

HYDRO-ELECTRIC
DEVELOPMENT
IN
INDIA

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CENTRAL BOARD OF IRRIGATION

Popular Series

Leaflet No. 5

FOREWORD

This is the fifth of a series of leaflets of general interest issued from time to time by the Central Board of Irrigation. A description is given herein of sources that constitute electric power and what has been done in our country, in the past, to develop such sources. India is fortunate in her vast resources of large rivers and high mountains and has a large hydro-electric power potential. The slow growth of hydro-electric power undertakings in India is compared with the rapid strides made by other countries of the world and a short account of the projects now under construction or investigation for the production of hydro-electric energy in India has been added.

KENNEDY HOUSE,
SOOLA S.W.
August 31, 1948.

N. D. GULHATI,
Secretary.

HYDRO-ELECTRIC DEVELOPMENT IN INDIA

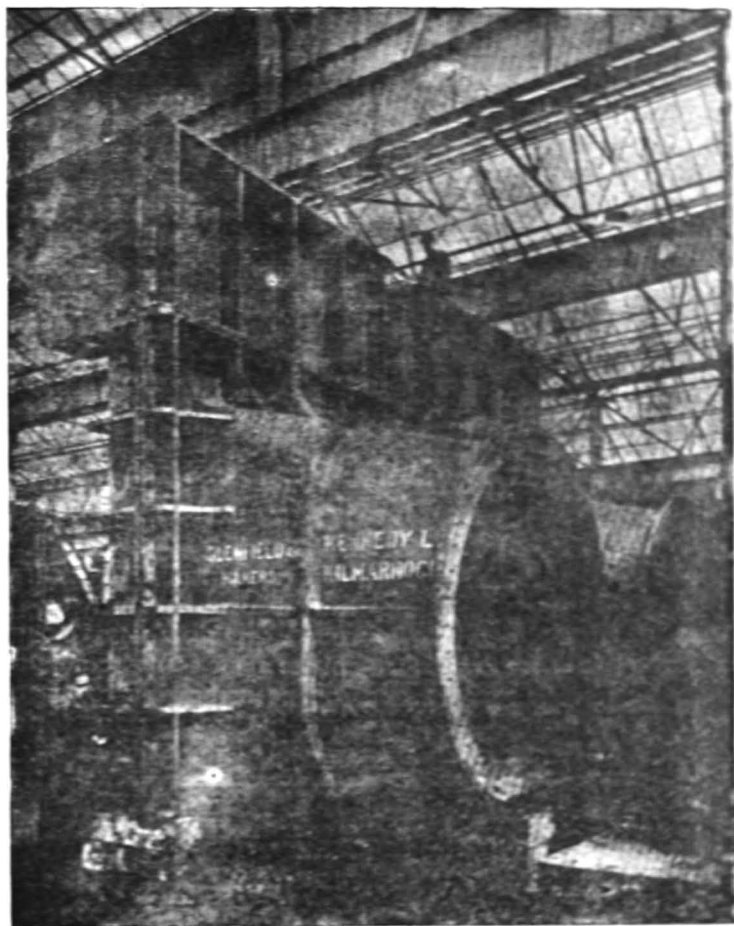
ELECTRICITY—A MODERN NECESSITY

Electricity has a remarkable diversity of application. In the home, electric lights, fans, irons, vacuum cleaners, refrigerators, cold storage lockers, water pumps, stoves and kettles lead to comfort and cleanliness and lend charm to life. In the farm, electricity can be used in a number of ways—for grain grinders, feed mixers, cream separators, milk sterilizing equipment and incubators. Portable utility sets can be used for wood cutting, elevating grain and cleaning seeds. Electricity can provide cheap power for pumping water for irrigation and other agricultural operations. By these and many other labour-saving devices, too numerous to mention, electricity can eliminate the drudgery of the rural population and make their life rich and pleasant. Through the radio, electricity assists in providing both entertainment and education. The extensive use of electricity can thus bring about a radical and much needed change in rural life and surroundings and can thus assist considerably in reducing the influx of rural population into cities—a feature worthy of serious consideration at the present time when housing is a big problem in all cities in India.

Cheap electric power is regarded as a fundamental requirement for the industrial development of a country. In fact, modern life and industrial development depend so largely on the use of electricity that the quantity of electricity used per capita in any country is an index of the material and industrial development of that country and of the standard of modern civilization that has been attained in it.

SOURCES OF POWER

A student of Economics regards material and labour as the two fundamentals of production. In the olden days labour was synonymous with man-power. With the development of science, power from winds, from moving streams of water, from steam, from
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Cast iron bell-mouth to Hydro-electric pipe of the Mellar Dam Power House.

oils and from electricity has been progressively brought to the aid of man. All these sources of power can be divided broadly into two classes :

- (1) Exhaustible, or those which represent accumulation of energy gradually formed under the action of the Sun's light and heat, *e.g.* coal, mineral oil, peat, natural gasses and fuel ; and
- (2) Inexhaustible, or those which are replenished by Nature as fast as they are utilised, *e.g.* water falls, tides and winds.

The production of power from sources like tides and winds can by their very nature be limited. Among the fuels derived from growing vegetables, alcohol, which can be manufactured cheaply from potatoes, molasses and *mahu* flowers alone seems to hold out any promise. It has been used for some years in Mysore; but the output is negligible. Until atomic power comes into field, the development of the power resources in India can thus only be from oil, coal and hydro-electric generation.

India's resources in oil, so far as known, are poor. She imports the major part of the oil that is now being used either directly for the production of power or indirectly after conversion into electric energy. There is thus little prospect of the country being able to develop power or industries based on her meagre resources of oil.

India's wealth of coals confined mainly to Bihar and West Bengal with small outliers in Assam, Central Provinces and Hyderabad. The distribution is uneven and distance from the coal fields to different industrial centres so great that except at or near localities where coal mines occur, power cannot be produced economically from coal. It has also been estimated that the entire quantity of good quality coal available in India, excluding coking coal which can be used profitably for conversion into liquid fuel is only 3,500 million tons. If it is used at the present rate of consumption, the coal resources of the country would be exhausted in a little over 100 years. The Railways in India alone consume about seven million tons of coal annually—just one third of the total annual consumption in the country.

