CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS
MINES BRANCH

POWER AND POPULATION

CANADA'S PRESENT ELECTRICITY REQUIREMENTS AND THE LONG-TERM OUTLOOK

by

C. E. BALTZER AND JOHN CONVEY
FUELS DIVISION

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WILD WATER -- UNGAVA REGION OF QUEBEC.
Unharnessed potential at Eaton Canyon Falls, Kaniapiskau River. (N.F.B.)

PREFACE

No sector of utilization of Canada's resources reflects the economic growth of the Nation more than does the increasing use of electric power. During the decade since the war, the consumption of electric power has been doubled.

Part of this increase can be attributed to the rapid electrification of rural areas and a very large increase in the use of domestic appliances which have become readily available to a population whose standard of living generally has kept in step with the increased prosperity of the land. Population therefore plays an important part in the consideration of electric power requirements. On the other hand, Canada is one of the few countries of the world endowed with any large hydraulic resources capable of providing hydro-electric power at costs that have attracted and will continue to attract large electro-chemical industries.

The regional availability of energy resources and the varied geography of the Canadian provinces with concentration of population in some areas and sparsity in others are factors that have an important bearing on the development of electric power facilities. Also, the regional character of energy utilization for the generation of electric power is as important in this field as in most other Canadian fields of endeavour.

The Mines Branch has been conducting electric power studies with particular reference to thermo-electric power, as it is evident that hydro-electric power, though plentiful in certain areas, is becoming scarce in others. This report was prepared in the light of these studies and of the Department's intimate knowledge of the mineral areas which are actual or potential large users of electric power, particularly at the smelting and refining stages of the metallurgical industry.

The last decade's upsurge in the use of electric power raises the question as to whether this rate of increase will be maintained in the future, bearing in mind that the Canadian level of consumption - it is second largest in the world per capita - is so much higher than say in 1946. An attempt is made in this report to give a regional forecast of the requirements terminating with the next two decades.

A survey of this nature must necessarily be statistical in character, but for easier reading an attempt has been made to write in a popular or non-technical style.

Ottawa, Canada.
July, 1956.

G. S. Hume,
Acting Deputy Minister.

POWER AND POPULATION

Canada's Present Electricity Requirements and the Long-term Outlook

by

C.E. Baltzer and John Convey*

When the history of the western civilization of our time is written the second half of the twentieth century will undoubtedly be termed the era of power - and we are only at the threshold of this era.

Through the ages man has endeavoured to replace muscle power by mechanical power. Would not the builders of the Pyramids, which are a marvel to us, be astonished to see the much more massive structure of a large modern hydro-electric dam constructed - in a fraction of the time needed to build a pyramid - with the aid of mechanical power and in turn used for producing more power ?

Power is derived from energy, provided by falling water, the blowing of wind, the radiation of heat from the sun, the burning of wood and fossil fuels, such as coal, oil, and natural gas and, more recently, by the fission of the atom. Man has wished to harness all these to give him power that would multiply the effort of his arm or the pull of a trained animal.

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All these forms of energy contribute to the power pool. Some as yet not commercially applied, like solar energy and atomic fission, may play a more important role with better understanding of the science of heat transfer. But it is the energy of steam and, latterly, electricity, converted to useful mechanical power, that has given impetus to the use of power on a large scale, thereby contributing in a revolutionary manner to the wealth of the world and to an improved standard of living. It has been estimated that during the last 100 years there has been consumed almost half as much energy as was consumed in the world from the birth of Christ to the mid-nineteenth century, when the Industrial Revolution was just commencing. The consumption in 1950 was 10 times that of 1850, and the prediction has been made that by the end of the present century the rate of consumption will again have multiplied at least ten times.

It was the invention and perfecting of the steam-engine, followed by the electric motor and, at the turn of the last century, the internal combustion engine, that caused the spectacular upsurge in the consumption of energy for conversion to useful power. Their impact revolutionized human society. Today, steam and electricity make their greatest contribution in the stationary power field, and the internal-combustion engine in that of mobile power. The use of all three is interrelated and has caused the "industrialization" in any given nation and in the world as a whole. In common usage, the term "industrialization" implies the development of industry other than agriculture, but in the broader sense of productiveness agriculture should be included. From an occupation which was manual and animal-powered at the beginning of the century, agriculture in advanced countries has

become a mechanized industry; for example in Canada the rural population 25 years ago was about 32 per cent of the country's total, and is now only 19 per cent, yet the productivity of the farms has increased about 60 per cent.

The increase in productiveness in all of man's undertakings goes hand in hand with increase in use of power. A convenient index of growth of a country's industrialization is provided by the amount of electricity produced and consumed. In this article these growth factors, rather than the over-all consumption of energy, are used to inter-relate "Power and Population". It is interesting to note that the architect of the modern communist state - Lenin - speaking of Russia, said in 1917 that "Communism is soviet power plus electrification of the entire land".

