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IT is a far cry from the time when a university rejected the application of Michael Faraday, father of electricity, for a position as professor of physics, to the present world-wide use of electric power, servant of industry, agriculture, and the home. Men were puzzled by its elusive forces from the time of their first discovery at least 3,000 years ago up to the end of the last century, but nowadays the functions performed by harnessed electricity are extended year by year. New and more powerful techniques of its use are opening up new ways of life, and creating new needs as well as easier ways of meeting old needs. In Canada, development of water power has been one of the greatest forces in making available for use in industry and the home the natural resources of farm, forest and mine. Significant in the growth of manufacturing is the fact that 50 per cent of the total available water resources, and about 83 per cent of the developed water power, are located in the highly-industrialized provinces, in which there are no known adequate coal resources. Hydro-electric production has been increased greatly in the central provinces, and especially in Quebec, during the war, and they are now facing the need to secure peace-time users, while the other provinces are seized of the need for development of power and the servicing of many municipalities and farm homes hitherto without electricity. Just last month, an agreement was reached between Quebec and Ontario with the effect of setting in motion the latter's five-year program in which $200 million will be expended. This plan, for development of a site on the Upper Ottawa River, will provide employment for 15,000 workers.

The fear of some that there will be an uneconomic glut in the first several peace years is unfounded, according to widespread opinion among leaders in the electrical field, because new uses, adaptable to peace-time, have been developed, and new machines will call for a greater current, while extension of service to municipalities not now served will help take up the slack.

After all the difficulties which beset the production of electric power in its early days, and the invention of apparatus to employ it, the distribution and use problems of today will seem relatively simple. It is recalled that Sir Humphrey Davy devised the electric arc lamp, but to produce light he needed a battery of 2,000 cells; as late as 1834 it still cost about $5 a minute. Edison took up the problem in 1877, spending $100,000 and trying 6,000 different substances before he produced a satisfactory filament for the first incandescent lamp. Canada has progressed rapidly in making use of electricity. The first telegraph line was set up in 1846-7, linking Toronto with Hamilton, St. Catharines, and Niagara Falls, and in the latter year Quebec and Toronto were linked. The telephone was invented in Canada, and in 1876 Alexander Graham Bell spoke a distance of 8 miles, from Brantford to Paris, Ontario. The incandescent lamp made its appearance in Canada in 1880, and two years later power developed by water flow was used to illuminate a sawmill in Ottawa, the earliest recorded operation in Canada. St. Catharines is credited with having the first electric street car service in the country, starting in 1887. It is not generally known that Canada pioneered in the transmission of electric power. Following development of the high-tension transformer, and improvement in insulating materials, a line was constructed in 1897 between St. Narcisse and Three Rivers, Quebec, the first high-tension transmission line in the British Empire. Five years later the 85-mile line from Shaw-

inigan to Montreal was the longest in the world. Technical advances have resulted in the steady growth of transmission distances and voltages in Canada. At the beginning of the first world war, water-power plants in Canada had a total installed capacity of 1,700,000 horse-power; by the end of 1939, when the second war had just started, this total had grown to 8,289,000 horse-power, 4¾ times the installed capacity of 1914, and in January 1945 the hydraulic turbine horsepower was 10,283,763.

This expansion in the production of electric power from water is made possible by Canada's great fresh water reservoir with a lake area of 228,307 square miles, larger than that of any other country. In its flow to the sea, much of it from considerable altitudes, this water can be tapped again and again to operate turbines at points where there are rapids and falls. The available water-power totals 25,439,000 horse-power under conditions of ordinary minimum flow, and 39,511,700 horse-power ordinarily available for 6 months of the year. These figures include only sites of which the actual drop or the head possible of concentration has been measured or carefully estimated, and in addition there are many unrecorded rapids and falls of undetermined power capacity, according to the latest report of the Department of Mines and Resources. In the current Canada Year Book it is recorded that the turbine installation at the end of 1943 represents slightly less than 20 per cent of the present recorded water-power resources. This estimate, involving 51,350,000 horse-power, is based upon the fact that it is feasible in most developments to install equipment with capacity considerably greater than the theoretical continuous power of the water fall.