With her large rivers and high mountains, India's resources of hydro-electric power are vast. As will be shown later, these resources have not even been surveyed so far in their entirety, while the limited resources of coal are being rapidly wasted. So far as the generation of electric energy in India is concerned, the first thermal station, Calcutta Electric Supply Corporation commenced supply in the year 1899. This was followed by the Bombay Electric Supply and Tramway Co. in 1905, the Kanpur Electric Supply Corporation

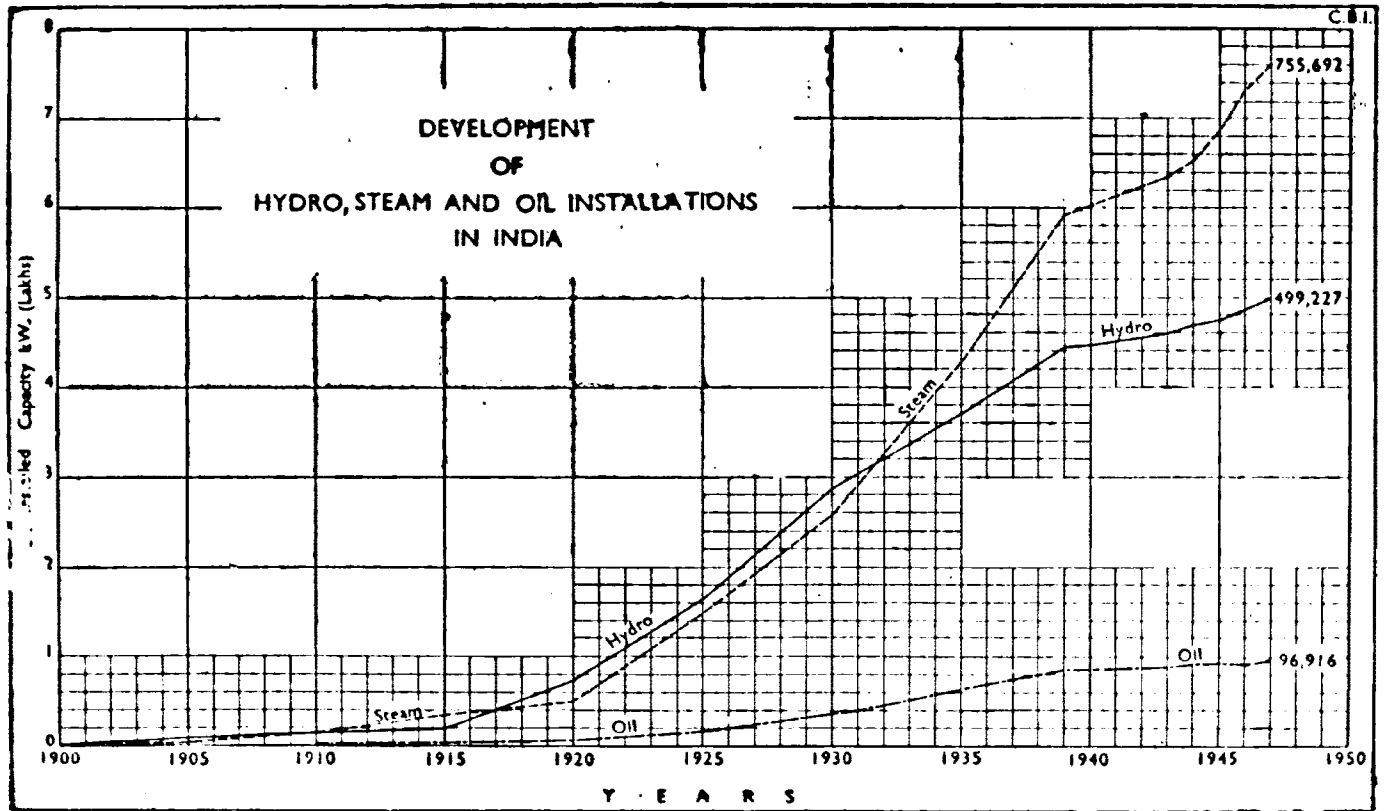


Figure-1.

and the Madras Supply Corporation in 1906. Other installations followed and the following table (also see figure 1) indicates the relative use in India, today, of different sources of power for the production of electric energy.

Kilowatts installed in Public Electric Supply Undertakings :

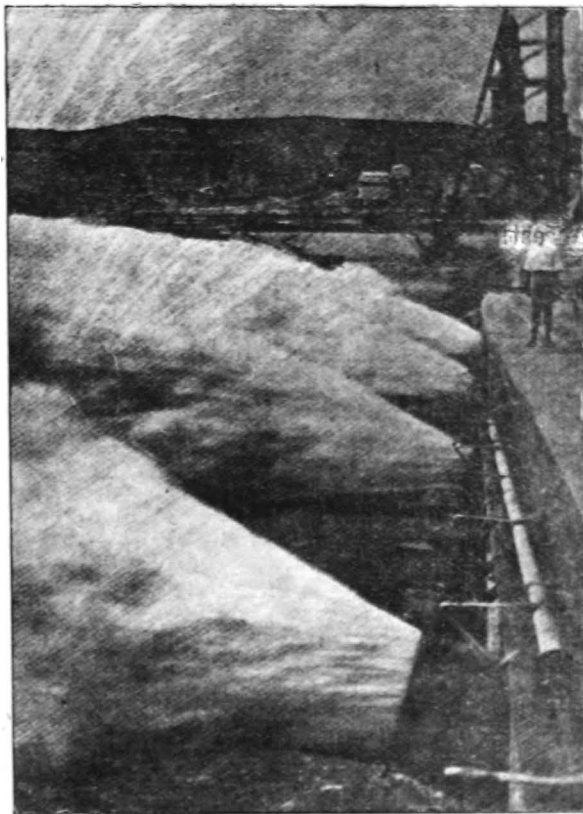
			1920	1947
Oil	..	..	5,847	96,916
Coal	—	..	48,495	755,692
Hydro	..	..	79,505	499,227

It has been estimated that each installed kilowatt of hydro-electric power if operated continuously for a year is equivalent to about five to six tons of coal. In Canada, which is exploiting hardly 20 per cent. of her water resources, the total hydro-electric power generated during 1946 was equivalent to more than 22 million tons of coal. An idea of India's potential of hydro-electric power can be had from the fact that the equivalent of the entire power now utilised on the Railways in India can be generated from a single scheme like the Kosi Project. Coal can thus be reserved for more profitable use in metallurgical and other operations. The solution of India's poverty and material backwardness lies in the utilisation of the vast sources of energy available in her large rivers and high hills. It is proposed in this leaflet to examine in brief how these resources have been utilised so far in comparison with the other countries of the world and to give a short account of the projects now under construction or under investigation for the production of hydro-electric energy in India.