Energy, in itself, is not an asset. Until used by man, it has only potential value. Many a hydro-electric generating plant in Canada stands at a site where there was only falling water for eons of time until man was ready to use the energy for conversion to power. It has become axiomatic that power and population are closely related. For background of our power study we should therefore take a brief survey of the world's population. This has been estimated at somewhat under 300 million at the birth of Christ, had increased by 1850 to somewhat over one billion inhabitants, at 1950 had again more than doubled, and may be estimated as high as six billion inhabitants 100 years from now. If we consider energy requirements, it has been estimated that each present world inhabitant consumes on the average 2,400 heat units daily in the form of food and 6,000 units for heat and power.

It is interesting to compare these average consumption figures with those for the United States, where the daily use of each inhabitant is estimated at 3,000 heat units for nourishment and 125,000 heat units (20 times the world's average) for heat and power. This strikingly underlines the enormous difference that exists between the most advanced country in the world and the host of under-developed countries in which industrial progress will surely accelerate in the next century.

How do the world's resources of energy measure up to the tremendous potential demand for power? If we consider only fossil fuels, from which three-quarters of the world's energy is currently derived, there are sufficient known coal, oil, and gas resources to meet global requirements for something less than a century at the projected rate of consumption, coal representing more than four-fifths of these resources. It is, therefore, not surprising that there is absorbing interest in the possibilities for power from atomic fission, particularly as estimates for the energy resources of nuclear fuel indicate more than 20 times those of the fossil fuels. These estimates are based on present efficiency rates of energy conversion and undoubtedly economies will be made as the efficiencies increase.

The implications of global figures, as between countries like Canada with surplus energy potentials for many years ahead and countries with energy deficiencies, are outside of scope of this article, but must be of serious concern to all thoughtful people.

What of Canada in regard to power and population? Territorially it is a vast land in which the irregularly distributed populations aggregate less than in

many of the advanced countries of the world, but its people nevertheless enjoy a standard of living second only to that of the United States. In no small measure, Canada's prosperity is due to abundant and cheap hydro-electric power - only in one country (Norway) is there greater use per capita of hydro-electric power. At the turn of the century the population of Canada was not much larger than that of greater New York or greater London, being about 5 million; but from 1900 onward the rate of growth accelerated to give a population of 10 million by around 1930, and exceeding 15 million in 1955. The highest estimate indicates that by 1975 the population should reach 25 million.

The story of Canada's electric power properly begins with this century and is mainly concerned with Central Canada. Here, the broad expanse of the southern portions of the central provinces had abundant waters flowing from lakes of glacial origin constantly replenished by ample precipitation, and an undulating terrain covered by forest that concealed a veritable storehouse of mineral wealth. The forests, having first served a large lumbering industry in the last century, gave birth to the great pulp and paper industry which today is the largest single user of industrial electric power. The mineral industry, developing more slowly because the minerals had to be found by searching, over the years became an important factor, second only to pulp and paper in the demand for power.

This hinterland of forest and mineral wealth had a narrow fringe of early settlement to which the availability of labour attracted small-scale industry from the start, but "industrialization" of southern Ontario and southwest Quebec and, more recently, of Canada as a whole is undoubtedly due in no small measure to the

abundance of cheap power. The story of Ontario and southwest Quebec is presently being duplicated farther eastward in Quebec, also in British Columbia. The yearly figures on per capita production of electricity most strikingly illustrate Canada's position in relation to the two most highly industrialized countries, the United States and United Kingdom, and to the world as a whole. Thus, in 1953 Canada generated 4,734 kilowatt hours per capita; United States 3,231; United Kingdom 1,290; while the world average was 494 kilowatt hours.

The leading position of Canada in per capita production of electricity should not by itself be considered a true index of economic growth or prosperity. A high per capita consumption of electricity in a country or area may merely signify that cheap power has encouraged the exploitation of indigenous resources, for example forests for pulp and paper, and such high utilization of electric power may be achieved with a low population, as in Canada and Norway. In another case, the high per capita consumption of electric power may be due to high standards of living and diversified industries, as in the United States. It will be seen later, from a regional analysis, that in Canada both situations exist.