Compared with other nations, Canada stands very high in electrical possibilities. She has a relatively small population, scattered throughout the Dominion, but remarkable industrial developments have been achieved because of the proximity of water power to her great natural resources, though the saturation point is still far distant. In 1938, Canada was second only to the United States in developed water power, and in potential water power resources Canada ranked fifth among the nations. The Dominion has one great advantage in that abundant power is available within transmission distance of prospective markets, a condition not believed to exist in Russia, India or Brazil, the only other countries, besides the United States, outranking Canada's potential resources. Just before the war, the London Economist found the consumption of electricity per head of population to be: Great Britain 414, United States 771, and Canada 2,200 kilowatt hours, while the average installation per 1,000 population in Canada at the beginning of 1945 was 859 horse-power, a total which gives Canada an outstanding position among water power using countries.

What this development means in terms of man-power may be seen by comparing the results of muscular power and electric power. The labour of a strong man is said to be equal to about one-tenth of a horse-power, so the presently developed horse-power in Canada is equal to the labour of 103 million men. Electricity has become the greatest tool of the age, lessening manual labour greatly, and giving greater efficiency to productive activity through its flexibility and economy. This was revealed during the war, when the continuous flow of energy from power stations over networks of interconnected transmission systems made possible Canada's tremendous production of war materials. All available power was absorbed, and there had to be, of course, a re-alignment of distribution to meet the demands of munition factories. Secondary power was diverted to primary use; there was a diversion of additional water at Niagara Falls; existing transmission lines and new lines were interconnected so as to permit the shuttling of power to the points of greatest demand; limitations were placed upon the use of street light, store window lighting, and outdoor signs, and there were other slight curtailments in the use of electricity for commercial and domestic purposes. Measures taken up to 1942 were satisfactory, but a deficit of power at that time resulted in an enforced reduction of output in the paper industry, and in other non-war activities.

After the first world war surplus power was diverted to some extent to the raising of process steam in the pulp and paper industry, and the use of surplus or secondary power in electric boilers reached a maximum in 1937, when 7,313 million kilowatt hours were sold for this purpose. At the outbreak of the second war, a large volume of power existed that could be turned back to primary use in war industries. Primary power is the highest type of service, and the highest priced. It is available to the consumer at uniform voltage, 24 hours a day, up to the limit of his contract, while secondary power supply is indefinite and service is not guaranteed. During the period September 1939 to September 1943, production of primary power for use in Canada increased 84 per cent, while secondary power was reduced by 67 per cent, and instead of constituting 25 per cent of the total power output of central electric stations it was only 5.4 per cent.

Because of its abundance of water resources, Canada as a whole is not much involved in the question of water power versus fuel-generated power. More than 97½ per cent of all electricity produced for sale in Canada or for export originates in water power. It is said that a ton of water would have to drop a mile to generate the same amount of energy as there is in a pound of coal, properly burned, but when coal and water power are equally plentiful the choice lies between hydro installation's high capital outlay but low running costs, and the lower installation expense but much higher running costs of coal provision. In the long view, notice must be taken of the fact that water power resources are not diminished with use, while coal supplies do become depleted. Saskatchewan and Nova Scotia are the only two provinces using substantial quantities of fuel to develop electric power. New Brunswick and Nova Scotia have strategically-located coal; Saskatchewan has coal and lignite deposits; Alberta has coal, natural

gas and oil; British Columbia has coal. In localities where adequate water-power resources are not available, fuel will continue to play an important part in development of power, but in Canada as a whole, power produced by water flow will continue to predominate. The Department of Mines and Rescources points out that the equivalent of hydro-electric energy actually used in 1944 would be 25½ million tons of coal. In 1943 Canada's total coal production amounted to 18 million tons. Besides the fuels already mentioned, there are many practical and some as yet unproven ways of generating electricity. Tidal water power may become important in the Maritimes, though it has not been developed to date. Fumaroles (crevices in the ground through which steam escapes) have been developed in recent years so as to yield large supplies of steam for power generation. Italy set up four fumarole central power houses which develop 25,000 horse power to serve Florence, Pisa, and other cities, while four of the wells sunk in fumarole fields in California are said to deliver an average of 1,300 horse-power each.

