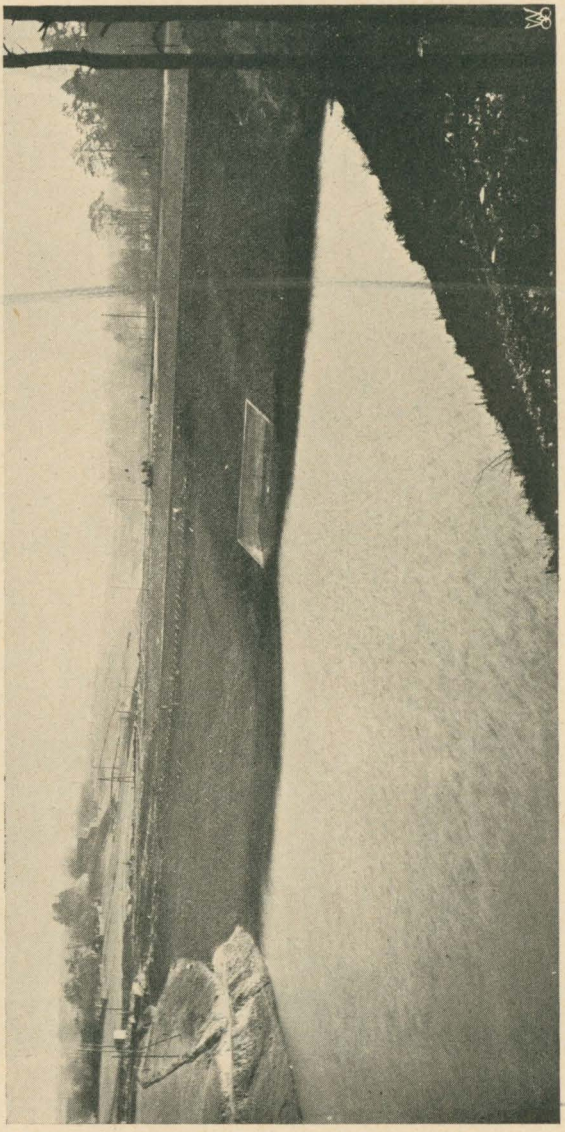


Fig. 5. Dam and retention tank of the hydro-electric plant „Žur".

88% at 70% load, 83% at full load, decreasing to 82% at 40% (250 r. p. m.) of 6 000 HP each, or of an aggregate capacity of 12 000 HP. These turbines have an extremely high efficiency of

load. The reservoir formed by the raising of the water by 14,5 metres by means of a dam 18 metres high, 20 metres wide at the

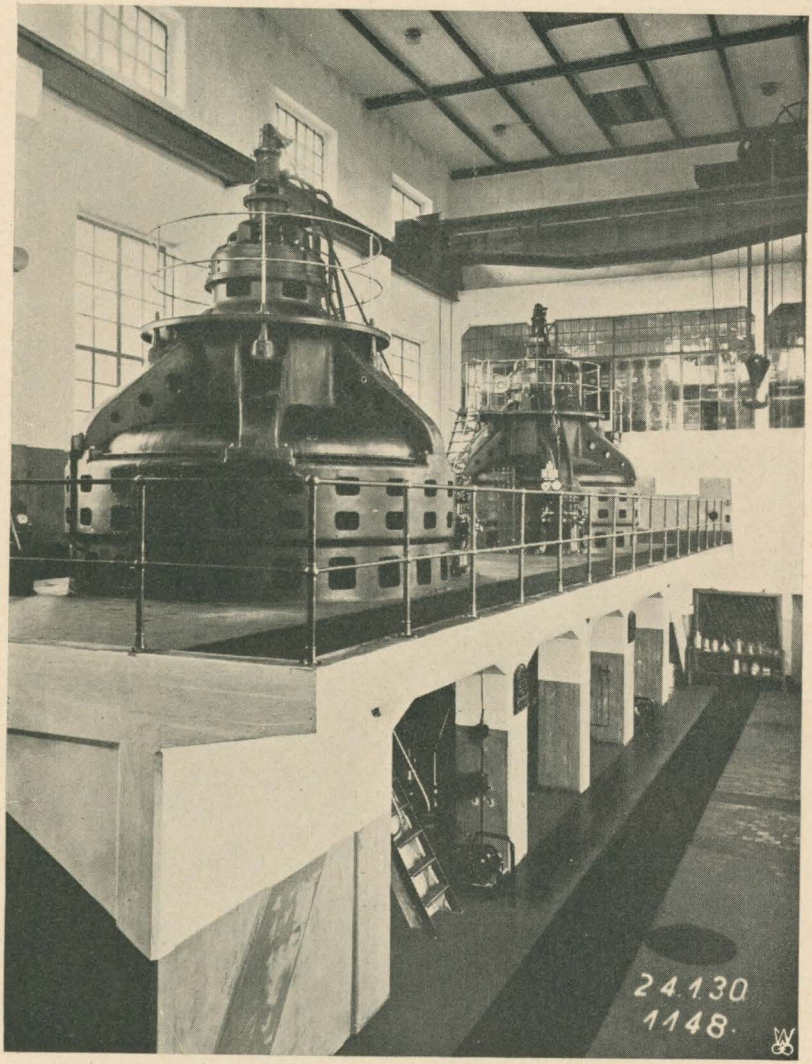


Fig. 6. Interior of the engine room at the „Żur" hydro-electric plant: 2 generators driven by water turbines of an aggregate capacity of 12000 HP.

top and 173 metres at the bottom and 160 metres long, constructed of third-grade clay, reinforced by Larsen type piles and protected

TABLE IV.

Existing hydro-plants or groups of plants of more than 300 HP capacity.

Item	Site of plant (on what river)	Number of plants	Installed capacity HP	Average annual output kWh	Capacity of reservoir in cub. metres
1	Vistula at Ustroń. . .	1	320	1 400 000	—
2	Wieprz and Bystrzyca .	2	340	2 200 000	—
3	Prosna	3	463	2 488 000	—
4	Noteć	2	300	1 393 000	—
5	Drwęca and Wel . . .	2	600	2 000 000	—
6	Brda	3	1 264	6 146 000	—
7	Brda — Smukały . . .	1	3 100	9 803 000	1 400 000
8	Czarna Woda	2	695	3 320 000	—
9	Czarna Woda — Gródek.	1	5 630	12 434 900	6 000 000
10	Czarna Woda — Żur. .	1	12 000	14 500 000	14 200 000
11	Wierzyca.	7	2 550	7 562 000	80 000
12	Radunia	2	905	2 600 000	4 000 000
13	Reda	3	398	1 520 000	—
14	Prut	3	650	—	—
15	Wilejka and Waka . .	4	1 240	—	—
	Total . . .	37	30 455		

by a layer of stones, has a capacity of 14,2 million m^3. The area of the reservoir is approximately 400 hectares, yielding a useful volume of approx. 1 500 000 m^3 at a 0,4 m useful layer. The estimated average annual output, at the generator terminals, is 14 500 million kWh. The cost of construction per 1 kW amounted to approx. 2 000 Zloties and the cost of output, bearing in mind that the plant is intended for peak load, will amount to approx. 1,10 Zloties per 1 kWh. There are no direct thermal reserves at either the Gródek or the Żur plants, but such reserves are available from other electric plants interconnected with them, namely from those at Grudziądz (7800 kW) and at Toruń (2200 kW). In addition to the plants under reference above, there are another 47 hydro-plants in Poland (Table IV) of an installed capacity in excess of 100 HP each, the aggregate installed capacity of which amounts to 29 500 HP. The aggregate capacity of further numerous smaller hydro-plants is estimated at approximately 100 000 HP.

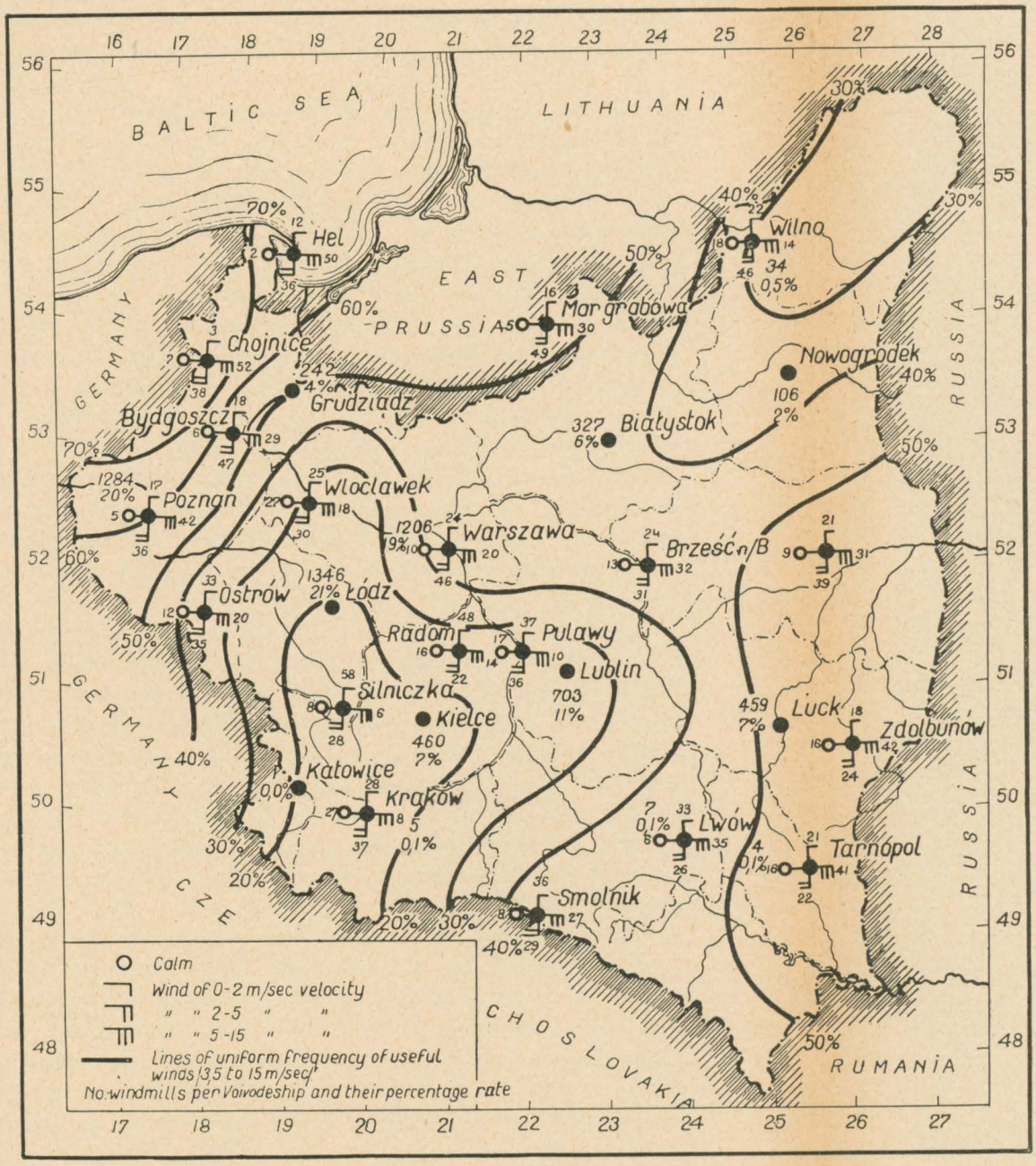
WIND POWER

By St. Kosińska-Bartnicka

In spite of its commonness, wind power so far is neither properly utilized nor sufficiently researched. It is a power most capricious, dependant not only on the season and time of day, but also on the weather conditions and, to a considerable extent, on the configuration of the country. The investigation of the wind, thus, forms part of the scope of climatological research of a country. In the climatological monographies of Poland a detailed survey of winds has only recently been dealt with *).

The wind direction in Poland is fairly uniform: West winds prevail practically throughout the country and throughout the year. Although in the eastern part of Poland East and South-East winds are fairly frequent, yet they play a dominating role only in Volhynia, in the valley of the river Horyń, where at Zdolbunów they come up to a figure of 39% per annum. East and South-East winds occur in Poland only during the intermediate seasonal periods, i. e. in March and April, as well as in September and October in which latter month they considerably exceed West winds in the districts of Podlasie, Polesie and Volhynia and in the eastern part of the Carpathian lowlands. The Carpathian mountain range is marked by an entirely different constitution of wind direction: the prevailing air currents there float along the arc of the Carpathian range being guided in their course by local sloping of the territory and, on the other hand, as a result of the weakening of the general circulation by territorial impediments,

*) Dr. L. Bartnicki. Power air currents in Poland. Geophysical research. Volume 3 (9) in course of printing.



Winds and Windmills in Poland.

a strictly local circulation is prominent, that is to say, territorial mountain and valley winds prevail, blowing periodically; these winds, being as a rule weak, are of no importance as a power source.

The wind velocity, theoretically, has two periods, annual and daily, yet in our latitude both these periods have no pronounced features, due to the irregularity of atmospheric disturbances. It can be said in general, that although the winds during the winter season are more powerful, their daily amplitude is considerably smaller. The annual period of wind velocity in our latitude is at its maximum in winter, spring and sometimes, in localities close to the Baltic Sea, in autumn, with a minimum in summer, the entire winter period being marked by intensified wind force, irrespective of the time of day. The maximum both of the daily amplitude and often of the absolute velocity occurs in spring. In summer the daily amplitude continues to remain fairly considerable in spite of a pronounced weakening of the absolute wind power. An increase in velocity at a large daily amplitude occurs occasionally in the lowlands in the course of August, whereas from October onwards the winds gain in velocity, increasing in daily uniformity in the course of December and January. The most advantageous periods for practical utilization of wind velocity are: winter, irrespective of the time of day, spring and autumn in day time, and summer during the morning hours. Yet these periods are prominent only on an average for many years, whereas in actual practice numerous exceptions occur. In summer, for instance, it often happens that after a comparatively calm day the wind increases towards the evening and night. On the contrary, the calming down of the wind during the day after a windy night is rare in summer. All these periodical occurrences are not uniform for all localities in Poland. Each station has its specific deflections and features, dependant on the hypso- and orographical conditions; uneven territory, in general, enhances the daily period, though weakening the general wind velocities in air layers closer to the earth. Observations over a period from 1886 to 1910 show the majority of fairly strong and strong winds, within the limits of their useful value, for the area of Poland, in the following manner: on the Pommeranian coast the majority of useful winds occurs during the autumn and winter months, particularly in October. On the slopes of the Pommeranian lake district the number of such winds

considerably increases in winter and spring; it becomes somewhat less in autumn, whereas the summer also has a fair quantity of useful winds.

The Mazurian lake district, similarly to the Pommeranian one, abounds in useful winds, and their annual course is similarly more intense in winter, autumn and spring, although even during the summer the amount of wind is fairly considerable.

On the other hand the Vilno lake district, being considerably far from the sea, shows a relative scarcity of useful winds throughout the year. Beyond the lake district slopes the wind velocity in the Polish lowlands develops fairly freely, both in western and eastern Poland, and the frequency of the stronger winds considerably decreases only towards the South-West, in the Galician highlands. Immediately beyond the Pommeranian lake district, in the valley of the rivers Brda and the lower Vistula a certain specific feature occurs in the volocity of the wind, namely, there is a considerable number of fairly strong winds, both during winter and during spring and summer, decreasing in autumn.

In the Poznań Province the number of useful winds is considerable, namely approx. 60% of the annual period, mainly in spring, winter and summer, slightly less in autumn. The daily amplitude of wind velocity in that district is fairly uniform and low throughout the year. Towards the South of the Poznań Province, however, the number of useful winds rapidly decreases, more or less by one half; the percentage in winter and spring is only about 33%, that for summer and autumn being still less (30%). In Mazuria the number of stronger and strong winds is greatest in winter (more than 50%), smallest in summer (30%) and somewhat higher in autumn and spring. In Podlasie, where the virgin river valley narrows, the frequency of the stronger winds materially decreases; thus, for instance, at Brześć on the river Bug they amount to 47% in winter and to less than 40% in summer; intermediate figures of frequency of winds occur in spring and autumn. Farther East, with the gradual widening of the virgin valley, the number of useful winds again increases: in Polesie the percentage for winter and spring amounts to 60% odd, whereas in summer there is a pronounced decrease, increasing fairly rapidly in autumn. Thus the annual period here has a very pronounced maximum and minimum. The total number of useful

winds in Polesie is almost similar to that in the Poznań Province. In Volhynia, near the town of Zdolbunów, the allocation of wind velocity during the year is practically similar to that in Polesie, the maximum occurring in winter, the spring also abounding in stronger winds; the smallest number of winds occurs in summer, yet remaining considerable (43%), there being a certain increase in autumn, though none too rapid.

Farther South the surface of Poland rises, yet the Podolian rise, fairly flat, does not present any territorial impediment to the development of air currents at the stations situated along it; Podolia, as compared with Volhynia, has even somewhat more useful winds, as at a similar abundance during the winter, the decrease in summer, and particularly in autumn, is smaller, so that the average throughout the year is approx. 55% (autumn 50%, winter 57%).

In the eastern Carpathian lowlands, the number of stronger winds decreases, and does not exceed 48% in spring, decreasing to 42% in autumn; in this district the minima of wind velocities thus occur not during the summer, but during autumn, this being incidental to the beautiful autumn in the Carpathian lowlands and Pokucie. Finally, farther West along the foot of the Carpathian range, the districts gradually become poorer in respect of useful winds, the daily periods, however, being more pronounced, this being due to the availability of local mountain and valley winds; the number of useful winds comes up to 45% in winter only, decreasing during the summer to 37%.

In the Radom district the number of stronger winds reaches up to 30% in winter, 20% in summer and 23% in autumn; finally in the Galician highlands, at the breach of their southern cornice near the city of Cracow, the number of useful winds is the smallest in Poland, amounting to barely 24% in winter and to 15% in summer.

The percentage of useful winds during the year is represented in table I.

Wind power engines in Poland are used almost exclusively for flour milling purposes, a very small fraction of existing wind mills serving as a source of power for the raising of water (for the melioration of soil and water supply to certain localities) and for the generation of electric energy.

The number of wind mills in Poland *) is only to a certain extent dependant on the percentage of useful winds in any particular locality, a considerable role being played by other factors, such as 1) the configuration of the territory, 2) the availability of another more convenient or more remunerable source of power, 3) the general state of industrial development of particular districts, as well as a number of economic factors. The greatest number of wind mills is located in the following Voivodeships **): Lodz, Poznań and Warsaw; a comparatively smaller number in Volhynia, Pommerania, Podlasie and Polesie, a considerable number on the Lublin rise and in the Kielce district; in the Vilno district the number of windmills is extremely small, and in the Carpathian lowlands, from Pokucie down to Silesia, their number is quite insignificant.

TABLE I.

Percentage of useful winds (3,5 to 15 m/sec.) as well as absolute and relative number of windmills in the individual Voivodeships.

Voivodeships	% of useful winds	No. of windmills	% of windmills
Pommerania	65	242	3,8
Poznań	48	1284	20,2
Warsaw	34	1206	18,9
Białystok	45	327	5,2
Vilno	29	34	0,5
Nowogródek	35	106	1,7
Polesie	49	176	2,8
Volhynia	50	459	7,2
Tarnopol	56	4	0,1
Stanisławów	40	—	—
Lwów	44	7	0,1
Lublin	22	703	11,1
Lodz	30	1346	21,1
Kielce	20	460	7,2
Cracow	20	5	0,1
Silesia	20	1	0,0

*) A. Dzik: Flour Milling Industry in Poland, Warsaw, 1928.
**) The largest administrative division in Poland.

The percentage ratio of windmills to the useful winds, relatively to a 100% for the entire area of Poland, is highest in the Voivodeships of Lodz, Warsaw, Lublin, Poznań and Kielce. In Pommerania in spite of the highest figure of useful winds, the number of windmills is small, owing to the available water, being more suitable for the flour milling industry. In the Voivodeship of Vilno, along the eastern border and along the entire Carpathian lowlands, particularly in hilly areas, both the force of the fall of water and the extremely unfavourable wind conditions prompt the flour milling industry to almost entirely avoid the utilization of wind power in favour of other sources of power.

TRANSPORT FACILITIES

By Prof. M. Rybczyński

Owing to the scattered nature of the sources of power, transport facilities play a prominent part in the supply of power throughout the country, and on them depends the participation of Poland in the world power management.

The present state of transport facilities in Poland is not of the best. Poland for many years was under the sovereignty of three conquerors, each of whom pursued his own and specific transport policy, as a result of which, in spite of Poland being situated on the crossing of industrial roads leading from western and northern Europe to the East and South, these roads had not been properly developed or adapted, neither to the requirements of foreign trade and transit, nor even to local necessities.

This remark applies to all means of transport, but in particular to the water ways which had been entirely neglected in the territory which constituted part of the former Russian Empire.

But also the railroads, in their present state, are far from being able to comply with all the requirements of the country, moreso, as the condition in which Poland took them over from the previous owners, necessitated strenuous efforts on the part of Poland to repair the damages caused by the war which even now have not been fully completed yet. Further, the direction of the lines of transport, entirely different from that for which they were originally constructed by the former sovereigns, compelled the Polish Government to effect extensive investments, particularly in the coal mining district.

It was only in recent years that the Polish Government was able to commence with the partial development of the transport system, primarily by establishing a second junction with the sea

by means of a new line via Kalety — Herby — Inowroclaw — Bydgoszcz to Gdynia, which line at the same time reduced the distance from the coal mining district to the sea ports by almost 100 kilometres.

There still remains such work as the construction of lines, also important for international trade, as the reconstruction of, and the laying of a second track along the Warsaw — Lwów — Czerniowce (Cernauti) line, which is on the route from the Baltic to the Black Sea, and the construction of a line from the coal mining district to Luck, on the international route Paris — Rostow — Caucasus, etc.

Road transport so far plays an important part in respect of passenger traffic, as well as for the transport of power fuels from railway stations to the interior of the country, and the inadequacy of such service is bound to seriously affect the economic development of the country.

Trunk lines for oil and gas, as well as high tension transmission lines have so far not been of any prominence in the power management of the country, though their importance, particularly of high tension transmission lines, increases from year to year.

Statistical data obtained in 1926, contain the following figures as to the allocation of traffic to the various means of transport, on the basis of ton-kilometres:

Railway transport	95,59%
Road transport (State highways)	2,62%
Transport by waterways	1,71%
„ „ oil trunk lines	0,03%
„ „ gas trunk lines	0,03%
„ „ high tension transmission lines .	0,02%
Total:	100,00%

The changes which have occurred during recent years have still further altered the above ratio in favour of the railroads, due to considerable increase in goods traffic and to a certain slump in transport by waterways, the transmission of electric energy by means of high tension lines alone showing a considerable increase, without, however, materially changing the above figures, owing to its relatively small quantities.

Below we quote certain particulars dealing with the individual means of transport in Poland.

RAILROADS.

(According to traffic figures for 1928):

Aggregate length of lines in operation . .	17 257	km.
whereof single track lines	12 094	„
Length of sidings	2 300	„

There was 1 kilometre of railroad per 22,5 km^2 of area, and per 1 750 inhabitants.