As might be expected in a country of Canada's size, the varying kinds of energy resources, although plentiful (Chart I), are unequally distributed, and a number of social and economic problems arise from this fact. For this reason, the sources of future power supplies in the various provinces have become a matter of thoughtful concern and urgent study for many Canadians. With the water-power resources of present economic significance already almost completely developed in certain areas, how will the needed electric power be supplied to

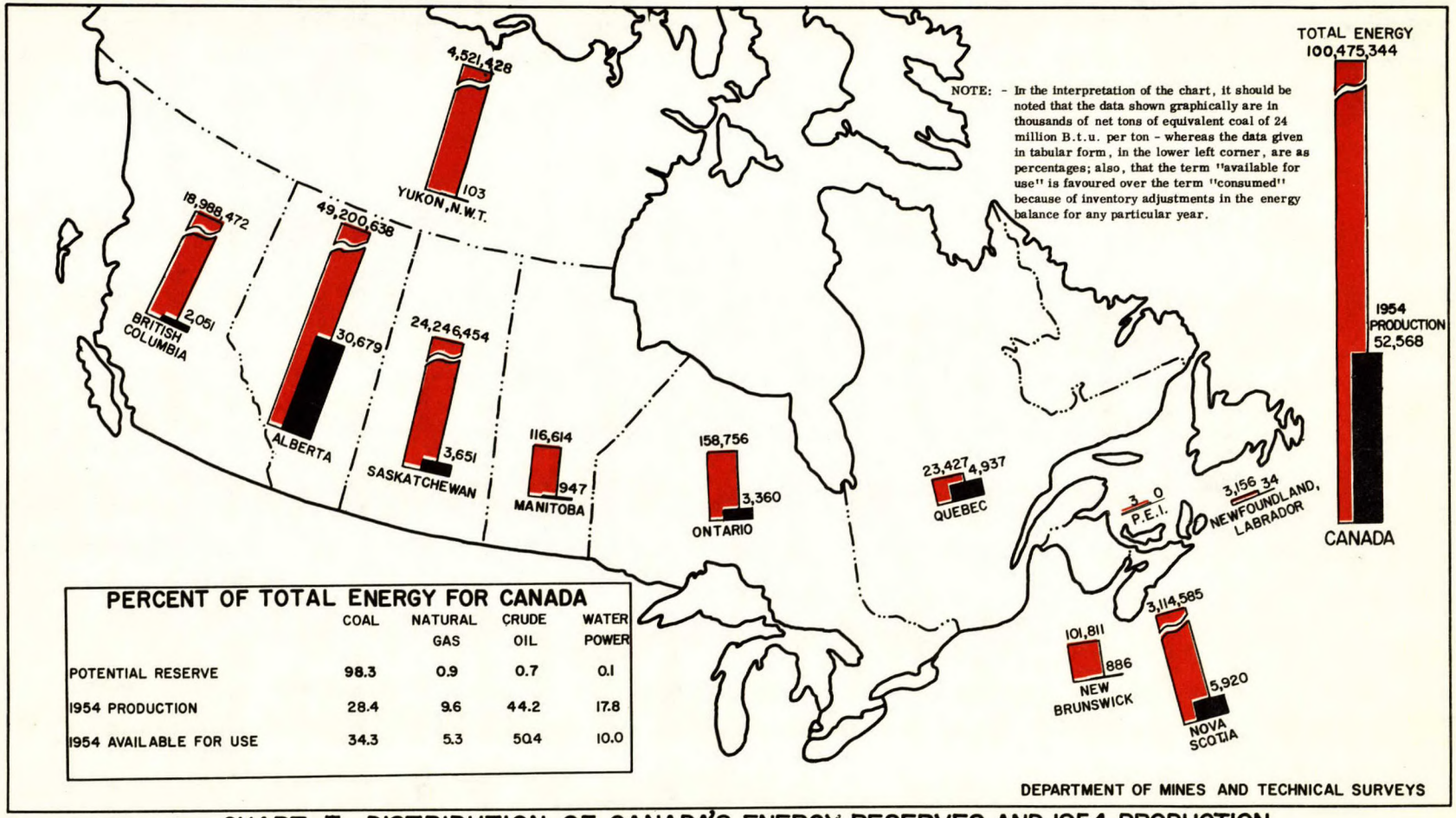


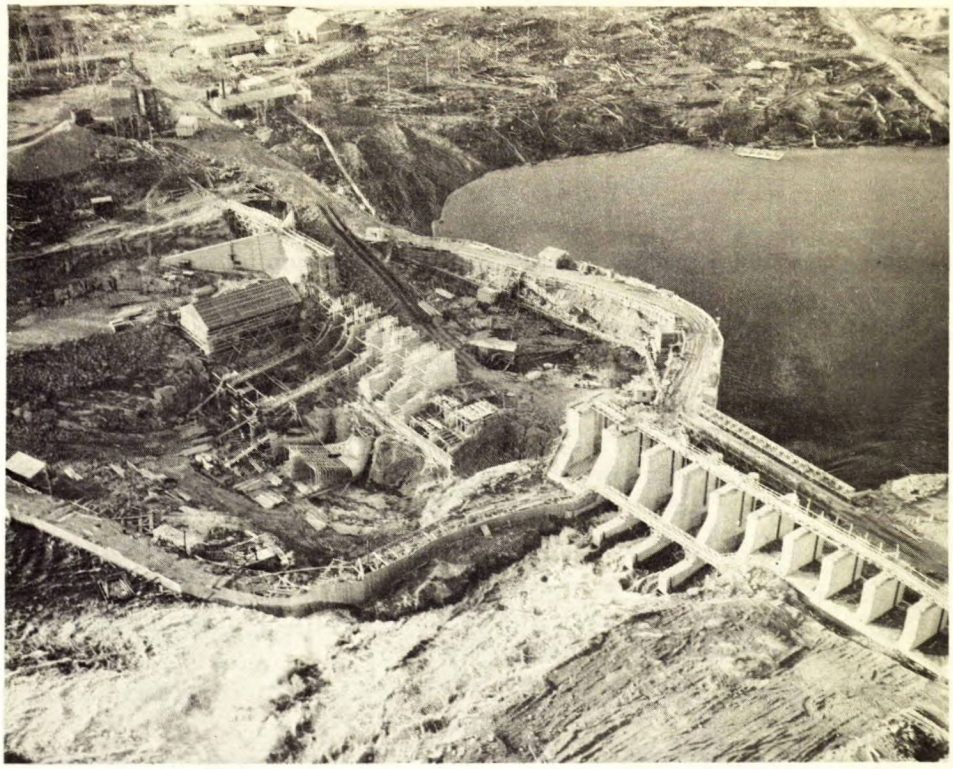
CHART I - DISTRIBUTION OF CANADA'S ENERGY RESERVES AND 1954 PRODUCTION IN THOUSANDS OF NET TONS OF EQUIVALENT COAL

energize further expansion of manufacturing and productive industry and to steadily improve standards of living by greater and more diversified uses of home appliances? Will utilization of fossil fuels, namely coal, petroleum, and natural gas, bulk most largely in providing the power increases, or will the new thermal fuel, uranium, be the source of most of the heat for conversion to power? Some scientists and engineers are looking ahead to harnessing the sun's rays, the power of tide and wind, and the stored heat of earth and water in a more effective manner than has heretofore applied.

The answers to these questions will, of course, depend largely upon how far one cares to look ahead, and in this article an endeavour is made to give a close analytical glance at the requirements and sources of power in the next twenty years to 1975. There are optimists in the field of atomic energy who foresee this source of energy as making a substantial contribution within twenty years. Others view the design problems as stretching out for years and years. Many types of reactors