More than 90 per cent of Canada's hydraulic power is developed in central power stations, which include stations privately owned and operated, stations owned and operated by municipal or provincial governments, and stations selling or distributing electric energy whether generated by themselves or purchased for resale. In 1900 the total installation in central electric stations was only 33 per cent of the total installation, whereas now it is 90 per cent. The war-time increase in electric energy generated in central stations was 43 per cent. There were, in 1942, nearly 20,000 persons employed, and customers numbered 2,126,000. The number of customers increased every year since 1920, except two, and the 18-year increase up to 1938 was 110 per cent. While domestic service customers make up 80 per cent of the increase, domestic service consumption of electricity is only about 8 per cent of the total consumption.

Water developed power is the driving force of the machinery used in the manufacturing and mining industries, both of which relied upon electricity for more than one-half of their power needs as far back as 1923, and today electric motors do four-fifths of the work in these industries. In the 17 years prior to 1942, the increase in total capacity of power equipment in the two industries was 189 per cent, and in the ten years previous to the outbreak of war the number of electric motors in the manufacturing industry increased 41 per cent.

Canada's mining industries are highly electrified. There was an almost continuous increase in hydro-electric power development for mining from the turn of the century up to 1941, when the war had a reducing effect upon gold and some other mining activities. According to a booklet published by Ontario's Hydro Commission, the first hydro-electric power to be used by the mining industry was generated on the Spanish River, one plant being completed in 1905. More than 80 per cent of equipment employed in metal mining and in the smelting and refining of ores is operated by hydro-electricity supplied by central stations, and most of the small amount of fuel-operated equipment at the mines is for emergency use. The economy involved in use of hydro power enables the mines to treat lower grade ores than would be possible with any other motive power.

The pulp and paper industry is the largest individual buyer of central station power, using as much as 40 to 50 per cent of all power sold for industrial purposes. War reduced this percentage to less than 25 per cent, due to diversion of great amounts of power to munitions production.

There has been a steady growth in the use of electricity in the home, and Ontario's Hydro Commission reports that during the past 30 years kilowatt hours consumption per month has increased from an average of 21 to 185, while cost in Ontario has decreased from 5.8 cents to 1.19 cents per kilowatt hour. This is a long way from the surprise of guests at a banquet in Ottawa celebrating the opening of the newly electrified street railway in 1893, when it was announced that the meal had been cooked by electricity. The average number of domestic customers per 100 population has increased from 9 in 1920 to 16 in 1943, a jump of 77 per cent. Electricity is wired into about 60 per cent of all Canadian homes. There was an increase of 500,000 customers between 1930 and 1942; average domestic consumption per customer increased 400 kilowatt hours; and the average charge per kilowatt hour decreased 0.42 cents. Increase in the number of customers ranged from 20 per cent in Manitoba to 64 per cent in Nova Scotia during the years 1934 to 1943.

Electric power on the farm, much talked about today, would be no cure-all for the disabilities of agriculture, but it would make a substantial contribution to improvement. Electricity would be a great aid to farmers by increasing production, saving labour, and improving their standard of living at low cost. Larger output at smaller cost can be achieved by electricity in most kinds of farming, and advancing techniques in artificial sunlight, quick freezing of fruits and vegetables, and dehydration, open up new avenues of revenue-paying activities. Dr. Lee de Forest has predicted that one of the next big developments in electricity will be a method of electrifying farms so that two and three crops will be harvested every year. It hasn't come to that yet, but proper use of electric power will increase farm income, and the growth of rural electrification indicates that farmers regard it as practical. It removes drudgery and inconvenience from farm work and farm living; it will reduce the working hours of the farmer, his wife and children; it will help to keep young people on the land. There are more than 300 uses for electricity on farms, according to the United States Rural Electrification Administration, because, unlike the city home, the farmstead is a miniature factory as well as a residence. Provision of abundant fresh water on a farm where cows are kept improves milk production and increases the poundage of butter fat, but this cannot be assured until electric pumps, keeping cisterns filled automatically, oust the old oaken bucket. To provide the average farm family of 5 with water for a year, and to supply water for 4 cows, 3 beef cattle, a team of

horses, 12 hogs, and 150 poultry would consume 440 hours of hand pumping a year, equal to 55 eight-hour days. All of that can be eliminated by installation of an electrically-driven pump.