THE SCIENCE OF ELECTRICITY

It is difficult to state when electricity as such came to be known. There are references to Thales with whom the science is reported to have started about 600 B. C. with intermittent developments since then. One can, however, recall readily the work of Gilbert (1600) of Franklin (1750), of Winshurst and Volta (1800) and of Faraday who in 1831 made the fundamental discovery of electro-magnet induction which is the foundation of the electric power industry.

Hydro-electric energy is of more recent origin. It is difficult to find when the first hydro-electric plant in the world was constructed



Mettur Dam Power House—Hydro-electric pipes discharging.

References have been traced, however, to the first hydro-electric plants having been installed in

U. S. A.	in	1882
Japan	in	1892
Australia	in	1895
India	in	1897
Canada	in	1900
New Zealand	in	1904

Towards the close of the last century, in the November 1897 issue of the Scientific American it was recorded—

“ The statistics of the present state of water power utilisation show that it is advancing with rapid strides. America leads the world with a total installation of over 70,000 h.p. Switzerland comes next with 32,000 h.p. France has 18,000 h.p. and the great power plant at Rheinfelden Germany, gives Germany the fourth place with about 17,000 h.p. Italy has nearly as much and Norway and Sweden are each credited with 15,000 h.p. In Great Britain there is a total installation of 4,000 h.p.”

Thus about the beginning of the present century the hydro-electric installations in the world had a total capacity of the order of 150,000 kW. and it was little realised that what was then regarded as ‘rapid strides’ would before long become insignificant in the race for electric development.

GROWTH OF HYDEL POWER IN INDIA

Water Power has been used in India and the East for centuries past in wooden water-wheels for driving corn mills ; these are found in almost every valley of the Himalayas, even at the present day. Hydro-electric power development as already stated is an invention of the last quarter of the nineteenth century. The pioneer public utility hydro-electric undertaking in India is the small Municipal Town Lighting Plant at Darjeeling which was erected in 1897-98. This was followed by the hydro electric scheme on the Cauvery river—the first of any magnitude—in Mysore in 1902. The principal object of this scheme was the supply of power to the mining companies on the Kolar Gold Fields about 92 miles from Sivasamudram, the site of the generating station. This initial undertaking has since grown steadily. Considerable expansion was made possible by the construction of the Krishnarajasagar dam and the plant there has now an installed capacity of 60,000 kW. Power was also generated in small quantities in Madras on the Kaveri River in 1904 and in the high ranges in the Travancore State in 1905. Kashmir hydro-electric



Pipe line of the Tata Hydro—Electric Scheme, Bombay.



The Mandi Hydro-electric scheme—Power House at Jogindernagar.

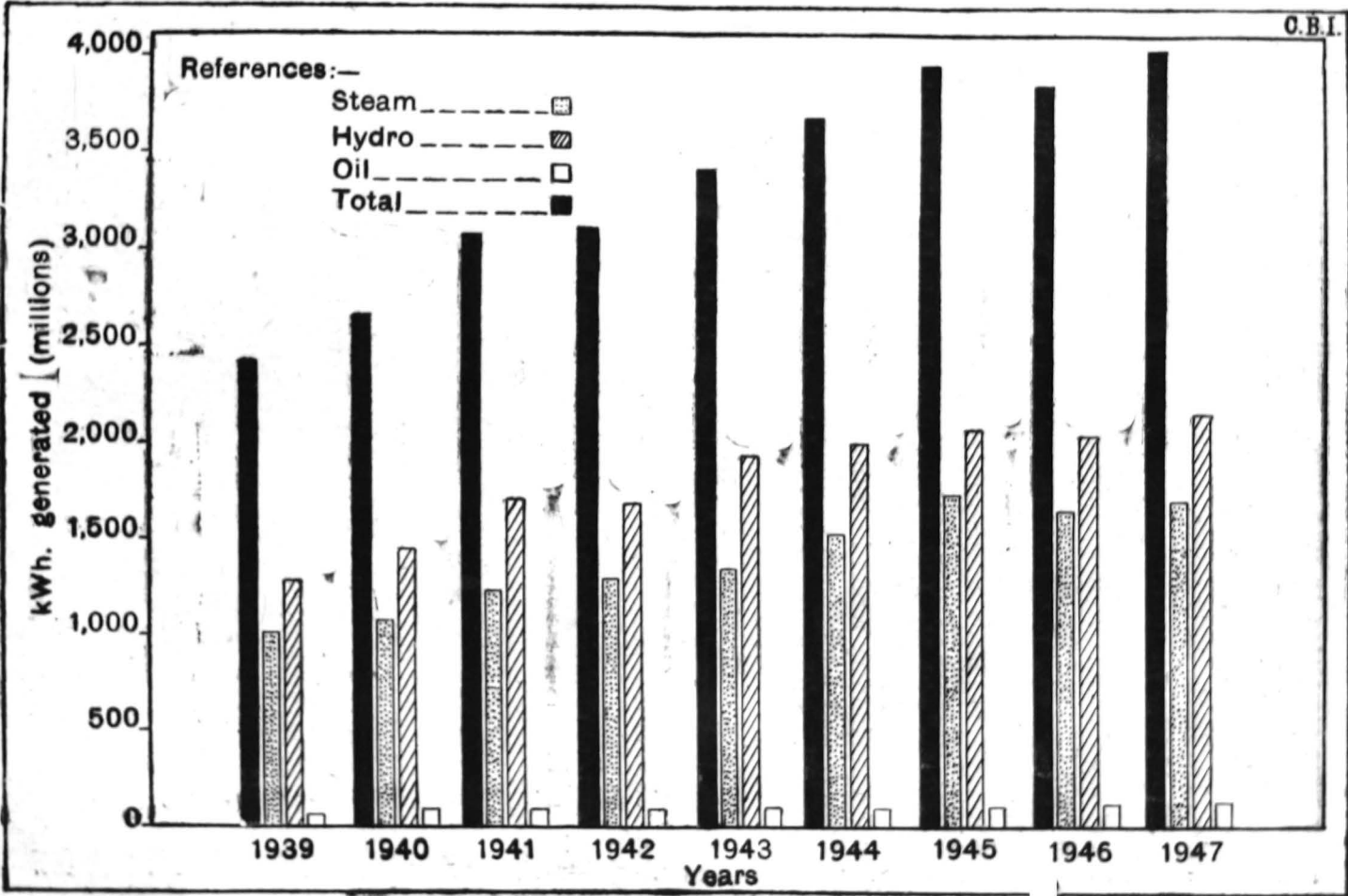
works were completed in 1908-1909. Small water power stations for the supply of electricity to municipal areas were constructed at Mussoori in 1909 and Simla in 1913. Gokak Falls in Bombay were harnessed in 1914. No major work, however, appears to have been undertaken in the early stages.

