Recent Progress in Canadian Hydro-Electric Power Development.

By Dr. BRYSSON CUNNINGHAM.

IT is just about two years (*vide* NATURE, Aug. 27, 1927, and Sept. 3, 1927) since, on my return from a round of visits to some of the principal waterfalls and generating stations in eastern Canada, I described the situation in the Dominion as regards the development of its water resources for power purposes. It will probably be of interest at this stage to recount the progress which has been made during the intervening period, particularly as it continues to be of a very notable and far-reaching character. The statistics used for the purpose and the tabular information incorporated in this article have been derived from recent reports issued by the Water Powers Branch of the Canadian Department of the Interior.[1]

In order to appreciate fully the importance of water power development in Canada, it is necessary at the outset to bear in mind two salient facts; first, that the Dominion as a whole, and particularly its two chief industrial and manufacturing provinces, Quebec and Ontario, are very favourably endowed with abundant natural sources of water power; and secondly, that these same two provinces are singularly lacking in geological deposits of coal. Distinguished as the Acute Fuel Area, the two provinces, comprising the bulk of the population and the predominant share of commercial, mining, and manufacturing interests, would be lamentably crippled in their activities were it not for the fortunate compensation. Water power, therefore, is an essential feature of the industrial development of the Dominion.

In Great Britain, developable water power supplies are relatively meagre and of an insignificant order. Estimates of the aggregate are somewhat varied and range up to a million horse-power or perhaps slightly more. In Canada, although there are important regions incompletely surveyed and imperfectly scheduled, fully forty million horse-power is now definitely located and accounted for, and of this about $5\frac{1}{2}$ million h.p. has been actually developed up to the present time. It is true that the developed horse-power amounts to little more than 13 per cent of the estimated available total, yet it is greatly in excess of anything realised or even realisable in Great Britain. Moreover, it is steadily increasing at a rapid rate. Less than five years ago the total of developed horse-power was only $3\frac{1}{2}$ millions; nine years ago, $2\frac{1}{2}$ millions; and in 1900, less than a quarter of a million. If we take the rate of progress (nearly 500,000 h.p. per annum) which has obtained during the last five years, another decade will suffice to see more than ten

FIG. 1.—Hydro-electric installation (540,000 h.p.) at Isle Maligne, Lake St. John, Province of Quebec. (By courtesy of the High Commissioner of Canada.)

[1] No. 1227, Water Power in the Mineral Industries of Canada. No. 1231, Water Power in the Pulp and Paper Industry of Canada. No. 1242, Hydro-electric Progress in Canada during 1928. No. 1253, Water Power Resources of Canada.

million horse-power in operation. Fig. 1 illustrates a single development of 540,000 h.p. carried out within a period of five years.

From the economical point of view, the present achievement and its future possibilities are specially noteworthy. It has just been pointed out that the provinces of Ontario and Quebec, covering an area of well over a million square miles, are practically destitute of internal coal supplies, and are dependent on external sources for mineral fuel. On a reasonable computation under existing conditions, each installed water horse-power is the equivalent of six tons of coal per annum. This means that at the present time there is a saving in coal consumption in Canada of no less than 33 million tons—a remarkable quantity. In districts with coal readily obtainable by mining, the consideration to industry is significant enough; where coal has necessarily to be imported, it is vital.

The only European countries which compare with Canada in intensity of water power development per head of population are the Scandinavian kingdoms and Switzerland. Norway, Sweden, and Switzerland are each much smaller in area, have smaller populations, and are less industrially exploited. In the return published by the U.S. Geological Survey in January 1927 (the latest figures which I have at hand) the developed water horse-power of Norway is given as 717 per thousand of the population, of Sweden as 223 per thousand, and of Switzerland as 476 per thousand. At the present time the average for Canada is 554 per thousand. In certain provinces the ratio is much higher; for example, in British Columbia it is 952, and in Quebec 902. In Yukon and the North-West Territories, where the population is scanty and there are heavy demands for power for low-grade gold mining, the figure is as high as 1039.