Rolling stock: number of engines . .	5 184	
whereof average number in daily use.	3 263	
Number of passenger carriages . . .	10 017	
whereof average number in daily use.	6 739	
Number of goods trucks	152 671	
whereof average number in daily use.	118 044	
Total of freight traffic	81 091 197	tons
representing	21 968 250 910	ton-km.
Total of passenger traffic	174 358 563	passengers
representing	7 076 575 492	pass.-km.

Average length of run per 1 ton — 272 kilometres.

The total weight of ordinary goods traffic amounted to 70 839 289 tons

whereof:

coal	30 310 116	tons
oil, etc.	796 387	„
wood for fuel purposes	1 420 791	„
peat	7 784	„
Total for power fuels	32 535 078	tons

i. e. 43%.

In respect of traffic in ton-kilometres, the proportion of power fuels amounted to 51.4%.

The average freight lading per 1 kilometre of line amounted to 4105 tons, though fluctuating within very wide limits, viz. from 1658 tons in the Vilno railway sector to 47 866 tons in the Katowice railway sector.

The average goods traffic amounted to 1 156 000 tons per 1 kilometre, varying from 341 955 tons in the Vilno railway sector to 2 839 870 tons in the Warsaw railway sector.

The maximum local freight density exceeds 10 000 000 tons.

Railway traffic in Poland shows a rapid increase, as will be seen from the following figures:

Year	Quantity of ordinary goods traffic in tons	No. of ton-kilometres effected
1924	53 557 329	11 036 908 675
1925	52 161 904	12 634 444 000
1926	58 028 821	16 368 033 103
1927	64 495 358	19 238 271 088
1928	70 839 289	21 968 250 910

The management of the State Railways also extends over a system of narrow gauge railway lines, the figures as to which, for 1928, were as follows:

Total length of lines	2 398	km
No. of passengers carried	1 571 995	„
No. of passenger-kilometres effected . .	34 420 937	„
Quantity of goods carried	5 066 182	„
No. of ton-kilometres effected	98 932 532	„

HIGHWAYS.

At a total length of highways in Poland of 240 000 km the length of improved highways amounted to barely 44 500 km, of which 13 320 km represent State highways.

There is 1 km of highway per 8,7 km^2 of the area of the country, or per 678,9 inhabitants. The density of highways, however, is not uniform and markedly declines from South-West towards the North-East.

The traffic statistics for State highways compiled for 1926 show a figure of 440 000 000 ton-kilometres effected. This traffic does not play thus any important role, particularly in respect of transport of power fuels, being of but local character.

Motor bus transport in Poland, on the other hand, is developing most rapidly. The number of passengers and goods carried at present amounts to $^1/_3$ of such traffic on railroads.

The increase in motor bus traffic is represented in the following table

	1926	1927	1928	1929	
No. of motor buses	710	1067	2121	3224	
Total length of lines served		14050	20281	25710	
No. of passengers carried	20	30	41.6	56.9	millions
No. of passenger-kilometres effected .	490	708,3	1347,2	2163,4	„

WATERWAYS.

The total length of waterways in actual operation in Poland amounts to: 1515 km used both for navigation and floating and 7053 km operated solely for the floating of timber on rafts.

The navigable stock in 1928 amounted to:

154 ships with own drive, of a total capacity of 5534 tons and an aggegate power of 14 905 HP.

1684 freight barges of a total capacity of 110 350 tons, viz.

1418 barges of less than 100 tons capacity
199 barges of from 100 to 300 tons capacity
67 barges of more than 300 tons capacity.

The traffic figures for 1926 show:

1 080 297 tons of goods carried on ships and barges, the total of ton-kilometres effected amounting to 152 362 000,

956 326 tons of timber floated on rafts, the total of ton-kilometres floated amounting to 139 668 000.

The participation of coal in the waterways traffic represented 31% and that of wood for fuel — to 5%.

In the course of subsequent years the traffic by ships and barges considerably decreased, the traffic by rafts on the other hand increasing to 1 500 000 tons and approx. 200 000 000 ton-kilometres.

The largest port for river traffic, as far as the quantity of freights handled is concerned, was Danzig. The following is a list of ports which in 1928 handled more than 100 000 tons of freights:

Danzig	353 904	tons
Cracow	132 536	„
Warsaw	131 556	„
Poznań	114 558	„

A turn-over of from 20 000 to 50 000 tons was reached by the following ports: Bydgoszcz, Pińsk, Plock, Tczew and Wloclawek.

SEA PORTS.

The statistical figures for 1929 were as follows:

	Import	Export	Total
Danzig	1 792 951 t.	6 766 699 t.	8 559 650 t.
Gdynia	324 543 t.	2 494 245 t.	2 818 788 t.
Total . . .	2 117 494 t.	9 260 944 t.	11 378 438 t.

In this latter traffic power fuels play a dominating role, amounting to 76% of goods handled (in Danzig 65%, in Gdynia 90%). The greatest role in this instance is, naturally, that of export coal.

The increase in the traffic in both aforesaid ports is represented in the following table:

Aggregate turnover of goods	1925	1926	1927	1928	1929
Danzig . .	2 722 748 t.	6 300 301 t.	7 897 614 t.	8 615 682 t.	8 559 650 t.
Gdynia . .	55 571 t.	404 561 t.	898 094 t.	1 957 769 t.	2 822 502 t.
Total .	2 778 319 t.	6 704 862 t.	8 795 708 t.	10 573 451 t.	11 382 152 t.

OIL TRUNK LINES.

The length of trunk lines through which oil is being forced for long distances amounts to 174 km. The length of pipes (inter-urban lines only) amounts to 311 km.

The quantity of oil forced through these lines in 1926 in inter-urban traffic amounted to 527 000 tons, at 6 232 000 ton-kilometres.

GAS TRUNK LINES.

The length of natural gas trunk lines, allowing only for inter-urban lines, in 1929 amounted to 212 km, the length of pipes amounting to 270 km.

The quantity of natural gas forced through these lines in 1929 amounted to 139 022 000 m^3, representing 30% of the total output of natural gas.

HIGH TENSION TRANSMISSION LINES.

In 1926 there were 271 km of high tension lines in Poland which transmitted, if converted into coal equivalent, 221 342 tons, at 2 891 000 ton-kilometres. Since then the length of high tension transmission lines considerably increased, so that at the end of 1929 it reached 900 km. The amount of energy transmitted increased in a similar manner, the lack of reliable statistics, however, prevents us from quoting the corresponding figures.

STATE AND DEVELOPMENT OF THE GAS INDUSTRY

By J. Konopka.

The development of the Gas industry in Poland is closely connected with the life of the cities.

In the whole of the Republic of Poland there are 122 gas works in existence, whereof 101 are owned by Municipalities, 16 by private enterprises or factories, 3 by the State railways, whereas 2 are dependant on natural gas.

The gas works serve some 130 localities. A further eight cities and small towns are served by a natural gas trunk line, and two other gas works obtain gas from plants situated outside of Poland.

The greatest number of gas works is situated in the Voivodeships *) of Poznań, Pommerania and Silesia, a smaller number in Little Poland (Galicia), the smallest number being situated in former Russian Poland, the eastern provinces, for instance, having but one gas works in Vilno.

The majority of gas works produce coal gas or mixed gas, others produce water gas, oil gas, carburetted air gas, one plant (at Vilno) producing wood gas.

As regards auxiliary gas, 8 gas works are using water gas, 1 gas works water-petroleum gas and 1 gas works — dual gas.

The majority of ovens in the smaller gas works are of the semi-generator and generator types with horizontal retorts; the larger gas works are equipped with the latest type vertical chamber

*) The largest administrative division in Poland.

ovens, and recently the Warsaw gas works erected a battery of British type continuous-working ovens with vertical retorts.

The total output of gas in 1928 amounted to 180 000 000 m^3. The quantity of coal converted amounted to 550 000 tons and, in addition to gas, yielded 320 000 tons of coke and approx. 18 000 tons of crude tar.

In addition to these, the following main by-products were obtained: 700 000 kg crude and refined benzene, 850 000 kg sulphate of ammonia and 50 000 kg pure ammonia, not counting minor by-products.

There are four fully equipped chemical factories in Poland for converting tar, the largest of which belongs to the Warsaw gas works.

The per capita consumption of gas varies from 25 m^3 to 110 m^3. The average per capita consumption in Poland roughly amounts to 45,1 m^3 in towns served by gas, with a population of 4 millions.

This figure is exceedingly low and proves that the capacity of Poland in respect of gas consumption is still very considerable, particularly in the central and eastern Voivodeships.

The number of gasometers in operation in Poland is 312 000.

The charges for gas are comparatively low and vary from 0,22 to 0,70 zloties *) per m^3, the average charge, however, being approx. 0,40 zloties.

The charges, for some considerable time, have not displayed any tendency towards an increase. The charge of the largest gas works in Poland, i. e. Warsaw, is 0,27 zloties per m^3, at an output of 59 millions m^3 p. a.

The length of the pipe line system in gasified towns totals 2670 kilometres.

The street lighting in small and medium towns is almost entirely by means of gas, and even in larger cities gas is still leading electricity for street lighting. The total number of gas lamps for street lighting exceeds 40 000, of which approx. 15 000 are fitted with automatic lighting device.

The number of employees in all Polish gas works in 1929 amounted to more than 4 300, which number steadily decreases as a result of constant mechanization of operation.

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*) 1 £ = 43,4 zloties.

The rate of remunerability of the Polish Gas Works is exceedingly satisfactory.

Polish gas works owned by Municipalities are exempted from industrial tax (tax on the turn-over), whereas newly erected gas works are exempted, for a period of 15 years, from all Government and Municipal taxes and rates.

Since the war one Municipal gas works at Radom as well as two factory gas works were erected.

At present two cities, Wloclawek and Częstochowa, have decided to erect new gas works, by granting concessions for the erection and operation thereof for 40 years.

A thorough enquiry recently instituted, proved that 25 cities in Poland are anxious to erect gas works, the more important ones being:

(1)	Gdynia	with	35 000	inhabitants
(2)	Vilno	„	130 000	„
(3)	Kielce	„	51 000	„
(4)	Przemyśl	„	50 000	„
(5)	Siedlce	„	35 000	„
(6)	Luck	„	27 000	„
(7)	Bialystok	„	98 000	„
(8)	Grodno	„	35 000	„
(9)	Pabjanice . . .	„	38 000	„
(10)	Plock	„	27 000	„
(11)	Mlawa	„	17 000	„

There are altogether 100 towns in Poland, with a population of more than 10 000 each, which so far have no gas service.

In addition to the aforesaid cities, gas works ought also to be erected in the larger health resorts, such as Zakopane, Krynica, Ciechocinek, Rabka, etc.

Apart from the erection of new gas plants in various cities, the erection of gas trunk lines from the Upper Silesia gas plants *) is also contemplated.

This latter scheme comprises the erection of several lines, the first of which would issue from the coke plant at Ruda and run via Będzin, Dombrowa, Sosnowiec, Zawiercie to Częstochowa. The second line would run through the Cracow coal district and will

*) There are 9 coke plants with an available surplus of coke gas of approx. 270 millions m^3.

probably reach as far as Cracow, being later extended to Tarnów. The third line would issue from the coke plants at Knurów or Rybnik in Upper Silesia and run through Biala, Bielsk to Cieszyn, a fourth line being intended to serve Tarnowskie Góry and Lubliniec. The total consumption in said districts is estimated for the first years following the completion of the lines at approx. 60 millions m^3, apart from the demand on the part of industrial enterprises. The coke gas is also intended to feed Municipal gas works in existence in these districts.

ELECTRIFICATION POLICY IN POLAND

By W. Rosental.

Little can be said of the state of electrification in Poland previous to 1918 owing to the lack of proper statistical data. It is, however, possible to say with full certainty that neither the political nor economic conditions prevalent at that time were in favour of development of electrification. The consequences of the long and devastating world war to a great extent were contributory factors to the neglecting of this important branch of national utility. The general decline in the oppulence of the country, and in particular the extremely onerous inflation period, did not render it possible to materially improve matters within the comparatively short time since the termination of the war.

From statistical figures quoted below it will, however, be easy to appreciate certain facts which, bearing the indication of considerable improvement for the future, point to the steady progress which is being made in respect of providing Poland with electric energy.

In accordance with the Statistics of the Ministry of Public Works *) (table I) the total number of electric plants in existence in Poland at the end of 1929 amounted to 864 (exclusive of some 818 private utility electric plants of less than 100 kW capacity) with an aggregate annual output of 3023 millions kWh and with

*) Statistics of electric plants in Poland, published for 1925, 1926, 1927, 1928 and 1929.

TABLE I.

General features of the state of electrification in 1929.

Electric Plants	No. of electric plants	Installed capacity in kW			Annual output in kWh			Time of use in hours
		Total	per 1000 inhabitants	per 1 electric plant	Total	per 1 inhabitant	per 1 electric plant	
All plants*)	864	1 273 525	41,9	1 474,0	3023×10^6	99,4	$3{,}50 \times 10^6$	2 374
a) Public utility plants	457	452 009	14,9	989,1	978×10^6	32,2	$2{,}14 \times 10^6$	2 164
b) Private utility plants, selling energy incidentally	128	262 304	8,6	2 049,3	807×10^6	26,5	$6{,}30 \times 10^6$	3 077
c) Private utility plants	279	559 212	18,4	2 004,3	1238×18^6	40,7	$4{,}44 \times 10^6$	2 214

Note: The population of Poland, as of the 1st January 1929 was approx. 30 408 000.

*) The above figures do not include 818 electric plants of private utility of an installed capacity of less than 100 kW. Their capacity, in 1929, was of 15 081 kW, and their output of (approx.) 25 millions kWh. Besides, there were 8 plants under construction.

an installed capacity of 1 273 525 kW. These figures work out at the rate of 99,4 kWh of output and 41,9 W of installed capacity per inhabitant and at the rate of 7 783 kWh and 3,28 kW respectively per square kilometre of area.

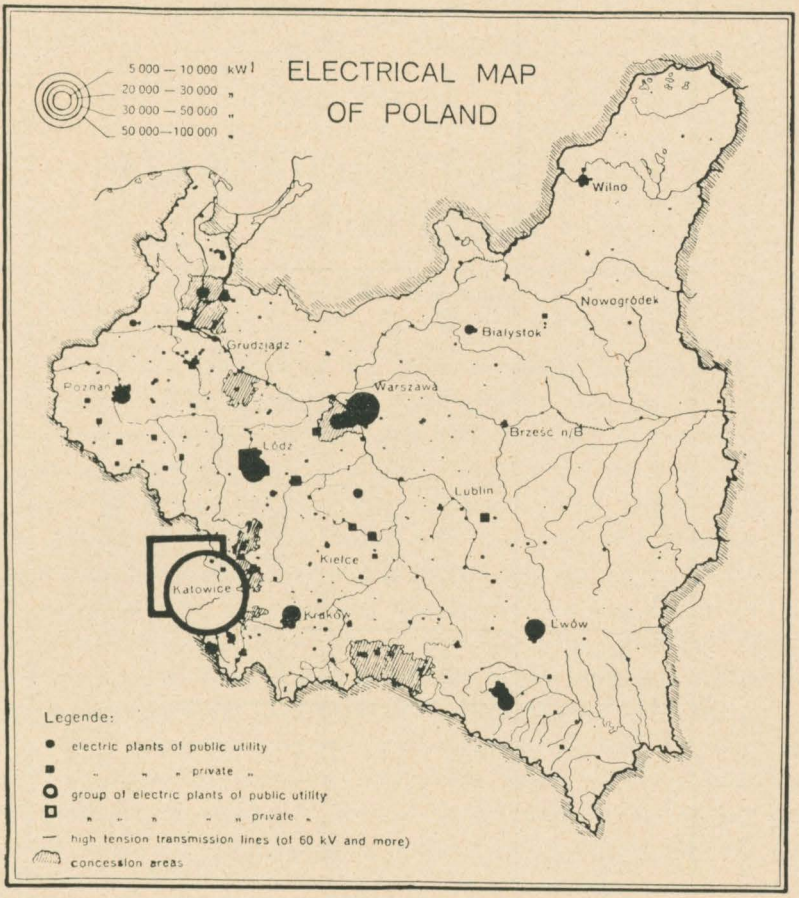
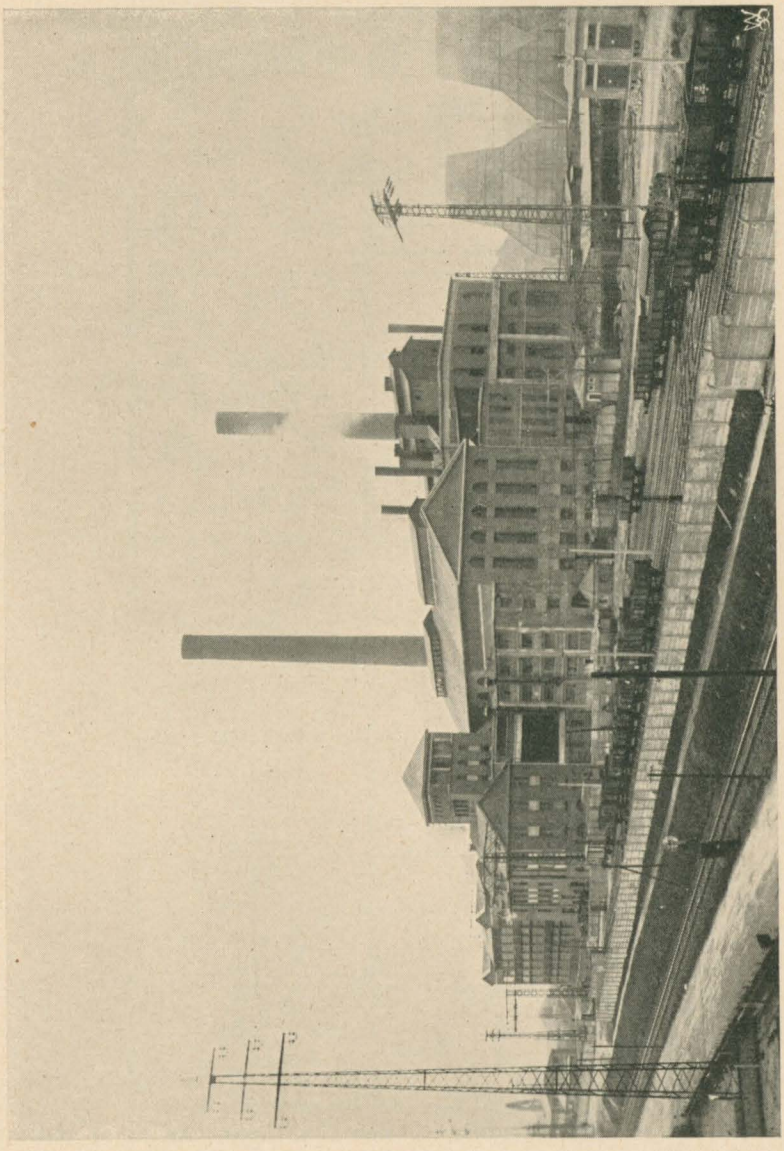


Fig. 1.

Taking into consideration electric plants of exclusively public utility, that is to say such as professionally supply energy for general use, as well as such electric plants which, whereas serving for private use, also effect sales of energy as a side line, i. e. incidentally, we arrive at a total figure of 585 electric plants with

an annual output of 1 785 000 000 kWh and with an installed capacity of 714 313 kW. This works out at a rate of 58,7 kWh



General view of the new electric plant „Electro" at Laziska (Silesia).

and 23,5 W per capita of population and to 4 596 kWh and 1,84 kW respectively per square kilometre of area. The remaining

279 plants with an annual output of 1 238 000 000 kWh and an installed capacity of 559 212 kW represent electric plants of exclusively private utility, that is to say such as are intended for the

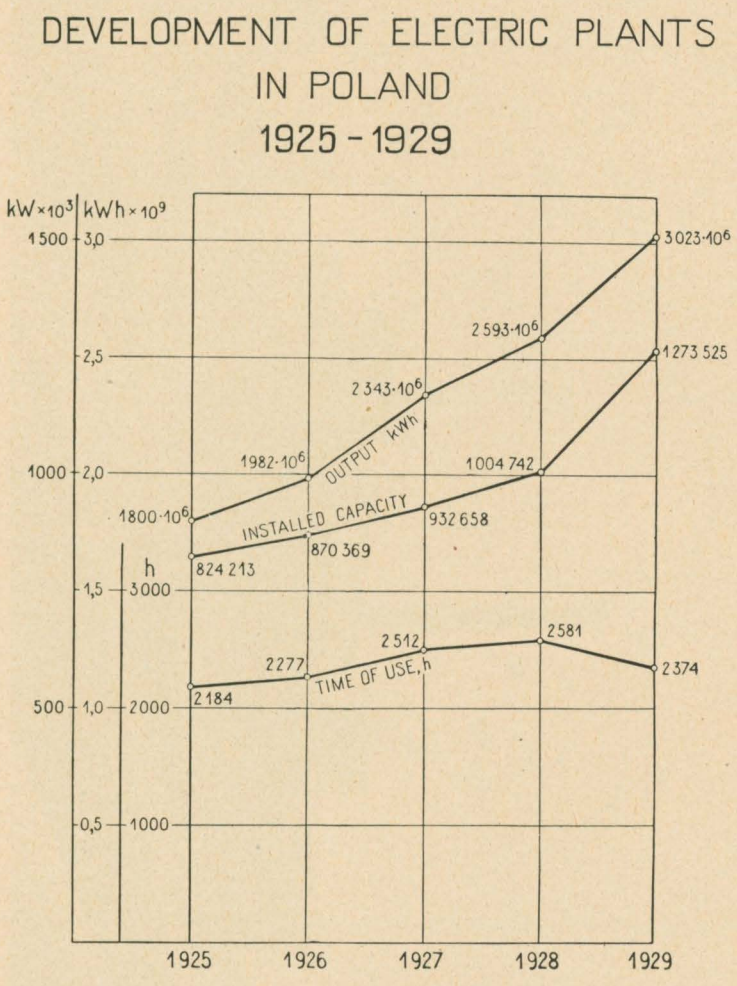


Fig. 2.

exclusive use of their owners, or for the requirements of industrial enterprises to which they belong.

The electrical map (fig. 1) shows the location of electric plants and of concession areas in Poland (1927). The electric

TABLE II.

Development of electric plants in Poland 1925 — 1929.