World War I—1914-18 gave an impetus to the use of electricity all over the world. In India, the formation of the Indian Munitions Board was the first step in coordinating existing industries, and this was soon followed by the appointment of the Indian Industrial Commission. The Industrial Commission in its Report 1916-18 emphasized the necessity for a hydro-graphic survey of India. The Government of India appointed Mr. G. T. Barlow, then Chief Engineer Irrigation Branch, United Provinces, to undertake the work in association with Mr. J.W. Meares, then Electrical Advisor to the Government of India. After the death of Mr. Barlow, Mr. Meares, issued a preliminary report in 1919 and a Triennial Report in 1921, indicating that a minimum continuous water power of nearly 3.5 million kW. with a maximum of eight million kilowatts could be developed in India.

By the time Mr. Meares Report was published, the Government of India had ceased to take direct interest in the development of Provincial Public Works and thus no serious notice appears to have been taken of the recommendations made in the Report, inadequate as these were. Meanwhile other countries went head long in the development of their hydro-electric resources and India was left far behind in the race for electrification and consequently of industrialisation.

It is indeed a great compliment to Indian enterprise that the three biggest hydro-electric installations that exist in India today are the result of private effort sponsored by that great industrialist Sir Jamssetjee N. Tata. The first of these is owned by the Tata Hydro-electric Power Co., and came into operation as early as 1915. This was followed by the Andhra Valley Power Supply Co., in 1922 and by the Tata Power Co. in 1927. Between these three companies the power installed amounts to 232,000 kW., almost half of the total hydro-electric installation in India today.

The major state-managed hydro-electric works completed in recent years are the Pykara Hydro-electric scheme, Madras and the Mandi Hydro-electric Scheme, East Punjab (1933) the Mettur Hydro-electric Scheme Madras (1937), the Pallivassal System, Travancore (1940), Papanasam Scheme, Madras (1943), and the Ganga Hydro-electric Grid, United Provinces (1930-1947). The last system is still under development.



Figure—2.

A table showing year to year development of hydro-electric installation is also given at the end.

Figure 2 shows the electric energy generated in India from 1939 to 1947 from oil, coal and water power plants. Reliable figures prior to 1939 are not available. It will be noticed by comparison with figure 1 that although the installed capacity of steam power plants is about one and a half times that of the hydro-electric plants, the energy generated annually by the latter is more than that generated by steam power plants.

As already stated, the total installed hydro-electric capacity in India is 499, 227 kW. which is only 14 per cent. of Mr. Meares estimate of about 3.5 million kilowatts of firm potential power. Mr. Meare's estimate itself represents about ten per cent. of the real water power potential of the country; or in other words the hydro-power so far developed in India is only 1.5 per cent. of the country's potential.

HYDEL POWER DEVELOPMENT IN THE WORLD

Having outlined the scanty progress made in India in the field of hydro-electric endeavour, it is proposed to review briefly the long strides taken in this direction by other Nations of the world who had the shaping of their destinies in their own hands.

The pioneers in the field of hydro-electric development are the U.S.S.R., U.S.A., and Canada, but if the criterion be the percentage of a country's potential that has been developed, the place of honour today is taken by Switzerland, Germany, Norway, France and Sweden in the order stated.

U. S. S. R., a country with the highest potential water power in the world is believed to have developed 22.4 million kilowatts. The first state-planned organisation for the development of electric power in Russia was established in 1921. From 1923 to 1935, twelve major hydro-electric plants were installed, the most important of which is Dnieprestrio Hydro-electric Station with an installed capacity of 310,000 kW. The country is now stated to have developed 20 per cent. of her potential hydro power which is being used mainly in electro-metallurgical and electro-chemical industries and coal mining.

The United States of America is one of the most advanced country in hydro-electric development in the world. In the first twenty years of the present century she built up an installed capacity of about 4.0 million kilowatts; but the biggest achievement is in the period after 1920 during which she has added as much as ten million kilowatts of installed capacity. The total installed capacity of the Tennessee Valley Authority dams alone exceeds two million