Perhaps a fairer and more apposite comparison would be with the United States, where, reduced to the same basis of computation (ordinary six months' flow and 80 per cent turbine efficiency), the developable horse-power may be put at about 60 millions. The quantity actually developed at the present time is 13½ millions, equivalent to 127 per thousand of the population.

FIG. 2.—Two hydro-electric power stations on Gatineau River, Province of Quebec. Farmers' Rapids (120,000 h.p.) in foreground; Chelsea Dam (170,000 h.p.) beyond. (By courtesy of the High Commissioner of Canada.)

Table I. below shows the available and developed water power in the respective provinces of the Dominion of Canada as determined to Jan. 1, 1929. Compared with the similar table to January 1927, published in NATURE in August 1927, there is an increase of nearly two millions in the available 24-hour horse-power at ordinary minimum flow, of more than one million horse-power for the same 24-hour period at ordinary six months' flow, and of rather more than three-quarters of a million in the horse-power of actual turbine installations. It will be noted that the provinces of Ontario and Quebec possess more than 60 per cent of the available power and more than 80 per cent of the installed power.

Comparison of the corresponding figures for available horse-power at ordinary six months' flow with those of turbine horse-power at sites where

generating plant is actually installed, shows the turbine installation to be 30 per cent in excess of the scheduled available quantity, and this has proved to be good commercial practice. Hence, it is reasonable to apply a similar percentage

TABLE I.

AVAILABLE AND DEVELOPED WATER POWER IN CANADA.

Jan. 1, 1929.

Province.	Available 24-hour Power at 80 per cent Efficiency.		Turbine Installation, H.P.
	At Ordinary Min. Flow, H.P.	At Ordinary Six Months' Flow, H.P.	
British Columbia .	1,931,000	5,103,500	554,792
Alberta . .	390,000	1,049,500	34,532
Saskatchewan .	542,000	1,082,000	35
Manitoba . .	3,309,000	5,344,500	311,925
Ontario . .	5,330,000	6,940,000	1,903,705
Quebec . .	8,459,000	13,064,000	2,387,118
New Brunswick .	87,000	120,800	67,131
Nova Scotia . .	20,800	128,300	74,356
Prince Edward Island . .	3,000	5,300	2,439
Yukon and North-west Territories.	125,200	275,300	13,199
Canada . .	20,197,000	33,113,200	5,349,232

addition to the total of 33,113,200 at the foot of column 3, bringing it up to about 44,000,000 and justifying the use earlier in this article of the estimate of "fully 40 million horse-power" as definitely located up to the present.

The figure of 5,349,232 given as the total turbine installation horse-power to Jan. 1 last takes no account of a number of large installations which were nearing completion about that date, or of a number of others which were in the initial stages of development. It is estimated that these uncompleted undertakings will add something like 1,200,000 horse-power to the total, and there is every prospect of further important enterprises being begun. For example, the Gatineau Power Company placed six large units of generating plant, each of 34,000 h.p. capacity, in operation at their Paugan Station on the Gatineau River in September last, with provision for two additional units of the same capacity. The same Company was simultaneously installing a fourth unit at each of two other stations lower down the Gatineau River, namely, at Chelsea and Farmers' Rapids (Fig. 2). These new units were so far advanced as to be expected to be in operation early this year. At Chute-à-Carron, on the Saguenay River, works are in progress for an initial installation of four units each of 65,000 horse-power, and these are under contract to be completed by July 1931, to be followed by additional units of an aggregate of about a million horse-power.