YEAR	All Electric Plants					Plants *) of an installed capacity of more than 5 000 kW					
	Annual output		Installed capacity		Hours of use	Annual output			Installed capacity		Hours of use
	million kWh	rate of increase %	kW	rate of increase %		million kWh	rate of increase %	Ratio to the aggregate output	kW	rate of increase %	
1925	1 800	—	824 213	—	2 184	1 303	—	72,4	587 770	—	2 217
1926	1 982	10,1	870 369	5,6	2 277	1 460	12,0	73,7	589 081	0,2	2 478
1927	2 343	18,2	932 658	7,2	2 512	1 753	20,1	74,8	624 191	6,0	2 808
1928	2 593	10,7	1 004 742	7,7	2 581	1 927	9,9	74,3	665 416	6,6	2 896
1929	3 023	16,6	1 273 525	26,8	2 374	2 279	18,3	75,4	811 055	21,9	2 810

*) Figures refer to 50 electric plants.

plants are shown in a scale corresponding to their installed capacity, the circles representing those of the plants which are comprised within the first two categories under reference above, the squares marking those of the third category, i. e. electric plants of exclusively private utility. This map shows more or less pronounced features only in respect of the western area of Poland, and also partly of the southern area. In these areas the concentrations of electric plants tend to outline the boundaries of arising electrification areas, which outlines gradually assume more pronounced features. The state of electrification in the East and North is, in this respect, practically primeval.

Although the figures quoted are a definite sign of the backwardness of Poland in respect of electrification, yet in recent years there has been a marked rate of increase in the output of electric energy which points to the steady progress made in this direction.

It follows from the particulars of development of electric plants in Poland (table II and fig. 2) that the aggregate output of electric energy during the period from 1925 to 1929 increased by 67,9 (which corresponds to an average rate of increase during said period of approx. 14% p. a.,) with a fluctuation in the annual rate of progress in individual years of from 6,7% to 18,2%. The installed capacity during the aforesaid five years period increased by 54,5%, the average rate of increase amounting to over 11% p. a. In the event of the recent rate of progress being maintained, the doubling of output would occur every 6—7 years and that of installed capacity every 7—8 years.

Dealing with the figures representing the development of 50 electric plants of more than 5 000 kW installed capacity each (from the total number of 65 plants in 1929), it appears that the proportion of such plants to the total output steadily increases, from 72,4% in 1925 to 75,4% in 1929.

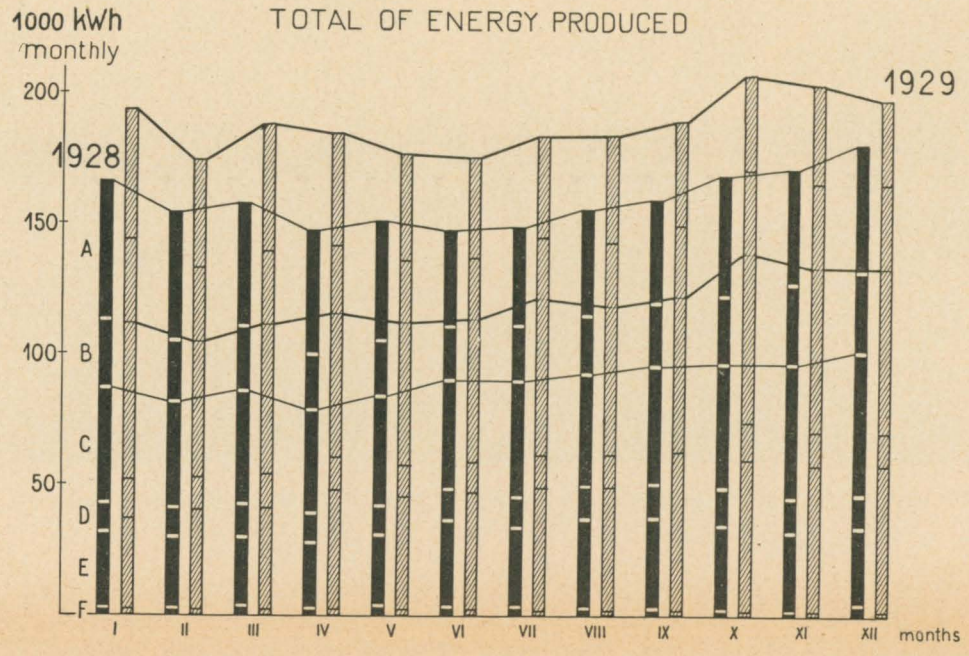
Fig. 3 represents the development, in comparative figures, of energy produced and disposed of during the individual months of 1928 and 1929, in respect of electric plants of an installed capacity of more than 5 000 kW.

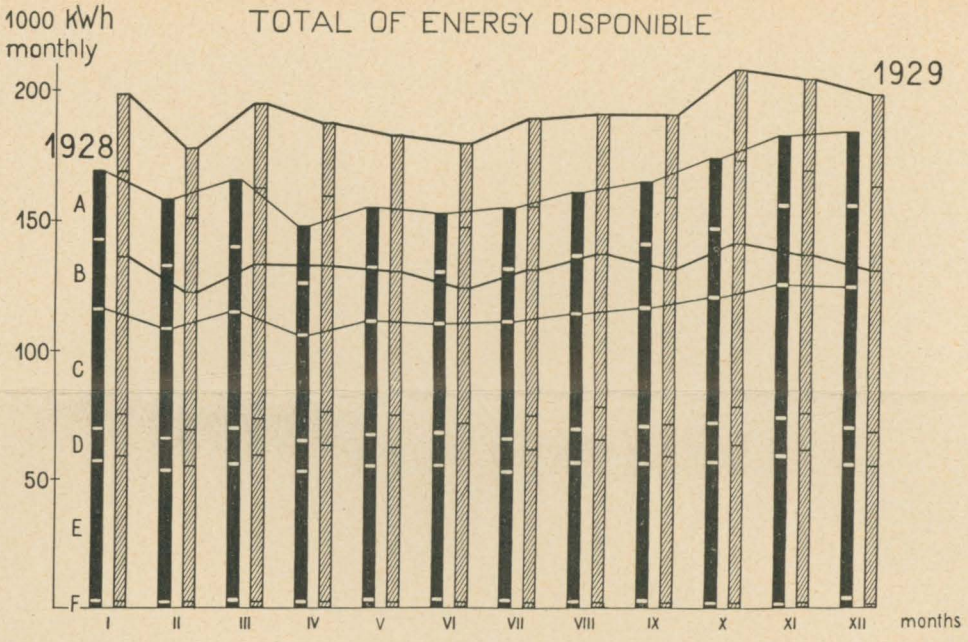
This increase in output, being far in excess of the average rate usually observed in the development of electrification, is all the more striking when we take into consideration that the breach between the present stage of electrification and the actual require-

OUTPUT OF ELECTRIC ENERGY

IN PLANTS OF AN INSTALLED CAPACITY OF MORE THAN 5000 kW

1928 1929





INDEPENDENT PLANTS

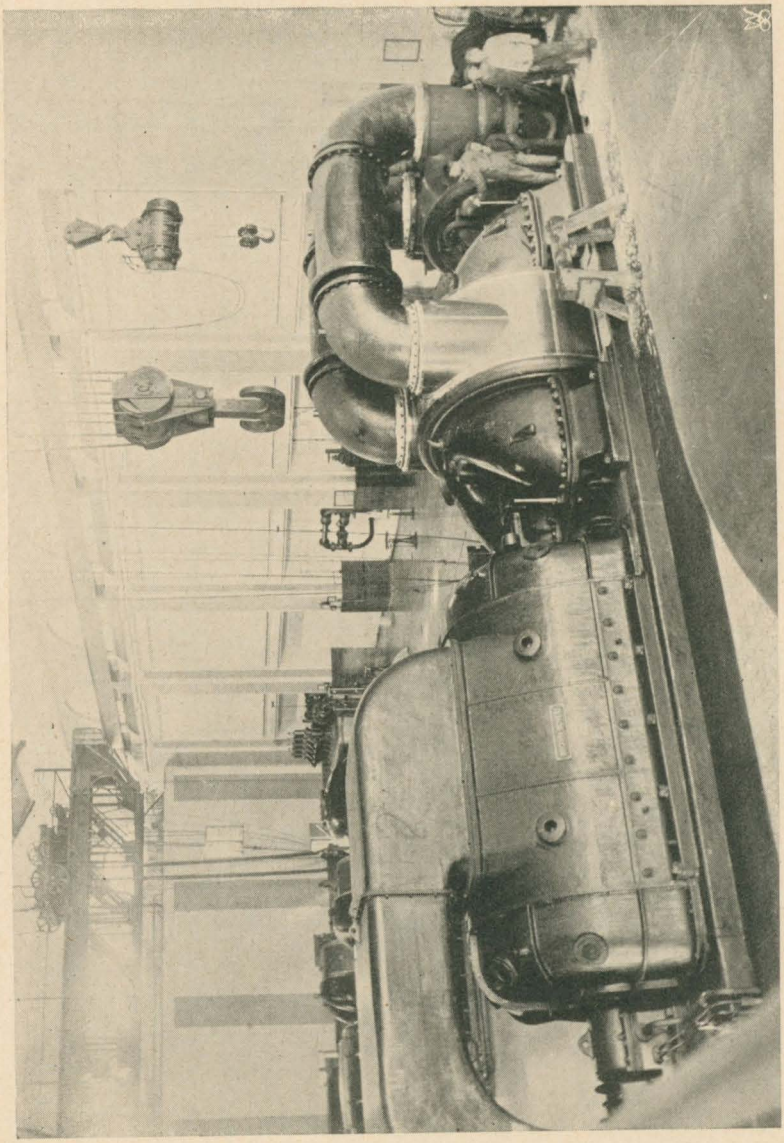
A—Regional plants
B—Local plants

PLANTS IN INDUSTRIAL ENTERPRISES

C—In coal mines
D—In iron works
E—In chemical manufactures
F—In the remaining enterprises

Fig. 3.

ments of the present economic life of Poland is very considerable, and that the requirements, even at a modest estimate, amount



Turbogenerators of 40 000 kVA, 3 000 R. P. M. on the new plant „Elektro" at Laziska (Silesia).

to approx. 8,5 milliard kWh and to approx. 3 million kW, i. e. at the rate of 279 kWh and 99 W per capita of population.

Figures featuring the development in installed capacity and in output, according to the utility nature of the plants (table III), prove that the rate of participation of electric plants of exclusively

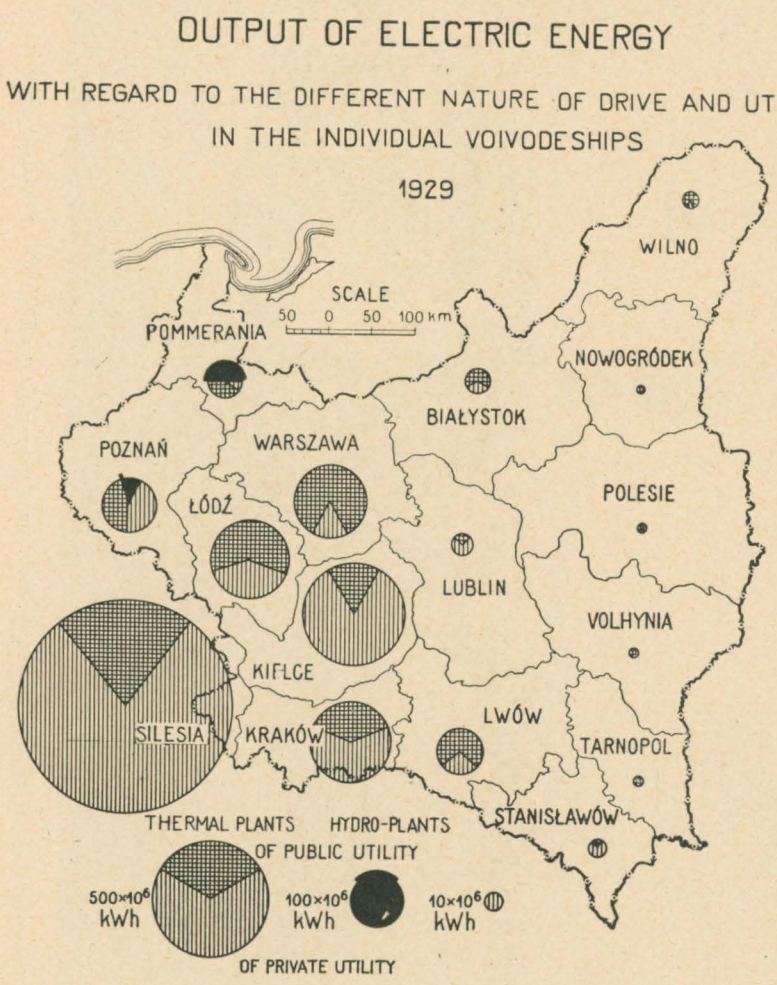


Fig. 4.

private utility in the aggregate capacity and output steadily decreases, and that the rate of decline in the output of such plants during the last five year period exceeded 10%. The centre of gravity of the generation of electric energy gradually inclines towards such

TABLE III.

Allocation of installed capacity and output according to utility nature of electric plants 1925 — 1929.

YEAR	Public utility plants				Plants with incidental sale of energy				Plants *) of exclusively private utility			
	Installed capacity		Output		Installed capacity		Output		Installed capacity		Output	
	kW	% of total output	million kWh	% of total output	kW	of total output	million kWh	% of total output	kW	% of total output	million kWh	% of total output
1925	285 875	34,7	633,7	35,5	156 141	18,9	350,7	19,6	382 197	46,4	800,6	44,9
1926	304 522	35,0	700	35,7	175 076	20,1	397	20,2	390 771	44,9	864	44,1
1927	344 079	36,9	877	37,8	175 193	18,8	441	19,0	413 386	44,3	1 002	43,2
1928	386 564	38,5	961	37,1	177 051	17,6	484	18,7	441 127	43,9	1 148	44,2
1929	452 009	35,5	978	32,4	262 304	20,6	807	26,7	559 212	43,9	1 238	40,9

*) Figures refer to 50 plants.

electric plants which are directly concerned in supplying the country with energy for general purposes. This contention applies mainly to electric plants with an incidental sale of energy and is a characteristic feature of the present phase of producing electric energy in Poland.

Fig. 4 shows the output of energy, as allocated to the particular Voivodeships *), simultaneously subdivided according to the nature of drive and utility.

A striking feature is the unusually small participation of water power in the aggregate power balance sheet of electrification. Hydro-electric plants provide barely 1,2% of the aggregate output. The only exceptions are Pommerania where hydro-electric plants provide approx. 50%, and to a certain extent the Poznań Voivodeship, where the output of hydro-electric plants constitutes 10% of the aggregate output of electric energy. In other Voivodeships the output of such plants does not even reach 1%. Thus, thermal electric plants supply an aggregate of 98,8% of energy.

It must be pointed out that with the exception of the Polish Coal Fields situated partly in the Voivodeships of Silesia, Cracow and Kielce, of the Polish Oil Fields in the Carpathian foreland in the southern Voivodeships and of Pommerania, all of which have local sources of power, the remainder of Poland has to rely on imported power material. As regards the amount of energy generated, this evidences a distinct course from the East towards the West. The output of energy in the eastern Voivodeships is most negligible, whereas it gradually increases farther towards the West, particularly in Voivodeships where industries are in existence or where agriculture is in a high state of development, finally reaching an incompatibly high figure in the Silesian Voivodeship. The preponderance of electric public utility plants in the output of energy occurs in those Voivodeships where regional service lines have found more favourable ground for development, or where, similarly as in the eastern Voivodeships, there is a lack of larger industrial enterprises owning electric plants.

Fig. 5 (table IV) represents the intensity of output in individual Voivodeships on a kilowatt-hour scale per capita of population. It will be seen from this figure that the area of the Republic

*) The largest administrative division in Poland.

of Poland, from the point of view of electrification, is most irregular. There is a strong contrast between the eastern regions of the country (up to 5 kWh per capita) and the Voivodeship of

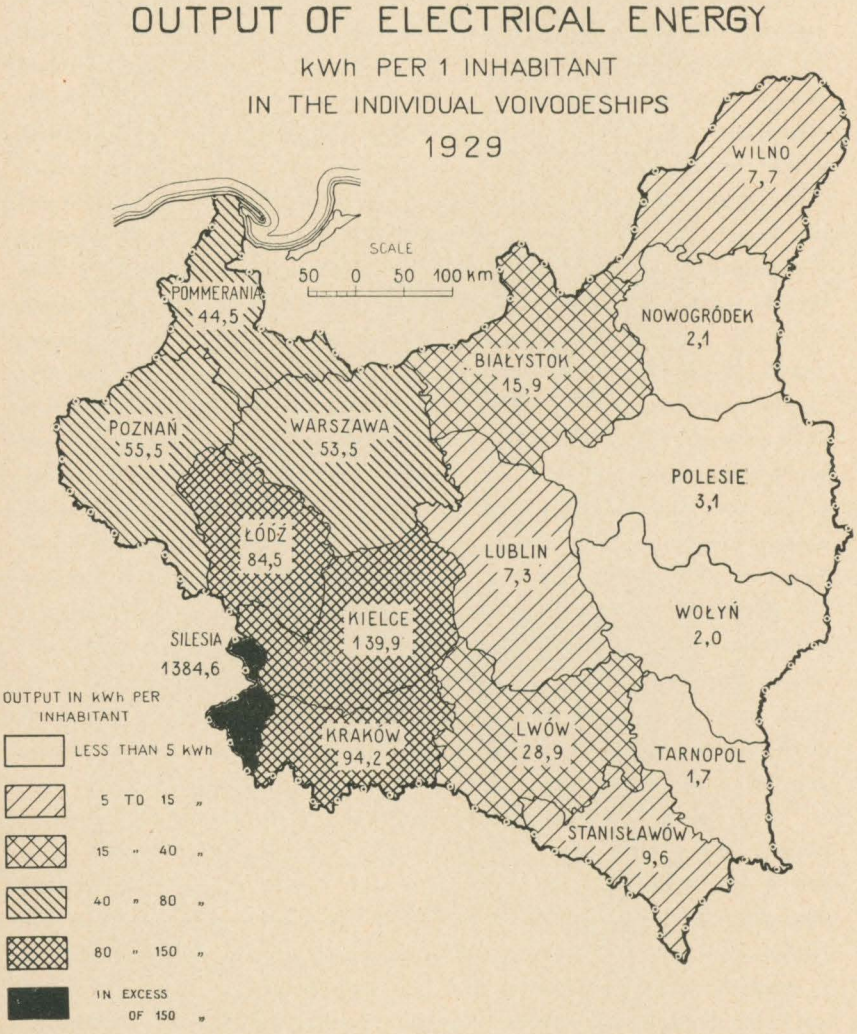


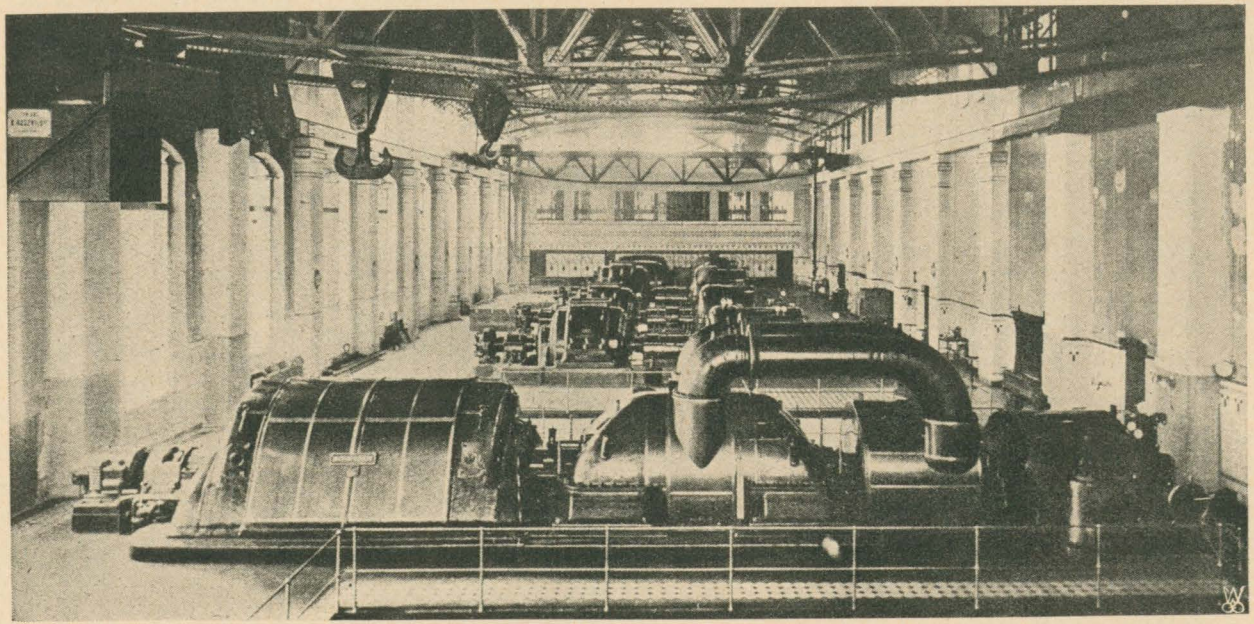
Fig. 5.

Silesia in the extreme West (1385 kWh per capita), which latter presents an exceptional phenomenon, not only for Poland, but even in comparison to many industrial centres of Western Europe

with a high standard of electrification. All Voivodeships may be classified into 6 consecutive groups. The poorest among them, with but up to 5 kWh per capita, are: the Voivodeships of: Tarnopol, Volhynia, Polesie and Nowogródek which for a long time have been entirely neglected from an economic point of view and are devoid of industry. They are headed by Tarnopol with 1,7 kWh and Volhynia with 2,0 kWh per capita. The second group, with an annual output of from 5 to 15 kWh per capita comprises the Voivodeships of: Vilno, Stanislawów and Lublin, which have a partly developed industry, or, as for instance Lublin, oppulent agricultural areas. The third group, with an annual per capita output of from 15 to 40 kWh comprises the following Voivodeships: Lwów, embracing the Boryslaw oil fields, and Bialystok with an old-established textile industry. The fourth group, from 40 to 80 kWh, consists of the Voivodeships of: Warsaw, partly comprising industrial districts, Pommerania, which has the largest percentage of hydro-electric plants in Poland, and Poznań with an important victualling industry based on the highly developed local agriculture. The fifth group, from 80 to 150 kWh, comprises the Voivodeships of Lodz with its highly developed textile industry; Kielce which embraces part of the Dombrowa Coal Fields; Cracow, also embracing part of the Coal Fields and the Krosno Oil Fields in the South-East. The sixth and last group, with an annual per capita output in excess of 150 kWh comprises Silesia where the annual output amounts to 1385 kWh per capita. It will, thus, be seen that the Coal Fields area has, in respect of the standard of electrification, considerably outdistanced the remaining area of Poland.

Fig. 6a and 6b show the development in the number of electric plants, installed capacity and output (in absolute figures and per 1 electric plant) as well as in the hours of use, subdivided into the three categories of utility. The graphs provide for the status as of 1929 and 1925, the scales having been selected in such a manner as to render it easy to appreciate the mutual ratio between the elements of the graphs relatively to each particular status, or quadrennial rate of increase, without further comments.

In 1929 the first category comprised 52,9% of the total number of electric plants, 35,5% of the aggregate installed capacity and 32,4% of the aggregate output; the first category, to-



Engine-room of the Lodz Electric Co.

gether with the second category (incidental sale of energy) comprised 67,7% of the total number of electric plants, 56,1% of the aggregate installed capacity and 59,1% of the aggregate output, the balance of 32,3% of the number of plants, 43,9% of capacity and 40,9% of output being allocated to electric plants of the third category (exclusively of private utility).