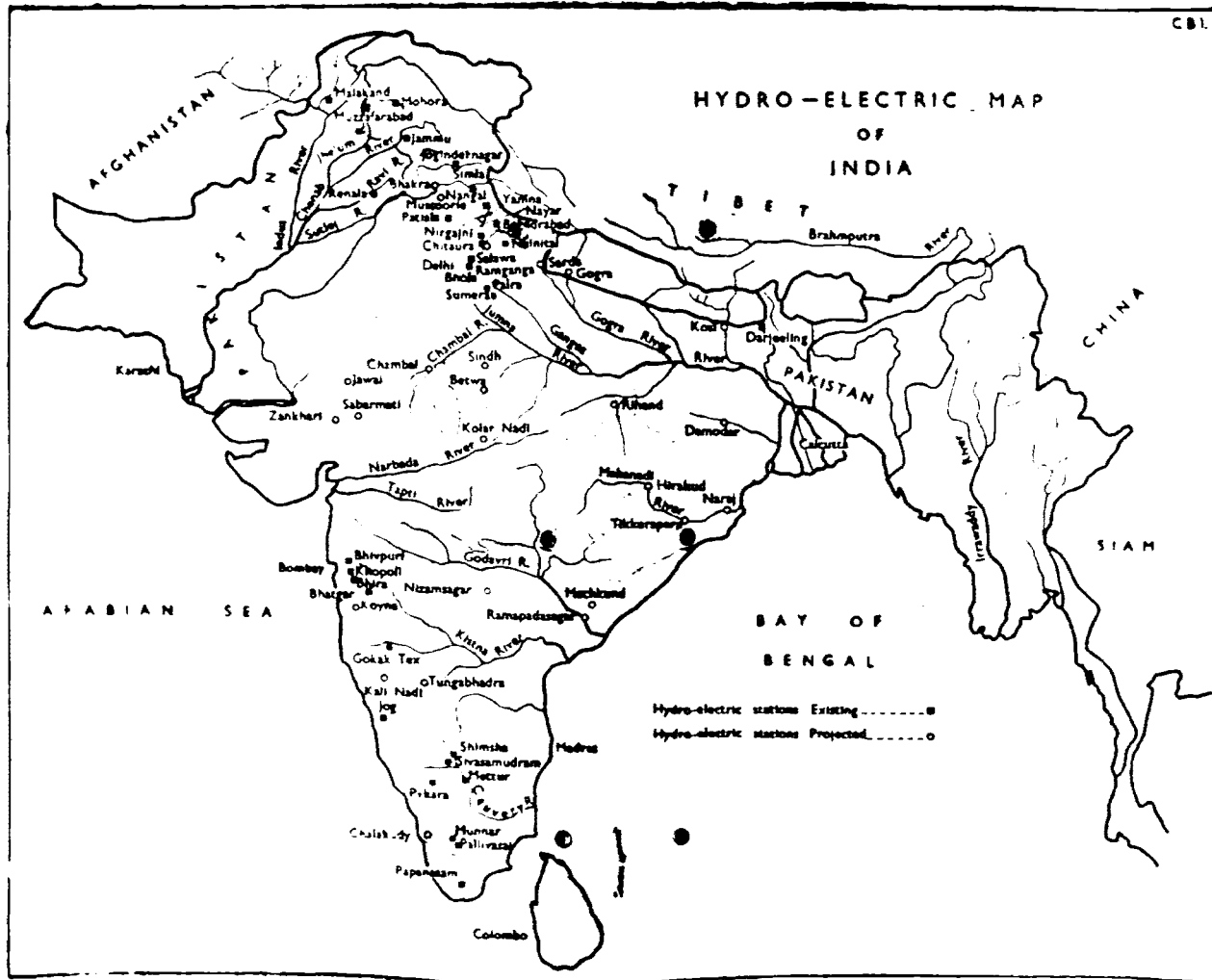


Figure-8.

kilowatts which is a little over four times the total installed capacity in India. The Grand Coulee Dam and Boulder Dam, on full development, will have installed capacity of 2.0 million kW. and 1.4 million kW. respectively.

The Dominion of Canada presents a picture of a country whose economy as regards power is based on a non-wasting asset—water power. More than 98 per cent. of the electricity sold by public power stations is generated from this source. The major hydro-electric plant is the Queenston—Chippawa on the Niagra falls with an installed capacity of 417,760 kW. The total installed capacity in Canada, at the end of 1945 was 7.67 million kW., but 70 per cent. of which was installed during the last 25 years. It is remarkable that Canada with about half per cent. of the world's population has attained a position of the world's third trading nation due to her industries based on electricity.

Switzerland, the playground of the world, has contributed in no small measure to the advancement of hydro-electric development. More than 50 per cent. mileage of her broad gauge railway lines are now electrified from water power. The Fully Power Station, utilises a net head of 5,410 feet, the highest so far in the world. A new enterprise is the power station located in the Rhone Valley near Sion, equipped for 134, 280 kW., and which will work under an effective head of 5,740 feet. Switzerland has an installed capacity of 2.4 million kW. and has exploited 67 per cent. of her water power potentials, the highest percentage in the world. About 80 per cent. of her works were constructed during the last 25 years.

No country in Europe has so many glaciers and fields of perpetual snow as Norway, and she has taken full advantage of these natural facilities for the development of water power the most intensive in Europe. It is claimed that the height of the Norwegian waterfalls added together exceeds the total of all other waterfalls in the world. The total installed capacity of hydro-electric plants is 2.4 million kilowatts for a population of three millions. To attain this rate of electrification India should have an installed capacity of 27 million kilowatts.

France has an installed capacity of about four million kW., and has many interesting hydro-electric works. One of the most fascinating works is in the Pyrennes where a head of 4,620 feet is utilised by a small quantity of water collected by various devices from a number of small lakes; the average discharge for the year not exceeding 50 cusecs. At this place, as also in some other countries, surplus power during periods of high supply is utilised for lifting water which is again used for hydro-electric development during the period of low supply.

Sweden claims to have electrified 85 per cent. of all homes in rural areas. She has an installed capacity of 2.5 million kW. Her output of electric energy in 1946 was 14,200 million kWh. based almost exclusively on water power. Like Norway she has immense possibilities of hydro-electric development and with the works now in progress, she will soon have an installed capacity of 3.5 million kilowatts for a population of seven millions.

The table below gives important facts about the relative development of hydro-electric power in various countries of the world.

Name of country	Population (million)	Water power potential (million kW.)	Water power developed and installed (million kW.)		Water power developed as percentage of potential		Per capita consumption of electrical energy (all types kW.)
			1920	At present	1920	At present	
1. U. S. S. R. ..	170	100	?	22.4	..	22	2150
2. U. S. A. ..	133	45	3.8	14.5	8	34	1,660
3. Canada ..	10	38	2.5	7.7	7	20	4,000
4. Switzerland ..	4	4.5	0.5	2.4	11	67	1,944
5. Germany ..	70	6	0.6	3.2	9	54	1,240
6. Norway ..	3	4.5	0.9	2.4	21	53	3,090
7. France ..	42	9	1.1	3.7	13	42	431
8. Sweden ..	7	7.5	0.8	2.6	11	33	2,100
9. U. K. ..	44	1.5	0.15	0.5	10	31	938
10. Japan ..	75	20	0.23 B	5.8	..	30	..
11. New Zealand ..	1	4	0.02	0.5	0.5	15	2,000
12. Australia ..	7	3	0.02	0.3	0.5	9	1,014
13. India ..	330	30-40	0.08	0.5	..	1.5	9.2
14. China ..	500	?	?	0.6 A	..	..	3.7

A—1935 figures.