are being evolved, but pending long operational runs of demonstration plants there is no assurance of commercial success. The degree of heat of the atomic combustion or fission that may be controlled needs determination, as do the effects of high temperatures and radiation on fuel elements and on structural components within the reactor. A new science of heat transfer involving radioactive materials has to be developed, and initially only a very small fraction of the potential heat in the fissionable fuel can be extracted, removed from the reactor, and converted to driving force in the steam turbine. Whether it will be more economic to use one-pass fuel elements and waste most of the uranium, or to stretch out the fuel

NEW POWER
FOR
NORTHERN ONTARIO

Under construction
for 1956 operation.



Manitou Falls Generating Station on the English River, 100 miles northwest of Port Arthur. Head - 55 feet. Units - 4 at 18,500 hp each, with provision for the later addition of a fifth unit. (Ontario Hydro photo)

supplies by adopting expensive and involved reprocessing, is not likely to be known for some time.

Before atomic power becomes a commercial reality, a great many engineering and metallurgical problems must be solved. Much design and development will be necessary to scale-up from pilot or prototype units to thermally efficient, long-life, large units, and it is unlikely that great nuclear fission power stations will be brought into operation until after 1975. In the meantime, relatively small commercial atomic stations may enter the economy in areas particularly suitable for their installation and experimental operation. This could happen in northern areas devoid of sources of energy and also in locations where large-scale hydro-electric installation would not be warranted in the next 20 years.