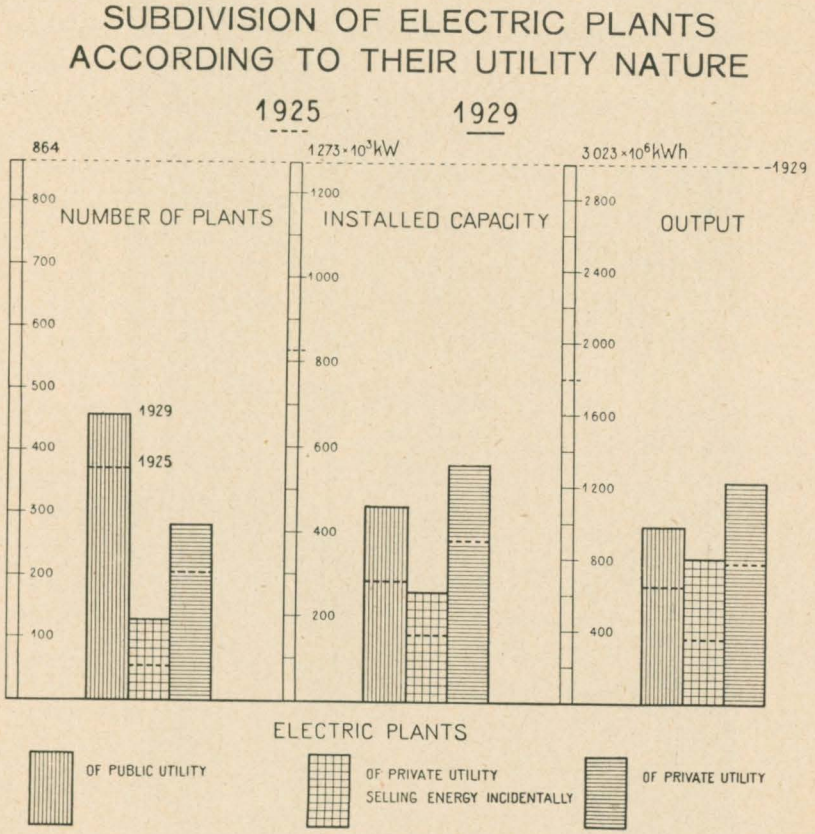


Fig. 6 a.

The average rate of use, relatively to the aggregate output and installed capacity, in 1929 amounted to 27%, or 2374 hours, or 2164 hours in the case of the first category of electric plants, 3077 in the case of the second category and 2214 in the case of the third.

The average figures as to installed capacity and output per 1 electric plant amounted to 1474 kW and 3,50 million kWh respectively, the two largest electric plants in Poland, namely at Chorzów and at Laziska Górne, having an aggregate installed capacity of 161 100 kW (12,6%) and an aggregate output of 690 million kWh (22,8%).

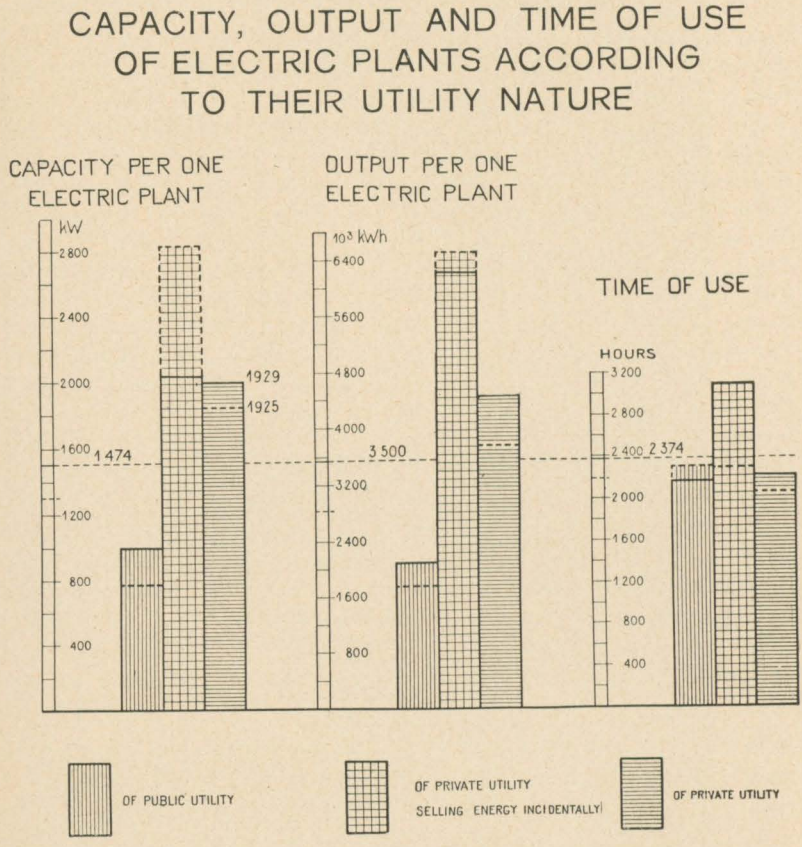


Fig. 6 b.

The average figure of capacity of the electric plants will be considerably reduced if we eliminate 65 plants of an installed capacity in excess of 5 000 kW. The average capacity for the remaining electric plants, representing 92,5% of the total number, would in that case amount to 404 kW, or to barely 27% of the

TABLE IV.

Output of electric energy according to territorial allocation.

Voivodeship	1929	1927	Increase in 1929 over 1927 %	1929	
	in thousands kWh			per capita of population kWh	per 1 km² of area kWh
Total for all Poland . .	3 008 276*)	2 301 810	30,7	98,9	7 746
Warsaw (Warszawa) . . .	193 793	149 594	29,5	53,5	6 578
Lodz	216 308	171 515	26,1	84,5	11 364
Kielce	403 203	290 048	39,0	139,9	15 664
Lublin	17 297	11 743	47,3	7,3	556
Bialystok	23 512	16 789	40,0	15,9	724
Vilno (Wilno)	9 683	7 695	25,8	7,7	332
Nowogródek	2 091	1 276	63,9	2,1	92
Polesie	3 462	2 203	57,1	3,1	82
Volhynia (Wołyń) . . .	3 595	2 202	63,3	2,0	119
Poznań	117 083	78 943	48,3	55,5	4 414
Pommerania	44 696	30 730	45,4	44,5	2 728
Silesia	1 670 404	1 292 211	29,3	1 384,6	394 894
Cracow (Kraków) . . .	205 799	181 167	13,6	94,2	11 795
Lwów	80 731	56 301	43,4	28,9	2 988
Stanisławów	14 022	8 003	75,2	9,6	763
Tarnopol	2 597	1 390	86,8	1,7	160

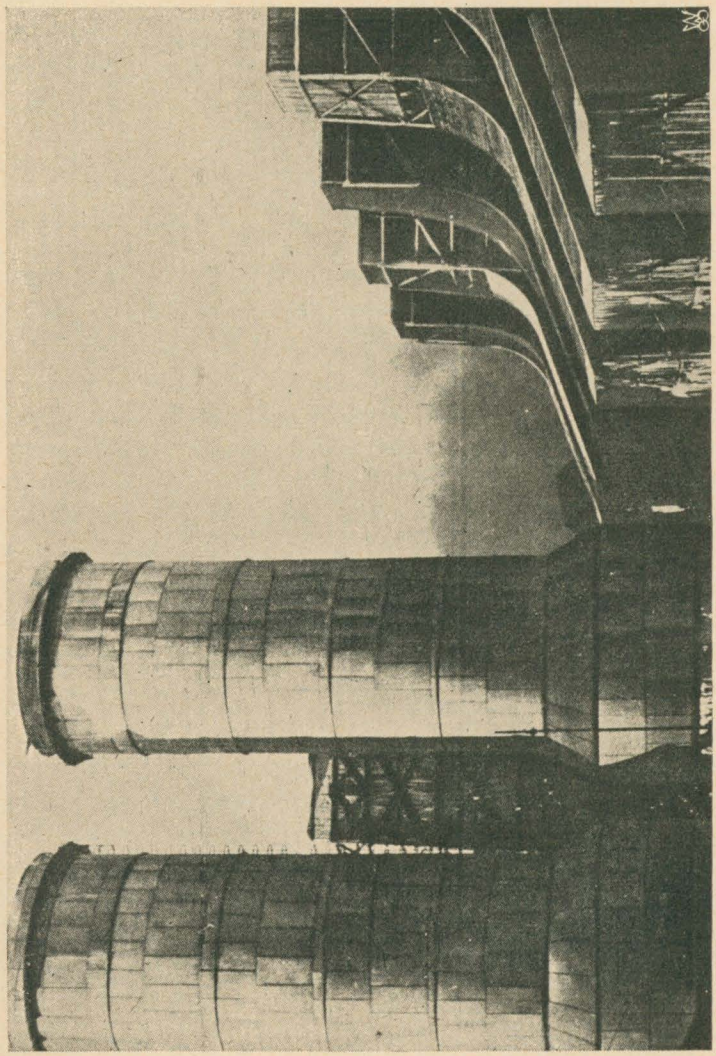
*) Total output of the plants of a known capacity. (In table I the figure $3\,023.10^6$ kWh represents the above figure $3\,008.10^6$ + the estimated output of the plants, the capacity of which is unknown).

previously quoted figure. By further eliminating electric plants of more than 1000 kW of installed capacity the remaining electric plants, representing 81,8% of the total number of electric plants, show an average of installed capacity of barely 171 kW, or 11,6% of the aggregate average.

These computations prove that the overwhelming majority of Polish electric plants represents small local plants.

Table V shows the subdivision of electric plants according to groups in respect of capacity. The higher the group the smaller the number of plants; on the other hand, the installed capacity, output and time of use increases. The installed capacity in respect of 26 electric plants of more than 10 000 kW, representing but 3,0% of the total number of plants, amounts to a similar figure

as that of the remaining 838 electric plants of less than 10 000 kW installed capacity, and the output of the former — to one and a half times that of the latter. The time of use, from 997 hours p. a.



The new big refrigerating steel towers of the power plant of the Lodz Electric Co. compared with the old wooden ones.

in respect of the up to 100 kW group, increases to 2724 hours in the case of electric plants in the more than 10 000 kW group, the aggregate average being 2 374 hours p. a.

TABLE V.

Subdivision of installed capacity and of output, according to capacity of plants (1929).

Electric plants of an installed capacity	No. of electric plants		Installed capacity		Annual output		Hours of use
	absolute figures	%	kW	%	1000 kWh	%	
Total, all plants .	864*)	100,0	1 273 525	100,0	3 023 206	100,0	2 374
In excess of 10 000 kW	26	3,0	675 972	53,1	1 841 356	60,9	2 724
From 5 000 to 10 000 kW . . .	39	4,5	274 987	21,6	609 348	20,2	2 216
From 1 000 to 5 000 kW . . .	92	10,7	201 699	15,8	374 090	12,4	1 855
From 100 to 1 000 kW	351	40,6	106 721	8,4	184 308	6,1	1 727
Less than 100 kW .	356**)	41,2	14 146	1,1	14 104	0,4	997

*) There are a further 600 electric plants of exclusively private utility, of less than 100 kW installed capacity each. Their aggregate capacity amounts to 15 081 kW and the output to 25 000 000 kWh.

**) These figures apply to public utility plants, as well as to such of the private utility plants which are selling current incidentally.

TABLE VI.

Electric plants of an installed capacity in excess of 1000 kW each (1925 — 1929).

Year	No. of electric plants	Installed capacity			Output			Hours of use
		kW	per 1 electric plant kW	% of aggregate capacity	millions kWh	per 1 electric plant mil. kWh	% of aggregate output	
1925	128	735 476	5 762	89,5	1 606,8	12,55	90,0	2 179
1926	134	770 479	5 750	88,5	1 773,1	13,23	90,4	2 301
1927	138	830 544	6 018	89,1	2 135,4	15,47	92,0	2 571
1928	138	888 642	6 439	88,4	2 391,1	17,33	93,2	2 691
1929	157	1 152 658	7 342	90,5	2 824,8	17,99	93,5	2 451

The steadily increasing participation of capacity and output of electric plants of more than 1 000 kW during the recent 5 years period (1925—1929) is represented in Table VI. Relatively to the aggregate figure, their installed capacity increased from 89,5% to 90,5% and the output from 90% to 93,5%, the participation

of electric plants of less than 1000 kW at the same time showing a decrease by 9,5% in respect of installed capacity, and by 35% in respect of output. The average capacity per electric plant during said period increased by 27%, and the average output by 43%, which exemplifies the improvement in the rate of concentration of capacity and centralization of the operation in such plants. The time of use also shows continued progress, having increased from 2 179 hours in 1925 to 2 451 hours in 1929.

The number of regional electric plants in Poland amounted to 28 (3,3% of the total) of an aggregate installed capacity of 314 720 kW (24,7% of the total) and an aggregate annual output of 984,8 million kWh (32,6% of the total). These latter electric plants had an aggregate number of 62 772 consumers by meter service and 38 831 flat-rate consumers (1929). In 14 of the regional electric plants the maximum tension in transmission lines amounted to 15 kV, in 9 plants to 35 kV and in 3 — to 60 kV. Poland so far has no long distance transmission lines of a national character. On the other hand, both transmission lines and regional systems of higher tension within the precincts of individual Voivodeships have recently shown steady development. The highest tension used in the latter is 60 kV, the length of lines of such tension at the end of 1927 amounting to approx. 300 km, and the length of the system of lines of from 30 to 40 kV tension — to approx. 600 km.

TABLE VII.

Participation of regional electric plants in the electrification of Poland (1925 — 1929).

Year	No. of electric plants	Installed capacity of electric plants			Output			Hours of use
		kW	per 1 electric plant kW	% of aggregate capacity	kWh	per 1 electric plant kWh	% of aggregate capacity	
1925	22	170 539	7 749	20,7	473 328	21 514	26,3	2 775
1926	26	204 051	7 848	23,4	608 065	23 387	31,0	2 980
1927	26	223 851	8 610	24,0	749 201	28 815	32,0	3 347
1928	27	236 920	8 775	23,6	795 956	29 480	30,7	3 360
1929	28	314 720	11 240	24,7	984 848	35 175	32,6	3 129

The changing over from local to regional method of electric service is most significant according to the figures in table VII which covers the period of from 1925 to 1929. The rate of participation of regional electric plants relatively to the total figure, in respect of installed capacity, increased from 20,7% to 24,7%, thus increasing the participation by 19,3%, the rate of output increasing from 26,3% to 32,6%, thus increasing the participation by 24%.

The decrease in the rate of participation of local electric plants, which in this instance serves as evidence of the progress of evolution in electrification on the path from the lower class of local plants to the higher one of regional plants, during said 5 years period amounted to 8,5%. The average capacity per plant during said period increased by 45% and the average output by 64%.

Out of the total number of 632 towns with a population of approx. 7,8 millions, 302 towns with a population of approx. 5,8 millions possesed electric plants, a further 57 towns with a population of approx. 0,7 millions being served by electricity from regional plants, so that in all electrical service is being rendered to 359 towns (56,8% of the total number) with a population of 6,5 millions (83,3% of the total population in all towns).

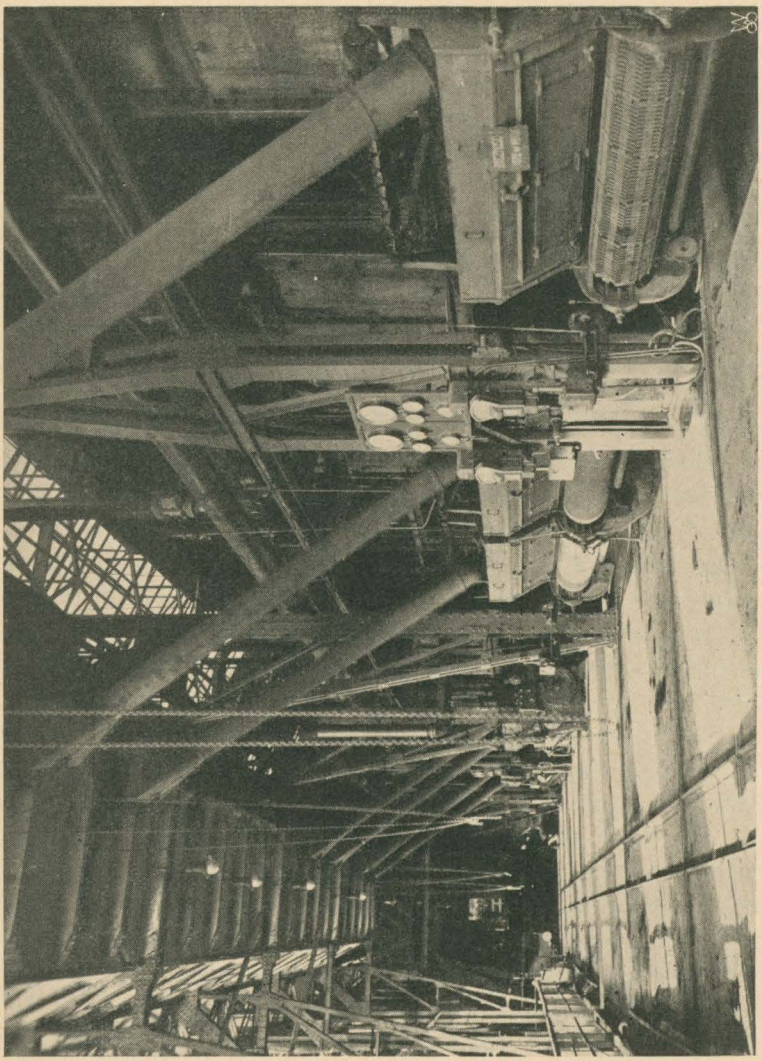
Out of a total of 12 578 rural communities with a population of approx. 22,6 millions, only 351 are served by electric energy, whereof 78 communities have their own plants, the balance being served from regional electric plants.

Electric tramways were in existence in 11 towns. The length of municipal tramway lines amounted to 239,5 kilometres, the length of track to 461 kilometres. In respect of towns having tramway service, there were 21,77 kilometres per town. The number of inter-urban electric traction enterprises amounted to 4.

The main features of the energy generated, such as tension, frequency and system, with a very few exceptions, comply with the requirements now effective and may be considered as entirely normalized.

Frequency and tensions are standardized by virtue of Government regulations. In granting electrical concessions and licences for the erection of new electric enterprises or for the extension of existing ones, the competent authorities assure themselves of

their rationality and supervise that they comply with the general electrification plan, both from an engineering and economic point of view.



Boiler room of the electric plant of the Regional Station in the Dombrowa Coal District.

The participation of D. C. electric plants, relatively to the total number of plants in existence, amounts to 55%, and to the total installed capacity — to 8%; if these figures are applied to exclusively public utility plants, eliminating electric tramway

plants, the participation of such plants, relatively to the total number of electric plants in existence, will amount to 47%, and to the total installed capacity — to 5%. It thus follows that the existence of D. C. electric plants is rendered necessary either by the special requirements of production of such industrial enterprises to which they belong, or by the fact that such plants serve for the supply of energy for local tramway traction, whereas in the case of those exceptional instances in which they feed public utility distributing lines, they may be considered as a temporary remedy.

The relative figures of installed capacity, according to the nature of motive power are as follows: steam engine drive represents an aggregate of 95%, whereof turbines 85%, reciprocating steam engines 10%. The percentage figure for internal combustion engines is approx. 3,7% and for water turbines approx. 1,3%.

All of the 65 electric plants of more than 5 000 kW installed capacity each, including 26 plants of more than 10 000 kW each, generate energy exclusively by means of steam turbines. The proportion of steam turbines in the total output amounts to 87%. In all there are 362 turbines in operation in Polish electric plants, of an aggregate installed capacity of approx. 1 057 600 kW. The average capacity per turbine thus amounts to 2 920 kW, and, if we neglect turbines of less than 1 000 kW capacity, the number of which represents 22% of the total and the capacity but 5,2%, the average capacity per turbine would amount to approx. 3 560 kW. The capacity of the largest turbine in operation in 1929 amounted to 28 000 kW (at the „Elektro" Plant in Laziska Górne).

All forecasts pertaining to the future conditions of generating electric energy, based on a detailed survey of the features of Polish power policy, tend to show that the electrification of Poland will, at least for the nearest future, develop mainly under the auspices of coal, steam and, consequently, of the turbine.

Those of the power plants which show the largest participation in the aggregate generation of electric energy, have boiler plants for a steam pressure averaging from 12 to 15 kg/cm^2, at a temperature of steam tanging from 250° to 350° C. In the case of plants recently erected the steam pressure sometimes reaches 30 kg/cm^2 at a temperature of 400° C. Fuel consumption averages

approx. 1,3 kg of coal per kilowatt hour of energy generated. In individual plants, according to the size of units, working conditions and the quality of coal, the fuel consumption varies from 0,9 to 3,5 kg per 1 kWh.

The generating equipment of an overwhelming majority of Polish electric plants does not comply with modern requirements of rational power policy. This is due to the comparatively low cost of coal and also to the difficulty in securing the necessary means for the financing of investments. This explanation applies principally to electric plants situated within the Coal Fields area (approx. 60% of the aggregate capacity of all plants) or close to it, and which are able to avail themselves of the cheapest grades of coal, mainly dust coal, the transport of which by railway over longer distances would prove too expensive. Thus, the modernizing of the equipment of said electric plants with a view to reaching a higher power efficiency is not justified from the point of view of remunerability. The adoption of expensive equipment of high efficiency could only be justified in the case of electric plants in a considerably advanced state of concentration of the generating process, and having a high utility factor, as well as in the case of electric plants situated at a considerable distance from the Coal Fields and forced to use better coal of high calorific value.