So much for the sources and extent of generation. It will be interesting now to consider the ultimate application of this vast accumulation of motive power. There are three main sources of absorption; first, the central electric station for general and municipal purposes; secondly, the pulp and paper industry; and lastly, miscellaneous industries, including mining. The first requires little or no comment. The central station is a characteristic and outstanding feature in modern civilisation; from it radiate supplies of electricity for domestic and street lighting, for power, heating, traction, and numerous uses of various kinds. The pulp and paper industry is Canada's chief manufacturing activity. The gross and net values of production and the disbursements in salaries and wages in this industry are greater than those of any other Canadian industry, while the national output of newsprint, that is, paper prepared for the newspaper printing press, during the last completed census year exceeded that of any other country. Some of the power required for the purpose is generated directly at the mills from a local water supply, in other cases it is taken by purchase from a central station; jointly, the quantity utilised in the industry is 25 per cent of the whole output of the Dominion. As regards the mineral industries, it can be said that the profitable operation of many

TABLE II.

DEVELOPED WATER POWER IN CANADA.

Distribution by Industries and Per 1000 of Population.

Jan. 1, 1929.

Province.	Turbine Installation in H.P.				Population, June 1, 1928.	Total Installation per 1000 Population, H.P.
	In Central Electric Stations.	In Pulp and Paper Mills.	In other Industries.	Total.		
British Columbia	412,960	81,000	60,832	554,792	583,000	952
Alberta	34,320	..	212	34,532	631,900	55
Saskatchewan	..	..	35	35	851,000	0·04
Manitoba	311,925	..	..	311,925	655,000	476
Ontario	1,568,423	240,880	94,402	1,903,705	3,229,000	590
Quebec	2,030,850	220,810	135,458	2,387,118	2,647,000	902
New Brunswick	43,910	14,278	8,943	67,131	415,000	162
Nova Scotia	42,929	16,008	15,419	74,356	547,000	136
Prince Edward Island . . .	376	..	2,063	2,439	86,400	28
Yukon and North-west Territories .	..	..	13,199	13,199	12,700	1,039
Canada	4,445,693	572,976	330,563	5,349,232	9,658,000	554

of the Canadian mines is only made possible by the low cost at which ample supplies of power can be obtained from hydro-electric sources. Fuel power would in many cases be prohibitive. It is affirmed in one of the Government reports that without the aid of water power the mining industry of Canada could not have approached its present magnitude.

Table II. shows, as at Jan. 1, 1929, the distribution of developed water power in Canada under the three heads detailed above. Column 2 in the table includes only hydro-electric stations which develop power for sale. Columns 3 and 4 comprise the power specifically generated for the industries in question. As explained above, additional and large supplies of power are obtained by purchase from the central stations.

It is interesting to note that the total outstanding capital invested in water-power developments represents an average of 219 dollars, or about £44 per horse-power installed, including transmission and distribution—quite a low figure compared with that of other countries under similar conditions.

Fully to describe and expound the striking figures collected and published by the Canadian Government would require much more space than can be allocated to the subject here. They are eloquent of vigorous progress and unflagging enterprise. To the ordinary reader they are full of interest; to the observant visitor they are a confirmation of impressions received from numerous striking spectacles; and to the scientific inquirer they open out a vista of wonderful possibilities for a country which is yet on the threshold of its career.

The Original Home and Mode of Dispersal of the Coconut.

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THE origin and mode of dispersal of the coconut, which is now widespread throughout the tropics of the Old and New Worlds, has long been a subject of discussion. De Candolle, Beccari, Chiovenda,[1] and others consider the coconut originated in the Indian Archipelago or in the Pacific Islands, while O. F. Cook[2] attempts to prove that its origin was in the valleys of the Andes of Colombia in South America and that it was transported thence, entirely by human agency, far and wide across the tropic seas. H. B. Guppy[3] also holds the opinion that the home of the genus *Cocos* is in America, while Geoffrey Smith[4] states, on information given him by Mr. Hedley of Sydney, that the coconut was introduced to the Pacific Islands from Mexico by Polynesian mariners. Cook asserts that it is highly improbable that sea-borne coconuts could ever be cast up on a shore in such a favourable position that they could germinate without the aid of man, and Schimper[5] considers that the coconut groves "fringing most tropical coasts have only exceptionally originated without human aid". The fact remains, however, that coconuts are the common strand palms on almost every tropical island and that they were found well-established when many of these uninhabited islands were discovered.