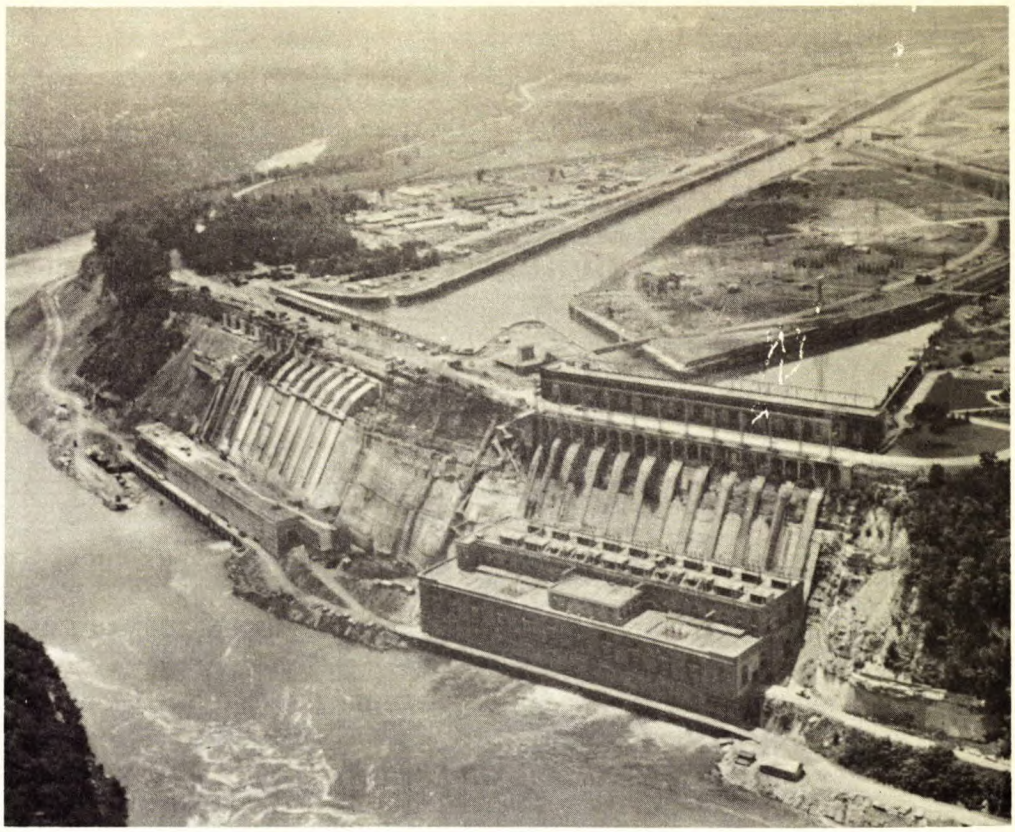
Viewed from the economic standpoint, atomic power can be presently

regarded only as a possible supplement to the power resources in energy-deficient areas. Moreover, Canada could not derive any particular advantage over other countries, since presumably the cost of power from atomic fission will be approximately the same everywhere.

It is obvious that Canada's favourable position in the power field has been responsible for attracting heavy power-consuming industries such as the aluminum industry, and this position will continue to attract them only so long as the cost of power is less than prevails in other industrialized countries. It is, therefore, to the country's advantage to continue to develop hydro-electric power, which, in the view of most authorities, will remain the cheapest power available. The most important contribution that electric power engineers could make would be to devise means for increasing the efficiency and lowering the costs of long-distance transmission, in order to make possible the development of hydraulic sites presently considered too distant from centres of consumption to be economic.

There will be no one solution for providing Canada's power needs in the next two decades, and it may be expected that great smelting, electro-chemical, and other industries relying on heavy power demands will continue to seek locations where large amounts of hydro-electricity can be provided at attractive costs in comparison with other countries. In other areas that may be the most comfortable to live in because of climate, food, transportation, and other amenities, the power demands for manufacturing and for improving standards of living will be great and must be increasingly met by thermal power through the burning of fuel.

ONE OF THE
WORLD'S LARGEST
HYDRO-ELECTRIC
POWER DEVELOPMENTS



The Sir Adam Beck generating stations on the Niagara River at Queenston. Head - 294 feet. Capacity - 1,760,000 hp, to be increased ultimately to 2,388,000. The 2 stations operate as a unit through a centralized control. (Ontario Hydro photo)