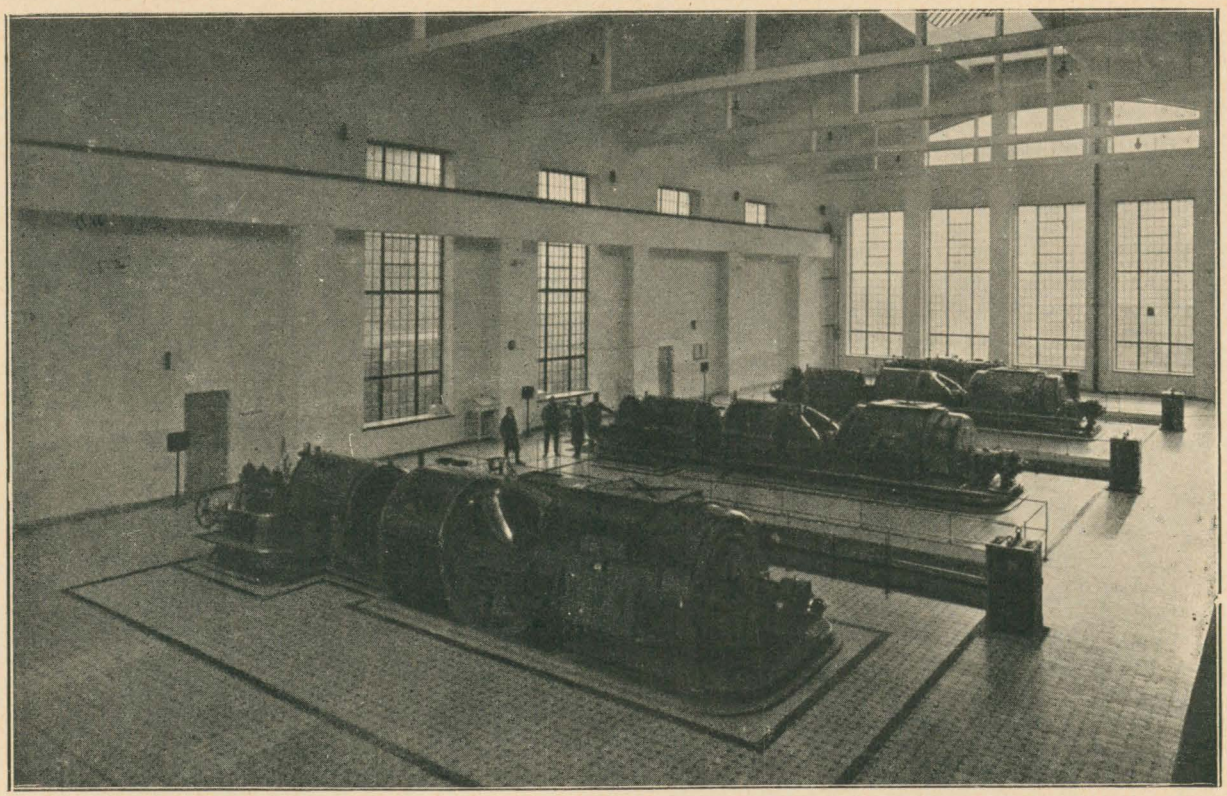
One of most topical problems of Polish power policy is the question of electrification of the Coal Fields area. This is a problem of national importance and dependant on the final solution of a scheme which has been maturing for some years, in respect of interconnecting existing local electric plants, making full use of the large quantities of waste coal available for the generation of electric energy and meeting both the local and outside demand for electric energy by transmitting it beyond the Coal Fields area, to other districts of the Republic.

The participation of the Coal area in the national electrification policy will be appreciated from the figures in Table VIII, from which it follows that the electric plants in the Coal Fields area represent 58,5% of aggregate capacity and 70,4% of aggregate output. The rate of output per capita of population which in respect of the whole of Poland, exclusively of the Coal Fields area, amounts to 31,4 kWh is, due to the participation of the Coal Fields area, increased to 99,4 kWh, that is to say 3,2 times, both the concentration of output and the utilization factor of installed

capacity of the electric plants in the Coal Fields area considerably exceeding the remainder of Poland.

In the comparatively small area occupied by the Coal Fields there are 42 electric plants in existence of more than 5 000 kW each. The aggregate capacity of all these plants amounts to 660 878 kW, whereof 200 000 kW are of but potential value, representing available reserves. Out of said aggregate figure, approx. 80 000 kW have full capacity of output and may be used for meeting the basic load, the balance of approx. 120 000 kW representing old equipment suitable for meeting peak load, or as reserves. By interconnecting the electric plants, effecting the necessary extensions and synchronizing the operation under a mutual electrical scheme, it would be possible to put into action a considerable part of that capacity which is so far standing by as reserves, to enhance the general efficiency of work of the power plants and to increase their output by approx. 600 millions kWh per annum.

The synchronizing of the cooperation of the electric plants in the Coal Fields area is already considerably advanced and is well on the path towards reaching a uniform electrical system which, in due course of time, will embrace the entire Coal Fields area. Already at present 20 of the larger electric plants cooperate in individual blocks, or are able to work in parallel with other electric plants. Certain of the cooperating electrical groups are getting into closer touch with the main block comprising the electric plants at Chorzów and Laziska Górne and constituting the embryo of the future uniform general system in the Coal Fields area. It must be pointed out that the said block, which is the pivot of power operations in the Coal Fields area, at the present moment concentrates 22% of aggregate capacity and 32% of aggregate output in the entire Coal Fields area. The scope of such power cooperation will be appreciated from the fact that 38 electric plants of an installed capacity of more than 5 000 kW each, in 1929 had an aggregate output of 1855 millions kWh, out of which they supplied 518,8 millions kWh to other electric plants, the interchange of energy thus constituting 28% of the output. The cooperation between the electric plants is so far based mainly on one-sided supply, although in certain particular instances mutual interchange is also effected. Apart from an insignificant foreign interchange of current between the electric plant at Chorzów and the electric plant at Zabrze in German Upper Silesia with



Turbine-room in the power plant of the State Nitrogen Compounds Factory at Mościce.

which it is connected by a long-distance line (60 kW) (fig. 7), it can be said that the entire output of electricity in the Coal Fields area is used exclusively for local requirements, mainly for those of the collieries, the chemical and other existing industries.

There, howerer, remains no doubt as to that the proper role of the Coal Fields area in the national electrification policy depends on the transmission of electric energy into the interior of the country. This contention is primarily justified by the prevailing coal problem, owing to the availability of exceedingly large supplies of inferior cheap waste coal which, under the present economic conditions, could not be to advantage transported over long distances.

The quantity of dust coal alone, the sale of which meets with serious difficulties, exceeds 20% of the aggregate output of coal, and, if converted into the power equivalent, represents approx. 7 milliards kWh, reckoning at the rate of 1,2 kg of dust per 1 kWh.

The most noteworthy perhaps of the larger electrical schemes which are now being realized in the Coal Fields area is the extension of the capacity of the electric plant „Elektro" at Laziska Górne (Upper Silesia) up to 120 000 kVA (4 boilers for dust coal fuel, of 1 100 m^2 heating surface each, and 2 turbine units of 28 000 kW each) as well as the consequent erection of long-distance lines for 60 kV tension intended for the supply of energy to the Government Nitrate Factory. Mention must also be made of the forming of an Association of Electric Colliery Plants (60 000 kW) in the Dombrowa Coal District and of the erection of a long-distance line by the Jaworzno Collieries in the Cracow Coal District for the purpose of supplying energy to the city of Cracow (60 kV).

The utilization of natural gas for the generation of electric energy begins to assume more and more marked proportions. Some years ago a thermal Regional Electric Plant was erected in the gas fields of the Boryslaw Oil District and continues to make satisfactorily progress, similarly as the Regional Electric Plant at Brzezówka (Central Galicia) driven by a gas engine and intended for the supply of energy to the Krosno Oil District.

The output of natural gas amounts to an average of approx. 500 millions m^3 per annum. The economic importance of the electrification of the oil districts, and in particular of the Bory-

TABLE VIII.

Participation of the coal fields area in the electrification of Poland (1929).

	Population	Area km²	Population per 1 km²	No. of electric plants	Area per one elec. plant km²	Installed capacity				Output				Hours of use
						kW	per 1000 inhabitants	per 1 km²	per one electric plant	mill. kWh	per capita	per 1 km²	per one electric plant mill. kWh	
						kilowatt				kilowatt hours				
Poland	30 408 247	388 390	78,3	864	449,5	1 273 525	41,9	3,28	1 474,0	3 023	99,4	7 783,0	3,50	2 374
Coal Fields . . .	1 974 420	8 475	233,0	134	63,2	745 638	377,6	87,98	5 564,5	2 129	1 078,3	251 209,0	15,89	2 856
Remainder of Poland	28 433 827	379 915	74,8	730	520,4	527 887	18,6	1,39	723,1	894	31,4	2 353,0	1,22	1 694

slaw district, is conditional upon the rationalization of the local power policy which has been in a state of utter neglect for many years, upon the effecting of considerable economy in using crude oil and natural gas, and upon the stimulation of the development of the oil industry, particularly as far as drillings are concerned.

Water power, as already stated, participates but to a minute extent in the aggregate generation of electric energy, and all hydro-electric plants are concentrated chiefly in Pommerania.

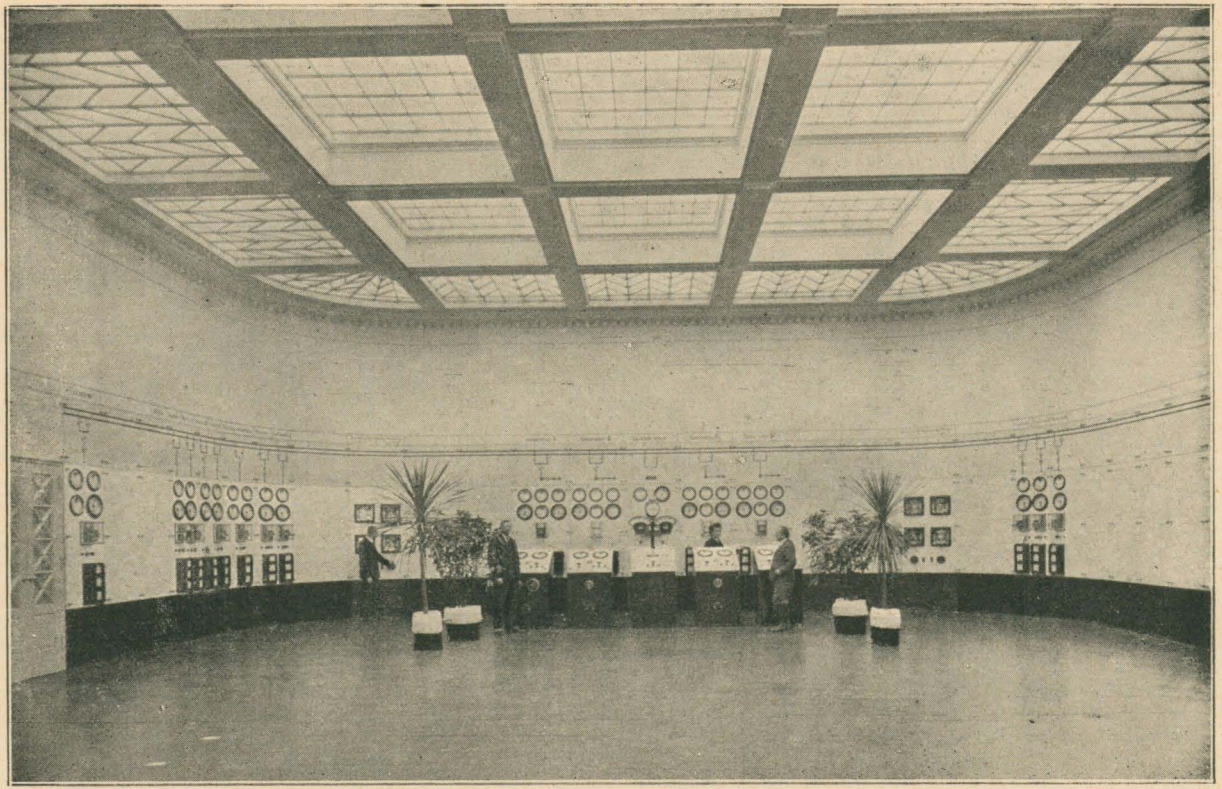
Of all existing hydro power plants, 24 are allocated to electric plants, with a capacity of 17 552 kW. The average capacity per hydro-electric plant amounts to 731 kW, the capacity of the largest of them — to 8 200 kW (Żur electric plant on the Czarna Woda river, put into operation in 1929).

The most suitable resources of water power available for utilization in Poland are mainly concentrated in two groups: in Pommerania and the Carpathian foreland. These two groups have entirely different water and economic features.

Pommerania has water power easy to utilize, with conveniently located natural retention tanks. The comparatively small distance separating the concentrated falls of Pommeranian rivers from the centres of consumption of electric energy, the lack of local administrative bodies, contribute towards exceptionally opportune economic conditions for the utilization of water power for the electrification of the country. In Pommerania electrification penetrates very deeply, right into the mainstay of the economic existence of Poland — agriculture. In no other province in Poland is there such considerable development of regional systems and such considerable consumption of electric energy for agricultural requirements, the latter amounting to 20% of the entire local output of electric energy.

The water power resources of the Carpathian foreland, although more imposing than those of Pommerania, do not possess such advantageous features as the latter.

Heavy cost of investments required in this area constitute a serious impediment in the realizations of schemes drawn up long ago. Further difficulties are presented by the location of the falls, concentrated almost on the borders of the country and at considerable distance from the centres of consumption of electric energy.



Switch-board control room in the power plant of the State Nitrogen Compounds Factory at Mościce.

The availability of an ideal thermal power fuel, namely natural gas, in the central and eastern part of the Carpathian foreland, as well as the proximity of the Coal Fields to the western part thereof, has given priority to the economically more advan-

TABLE IX.

Demand for electric energy (1929).

	millions kWh	%	%
Total { at the electric plants . . .	8 500	—	100
Total { at points of consumption .	6 757	—	79,6
I. *Industry*	*5 175*	*100*	*69,9*
1. Mining and foundry industries:	2 835	54,8	33,3
a) coal mining and mineral .	1 650	31.9	19,4
b) oil mining	160	3,1	—
c) foundry	1 025	19,8	12,1
2. Chemical industry	1 150	22,2	13,5
3. Victualling „	290	5,6	
4. Textile „	240	4,6	
5. Mineral „	160	3,1	
6. Paper „	130	2,5	
7. Metallurgical „	85	1,6	
8. Timber „	70	1,4	
9. Remaining industries	15	0,3	
10. Minor industries	200	3,9	
II. *Lighting and Heating*	*502*	—	*5,9*
III. *Agriculture*	*260*	—	*3,1*
IV. *Traction*	*660*	*100*	*7,8*
1. State railroads	520	78,8	
2. Suburban railroads	60	9,1	
3. Tramways	80	12,1	
V. *Requirements of Government and public utility enterprises*	*160*	*100*	*1,9*
1. Railways (motive power and lighting) and military enterprises	65	40,6	
2. Water supply and gas plants. .	95	59,4	
Loss	1 743	—	20,4

tageous thermal methods for generating electric energy, which are making steady progress.

The figures illustrating the present state of electrification policy are exceedingly unassuming, not only if compared with those in other countries, as they constitute a mere fraction of the actual requirements of Poland in that respect.

The results of the estimates of the electrical requirements of Poland, as they were at the end of 1929, are contained in table IX. It is evident from the figures contained therein that the requirements of industries, including the mining industry, amount to 5 175 millions kWh p. a. which, relatively to the total requirements (net), represents 76,65%. This item comprises, as will be observed, the main base on which the development of the electric policy depends. The requirements for domestic lighting and heating purposes amount to 502 millions kWh, those of agriculture — for threshing and minor agricultural purposes — to 260 millions kWh, those of Government and public utility enterprises to 160 millions kWh, representing a total of 13,6%. The requirements of traction which, in addition to tramways and suburban railway traffic, also provide for the electrification of 1 100 kilometres of State railway line most mature for such purpose, amount to a total of 660 millions kWh, or 9,75%. Under prevalent economic conditions in Poland, the estimated requirements for electric energy, thus, amount to a total of 6 757 millions kWh at the points of consumption, or to approx. 8,5 milliard kWh at the terminals of the electric plant. The installed capacity required to meet such output amounts to approx. 3 millions kW. This works out at the rate of 280 kWh and 98,6 W per capita, and to 21 900 kWh and 7,75 kW per km^2.

The rate of electric saturation which represents the ratio between output and demand, amounted in 1929 to 35%. It is significant that practically no change has been perceived in the rate of electric saturation during recent years, which goes to show that although the electrification of Poland has recently made considerable progress, yet due to the general economic improvement in the country, and in particular to industrial progress, the percentage figures remain practically at the same level as they were some years ago.

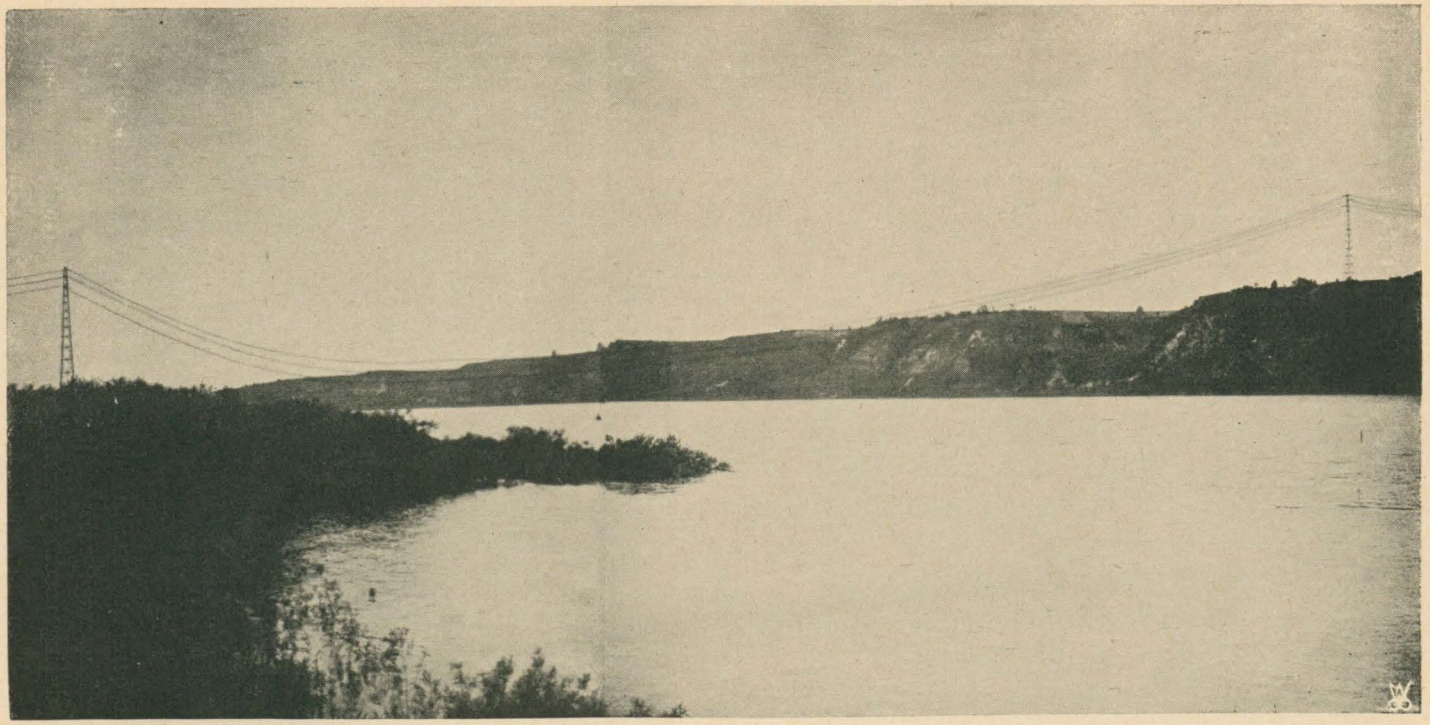
The output of electric energy, both actual and anticipated, subdivided according to the electric regions as adopted for the

TABLE X.

Output of electricity, actual and anticipated, subdivided according to regions 1929 — 1935 — 1950.

Electrical Region	Annual output			Remarks*)
	Actual in 1929	Anticipated		
		1935	1950	
	millions kilowatt-hours			
POLAND	3 023,0	5 650	18 460	
1. Pommerania	38,4	69	323	1, 2, 3, 4
2. Bydgoszcz	51,4	84	338	6
3. Poznań	60,4	140	590	7
4. Kalisz	20,1	45	190	8
5. Lodz (Łódź)	222,1	500	2 000	9
6. Radomsko	25,6	67	370	10
7. Radom	41,2	86	700	11
8. Lublin	15,7	32	135	12
9. Warsaw (Warszawa) — Siedlce	182,8	424	1 767	13, 16
10. Wloclawek - Ciechanów - Brodnica	12,7	29	126	5, 14, 15
11. Bialystok	23,9	36	100	17
12. Vilno (Wilno)	9,9	53	150	18
13. Nowogródek	2,2	3	10	19
14. Pińsk	4,5	7	20	20
15. Luck (Łuck)	3,1	10	42	21
16. Tarnopol	2,2	6	25	22
17. Stanislawów	11,8	25	97	23, 24
18. Lwów	37,4	65	270	25
19. Boryslaw	35,9	56	234	26
20. Przeworsk	5,5	10	42	27
21. Brzezówka	14,2	34	144	28
22. Cracov (Kraków) — Tarnów	55,1	343	880	29, 31
23. Porąbka — Rożnów	17,6	26	107	30, 32
24. Coal Fields	2 129,3	3 500	9 800	33

*) The figures in the Remarks column correspond to the numbering of the regions adopted for the publications of the Polish Power Committee (Bulletin of the Polish National Committee, volume III (1929) N. 50, page 76).



The crossing of the river Vistula (612 metres) by the high tension line (near Morsk, Pommerania).

publications of the Polish Power Committee, is represented in table X and in fig. 8.