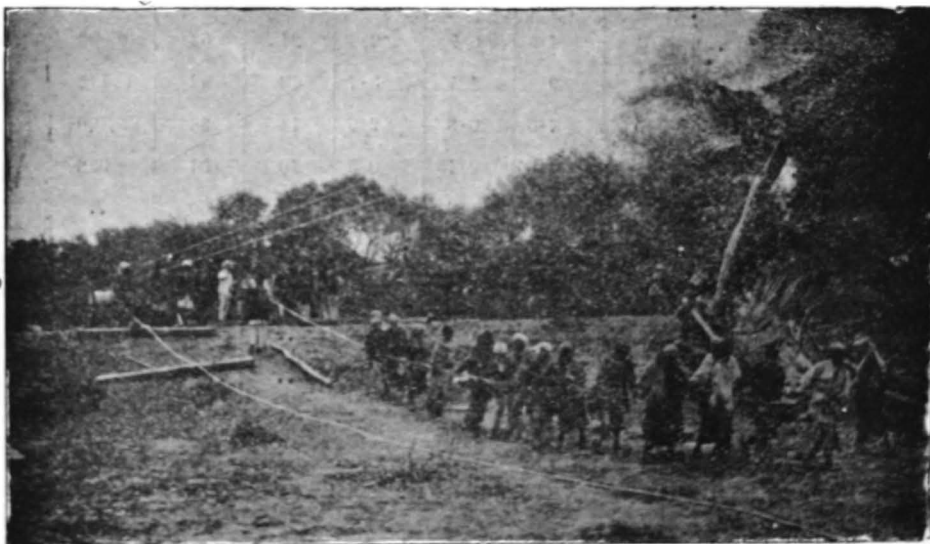
B—1912 figures.

C—1938 figures.

Notes—Figures other than those specified in the table generally relate to the period 1942-47.



Mandi Hydro-electric Scheme—Head-works area looking South.



*Mandi Hydro-electric Scheme—Pulling out the steel cored aluminium conductor on
Line No. 2 Amritsar Temporary Supply.*

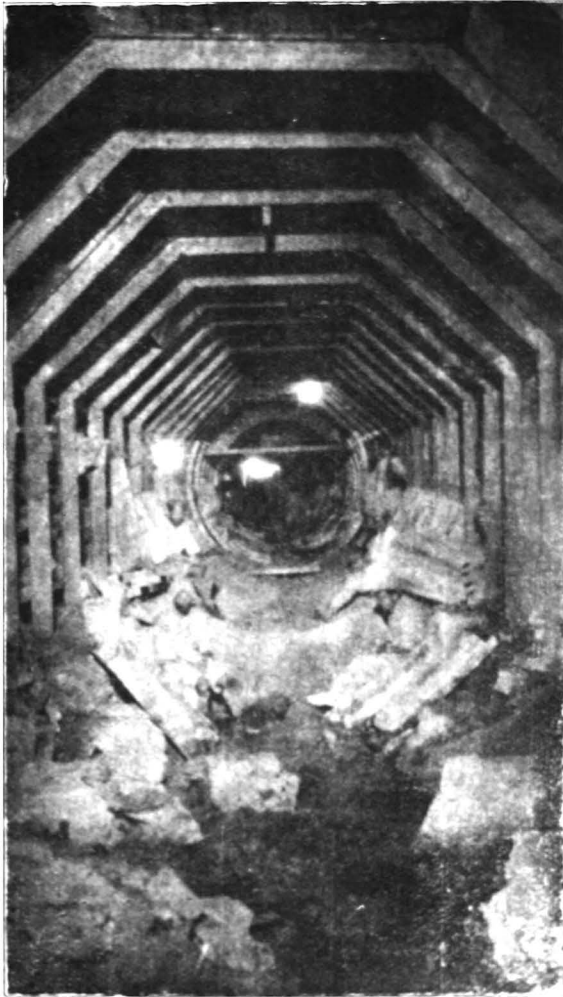
THE NEED FOR DEVELOPMENT

Judged by foreign standards, some of which have been described above, the progress on hydro-electric development in India is far from satisfactory. The total installed capacity to date is about 0·5 million kW., and the consumption of all kinds of electricity per capita, a true measure of the prosperity of a country, is only 9·2 kilowatt-hours against 4,000 kWh. in Canada, 3,090 kWh. in Norway, 2,100 kWh. in Sweden, 1,660 kWh. in U.S.A. and 1,944 kWh. in Switzerland. Another unwholesome feature of the scanty progress made in India is the fact that most of the existing installations have been planned to satisfy the demands of the urban areas. This will be clear when it is stated that Calcutta and Bombay, with a total population of one per cent. of the whole country between them consume half of the total electrical energy produced in India leaving the other half of the power for the remaining 99 per cent. of the population. Except in a few villages in Madras and Mysore, the amenities of electricity are unknown to the common man.

It will not be of much use to dilate on the reasons for the present deplorable conditions. There is no doubt that freedom of action was denied to Indians for long. Some of the early schemes taken up were unduly expensive. The system of financing public works insisted on a minimum direct return which ignored the many and very important indirect benefits to the community and the Government. The machinery for initiating inter-provincial projects was either non-existent or highly ineffective. Some of the difficulties mentioned above, have disappeared with the dawn of independence. The public and the Government should see to the removal of others so that the Nation can go ahead with determination and courage and utilise the available natural resources of the country for the benefit of the people.

SCOPE OF FURTHER DEVELOPMENT

Meare's estimate of the potentialities of hydro-electric development in India, to which reference has been made before, excluded many of the major rivers and many sites on smaller rivers. Although no regular All-India survey of the hydro-electric resources of the country has still been made, many projects not included in Meare's Survey have since been taken up for investigation and some



*Mandi Hydro-electric Scheme—Steel sets in the main
tunnels.*

of them are now in an advanced stage of development. The table below gives a comparison of Meare's forecast and figures now available for projects at present under various stages of development.