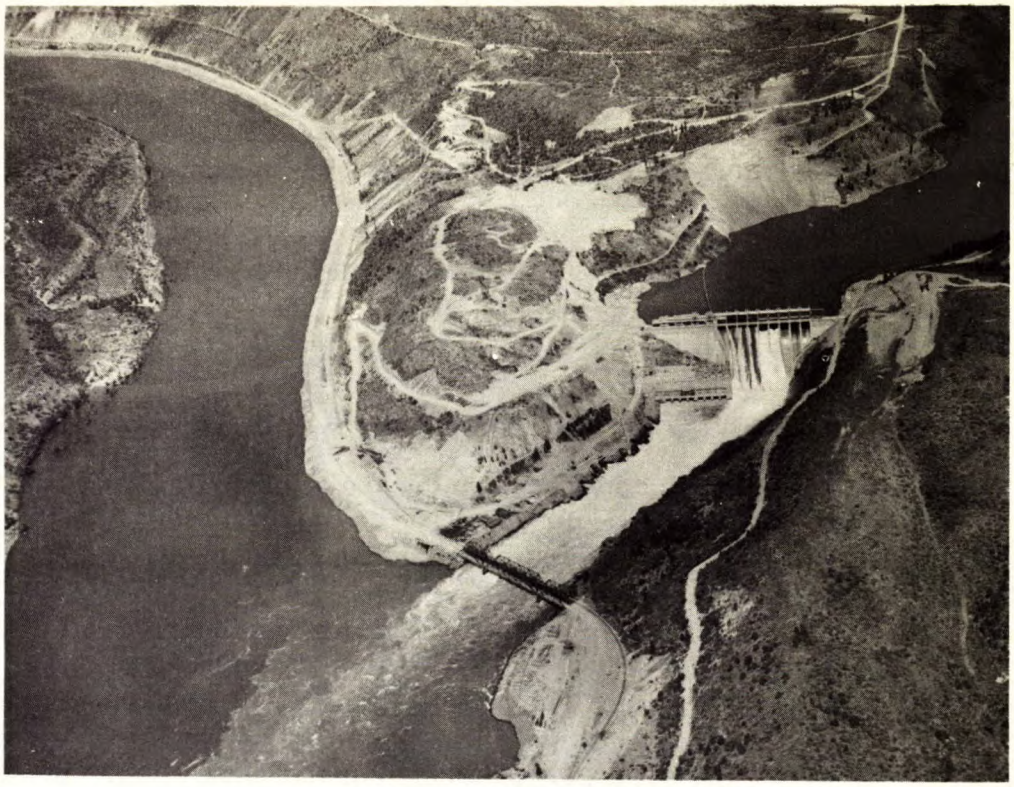
How great are these future demands for electricity expected to be? One estimate made in 1953 forecast the 1975 generating capacity at 46,667,000 kilowatts, requiring expenditures in excess of seventeen billion dollars to achieve. Other assessments since made have been of the same high order. Various bases for making estimates have been used, such as population increase or the economic growth as expressed in the dollar value of the Gross National Product. A more usual method is to make an estimate by applying an annual percentage rate of growth deduced from past growth experience, a method which has a compounding effect, as in the case of money at compound interest. Caution must be exercised in adopting a reasonable increment rate, and in selecting a representative period and one long enough to be considered indicative of the growth trend. Thus in Canada the growth in electricity production over a span of 16 years succeeding the depression showed an annual rate of increase or compound increment of slightly

less than 5 1/2 per cent. On the other hand, during the period 1950 to 1953, or a period of 3 years only, the annual increment rate was 8 per cent. Similarly in the United States, the annual increment rate for the period of 25 years from 1925 to 1950 was slightly over 6 per cent, but during the 1950 to 1953 period it was 10 per cent. The President's Materials Policy Commission (known as the Paley Commission) used an annual increment rate of somewhat more than 5 per cent for projecting the United States' electricity requirement from 1950 to 1975. This rate, when corrected for the shorter period 1953 to 1975, becomes somewhat less than 4 3/4 per cent. It seems justifiable, therefore, to use an annual increment rate of 4 per cent for projecting the Canadian requirement over the period of 22 years from 1953 to 1975.

The expected production for 1975 would then reach about 166 billion kilowatt hours, or somewhat less than 2 1/2 times the production of about 70 billion kilowatt hours in 1953. The population over the same period is estimated to grow to approximately 22,600,000, showing an annual increment rate of just under 2 per cent. Based on these forecasts, the per capita electricity production would rise from 4,734 kilowatt hours in 1953 to 7,331 in 1975.

Does this basis of estimation take sufficient account of relationships between power, industry, and population, not as of today, but as they are likely to be in a couple of decades from now in such a country as Canada, with its industrious population and great wealth in natural resources? Will any of the measuring sticks, for example, adequately allow for "automation", the great new tool of industry whereby electronic brains and other mechanisms will control

POWER FOR MINING, SMELTING, REFINING



Many similar plants serve the pulp and paper and electro-chemical industries. Waneta hydro-electric development on the Pend-d'Oreille River at its confluence with the Columbia, 11 miles south of Trail, B.C. Head - 210 feet. Capacity - 240,000 hp to be increased ultimately to 480,000 hp.

machine tools, furnaces, and other devices to produce a vastly increased output per man-day? Or will our estimated expansion provide the electricity for new conditions of work and living such as fully air-conditioned homes and factories? Against the catalogue of demands for more power, it is to be expected that there will be increased efficiency in the transformation of energy to mechanical power in thermal plants, a factor which could lower costs and again increase the demands for electricity.