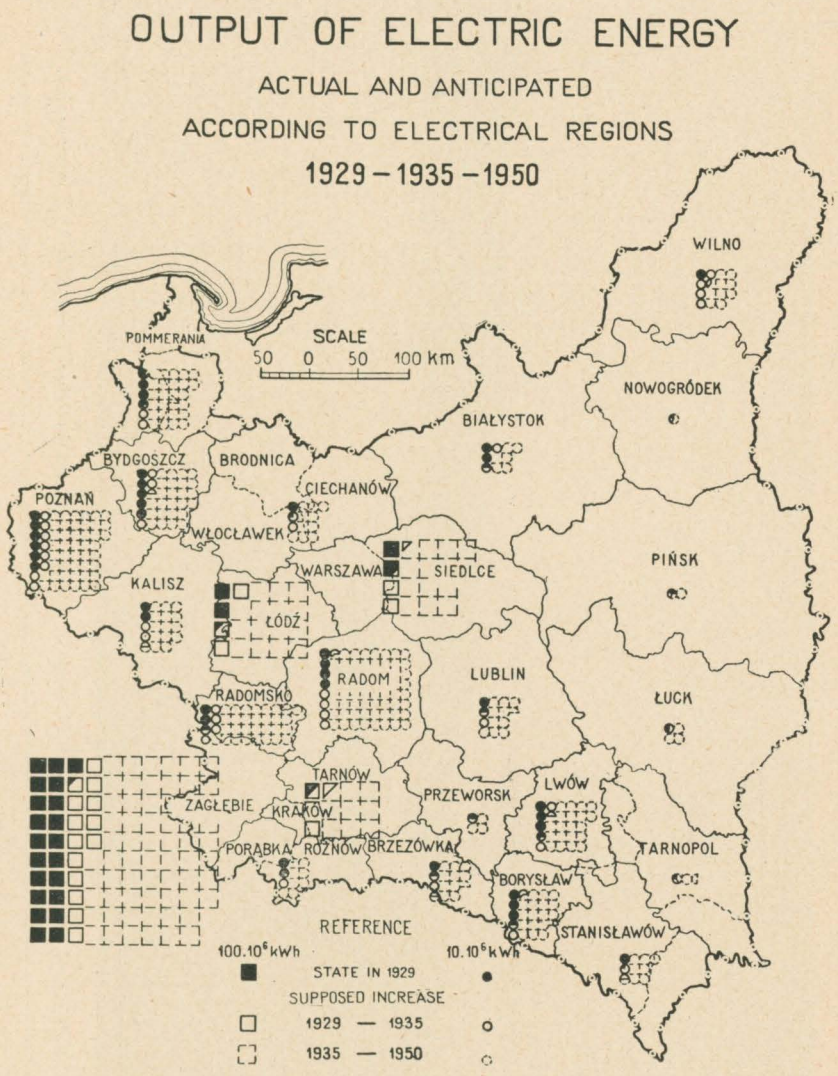
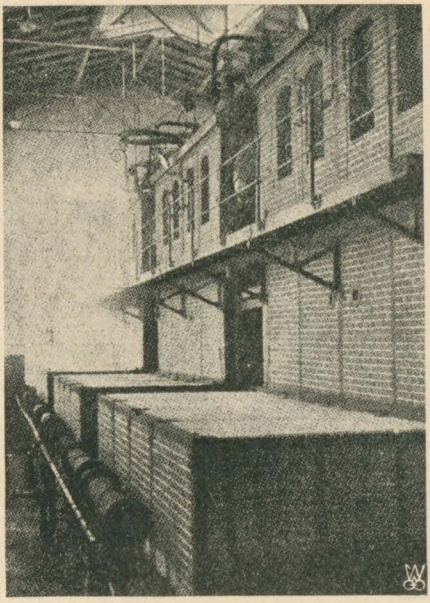


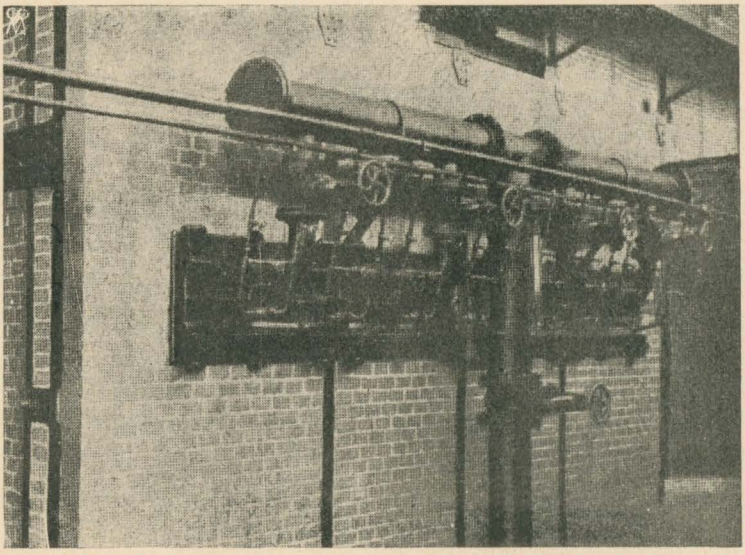
Fig. 8.

The computations in the latter table have been based on the figures of average rate of increase in output in the particular regions during recent years. For the first period of 6 years the

aggregate rate of increase amounted to 11,2%, the actual output of 3 milliard kWh in 1929 increasing to an anticipated figure of output of 5,65 milliard kWh in 1935. At the end of the second period of 15 years, i. e. in 1950, the output is expected to reach a figure of 18,46 milliard kWh, at an average rate of increase of 8,2%. It must be pointed out that the smaller rate of increase, as compared with the previous one, is explained by a corresponding increase in the rate of saturation, and by the fact that the anticipated increase in output in principle cor-



Boiler house of the electric plant „Premier" in the Polish Oil Basin. The boilers are fired with natural gas and oil.



Burners for firing the boilers of the above station with gas and oil.

responds to electrical characteristics of other countries of an economic structure similar to that of Poland and with analogous conditions in respect of electrical development.

The absence of an adequately developed industry for the manufacture of electrical equipment has a detrimental effect on the general progress of electrification.

The electro-technical industry before the war was practically non-existant in Poland. The coutry's requirements for the manufactures of this industry were met exclusively by imported foreign electro-technical goods. Since the war, the strife towards economic independence has created favourable conditions for the development of the home electrotechnical industry which, within barely 10 years of its existence, has made considerable progress. The number of intellectual employees and labourers employed in this industry in 1928 amounted to 12 400.

In all there were 84 larger or smaller industrial enterprises in Poland manufacturing electro-technical goods. They comprised the following: 14 factories for the manufacture of machinery and apparatus, 11 — for the manufacture of insulating materials, 9 for the manufacture of cables and wire, 4 — for electric bulbs, 4 — for accumulators, 4 — for telegraph, telephone and signalling apparatus, 12 — for voltaic cells, 10 — for lighting fittings and electrical advertisements, 2 — for electro-technical porcelain,

TABLE XI.

Development of the Polish electro-technical market (1925 — 1928).

Year	Home manufacture			Imports		Consumption of Poland		
	tons	value in millions zloties*)	% of the country's requirements	value in millions zloties	% of the country's requirements	value in millions zloties	%	rate of increase %
1925	4 777	31,0	31,3	67,9	68,7	98,9	100,0	—
1926	5 248	32,6	33,7	64,0	66,3	96,6	100,0	— 2,3
1927	8 152	53,6	35,2	98,6	64,8	152,2	100,0	57,5
1928	14 900	89,4	43,3	117,3	56,7	206,7	100,0	35,8

*) 1 £ = 43,4 zloties.

TABLE XII.

Turn-over of the electro-technical industry in Poland (1928).

Item	Description of goods	Home output		Imports	
		millions zloties	%	millions zloties	%
	Total	89,4	100,00	117,3	100,00
1	Cables, wires, copper for electro-technical purposes	25,0	27,97	18,8	16,03
2	Electrical machinery, motors, transformers . .	14,0	15,66	33,5	28,56
3	Telephone, telegraph and signalling apparatus . .	13,5	15,09	7,1	6,05
4	Incandescent lamps . . .	8,0	8,95	6,0	5,11
5	Wireless sets and equipment	5,5	6,15	10,7	9,12
6	Accumulators and galvanic elements	3,8	4,25	1,9	1,62
7	Installation material . .	3,6	4,03	5,0	4,26
8	Turbo-generators . . .	—	—	4,7	4,01
9	Electrical apparatus and equipment, electro-technical porcelain, insulating tubes, electro-technical goods for weak currents, electro-medical goods, arc lamps, electrical heating apparatus, electrodes, carbons, electrical fittings	16,0	17,90	29,6	25,24

3 — for electro-medical equipment, 8 — for wireless equipment and 3 — for installation material. The following are not being manufactured as yet: turbine units, large motors, large transformers and apparatus for higher tension.

The entire output of the electro-technical industry goes to meet requirements of the home market which it was able to satisfy only in 43,3% (1928), the balance of 56,7% of requirements having to be met by imported foreign goods.

The development of the Polish electro-technical market, of the home industry and of foreign imports is shown in the table XI.

During a period of 4 years (1925—1929) the capacity of the electro-technical market more than doubled, the home output simultaneously increasing 2,85 times, increasing its rate of participation in meeting the electro-technical demand in Poland from 31,3% to 43,3%. Imports during said period increased 1,73 times, though reducing its rate of participation from 68,7% to 56,7%, which corresponds to a reduction of 17,5%.

The turn-over figures in respect of electro-technical manufactures of home and foreign origin are given in table XII.

The present capacity of the Polish electro-technical market may be estimated at approx. 300 millions zloties per annum.

Due to the influence of the development in the home manufacture of electro-technical goods, the colonial nature of the Polish electro-technical market slowly but steadily disappears. It must, however, be stated that the absence of a properly organized and potential electro-technical industry which would be able to actively participate in the financing of Polish electric enterprises, places the development of electrification of Poland in a position considerably inferior to that of other countries.

The legal position in Poland in respect of electrification may be considered as fully regulated. Polish electric legislature is based on the Electricity Act of the 21st March, 1922.

In the interests of rational electrification policy, the provisions of the said Act make the founding of electric public utility enterprises conditional upon a Government concession which is being granted by the Minister of Public Works. The term of „public utility", as construed in the Act, comprises enterprises selling electric energy on a professional basis, or intended to serve public traction.

The Electricity Act endows enterprises, operating by virtue of a Government concession, with certain privileges of cardinal importance, at the same time encumbering them with certain responsibilities.

The more important privileges conferred upon the concessionnaire are: the right of exclusiveness (monopoly) in respect of distribution of energy throughout an area definitely fixed in the concession deed, the right of carrying lines through private territory against compensation, and the right of gratuitous use for such purpose of public highways, provision being also made for permanent or temporary expropriation, in favour of such en-

terprises, of sites required for the erection or maintenance of electric plants.

The obligations of the concessionnaire include the supply of energy to the concession area on the terms provided in the concession, as well as the submitting to Government control in respect of commitments assumed by the concessionaire.

The Ministry of Public Works has published a standard electrical concession form, on the basis of which concessions for electric enterprises are being granted.

RÉSUMÉ

La publication présente est l'édition nouvelle et augmentée d'une brochure publiée (en langue française) en 1925 sous le même titre. Elle renferme donc non seulement les données statistiques des années 1925 — 1929, mais aussi beaucoup de détails nouveaux sur l'exploitation des sources d'énergie en Pologne.

La houille.

Le bassin houiller polonais peut être partagé en quatre parties: La Haute Silésie avec une superficie de 2180 km^2, le bassin de Teschen avec 200 km^2, le bassin de Cracovie avec 1300 km^2, et celui de Dombrowa avec 200 km^2, la superfice totale étant donc de 3880 km^2. La limite d'ouest du bassin correspond à la frontière de l'État, celle du sud est marquée par les chaînes des Carpathes; un déplacement de la limite d'exploitation actuelle serait donc possible seulement vers l'est.

L'épaisseur des gisements de carbone utile diminue de 4500 m à la limite d'ouest, jusqu'à 2700 m à l'est. On distingue ordinairement les couches de houille du „Reden" et celles qui se trouvent au dessus et au dessous du „Reden". Dans la partie orientale du bassin, le „Reden" est représenté par une couche unique de l'épaisseur de 12 à 18 m. Du reste l'épaisseur des couches utiles excède ordinairement 2 m. Le rapport entre l'épaisseur des couches de carbone utile et l'épaisseur totale de la formation houillère est le meilleur à l'ouest, où il atteint 7,3%.

La plupart des sortes du charbon polonais appartiennent à celles du gaz et du charbon flamboyant, 6—7% de la production totale possédant les qualités nécessaires à la fabrication du coke. On ne trouve pas en Pologne de charbon de sorte maigre, comme p. ex. l'anthracite. Les valeurs calorifiques des charbons polonais sont très différentes; on trouve les chiffres plus bas dans le bassin de Cracovie (jusqu'à 5000 cal.), les chiffres plus hauts — dans la Haute Silésie (jusqu'à 7700 cal.).

Les produits secondaires, qu'on reçoit dans les cokeries en dehors du coke et du gaz, trouvent application dans la fabrication de divers produits chimiques. Le charbon polonais possède les qualités supérieures nécessaires aux combustibles, employés soit dans les usines, soit pour le chauffage domestique. Il possède très peu de cendres et de soufre; les cendres contiennent

un nombre très petit de silicates, pouvant fermer les interstices du gril. De plus il n'est pas susceptible aux influences atmosphériques. Grâce à sa dureté, il se laisse facilement partager en diverses sortes.

Ces qualités permettent une exploitation plus favorable que dans le reste de l'Europe. La quantité de charbon exploitée par ouvrier et par jour s'élevait en 1928 à 1267 kg, tandis que le chiffre plus haut pour les autres mines de l'Europe n'était que de 1191 kg.

En Pologne il y a 103 mines de houille, appartenant à 92 entreprises. La production annuelle des différentes entreprises varie beaucoup: elle équivaut à 2 000 000 de tonnes en Haute Silésie et à 1 000 000 de tonnes dans les autres bassins. Le capital investi dans les mines polonaises est évalué à 667 000 000 zlotys. La production de charbon en Pologne représente le 7% de la production européenne et le 3,26% de la production mondiale. Dans cette production la participation de la Haute Silésie est de 74,5%, celle du bassin de Dombrowa de 19,4% et celle du bassin de Cracovie de 6,1%. A partir de 1925, la production s'élevait chaque année de 12,8%, le 65% étant consommé dans le pays et le 35% éxporté à l'étranger. La consommation nationale donc n'excède pas 0,9 t par habitant et an (en 1924 seulement 0,59 t). Les consommateurs principaux sont: l'industrie avec 53,2%, l'emploi domestique avec 23,6% et les chemins de fer avec 18,6%. La plus grande partie de l'exportation est dirigée vers les États du nord, où le charbon polonais représente le 30% de la consommation totale. Au nombre des autres consommateurs principaux se trouvent l'Autriche, la Tchécoslovaquie et l'Hongrie.

Grâce aux perfectionnements modernes de la technique, les frais d'exploitation du charbon ont pu être réduits considérablement, néanmoins l'industrie houillère utilise à peine le 70% de sa capacité de production.

L'extraction du charbon est totalement mécanisée. Les couches de grande épaisseur sont exploitées complètement et les vides rembloyés avec du sable. Le transport est effectué à l'aide de couloirs oscillants, de funiculaires et de locomotives à moteur électrique ou à combustion interne. L'infiltration d'eau est, le plus souvant, de 5—10 m^3 par minute. L'eau est extraite ordinairement au moyen de pompes électriques.

L'industrie des produits dérivés du charbon possède 5 briquetteries, 9 cokeries, 3 distilleries de poix et fabriques de benzol et un nombre de fabriques chimiques spéciales, consommant les demi-produits de la distillation.

Les données statistiques des ressources de houille en Pologne, de leur production, consommation, exportation et de l'industrie du charbon sont renfermées dans les tables I — XIII.

Le lignite.

Les couches de lignite en Pologne appartiennent à la formation mésosoïque et néosoïque. Les premières se trouvent dans la région de Zawiercie et dans le talus nord-est des montagnes de la „Sainte Croix" (Góry Świętokrzyskie). Leur valeur calorifique est évaluée à 5400 — 6900 calories.

Les gisements de lignite néosoïque sont beaucoup plus riches. Ils s'étendent dans toute la voïvodie de Poznań, dans la plus grande partie de la voïvodie de Poméranie et dans les parties non encore exploitées des voï-

vodies de Lodz et de Varsovie. L'épaisseur de leurs couches atteint 3 m et la valeur calorifique 5000 cal.

A la même formation géologique appartiennent les îles de lignite dans la basse partie nord-est des Carpathes. L'épaisseur de ces gisements n'a qu'un mètre, et leur valeur calorifique est de 4 250 cal.

Une valeur calorifique encore plus faible, savoir 3000—4000 cal., présentent les couches de lignite de la Podolie (par ex. Żólkiew).

Les réserves de lignite sont évaluées seulement dans les voïvodies du nord-ouest de la Pologne. D'après les recherches des géologues allemands, on peut évaluer les réserves réelles du lignite à 29,7 millions de tonnes et les réserves probables à 1 milliard de tonnes.

Les conditions techniques de l'exploitation du lignite en Pologne sont en général difficiles.

Une des conséquences du manque de houille pendant la guerre et pendant les premières années après la guerre était l'accroissement de la production du lignite en Pologne. Aux derniers temps, l'exploitation a lieu seulement dans 3 mines dans la région de Zawiercie.

Les données statistiques de la production du lignite sont renfermées dans la table XIV.

Le pétrole.

On trouve le pétrole brut en Pologne dans la formation de Flysch des Carpathes. Les terrains pétroliers s'étendent de Limanowa à l'ouest, jusqu'à la frontière de la Roumanie à l'est. Les puits de pétrole à l'ouest sont situés dans la partie interne des Carpathes; leur profondeur surpasse rarement 1000 m, leur production moyenne n'est pas grande (environ 115 tonnes par an), mais elle est durable. Les puits à l'est se trouvent dans la partie bordière des Carpathes et possèdent une profondeur plus grande (en moyen 1400—1800 m), la production étant plus grande, mais moins durable (ca. 1200 tonnes par an).

Le bassin de Boryslaw, qui donne encore ca. 70% de la production totale, s'épuise peu à peu; on cherche donc de nouvelles couches de pétrole dans des terrains nouveaux et, entre autres, dans les avant-pays des Carpathes, où à Daszawa et à Kalusz on a découvert de grands gisements de gaz naturel.

Plus que la moitié des puits sont forés par la méthode Canadienne; jusqu'à 1923 cette méthode était dominante en Pologne; quelques puits sont forés par la méthode Pensylvanienne (à l'aide de la corde) et le reste par la méthode combinée Canadienne et Pensylvanienne, étant la plus pratique. On a essayé aussi quelques autres systèmes de forage, comme le systeme „Rotary", le systeme de l'ingénieur Wolski et autres.

La machine à vapeur, le moteur Diesel, le moteur a gaz et dernièrement l'électromoteur représentent la force motrice dans les mines de pétrole.

Le nombre des puits éruptifs est très petit en Pologne; on est forcé d'extraire le pétrole brut par les pompes ordinaires (1870 puits), tandis que pour les grandes profondeurs on use les pompes à pression (ca. 400 puits).

Comme la table à la page 50 nous montre, la production du pétrole brut baisse dans les dernières années spécialement dans les mines de Boryslaw,

mais elle monte dans le district de Jaslo (Galicie de l'ouest) et dans le district de Stanislawów (Galicie de l'est).

Le nombre des puits en forage, des puits productifs, etc est représenté par la table à la page 51.

Le nombre des puits qui sont déjà forés dans les nouveaux terrains monte à 20.

En moyenne on fore par an environ 100 000 mètres, quoique le nombre des puits en forage s'amoindrit, grâce à un éminent progrès dans la rapidité des forages.

Les raffineries de pétrole, occupant 4500 ouvriers, montent actuellement au nombre de 29. La performation du pétrole brut et les quantités des produits du pétrole sont représentées par la table à la page 52. Cette table nous montre l'augmentation de la fabrication de l'essence, correspondant à la consommation croissante de ce produit.

La consommation des produits pétroliers en Pologne et leur exportation sont représentées par les tables à la page 53.

L'exportation représente le 35% de la production totale.

Le gaz fossile.

L'industrie du pétrole est strictement rattachée en Pologne à l'industrie du gaz fossile. Celui-ci précède normalement l'apparition du naphte, indiquant généralement le voisinage de gisements pétrolifères. Dans certaines localités il apparaît cependant aussi d'une façon indépendante, comme par ex. dans les régions de Daszawa, Kalusz et Krosno.

La production totale de gaz était en 1929 de 375 millions de m^3, dont plus du 50% provenait du bassin de Boryslaw (503 m^3/min par rapport aux 979 m^3/min de production totale). Les puits les plus abondants se trouvent dans les environs de Stryj et de Daszawa où pendant les 10 dernières années ont été percés 8 puits d'une profondeur d'à peu près 700 m, donnant ensemble 225 m^3/min de gaz. Les autres mines dans la région de Drohobycz, comme Schodnica, Rypne, Wańkowa donnent ensemble 28 m^3/min, le nombre de puits étant de 542.

A l'ouest le bassin de Krosno-Jaslo comprend 19 puits, donnant 127 $m/^3$min. La production d'un seul puit d'une profondeur de 1200 m atteint les 25 $m/^3$min et même plus.

A l'est les mines les plus productives se trouvent dans les environs de Nadwórna, Bitków et Pasieczna. Le 4 puits à Bitków donnent 96 m^3/min (en 1924 ca 200 m^3/min). Un seul puit à Pasieczna a donné après l'éruption en 1927 ca 200 m^3/min.

La valeur calorifique moyenne du gaz fossile est d'environ 9000 cal.

Les conduits de gaz les plus longs sont ceux de Daszawa — Lwów (ca 90 km), de Krosno—Jaslo (ca 66 km) et du bassin de Drohobycz (ca 90 km).

Le gaz est employé pour le chauffage et pour l'éclairage; au lieu d'exploitation on l'emploit aussi pour la production de gazoline.

Le nombre de fabriques, transformant le gaz en gazoline liquide, s'élève à 21, dont 15 sont situées dans la région de Boryslaw.

La production totale de gazoline en Pologne s'élevait en 1929 à 35 000 tonnes.

Les données statistiques de la production du gaz fossile sont contenues dans la table à la page 55.

La tourbe.

La superficie probable des tourbières en Pologne est de 3 000 000 ha et constitue plus que 8% de la surface totale du pays. Le contingent des tourbières dans les différentes voïvodies varie de 5% à 38% (Polésie).

De la superficie totale des tourbières, 5% seulement appartient à la tourbe de sphaignes qui se trouve dans les voïvodies du nord, du nord-est et dans les montagnes du sud.

Les plus grandes tourbières (de 10 à 1000 km^2 de surface), en nombre de 70, comprennent une superficie de 1 200 000 ha. Les tourbières de grandeur moyenne (de 2 à 10 km^2 de surface) s'étendent sur une superficie totale de 1 000 000 ha. Le reste appartient aux petites tourbières, répandues dans tout le pays.

L'épaisseur de la couche de tourbe est relativement faible, l'épaisseur moyenne pouvant être fixée à 2—2,5 m environ; dans des cas peu nombreux seulement elle atteint 15 m.

Les réserves de tourbe en Pologne sont évaluées à 45 milliards de m^3, pouvant donner à peu près 6 milliards de m^3 de tourbe de chauffage.

La valeur calorifique des tourbes polonaises varie de 3 250 à 3 900 cal. La quantité moyenne des cendres dans les tourbes polonaises peut être évaluée à 10—15%. L'analyse chimique de la tourbe dans les voïvodies de l'est indique une petite quantité de CaO (0,57—2,3%) et une quantité plus considérable de N (3—4%).

L'exploitation de la tourbe a lieu en plusieurs endroits, mais presque uniquement pour des usages domestiques et beaucoup plus rarement pour le chauffage des fabriques et pour les usines électriques.

Le bois.

La superficie totale des forêts atteint actuellement environ 9 000 000 ha, ce qui constitue le 23% de la superficie totale du pays et 0,3 ha par habitant. Il y a en Pologne 17 régions avec de grandes forêts d'une superficie de plusières dizaines de milliers de ha. La forêt la plus grande est celle de „Bialowieża", d'une superficie de 142 926 ha.

Parmi les forêts de pin, représentant le 75% de la superficie totale des forêts de la Pologne, la plus grande partie est constituée par le sapin (60%); parmi celles de bois feuillu (25%) — par le hètre (10%).

L'accroissement annuel des bois en Pologne peut être évalué à 2,85 m^3/ha dans les forêts de l'État, et à 1,82 m^3/ha dans les forêts de propriété privée, ce qui fait à peu près 20 millions de m^3 par an.

L'exportation s'élevait en 1927 à 10,6 millions de m^3, dont le 60% était exporté à l'état brut.

Le 48% de la production normale est constitué par le bois de chauffage; si nous ajoutons encore 1,4 millions m^3 de siure, il en résulte que la production totale de cette source d'énergie est de 6,6 millions de tonnes par an, ce qui correspond à 3 millions de tonnes de houille.