Name of Province or State	Meare's figures (1917) based on ordinary minimum flow			Latest figures (1948)		
	Power Developed (kW.)	Potential (kW.)	Total	Power developed (kW.)	Projected or under investigation (kW.)	Total (kW.)
Assam .. ..	..	414,000	414,000	500	4,000,000	4,000,500
West Bengal ..	600	619,250	619,850	2,360	333,000	335,360
Bihar and Orissa ..	..	62,550	62,550	..	1,800,000	1,800,000
				..	3,860,000	3,860,000
Bombay	71,400	572,910	644,310	235,714	600,000	35,714
C. P. & Central India	..	138,240	138,240	..	250,000	250,000
Coorg .. ..	..	1,500	1,500	..	..	..
Madras	740	91,570	92,310	98,290	500,000	598,290
East Punjab ..	1,880	688,400	690,280	49,750	500,000	549,750
U. P.	4,330	399,040	403,370	22,700	1,200,000	1,222,700
Baroda .. ..	..	4,000	4,000	..	8,300	8,300
Cochin .. ..	..	4,000	4,000	..	200,000	200,000
Gwalior .. ..	..	49,300	49,300	..	16,000	16,000
Jammu & Kashmir	105,830	199,500	305,330	4,315	9,000	13,315
Mysore	24,000	24,500	48,500	71,200	240,680	311,880
Patiala	290	..	290	240	16,000	16,240
Hyderabad ..	..	..	..	..	639,000	639,000
Rajputana ..	..	160	160	..	153,570	153,570
Sikkim .. ..	..	5,000	5,000	..	..	..
Travancore ..	450	..	450	13,900	..	13,900
Other States ..	..	..	..	258	16,500	16,758
Total ..	209,520	3,267,420	3,477,440	499,227	14,342,050	14,841,277

It will be clear from a perusal of the table above that Meare's estimate of potential has already been exceeded four times over by projects which are already under contemplation. In addition there are several sites on the Nerbada, the Tapti on the Ghats and in the Himalayas which are still unexplored. It is not unlikely that the unsurveyed resources will far exceed those which have been developed or are under investigation. On a rough approximation, the hydro-electric resources of India are likely to be of the order of 30 to 40 million kilowatts. There is thus an immense scope for development.

NEW HYDRO-ELECTRIC PROJECTS

Different administrations in India have launched a number of hydro-electric projects. These have been shown on the map in figure—3. A brief description of the more important is given below.

(1) **Kosi Project (Bihar).**—The Kosi Dam Project, designed to provide for flood control, irrigation and power will comprise a dam, possibly 750 feet high, across the Chatra gorge above the temple of Baraha Kashetra, power plant at the dam site capable of generating upto 1·8 million kilowatts of cheap power at 50 per cent. load factor, a barrage in Nepal across Kosi with one canal taking off either bank for irrigating about a million acres in Nepal territory, and a second barrage near Nepal-Bihar border with two canals on the left and one on the right, for irrigating over two million acres in Bihar. The estimated cost is 850 to 950 million rupees. The preliminary survey and investigations are in progress.

(2) **The Kalinadi Hydro-electric Project (Bombay).**—The project contemplates harnessing the waters of the river Kati for the development of power. It is estimated that 350 000 kW. continuous is available in the Kalinadi basin distributed at five power stations.

(3) **Bhakra Dam (East Punjab).**—The Bhakra Dam Project comprises a dam, 480 feet high, across a gorge in the river Sutlej at Bhakra; the reservoir so formed will have a useful capacity of 3·5 million acre feet, sufficient to give a mean discharge of 6,600 cubic feet per second for a period of 270 days—the dry part of the year. The scheme which is expected to cost 700 million rupees will generate 160,000 kW. and irrigate 4·5 million acres. Work has been taken in hand. Investigations are also in progress for raising the height of the dam by about one hundred feet. This will increase considerably the power to be generated and the area to be irrigated from this project.

(4) **Nangal Power Project (East Punjab).**—The Nangal power project comprises a weir across the Sutlej at Nangal 18 miles

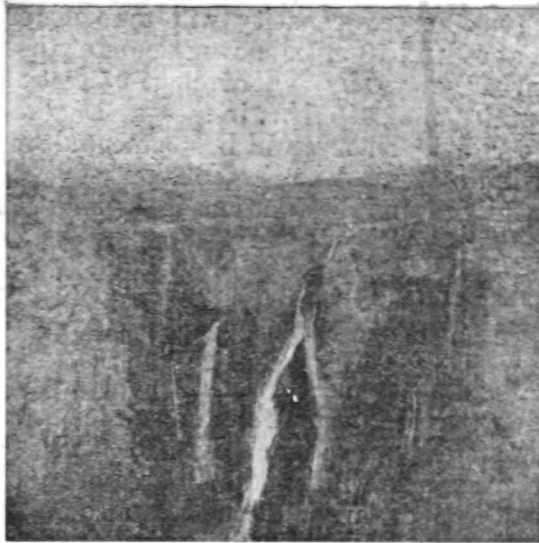
downstream of the site of the proposed Bhakra Dam from where a lined canal of 10,000 cusecs capacity will take off for two power houses situated at 12 and 18 miles downstream of the weir. Each power house will be operated by a fall of about 98 feet and will have an installed capacity of 48,000 kW. in the pre-Bhakra stage. The installation at each power house will be augmented by 24,000 kW. in the post-Bhakra stages. The Pre-Bhakra stage of the project including transmission and distribution is estimated to cost 220 million rupees.

(5) Ramapadasagar Project (Madras).—This is, by far, the most important multi-purpose scheme projected in Madras; the reservoir to be formed on the Godavari will be one of the biggest in the world. A 428 feet high masonry dam, with 190 feet of foundations below the river bed, a mile and half long, will be built to store 15.6 million acre feet of water. The two canals which will take off the dam on either side will irrigate an area of 2.35 acres in the dry tract above the Godavari delta and will also augment supplies to the existing delta canals which will bring another 2.1 million acres under irrigation. The project will further develop 100,000 kW. continuous power and 20,000 kW. secondary power at the dam site. The cost of the scheme as at present estimated is 860 million rupees.