However, the estimate of 166 billion kilowatt hours of production in 1975 is considered to be a conservative projection; the average rate applied takes into consideration accelerated growth in the immediate future and a reduced rate towards the end of the period.

In the foregoing discussion, mention has been made of various factors that could be taken into account in considering estimates of future power requirements. An attempt will now be made to forecast for the various regions of Canada making up the already indicated total requirement of 166 billion kilowatt hours in 1975. For this regional forecasting certain assumptions are made. The figures for production and consumption are considered synonymous. Furthermore, consumption of electric power for domestic, including farm, consumption, is separated from the remainder, which includes commercial and industrial use (Chart II). Domestic consumption is closely related to the standard of living, and it is considered appropriate to make comparisons with the present and projected consumption in the United States.

It is estimated that during the 22-year period from 1953 to 1975 the domestic and farm consumption of electric energy in the United States will increase about 2 1/2 times from 651 kilowatt hours per capita to 1,611. The 1953 figures for Canada is almost the same at 668 kilowatt hours. The projected average increase in the United States is applied to the several Canadian regions, which would seem to be a fair approach, although not applying rates of increase apparent during the last few years in some areas where the consumption has been much below the Canadian average. This basis gives estimates for Ontario, Manitoba, and British Columbia per capita domestic consumptions in 1975 substantially in excess of the projected average United States or Canadian figures, while in the other provinces the projected use would be below the Canadian projected average of 1,650 kilowatt hours.