Il y a en Pologne 1687 scieries, 3 fabriques de cellulose, 26 fabriques de pâte de bois, 10 fabriques d'allumettes, 117 menuiseries et 24 parqueteries.

La superficie pourcentuelle des forêts dans les différentes voïvodies est donnée par la table à la page 72.

Les forces hydrauliques.

Le recensement des forces hydrauliques de la Pologne n'est pas encore achevé. Néanmoins l'appréciation approximative des ressources de l'énergie hydraulique du pays peut être effectuée en se servant des résultats des études opérées avant la guerre par les institutions hydrographiques de l'Autriche et de l'Allemagne, ainsi qu'ultérieurement par la Bureau Hydrographique Central de Pologne.

On notera notamment que la concentration la plus importante de la houille blanche se trouve dans les bassins de la zone carpathienne, particulièrement dans ceux des affluents méridionaux de la Vistule, du Dniestr et du Prut. Une certaine valeur pour l'exploitation de la force motrice présentent également les cours d'eau du plateau lacustre de la Poméranie et ceux du bassin de la Wilja (affluent du Niemen).

Le reste du territoire du pays, tout particulièrement la région des grandes plaines, ne possède qu'une quantité minime d'énergie hydraulique.

La puissance totale des forces hydrauliques du pays, correspondant au débit annuel moyen, s'élève à 3,7 millions CV (ce qui fait environ 10 CV par 1 km^2, ou 13 CV par habitant), la production annuelle respective est de 16,2 milliards kWh.

Au point de vue de leur valeur comme forces hydrauliques, les cours d'eau de la Pologne peuvent être divisés en quatre catégories, dont ce n'est que la première qui présente une valeur économique plus considérable.

Dans cette catégorie on classera les 46 cours d'eau, dont les ressources d'énergie égalent au moins 200 CV par km et dont la pente dépasse le 0,5‰. Ces cours d'eau présentent une puissance de 1,32 millions CV (correspondant au débit moyen); leur énergie hydraulique peut être évaluée à 5,76 milliards kWh à l'état naturel et à 6,6 milliards kWh, si leur débit était regularisé à l'aide de réservoirs.

La part de l'énergie hydraulique dans l'ensemble des sources d'énergie du pays peut être évaluée à 12%.

Vu la grande variabilité des débits des cours d'eau carpathiens, ce ne furent que les cours d'eau, dont les conditions locales favorisent la construction de réservoirs-accumulateurs, qui ont été envisagés comme utilisables, les usines respectives s'adaptant facilement à la production de l'énergie en quantité suffisante pour couvrir les pics de la charge.

Ce fut dans les régions du nord et du nord-ouest de la Pologne, abondantes en lacs, où les cours d'eau accusent un régime favorable, que les ressources d'énergie hydraulique étaient devenues l'objet d'une exploitation réelle.

En effet les plus grandes usines hydroélectriques en Pologne sont celles de Gródek et de Żur, récemment construites en Poméranie sur la Czarna Woda, affluent de la Vistule. Leur puissance disponible est d'environ 18 000 CV, leur production moyenne de 26 millions kWh.

En outre, il y a en construction 8 usines, représentant en total une puissance de 24 600 CV ét une production moyenne annuelle de 66,2 millions kWh. La plus grande en est l'usine de Porąbka, avec un grand barrage sur la Sola, l'affluent carpathien de la Vistule. Sa production moyenne annuelle s'élève à 27,3 millions kWh.

On notera aussi environ 9 000 usines hydrauliques secondaires — pour la plupart des moulins — dont la puissance totale ne dépasse pas 100 000 CV. Parmi celles-ci il n'y a que 47 installations, dont la puissance dépasse 100 CV (leur puissance totale s'élévant à 12 000 CV et la production annuelle à environ 44 millions kWh).

Pour la statistique des forces hydrauliques brutes, des usines existantes, de celles en construction et de celles projétées on pourra consulter les tables I — III.

L'énergie des vents.

Les vents les plus forts sont recontrés en Pologne les plus souvant dans la Poméranie près des côtes de la mer et le long des grandes vallées. Dans les voïvodies du nord-est et du sud, la statistique metéorologique indique un grand nombre de jours tout à fait calmes ou avec des vents faibles. La figure jointe montre les courbes, représentant la quantité pourcentuelle des jours avec les vents utilisables, savoir des vents d'une vitesse de 3,5 à 15 m/sec.

Le nombre des moulins à vent est le plus grand dans les voïvodies de Lodz, Poznań et Varsovie. La plus grande fréquence des vents utilisables a été constatée dans la Poméranie, la voïvodie de Tarnopol et la Volhynie.

Les données statistiques sont renfermées dans la table à la page 94.

Moyens de transport.

Les moyens de transport en Pologne représentent la succession de trois États d'une organisation économique différente. C'est pourquoi ils ne peuvent pas suffire aux besoins d'un organisme nouveau. La nécessité de la réparation des dommages causés par la guerre, n'a pas permis la construction de nouveaux moyens de transport, pour compléter les lignes existantes et avant tout les lignes des chemins de fer. Du reste, les autres moyens de transport sont en Pologne insignifiants. Les transports par chemin de fer représentaient en 1926 le 95,6% du trafic en général.

En 1929 les chemins de fer avaient transporté, sur un total de 17 257 km de lignes, 83 883 626 tonnes de marchandises et effectué un trafic correspondant à 22 992 606 636 tonnes-kilomètres.

D'après les statistiques du 1929 le trafic des sources d'énergie représente le 54,6% du trafic total et le 48,3% de la quantité totale des marchandises.

De la longueur totale des routes (240 000 km), les chaussées font seulement ca. 18%. Elles ne jouent aucun rôle dans le trafic des combustibles. L'accroissement de l'automobilisme a une grande importance seulement pour le transport des voyageurs. En 1929 — 56,9 millions de voyageurs ont été transportés par les autobus, ce qui fait 2 163,4 millions de voyageurs-km sur une étendue totale de 25 171 km. Les mêmes chiffres pour les chemins de fer sont en 1928 de 174,8 millions de voyageurs et de 7 076,6 millions de voyageurs-km.

Il y a en Pologne 1 515 km de voies d'eau navigables et 7 053 km de voies d'eau flottables. On transporta en 1926 — 1,08 millions de tonnes en vaisseau, faisant 152 millions de tonnes-km, et 0,96 millions de tonnes par flottage, faisant 139,7 millions de tonnes-km.

Un trafic supérieur à 100 000 tonnes a lieu dans les ports de Dantzig, Varsovie, Cracovie et Poznań.

Le tonnage des vaisseaux est de ca. 116 275 tonnes et la puissance des remorqueurs de ca. 15 609 CV.

Le trafic des ports de mer: Dantzig et Gdynia était en 1929 de 11,4 millions de tonnes (Dantzig 75%, Gdynia 25%). La participation des combustibles dans ce trafic peut être évaluée à 76%.

Pour le transport des sources d'énergie, ou de l'énergie même, sont destinés encore en Pologne: 311 km de conduits pour le pétrole brut, avec un trafic de 527 000 tonnes en 1926, 270 km de conduits pour le gaz fossil, avec un trafic de 139 millions m^3 et 900 km de lignes électriques à haute tension.

État actuel et développement de l'industrie du gaz.

Il y actuellement en Pologne 122 usines à gaz, fournissant le gaz à 130 localités.

8 localités profitent du gaz naturel directement. La répartition des usines à gaz n'est pas régulière, on peut cependant noter que leur nombre augmente décidément en s'avançant vers l'ouest.

En 1928 la production de gaz s'élevait à 180 millions m^3; la consommation de charbon était de 550 000 tonnes, la production de coke de 320 000 tonnes. Il y a en Pologne 4 fabriques chimiques complètement arrangées, transformant la poix qui est de reste.

La consommation de gaz dans les différentes localités varie de 25 à 110 m^3 par habitant, son prix oscillant entre 0,22 et 0,70 zlotys par m^3.

Le réseau des tubes à gaz a une longueur totale de 2670 km, le nombre de lanternes sur les rues dépasse le chiffre de 40 000.

Après la guerre une usine à gaz et deux cokeries ont été construites.

Le projet de construire des conduits de gaz interurbains se base sur l'idée d'utiliser une partie (environ 60 000 m^3) du gaz des cokeries de la Silésie du nord, dont la production totale est de 270 000 m^3. Ce projet se propose de couvrir par son réseau, outre la Silésie, aussi le bassin de Dombrowa et la Galicie occidentale jusqu'à Cracovie.

État actuel de la production et de la distribution de l'énergie électrique en Pologne.

A la fin du 1929 il y avait en Pologne 864 usines électriques produisant 3023 millions kWh et ayant une puissance installée de 1 273 525 kW (savoir par habitant 99,4 kWh et 41,9 W, resp. 7 783 kWh/km^2 et 3,27 kW/km^2). En dehors de ce nombre il y avait 818 usines électriques privées d'une puissance inférieure à 100 kW.

Le nombre d'usines électriques d'utilité publique s'élevait à 585, dont la production était de 1785 millions de kWh et la puissance de 0,71 millions de kW (58,7 kWh et 23,5 W par habitant). Dès 1925 la production s'est élevée de 67,9%, tandis que la puissance de 54,5%. La part des grandes usines électriques (d'une puissance supérieure à 5 000 kW, dont le nombre s'élève à 65) à la production totale devient chaque année plus grande et représentait à la fin de 1929 le 75,4%. En même temps s'élève aussi le pourcent des usines électriques d'utilité publique.

La quantité d'énergie produite augmente graduellement en s'avançant vers le sud-ouest. Ainsi dans les voïvodies orientales la consommation par habitant d'énergie est de 1,7—5 kWh par an, dans le voïvodies centrales à l'est de la Vistule de 5—40 kWh, tandis que dans les voïvodies de l'ouest elle atteint 40—150 kWh, dans la Silésie même 1385 kWh.

Le degré moyen d'utilisation des usines génératrices représente le 27% (2374 heures pendant l'année), la puissance moyenne étant de 1474 kW; en éliminant, cependant, les 65 grandes stations génératrices, ce chiffre se réduit à 404 kW seulement.

Dans les usines électriques d'une puissance supérieure à 1000 kW, cette dernière augmenta pendant les 5 dernières années du 27% et la production du 43%, le temps d'exploitation atteignant 2451 heures.

Parmi les usines de cette catégorie, 28 usines régionales possédaient une puissance de 314 720 kW et une production de 984,8 millions de kWh (le 32,6% de la production totale). Environ 300 km du réseau avaient une tension de 60 kV et 600 km une tension de 30—40 kV.

L'augmentation de la participation des usines génératrices régionales était du 19,3% pour la puissance et du 24% pour la production. 359 villes (56,8% du nombre total), ayant une population de 6 500 000 habitants, et 351 communes rurales (du nombre total de 12 578) utilisaient l'énergie électrique. Le réseau des tramways était de 239,5 km dans 11 villes.

La tension et la fréquence sont standardisées. Le nombre d'usines génératrices à courant continu est assez considérable, leur puissance cependant représente le 8% seulement.

La source principale de l'énergie est la vapeur (95% de la puissance); les moteurs à combustion interne produisent environ 3,7%, tandis que les usines hydro-électriques — environ 1,3% seulement. Le 87% de la production est dû aux turbines à vapeur (362 turbines d'une puissance de 1 000 000 kW).

Les chaudières travaillent en général sous une pression de 12—15 kg/cm^2 (atteignant quelquefois 30 km/cm^2), et avec une température de 250°—350° C; (dans des cas exceptionnaux seulement la température arrive à 400°).

La consommation moyenne de combustibles est de 1,3 kg/kWh, oscillant entre 0,9 et 3,5 kg.

Actuellement on est en train de coordonner le travail des grandes usines électriques situées dans le bassin houiller dans le but d'arriver à l'électrification générale du bassin. Les usines génératrices en question représentent le 58,5% de la puissance et le 70,4% de la production totale du pays.

La demande d'énergie électrique en Pologne pourrait être évaluée à environ 8,5 milliards de kWh et la puissance à 3 millions de kW. Par conséquent on peut dire que le 35% à peine de la demande est, à l'heure actuelle, couvert par l'énergie électrique. Ce chiffre n'a presque pas été sujet à des changements pendant les 5 dernières années, ce qui prouve que le progrès dans l'électrification marche à peine au même pas avec l'augmentation de la demande d'énergie. Ainsi l'augmentation probable de la production est de 5,65 milliards kWh pour 1935 et de 18,5 milliards kWh pour 1950.

Dans l'industrie électrotechnique travaillent à présent 12 400 personnes dans 84 entreprises. La production de cette industrie cependant peut correspondre au 43,3% à peine de la demande actuelle.

La capacité du marché polonais peut être évaluée à 300 millions de zlotys par an.

La base de la législation électrique polonaise est constituée par la loi de 1922 sur l'énergie électrique, qui soumet la production, la transmission et la distribution de l'énergie à une concession conférée par le Ministre des Travaux Publiques.

Des données particularisées, concernant la production et la distribution de l'énergie électrique, sont renfermées dans les tables et dans les cartes qui se trouvent dans le texte.

ZUSAMMENFASSUNG

Das vorliegende Werk ist eine neue umgearbeitete und erweiterte Auflage einer im Jahre 1925 unter dem Titel „Les ressources d'énergie en Pologne" erschienenen Broschüre. Es umfasst, ausser den neueren statistischen Daten (das Jahr 1929 inbegriffen), umfangreiche Angaben über die Produktion und den Verbrauch der Energiequellen in Polen.

Steinkohle.

Das vorliegende Werk ist eine neue, umgearbeitete und erweiterte Auf- von denen 2380 km^2 in West-Polen, 1300 km^2 in Süd-Polen und 200 km^2 in Mittel-Polen gelegen sind. Die westliche Grenze des Kohlenbeckens fällt mit der Staatsgrenze zusammen, während sie im Süden von den Karpathen gebildet wird. Eine Verschiebung der heutigen Exploatationsgrenze scheint also nur gegen Osten möglich zu sein.

Die Mächtigkeit der nutzbaren Kohlenlagerstätten beträgt an der Westgrenze 4500 m, an der Ostgrenze 2700 m. Die Lagerstätten werden gewöhnlich in obere oder Muldenschichten, mittlere Sattel- oder Redenschichten, und in untere oder Randschichten geteilt. Im Osten bilden die Redenschichten ein einziges 12 bis 18 m dickes Kohlenlager. Ansonsten beträgt die Mächtigkeit der einzelnen Kohlenschichten gewöhnlich über 2 m. Das Verhältnis der Kohlenlager zur Mächtigkeit der ganzen Kohlenformation ist im Westen am vorteilhaftesten und beträgt dort 7,3%. Die Mächtigkeit der hängenden Schichten ist am geringsten im Norden, wo sie höchstens 150 m beträgt, während sie im Süden mehrere hundert Meter erreicht.

Der Qualität nach unterscheiden wir in Polen vorwiegend Gas- und Flammkohlen. Nur 6 — 7% der ganzen Produktion eignen sich für Kokereien. Die mageren Kohlengattungen finden wir in den polnischen Gruben nicht.

Der Heizwert der polnischen Kohle schwankt zwischen 5000 WE im Krakauer Becken und einem Höchstwert von 7 700 WE im Schlesischen Becken.

Was die Verwendung der polnischen Kohle anbelangt, so wird dieselbe teilweise in den Kokereien zu Koks verarbeitet, wobei die erzeugten Nebenprodukte als Rohstoffe für chemische Fabriken dienen, vor allem wird sie jedoch als ein vorzügliches Brennmaterial sowohl für Industriezwecke, als auch für den Hausbedarf verwendet. Sie enthält sehr wenig Asche und Schwefel. Die Zusammensetzung der Asche weist nur kleine Mengen von Si-

likaten, welche die Verstopfung der Rostspalten veranlassen könnten, auf. Die polnische Kohle ist auch gegen atmosphärischen Einflüsse widerstandsfähig, und lässt sich wegen ihrer Härte leicht zu verschiedenen Sortimenten verarbeiten. Demzufolge ist die Menge der pro Arbeitsschichte geförderten Kohle in Polen viel grösser als in anderen Ländern Europas; so betrug sie im Jahre 1928 1267 kg, während die höchsten Zahlen in anderen europäischen Gruben nur 1016—1191 kg erreichten.

Es gibt in Polen 92 Kohlengrubenunternehmungen und 103 Gruben. Die Jahresproduktion der einzelnen Unternehmungen ist sehr verschieden und erreicht in Oberschlesien manchmal 2 000 000 t., in den anderen Becken 1 000 000 t; es gibt jedoch Unternehmungen, welche nur einige tausend Tonnen jährlich produzieren. Das in den polnischen Gruben angelegte Kapital beträgt 667 000 000 zł.

Die Kohlenproduktion in Polen beträgt 7% der europäischen und 3,26% der Weltproduktion. Der Anteil an der Gesamtproduktion ist für Schlesien — 74,5%, für das Dombrowa-Becken — 19,4%, für das Krakauer Becken — 6,1%. Der Kohlenverbrauch wuchs in den letzten 5 Jahren um 10,8% jährlich. Davon wurden 65% im Lande verbraucht und 35% exportiert. — Im Verhältnis zur Einwohnerzahl ist der Landesverbrauch sehr gering und beträgt pro Kopf und Jahr nur 0,9 t (im Jahre 1925 nur 0,59 t). Zu den Hauptabnehmern gehören: die Industrie mit 53,2%, der Hausbedarf mit 23,6% und die Eisenbahnen mit 18,6%. Der Kohlenexport richtet sich vor allem nach den baltischen Staaten, von deren Bedarf 30% durch die polnische Kohle gedeckt wird. Zu den Hauptabnehmern gehören ausserdem: Oesterreich, Tschechoslovakei und Ungarn.

Der hohe Stand der technischen Einrichtungen in den polnischen Gruben ermöglicht das Herabsetzen der Exploatationskosten, obwohl nur etwa 70% der Produktionsfähigkeit dieser Einrichtungen ausgenützt werden.

Der Abbau der Kohle ist gänzlich mechanisiert. Sogar die dicken Flözen werden vollständig exploatiert und die leeren Räume mit Sand gefüllt. Der Kohlentransport in den Gruben wird mit Hilfe von Schüttelrinnen, Seilbahnen oder Lokomotiven mit elektrischen oder Verbrennungsmotoren bewerkstelligt. Die Aufzüge sind grösstenteils elektrifiziert.

Der Wasseranprall in den einzelnen Gruben beträgt gewöhnlich 5 — 10 m^3/min und wird mittels Elektropumpen bekämpft.

Die Kohlenindustrie umfasst 5 Brikettenfabriken, 9 Kokereien, 3 Pech- und Benzolfabriken, sowie mehrere chemische Fabriken, die diese Halbprodukte weiter verarbeiten.

Die statistischen Angaben über die Kohlenvorräte in Polen, deren Produktion, Verbrauch, Export und Verarbeitung sind in den Tafeln I bis XIII enthalten.

Braunkohle.

Die mesozoischen Braunkohlenfelder befinden sich in der Gegend von Zawiercie und an den nord-östlichen Abhängen der sogenannten Gebirgskette des Hl. Kreuzes (Góry Świętokrzyskie). Diese Kohlenschichten zeichnen sich durch ihren sehr hohen, zeitweise 6900 WE erreichenden Heizwert aus.

Viel geräumiger sind die Braunkohlenlager, welche der tertiären Formation und zwar dem Miocän angehören. Sie überlagern fast die ganze Wojewodschaft Posen, den überwiegenden Teil von Pommern, und die näher noch nicht erforschten Gebiete der Wojewodschaften Lodz und Warschau. Der Heizwert der tertiären Kohlenschichten übersteigt nicht 5000 WE, die Mächtigkeit der einzelnen Schichten erreicht 3 m.

Zu derselben geologischen Formation gehören auch die inselartigen Kohlenfelder in den Vorgebirgen der Ostkarpathen, deren Schichten 1 m Dicke nicht übersteigen, und einen mittleren Heizwert von nur 4250 WE aufweisen, wie auch die Braunkohle von Podolien, deren Heizwert bis auf 4000 WE (in Żólkiew sogar bis auf 3100 WE) herabfällt.

Die nachgewiesenen Kohlenvorräte in den nord-westlichen Wojewodschaften belaufen sich nach deutschen Quellen auf 29,7 Millionen Tonnen. Die wahrscheinlichen Vorräte werden auf etwa 1 Milliarde Tonnen geschätzt. Diese Zahl bezieht sich jedoch auf ein etwas umfangreicheres Terrain. Die Vorräte der anderen Kohlenfelder sind nicht bekannt.

Die Kohlenkrise während der Kriegszeit und den ersten Nachkriegsjahren hatte eine vorübergehende Entwickelung der Braunkohlengruben in Polen zur Folge. Jetzt begrenzt sich die Kohlenförderung zu einem einzigen Revier (3 Gruben) in der Gegend von Zawiercie.

Die Exploatation der Braunkohle in Polen muss in technischer Hinsicht als schwierig bezeichnet werden.

Die statistischen Angaben über die Braunkohlengewinnung in Polen sind in der Tabelle Nr. XIV enthalten.

Rohöl.

Das Rohöl findet man in Polen in der Flysch-Formation der Karpathen. Die Rohölterrains erstrecken sich von Limanowa im Westen bis zur rumänischen Grenze im Osten.

Die Gruben im Westen sind im Inneren der Karpathen gelegen, die Tiefe der Bohrungen übertrifft hier selten 1000 Meter; die Ergiebigkeit derselben ist nicht gross (durchschnittlich 115 Tonnen pro Jahr), aber dauerhaft; dagegen zeichnen sich die Schächte der meistens am Rande der Karpathen liegenden östlichen Gruben durch eine grössere, aber kürzer dauernde Produktion aus (ca 1200 Tonnen pro Jahr); die Tiefe dieser Schächte beträgt 1400—1800 Meter.

Die allmähliche Erschöpfung des reichlichsten Beckens in Boryslaw, welches jetzt noch ca 70% des ganzen in Polen gewonnenen Rohöls liefert, hat die Rohölproduzenten veranlasst, Pionierschächte auf neuen Terrains auch im Vorgebirge der Karpathen zu bohren, wo in Daszawa, Kalusz und anderen Ortschaften ergiebige Gasquellen entdeckt wurden.

Mehr als die Hälfte der Schächte wird mit der Kanadischen Bohrmethode (Stangen-System) gebohrt, welche bis zum Jahre 1923 die einzige in Polen angewandte Methode war; eine kleine Anzahl von Schächten bohrt man mit

der Pensylwanischen Methode (Seil-System); als sehr praktisch hat sich in der letzten Zeit eine kombinierte Methode dieser beiden Systeme erwiesen; hie und da wendet man versuchsweise das „Rotary"-System, die Spühlbohrung des Dipl.-Ing. Wolski und andere Methoden an.

Als Treibmaschinen kommen in Betracht: Dampfmaschinen, Dieselmotore, Benzin- und Gasmotore; in der letzten Zeit führt man auch den elektrischen Betrieb ein.