Due to war conditions and the need of industries for current, extension of power systems to rural areas has been curtailed during the past several years. Indeed, the situation has not yet brightened greatly. Shortage of materials, it was reported at the end of November, has held up farm electrification planned for this year in Manitoba, and only about half the farms looking forward to electric power will be served. However, indications are that many farmers will soon be carrying out the rite of burying a kerosene lantern at the site of new electrical installations to symbolize emergence from the farm's dark age. The Census showed that 19.8 per cent of farms were electrified in 1941, including those which were using wind and gasoline electric charger plants. The provincial percentages, comparing 1931 with 1941, follow:

Province	1931	1941
Prince Edward Island	3.5	5.4
Nova Scotia	8.3	26.0
New Brunswick	8.6	18.5
Quebec	13.2	23.3
Ontario	12.8	37.0
Manitoba	2.3	7.3
Saskatchewan	1.4	4.7
Alberta	1.7	5.4
British Columbia	21.8	35.8

It was pointed out that the larger percentages in some provinces could be attributed to the fact that they had smaller farms, closer together and therefore easier to serve. In Ontario, lines were not generally built unless there was assurance of at least two customers per mile of line, while in Quebec one area had nearly 6 customers per mile.

Some farms may be denied the benefit of laid-on electricity, because they are located in areas of sparse population, or are cut off from normal service by physical barriers. In such cases, self-contained electrical generating units may be used. There is great variety of wind and fuel driven plants, to suit various sizes of farms and differing needs. A survey in Alberta indicated the average investment to be $400 in wind and fuel plants, and $700 in combination plants.

The spread of electricity for domestic and farm use is not only a benefit to those receiving it, but to many industries and their workers. Besides using great quantities of steel and copper, the electrical industry must meet the demands of consumers for hundreds of other products on which considerable manufacturing has been done. Figures are difficult to obtain, but it is estimated that for every 100 hours employed in line construction the manufacturers are called upon to produce equipment requiring about 300 man-hours of work. A United States appraisal sets the expenditure by every newly-connected customer for appliances and equipment at $400, and asserts that in addition 35 per cent of the new users of electricity will install water systems and plumbing at a cost of $225. Ontario estimates that its five-year rural electrification plan will take 26,230 man-years, or an average of 5,000 men for each year. Direct labour required by the Commission amounts to 2,000 man-years, and the balance is made up of indirect labour employed in manufacture and installation of material and appliances. There were, in 1941, 211 establishments manufacturing electrical apparatus and supplies in Canada, with a combined capital of $128,317,208. They employed 24,000 men and 9,000 women, and the gross value of their products in a year was $178 million. Twenty five years ago there were 100 plants, with a gross product of $34½ million.

There is no single figure that will give an "average" cost of electricity, because this cost varies according to use, quantity and service. Comparisons between provinces and municipalities cannot be correct if they attempt to consider the cost of electricity in the aggregate of all services, since one section may charge a higher rate for domestic current and a lower rate for industrial current, while other sections have smaller bills for domestic use and higher bills for other purposes. With these limitations in mind, the following record of index numbers of the cost of electricity for domestic service in 1943 may still be interesting, though there have been changes in some provinces during the past two years. The index is computed on the base 1935 to 1939 equal to 100.

Prince Edward Island	94.12
Nova Scotia	89.03
New Brunswick	100.02
Quebec	97.19
Ontario	96.06
Manitoba	106.12
Saskatchewan	108.42
Alberta	89.18
British Columbia	100.54

Individual cost of operating household electrical appliances is very low, the cost per hour, as estimated by an electrical authority, being one-eight to one-tenth cent for a 60-watt bulb; less than a half cent for an electric refrigerator, and one to one and one-third cents for operation of an electric iron. This low cost is an important factor in making popular the household appliances which provide business for so many factories, and the low charge for industrial power is important in keeping down prices and providing employment.

Further promotion of the use of electric power may well be one of the projects helping toward prosperity in peace. Attention of those who express fear that increasing use of electricity will mean fewer jobs should be directed to the new industries which can arise only upon the basis of plentiful and cheap hydro power. New products will be made, and the general standard of living will improve. In its peace-time use, electricity has given more than 60 per cent of Canada's population the use of light, home conveniences and labour-saving machines which help living conditions. All provinces are determined that this boon shall be extended as quickly as possible to as many as possible of the remaining 40 per cent.

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