Another fact which lends support to the original home of the coconut being the Indian Archipelago or Polynesia is the great variety of the coconuts now found in the East. Many of these varieties have well-marked characteristics such as colour of the nuts, thickness of the husks, etc., and many of these special kinds are grown specially for religious ceremonies among the Hindus, which also points to the palm being of great antiquity in South India. The hereditary occupation of the Tiyans of the Malabar Coast also is the tapping of coconuts for toddy.[6] Then, again, the Tamil and Malayalum name for the coconut is *tengai* (*ten* = south, *kai* = fruit), that is, the fruit which comes from the south.

Chiovenda[1] (l.c. pp. 397-399) quotes a reference to the coconut in Indian medical literature, supposed to date back to 1400 B.C., and a statement of Ctesia that coconut oil was in common use in India in 400 B.C. He cites evidence that the coconut was widely cultivated in the Gangetic Plain in the first century of the Christian era, and refers also to two Arabian travellers, Abu Said and Ibn Wahab, who in the ninth century went as an envoy to China and reported that the Laccadive and Maldive Islands were covered with coconut palms, which appeared to be indigenous there. One of these travellers also made the interesting statement of the existence in India of a religious sect, which, for humanitarian reasons, introduced and propagated the coconut on those islands where it did not already exist.

The name 'coco' appears to be due to the Portuguese,[7] and they were made acquainted with the palm from their voyages in the East. The commonest word in the languages of the Pacific for the coconut is some form of the Indonesian

[1] Beccari, O. *Ann. Jard. Bot. Buitenzorg*, Supp. 3, pt. 2, 1910, pp. 799-806, and Malesia, I., p. 86. Chiovenda, Emilio, *Webbia*, vol. 5, pt. 2, pp. 359-449 (1923).

[2] Cook, O. F. *Contrib.* from U.S. Natl. Herb., **2**, p. 257 (1901), and also "History of the Cocoa-nut Palm in America", *Contrib.* from U.S. Natl. Herb., **14**, pt. 2, pp. 271-342 (1910).

[3] Guppy, H. B. "Observations of a Naturalist in the Pacific", vol. 2, 1906, pp. 67, 413.

[4] Smith, Geoffrey. "Cambridge Natural History", Crustacea, pp. 173-175.

[5] Schimper. "Plant Geography", Eng. ed., I., p. 231.

[6] See Sampson, H. C. "The Coconut Palm", 1923, p. 74 *et seq.*

[7] "The Simples and Drugs of India", Garcia Da Orta (1563), translated by Sir Clements Markham, p. 139; also "Roterio", Vasco da Gama (1498) and the book of Barbosa (1516).

Garcia da Orta generally spells the name *coquo*: "We, the Portuguese," he writes, "with reference to those three holes, gave it the name of Coco (Spanish *macoco*, for monkey-faced), because it seems like the face of an ape or other animal." With regard to other names, he says the palm is called Maro and the fruit Narel, and this word Narel is common to all, for it is used by Persians and Arabs (*narikela* Sanskrit, in Persian *nargila*, a name given to the 'hubble-bubble', or Indian smoking stand-pipe, from the shell of a coconut being generally used to contain the water through which the smoke from the tobacco bowl is sucked through a long, flexible serpentine pipe; and *nari-kela* simply means 'water spring' or 'squirt').

"Avicenna calls it Jauzialindi, which means 'nut of India' (Jauzulhindi, the Indian nut). Serapio and Rasis call the tree Jaralnare, which means 'the tree that yields Coco' (Jaralnari, the Naril tree). The Malabar people call the tree Tengamaram (the Southern Tree, *i.e.* introduced from Ceylon), and the fruit when it is ripe Tenga. The Malays call the tree Tricam (Trinarajah, 'King of Grasses,' is a Sanskrit name for the coconut palm), and the coconut Nihor."

It is also of interest (l.c. p. 141) to note that the word 'coir' comes from the Malabar Kayiru, the fibrous rind of the coconut (see also Watt, "Dictionary of the Economic Products of India").