Das Rohöl wird mit Pumpen und Presskolben geschöpft; die Zahl der eruptiven Schächte ist sehr gering. In Boryslaw werden hauptsächlich die Presskolben verwendet (ca 400 Schächte, davon 50 mit elektrischem Betrieb), in anderen Gegenden die Pumpen, welche teilweise auch elektrisch betrieben werden (300 von den 1870 gepumpten Schächten).

Wie aus der Tabelle auf Seite 50 ersichtlich ist, sinkt die Rohölproduktion in den letzten Jahren in den Boryslaw-Gruben; sie steigt dagegen in den Bergbezirken Jaslo (Westgalizien) und Stanislawów (Ostgalizien).

Die Anzahl der Schächte im Bohren, der produktiven Schächte usw. ist aus der Tabelle auf Seite 51 ersichtlich.

Die Anzahl der sogenannten Pionierschächte, welche in neuen Terrains angelegt sind, beläuft sich auf etwa 20.

Durchschnittlich bohrt man jährlich ca 100 000 m, obgleich sich die Anzahl der Schächte im Bohren vermindert hat, was einen grossen technischen Fortschritt in der Bohrgeschwindigkeit beweist.

Es gibt 29 Petroleum-Raffinerien welche ca 4500 Arbeiter beschäftigen. Die Rohölverarbeitung und die Mengen der erzeugten Produkte werden von der Tabelle auf Seite 52 dargestellt.

Wie aus dieser Tabelle ersichtlich ist, steigt die Erzeugung von Benzin, welche sich dem immer grösser werdenden Inlandsverbrauch anpasst.

Der Inlandsverbrauch der Naphtaprodukte und die Ausfuhr werden von den Tabellen auf Seite 53 und 54 veranschaulicht.

Die Ausfuhr beträgt jetzt ca 35% der ganzen Erzeugung.

Erdgas.

Das Vorkommen der Erdgase ist eng verbunden mit der Erdölproduktion, obwohl auch selbstständige Erdgasgruben (Daszawa, Kalusz, Krosno) zu verzeichnen sind. Ueber 50% und zwar 503 m^3/min, auf 979 m^3/min der ganzen Produktion, wird von den 411 Rohölschächten des Boryslaw Beckens geliefert. Die grösste und dauerhafteste Ergiebigkeit weisen die Gasschächte in Daszawa auf, wo im Laufe des letzten Jahrzehntes 8 Schächte in einer Tiefe von ca 700 m gebohrt worden sind, deren Ergiebigkeit 200 m^3/min erreicht. Die anderen Gruben im Bergbezirke von Drohobycz, wie Schodnica, Rypne, Wańkowa liefern aus 542 Schächten nur 28 m^3/min.

Im Westen liefert das Krosno-Jaslo Becken aus 19 Schächten 127 m^3/min. Die Produktion der einzelnen Schächte erreicht 25 m^3/min und mehr, ihre Tiefe 1200 m.

Im Südosten beläuft sich die Gasproduktion in der Gegend von Nadwórna (Bitków, Pasieczna) auf 96 m^3/min aus 4 Schächten. Im Jahre 1924 in Bitków

und im Jahre 1927 in Pasieczna lieferten einzelne Schächte nach dem Ausbruch bis 200 $m/^3min$. Mit Hinsicht auf den Mangel von Abnehmern für das Erdgas, musste die Produktion desselben künstlich gehemmt werden.

Der Heizwert der polnischen Erdgase erreicht 9000 WE, ihre chemische Zusammensetzung ist nicht identisch in den einzelnen Gruben.

Das Erdgas wird zu Heiz- und Beleuchtungszwecken verwendet. Interurbane Gasleitungen befinden sich im Jaslo-Krosno Becken (66 km), im Becken von Drohobycz (90 km), und zwischen Daszawa, Stryj und Lemberg (90 km).

In den letzten Jahren stieg die Verwendung des Erdgases zur Fabrikation der flüssigen Brennstoffe erheblich. Im Jahre 1929 wurden in 21 Gasolinfabriken 35 000 t Gasolin erzeugt. Zur seiner Erzeugung wird allgemein die Kohlenabsorptionsmethode benützt.

Die statistischen Angaben über die Gewinnung und den Verbrauch des Erdgases sind aus der Tabelle auf Seite 55 ersichtlich.

Torf.

Die Torfmoore in Polen umfassen eine Fläche von etwa 3 Millionen ha, d. i. über 8% der ganzen Landesfläche. Die Verteilung der Moore unter die einzelnen Wojewodschaften ist sehr verschieden, der Anteil der Torfmoore schwankt zwischen 5 und 38% (Polesie). Von der gesammten Fläche des Torfbodens wird nur etwa 5% zu den Hochmooren gezählt. Diese letzteren befinden sich in den nördlichen, nord-östlichen und südlichen Wojewodschaften.

Der Grösse nach zählt man 70 Moorgebiete von 10 bis 1000 km^2 Fläche, welche zusammen 1,2 Millionen ha umfassen, und eine grössere Anzahl von mittelgrossen Torfmooren (von 2 bis 10 km^2 Fläche) mit einer Gesamtfläche von 1 Million ha. Der Rest fällt den kleinen Moorflächen zu, welche sich fast überall in Polen befinden.

Die mittlere Mächtigkeit der erforschten Moorschichten beträgt etwa 2—2,5 m, die grösste etwa 15 m.

Die Torfvorräte werden auf etwa 45 Milliarden m^3 geschätzt, von denen etwa 6 Milliarden m^3 als Brennmaterial verwendet werden können. Der Heizwert der polnischen Torfe ist auf 3250 bis 3900 WE geschätzt worden. Der unverbrennbare Teil des Brennmaterials (die Asche) schwankt zwischen 10 und 15%. Die chemische Analise des Torfes in den östlichen und nördlichen Wojewodschaften weist einen kleinen Inhalt von CaO (0,57 bis 2,3%) und eine grosse Menge von Stickstoff (3 bis 4%) auf.

Der Abbau der Torfschichten zu Heizzwecken findet in vielen Gegenden Polens statt. Ausser zu Haushaltszwecken wird Torf hie und da auch als Brennmaterial für Ziegeleien, Zuckerfabriken, Brennereien und in einem einzigen Falle für ein Elektrizitätswerk verwendet.

Brennholz.

Die Waldungen umfassen in Polen 23% der ganzen Landesfläche, d. i. ungefähr 0,3 ha pro Einwohner. Man zählt in Polen 17 grössere Waldkomplexe, die sogenannten Waldwildnisse, von denen die grösste eine Fläche von

142 926 ha umfasst. In den Waldbeständen mit Nadelholz (75% der ganzen Waldfläche) ist die Tanne am stärksten vertreten (60%), in jenen mit Laubholz — die Buche (10%). Der normale jährliche Anwuchs beträgt in den staatlichen Waldungen 2,85 m^3 pro Jahr und ha, in den privaten — 1,82 m^3 pro Jahr und ha. Das gibt jährlich ca 20 Millionen m^3 Nutz- und Brennholz. Die Ausfuhr betrug im Jahre 1927 10,6 Millionen m^3 Holz, davon ca 60% Rundholz. Das Brennholz beträgt etwa 48% der normalen Produktion; hiezu kommen noch ca 1,4 Millionen m^3 Sägespäne. Zusammen gewinnt man jährlich 6,6 Millionen t von zu Brennzwerken geeigneter Holzmasse, was 3,0 Millionen t Steinkohle entspricht.

Die Holzindustrie in Polen umfasst: 1687 Sägewerke, 3 Cellulosefabriken, 26 Holzmühlen, 10 Streichholzfabriken, 117 Tischlereien, und 24 Parquettenfabriken.

Nähere Angaben über die Waldbestände in den einzelnen Wojewodschaften sind in der Tabelle auf Seite 72 enthalten.

Wasserkräfte.

Die Bearbeitung des Wasserkraftkatasters in Polen ist noch nicht beendet worden. Trotzdem ist es möglich auf Grund der bisherigen Erhebungen, welche vor dem Kriege durch die Fachanstalten Oesterreichs und Deutschlands auf einigen Flussgebieten vorgenommen wurden und gegenwärtig vom polnischen Hydrographischen Zentralbüro systematisch durchgeführt werden, ein angenähertes Bild der Wasserkraftvorräte Polens zusammenzustellen.

Die reichlichsten Vorräte der Wasserkräfte sind natürlich in den Gebirgsgegenden Südpolens, und zwar an den südlichen Zuflüssen der Weichsel und des Dniesters, sowie im Prutgebiete zu suchen.

Vorteilhaft können auch die Wasserkräfte in Pommern und im Gebiete des Wilja-Flusses ausgebaut werden. Das grösste Gebiet Polens jedoch, und zwar die sogenannten Grossen Niederungen, müssen als wasserkraftarm bezeichnet werden.

Die Rohwasserkräfte Polens werden auf 3,7 Millionen PS bei Mittelwasser geschätzt. Dies entspricht 10 PS pro 1 km^2, oder 0,13 PS pro Einwohner. Das Arbeitsvermögen der fliessenden Gewässer wird auf 16,2 Milliarden kWh jährlich geschätzt.

Die Flüsse Polens können je nach der Ausbauwürdigkeit in 4 Kategorien eingeteilt werden, von denen jedoch nur die erste eine grössere Bedeutung zu Energiezwecken haben kann. Zu dieser gehören 46 Flüsse, welche eine kilometrische Kraftleistung von wenigstens 200 PS und ein Gefälle von mindestens 0,5‰ aufweisen. Die Leistung dieser ausbauwürdigen Wasserkräfte wird auf 1,32 Millionen PS bei Mittelwasser, und das Arbeitsvermögen auf 5,76 Milliarden kWh ohne Speicheranlagen, und auf 6,6 Milliarden kWh mit Speicheranlagen geschätzt.

Der Anteil der Wasserkräfte an den Vorräten verschiedener Energiequellen wird auf 12% geschätzt.

Die sehr veränderliche Wasserführung der karpathischen Gebirgsflüsse hat zur Folge, dass vor allem die Wasserkraftanstalten mit Speicheranlagen, welche als Spitzenkraftwerke arbeiten können, als ausbauwürdig erachtet wer-

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den dürfen. Zu diesen können die Werke hinzugefügt werden, welche zwar nicht unmittelbar an Speicheranlagen gebunden sind, jedoch die unterhalb der Talsperren ausgeglichenen Abflüsse benützen.

Die grosse Anzahl von Seen, welche als natürliche Speicher wirken, sowie der vorteilhafte Wasserhaushalt der Flüsse in den nördlichen und nord-östlichen Gebieten Polens (welche Gebiete ausserdem weit von anderen Energiequellen gelegen sind), hatten zur Folge, dass die dortigen Wasserkräfte nicht nur als ausbauwürdig anerkannt, sondern auch wirklich ausgebaut werden. Zwei grosse Wasserkraftwerke mit Speicheranlagen, welche am Schwarzwasserflusse in Pommern und zwar in Gródek und Żur erbaut worden sind, gehören zu den grössten in der letzten Zeit entstandenen Wasserkraftanlagen Polens. Ihre Ausbauleistung erreicht 18 000 PS und ihr Arbeitsvermögen 26 Millionen kWh jährlich.

In Bau befinden sich 8 grössere Kraftwerke mit zusammen 24 000 PS Ausbauleistung, und 66,2 Millionen kWh Arbeitsvermögen. Zu den grössten gehört die Anstalt mit Speicheranlage am Sola-Flusse in Porąbka (27,3 Millionen kWh).

Die Projekte der Wasserkraftanlagen umfassen fast alle ausbauwürdigen Kraftwerke, wo der Verbrauch der erzeugten Energie gesichert ist.

Ausserdem besitzt Polen eine sehr grosse Anzahl von kleinen Wasserkraftanlagen, vorwiegend Mühlen, deren Leistung 100 000 PS nicht viel übersteigt. Unter diesen weisen nur 47 Anstalten eine Leistung von je 100 PS auf (zusammen 12 000 PS mit einer Jahresproduktion von 44 Millionen kWh).

Die statistischen Angaben über die Rohwasserkräfte, sowie über die bestehenden, sich im Bau befindlichen und projektierten Wasserkraftanlagen sind aus den Tabellen I — III ersichtlich.

Windenergie.

Die stärkeren Winde werden in Polen am öftesten in Pommern in der Nähe der Meeresküste, und im Zuge der grossen Urtäler verzeichnet. In den nord-östlichen und südlichen Wojewodschaften notiert die meteorologische Statistik eine beziehungsweise grosse Anzahl von Tagen mit Windstille, oder mit einer nur sehr schwachen Luftbewegung. In beigefügter Landkarte sind die Kurven der gleichen prozentuellen Anzahl von Tagen mit nützlichen Winden dargestellt, d. i. mit den Winden, deren Geschwindigkeit sich in den Grenzen von 3,5 bis 15,0 m/sek bewegt.

Die grösste Anzahl von Windmühlen befindet sich in den Wojewodschaften Lodz, Posen und Warschau. Die höchste Frequenz der nützlichen Winde ist in Pommern, der Wojewodschaft Tarnopol und in Volhynien verzeichnet worden.

Die diesbezüglichen statistischen Angaben sind in der Tabelle auf Seite 94 enthalten.

Transportmittel.

Die Transporteinrichtungen in Polen können, als eine Erbschaft von drei verschiedenen Wirtschaftsorganismen, den Bedürfnissen des neuen Staates nicht entsprechen. Die Notwendigkeit der Wiederherstellung der während des

Krieges beschädigten Transporteinrichtungen verhinderte deren planmässigen Ausbau. Am meisten wurde verhältnismässig im Bahnwesen geleistet. Übrigens ist der Anteil anderer Transportmittel in Polen ohne Bedeutung, denn die Bahntransporte bilden ca 96% der gesamten Transportleistungen.

Im Jahre 1929 sind 83 883 626 t mit Güterzügen auf 17 257 km Bahnlinien befördert worden, wobei 22 992 606 636 tkm geleistet wurden.

Nach der Statistik vom Jahre 1920 bildet der Transport der Energiequellen 54,6% der Gesamtleistung in tkm, und 48,3% der beförderten Güter in t.

Die Strassen sind für den Transport der Energiequellen bedeutungslos. Die Gesamtlänge der Strassen in Polen beträgt 240 000 km, von denen nur 18% chaussiert sind. Wegen Mangel an anderen Transportmitteln wächt von Jahr zu Jahr der Autoverkehr, vorwiegend aber nur als Personenverkehr. Im Jahre 1929 wurden auf einer Gesamtstrecke von 25 171 km 56,9 Millionen Personen befördet, mit 2163,4 Millionen Personen-Kilometern. Die diesbezüglichen Zahlen für den Bahntransport betragen für das Jahr 1928 174,8 Millionen Personen und 7076,6 Millionen Personen-Kilometer.

Auf den 1515 km schiffbaren und 7 053 km nur flossbaren Wasserwegen betrug im Jahre 1926 der Schiffsverkehr 1,08 Millionen Tonnen und 152 Millionen Tonnen-km und der Flossverkehr 0,96 Millionen Tonnen und 139,7 Tonnen-km.

Einen Hafenverkehr von mehr als 100 000 Tonnen weisen, ausser Danzig, nur noch Warschau, Krakau und Poznań auf.

Der Tonnengehalt des Schiffsparks betrug im Jahre 1930 116 275 t und die Maschinenstärke der Schlepper ca. 15 609 PS.

Der Verkehr der beiden Seehäfen Danzig und Gdynia betrug im Jahre 1929 11 381 841 Tonnen (im Verhältnisse 3 : 1), wovon 76% auf die Energiequellen (vorwiegend Kohle) fallen.

Ausserdem dienen dem Transporte der Energiequellen die Rohöl- und Gasleitungen. Mittels der ersteren wurden im Jahre 1926, auf einer Gesamtstrecke von 174 km mit 311 km Leitungen, 527 000 Tonnen Rohöl transportiert.

Die 270 km langen Erdgasleitungen haben im Jahre 1929 139 Millionen m^3 Erdgas befördert.

Zum Transport der elektrischen Energie dienen 900 km Fernleitungen.

Gegenwärtiger Stand und Entwickelung der Gasindustrie.

Polen besitzt gegenwärtig 122 Gaswerke, welche 130 Örtlichkeiten mit Gas versorgen. Erdgas wird direkt von 8 Örtlichkeiten benutzt. Die Verteilung der Gaswerke ist nicht regelmässig; die weitaus grössere Anzahl derselben befindet sich im Westen des Landes.

Im Jahre 1928 wurden 180 Millionen m^3 Gas erzeugt, dazu 550 000 Tonnen Kohle verbraucht. Die Koksproduktion betrug 320 000 Tonnen. Vier vollständig eingerichtete chemische Fabriken verarbeiten das bei der Gaserzeugung als Restprodukt erhaltene Pech.

Der Gasverbrauch in den mit Gas versorgten Örtlichkeiten schwankt zwischen 25 und 110 m^3 pro Kopf, der Preis — zwischen 0,22 und 0,70 Zloty pro m^3.

Das Rohrnetz hat eine Gesamtlänge von 2 670 km; die Anzahl der Strassenlaternen übersteigt 40 000.

Nach dem Weltkriege wurden in Polen ein städtisches Gaswerk und zwei Kokswerke erbaut; gegenwärtig ist der Bau von Gas- und Kokswerken in 25 Städten projektiert.

Der Plan interurbaner Gasleitungen setzt den Verbrauch eines Teiles des von den oberschlesischen Gaswerken erzeugten Gases voraus (ung. 60 000 m^3 von einer Gesamtproduktion von 270 000 m^3).

Das geplante Gasnetz soll, ausser Oberschlesien, auch das ganze Dombrowa-Becken und den westlichen Teil Kleinpolens bis Krakau bedecken.

Elektrizitätswirtschaft in Polen.

Ende 1929 besass Polen 864 Elektrizitätswerke, mit einer Energieabgabe von 3 023 Millionen kWh und einer Leistung von 1 273 525 kWh (d. i. pro Einwohner 99,4 kWh und 41,9 W, bezw. 7 783 kWh/km^2 und 3,27 kW/km^2). Ausserdem gab es 818 private Elektrizitätswerke mit einer Leistung unter 100 kW.

Die Anzahl der zum Absatz von Energie bestimmten Elektrizitätswerke belief sich auf 585; ihre Abgabe betrug 1 785 Millionen kWh und ihre Leistung 0,71 Millionen kW (58,7 kWh und 23,5 W pro Einwohner).

Seit 1925 ist die Energieabgabe um 67,9%, die Leistung dagegen um 54,5% gestiegen.

Der Anteil der grossen Elektrizitätswerke (mit einer Leistung von mehr als 5 000 kW) an der Gesamtabgabe wird von Jahr zu Jahr grösser und betrug Ende 1929 75,4%. Gleichzeitig wächst auch das Prozent der zu allgemeinem Nutzen bestimmten Elektrizitätswerke.

Die Menge der erzeugten Energie steigt allmählich gegen Süd-West. In den östlichen Wojewodschaften beträgt der Energieverbrauch 1,7—5 kWh pro Einwohner, in den im Zentrum des Landes, östlich von der Weichsel gelegenen Wojewodschaften 5—40 kWh, während er in den westlichen Wojewodschaften 40—150 kWh, in Schlesien sogar 1 385 kWh erreicht.

Der mittlere Ausnutzungsfaktor der Elektrizitätswerke beträgt 27% (2 374 Stunden jährlich), die mittlere Leistung 1 474 kW; rechnet man jedoch hievon die Leistung der 65 grossen Kraftwerke ab, so beschränkt sich diese Zahl auf 404 kW.

In den Elektrizitätswerken mit einer Leistung von über 1 000 kW, stieg dieselbe während der letzten 5 Jahre um 27% und die Energieabgabe um 43%; die Arbeitszeit betrug durchschnittlich 2 451 Stunden.

Von den Elektrizitätswerken dieser Kategorie, besassen 28 Überlandzentralen eine Leistung von 314 720 kW; ihre Abgabe betrug 984,8 Millionen kW (32,6% der Gesamtproduktion). Ungefähr 300 km des Leitungsnetzes hatten eine Spannung von 60 kV und 600 km eine Spannung von 30 — 40 kV.

Der Anteil der Überlandkraftwerke an der Gesamtproduktion stieg während der letzten 5 Jahre um 19,3% mit Bezug auf die Leistung und um 24% mit Bezug auf die Abgabe.

359 Städte (d. i. 56,8% der Gesamtanzahl) mit 6 500 000 Einwohnern, und 351 Dorfgemeinden (von einer Gesamtanzahl von 12 578) sind gegenwärtig mit elektrischer Energie versorgt. Das Strassenbahnnetz (in 11 Städten) hat eine Gesamtlänge von 239,5 km.

Die Spannung und Frequenz sind normalisiert. Die Anzahl der Gleichstromwerke ist ziemlich gross, ihre Leistung jedoch stellt nur 8% der Gesamtleistung dar.

Die wichtigste Energiequelle ist der Dampf (95% der Leistung); 3,7% werden durch Verbrennungskraftmaschinen und nur 1,3% durch Wasserkraft erzeugt, während 87% der Abgabe von Dampfturbinen erzeugt werden (362 Turbinen mit einer Leistung von 1 Million kW).

Die Dampfkessel arbeiten gewöhnlich unter einem Druck von 12—15 kg/cm^2 (nur selten 30 kg/cm^2), bei einer Temperatur von 250—350° (ausnahmsweise 400°).

Der Verbrauch von Brennmaterial beträgt durchschnittlich 1,3 kg/kWh und schwankt in den Grenzen zwischen 0,9 und 3,5 kg/kWh.

Gegenwärtig sucht man die systhematische Zusammenarbeit der grossen, sich im Kohlengebiet befindlichen Elektrizitätswerke zu fördern um dadurch die vollständige Stromversorgung des Kohlenbeckens zu erzielen.

Die obenerwähnten Zentralen geben 58,5% der Gesamtleistung und erzeugen 70,4% der Gesamtabgabe.

Die Totalabgabe elektrischer Energie deckt nur 35% des möglichen Bedarfes. Diese Zahl ist seit 5 Jahren unverändert geblieben, — ein Beweis dass der Fortschritt in der Stromversorgung des Landes kaum dem Grösserwerden des Energiebedarfes entspricht.

Die wahrscheinliche Zunahme der Energieabnahme beträgt für das Jahr 1935 5,65 Milliarden kWh, für das Jahr 1950 hingegen 18,5 Milliarden kWh.

In der elektrotechnischen Industrie sind gegenwärtig 12 400 Personen in 84 Unternehmungen beschäftigt; trotzdem deckt sie kaum 43,3% des Bedarfes.

Das Umsatzvermögen des polnischen Elektrizitätsmarktes kann auf 300 Millionen Zloty jährlich geschätzt werden.

Die Grundlage der polnischen Elektrizitätsgezetzgebung bildet das Elektrizitätsgesetz vom Jahre 1922, welches die Erzeugung, Übertragung und Verteilung der Energie von einer vom Minister für öffentliche Arbeiten erteilten Konzession abhängig macht.

Ausführliche Angaben über die Elektrizitätswirtschaft enthalten die in den Text eingereihten Tabellen.

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