(6) Tungabhadra Project.—The construction of this project is being taken up jointly by Madras and Hyderabad. It has as its main feature a concrete masonry dam, 8,200 feet long and 160 feet high across the Tungabhadra, a major tributary of the Kistna. The dam will impound 2.6 million acre feet of water.

(7) Jog Falls.—The magnificent Jog falls on the Sharvathi River in Mysore have been harnessed and the first unit capable of generating 12,000 kW. was switched on in February, 1948. The project, when completed, will have an installed generating capacity of 120,000 kW. The main works in the project are a storage reservoir designed for an ultimate capacity of 23,173 million cubic feet, an *anicut* lower down the river to divert the water into the power channel, the power channel, a forebay for controlling the inlet of water into the penstocks and the generating station at the bottom of the gorge. Gross static head for generation of power is 1,205.4 feet. The estimated cost of the scheme is about 57 million rupees.

(8) Unified Development of Mahanadi (Orissa).—This scheme will consist of three units, namely the Hirakud Dam Project, the Tikarpara Dam Project and the Nara J Dam Project, each with its own canal system and hydro-electric power installations. As a first



A view of the Gerasappa Fall. The photograph was taken from the Mysore end, in the month of February with low river.



Jog Falls—A distant view of the hill slope on which the pen stocks have been laid. The trolley leading to the Power House can also be seen.

step the Hirakud Dam Project has been taken in hand. This dam will be nearly three miles in length across the main channel with 17 miles of low dykes on the two sides. The maximum height of the dam above the deepest river bed will be 150 feet. It will have a gross storage capacity of 5.3 million acre feet, will irrigate a million acres and generate 3,50,000 kW.

(9) The Chambal Hydro-electric Scheme (Hoikar State).—This, the first of a series of reservoirs in the contemplated multipurpose regional development of the Chambal Valley, comprises the construction of a dam about 200 feet high across the river Chambal near Chaurasigarh about 30 miles on the North West of the Shree Chatrapur Railway Station on the B. B. & C. I. Railway. The reservoir will have a storage capacity of 6.89 million acres. Power produced will be 28,000 kW. Irrigation to the extent of about 100,000 acres is also possible from the reservoir by tunnelling through a ridge. The estimated cost of the scheme is 70 million rupees.

Two pick-up weirs proposed downstream are, one each in Mewar and Kotah State territories. It is expected that power stations to be constructed at these weirs will generate 68,000 kW. and 56,000 kW. of power respectively at 50 per cent. load factor. The total cost of the whole scheme is estimated at 225 million rupees.

(10) The Nayar Dam Project (United Provinces).—It will involve the construction of a 600 feet high dam to store 1.4 million acre feet of water on the river Nayar, a tributary of the Ganga. The supplies will be utilised for supplementing the existing discharge of the Ganga Canal and for generating 100,000 kW. Preliminary investigations are nearly completed and construction is likely to start soon. The scheme will cost 150 million rupees.

(11) The Pipri Dam and Power Station Project (United Provinces).—It is proposed to impound nine million acre feet of water by a 280 feet high dam across the river Rihand near Pipri village. The power house will have an installed capacity of 230,000 kW. and it will also bring under irrigation about four million acres. The estimated cost is 290 million rupees.

(12) Unified Development of Damodar River (West Bengal).—This important project comprises the building of a system of eight dams and a barrage. Seven of these dams are for storage and all of them will be equipped with hydro-electric generating plant. The aggregate controlled reservoir capacity would be about 4,700,000 acre feet. The proposed schemes would provide perennial irrigation to about 700,000 acres and will generate 65,000 kW. of primary

power and 65,000 kW. of secondary power. The project is expected to cost 550 million rupees. The details regarding administration of this project which will effect both Bengal and Bihar have been formulated and the Damodar Valley Corporation has been set up.

When the projects described above, some of which are being pursued with vigour by various administrations in India, are completed these will add more than 14 million kW. of power to the existing, partly half million. It will be possible to interlink different power houses into a grid so that loads can be transferred from one station to another in case of emergency. Electricity will be made available to villages in rural areas and life there will no longer be bleak.

Needless to add that a very high priority must be given in the national interest to supply funds, material, labour, personnel and transport for the early execution of these works.

TWO IMPORTANT SUGGESTIONS

Before the large blocks of power, proposed to be created by the projects described above, can be utilised in the service of the people, we shall require in the country large quantities of manufactured goods for the transmission and distribution of energy, poles, wires, transformers, insulators, switch gears, *etc.*, and huge numbers of different devices for the utilisation of this energy—motors, large and small, heaters, accumulators, pumps, various appliances and meters, *etc.* Some of these articles will be required by the thousand and hundreds of thousand. Very few of these are produced in the country at present and it is highly important that immediate steps be taken to establish in India sufficient factories for the manufacture of equipment and appliances for the utilisation of this energy. We cannot depend on imports for the large quantities required. Sufficient attention has not perhaps been paid to this aspect of development and it is important that due energies be directed towards this important field.

The creation and utilisation of these large blocks of energy present numerous problems for the engineer and the scientist. Some of these have been tackled in other countries, but there are many which call for a solution here in India, keeping in view the peculiar needs of the country. Research on hydro-electric machinery, electric transmission and distribution and electrical devices and appliances must, therefore, be taken up in India at a number of centres and without delay.

COMPREHEND THE TERMS

Falling through a height of 150 feet, a cubic foot of water can generate 10 KILOWATTS or units of electric energy sufficient to drive a 12 h. p. car at a speed of 40 miles per hour on a reasonably good road, and roughly equal to the energy out-put of a hundred men. One kilowatt or unit of electric energy is sufficient to light 25 average sized electric bulbs or to irrigate 50 acres of land per year by pumping water from a depth of about 20 feet. Not more than one thousand such units are required to drive a passenger train at a speed of 50 miles per hour. Every unit of electricity, generated by hydro, represents a saving of 5 tons of coal per year.

One cusec represents a volume of water equivalent to the flow of one cubic foot of water per second. An acre foot denotes a volume of water sufficient to cover an acre to a depth of one foot. Two acre-feet of water are equivalent to one cusec flowing for 24 hours. A million acre feet of water is equal to 43,560,000 cubic feet and is sufficient to cover an area of ten square miles to depth of 156 feet. This represents a storage sufficient to supply a mean discharge of 1 381 cusecs to a hydro-station throughout the year.