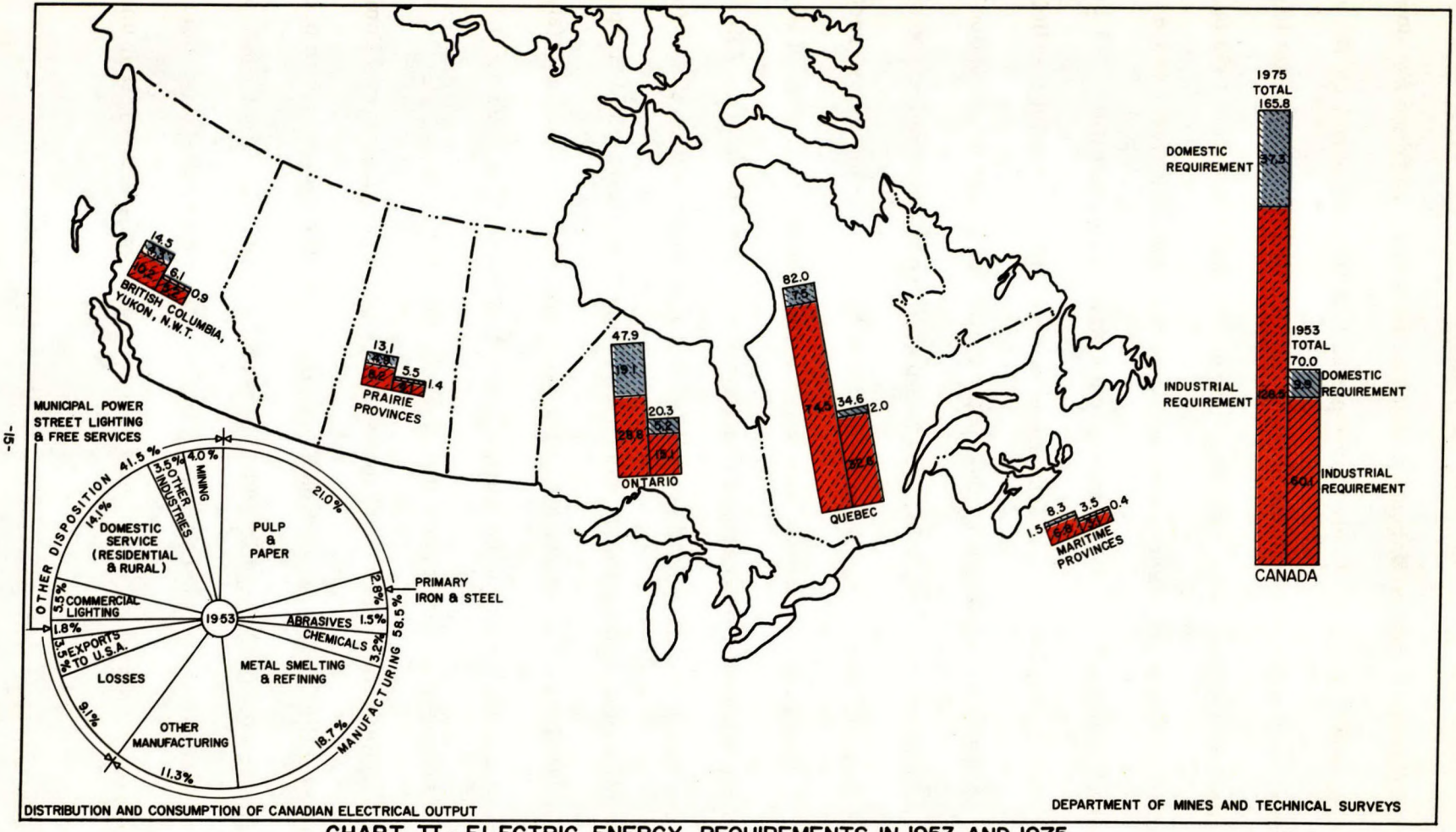


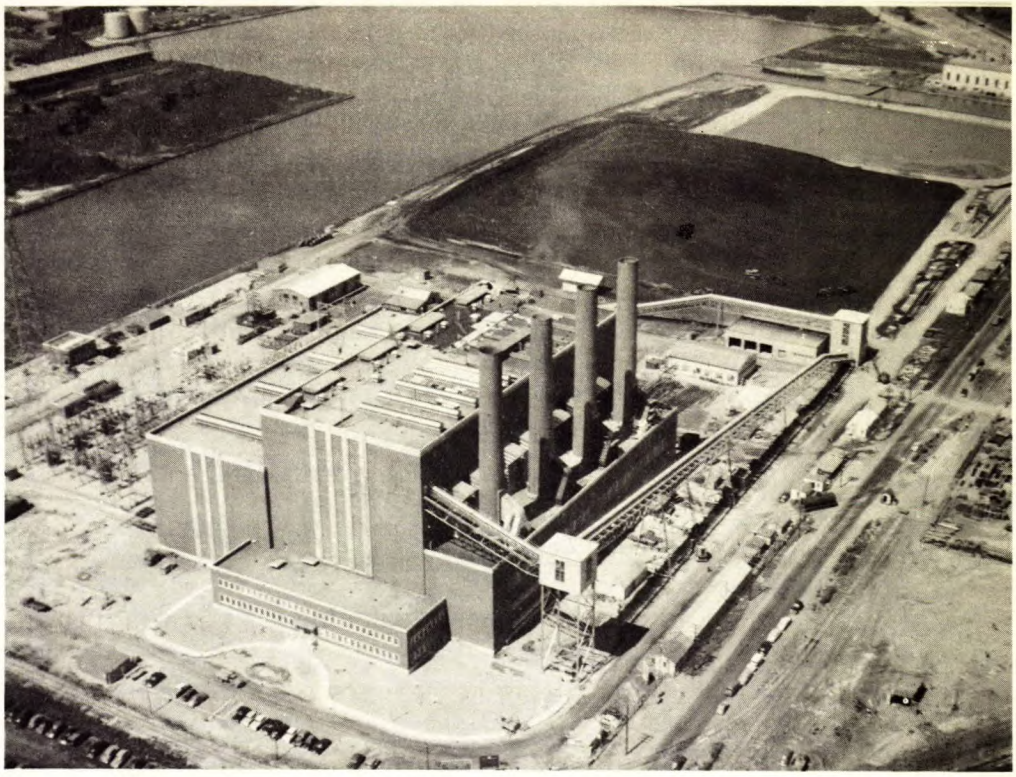
CHART II - ELECTRIC ENERGY REQUIREMENTS IN 1953 AND 1975
BY GEOGRAPHIC DIVISIONS IN BILLIONS OF KILOWATT HOURS

The remainder of the power requirement for industrial and commercial use is deduced by subtracting the amount estimated as required for domestic and farm use from the estimated total power requirement based on the annual growth rate of 4 per cent. It has not been possible from available data to separate commercial from industrial use. The figures indicate that in 1953 the ratio for Canada of domestic power to commercial and industrial power was 1:6 and for the United States 1:4. The estimate indicates that by 1975 a ratio of 1:3 1/2 will apply in both countries. The effect of heavy power-consuming industries in Canada at the present time is shown by the higher industrial power consumption in relation to domestic use. By 1975, Canada's power use would seemingly be similar to that in the United States, if the foregoing estimates are proved correct.

These estimates have been based on the general experience of the North American continent and on reasonable expectations for the future. After carefully reviewing the individual experience and reasonable expectations for each region, it was concluded that a standard mathematical basis could be applied in all computations for forecasting regional requirements. These figures (shown on Chart II) are considered to be generally on the conservative side but it is quite possible that events may prove them to be too conservative.

Let us now take a brief look at the regional power picture. Common to all the specified regions in Canada (Chart II) are the three broad zones of climate and flora, namely the Arctic and sub-Arctic tundra, the forest zone, and the arable lands of the southern border-country. With no artificial stimulus other than discovery of minerals (and the demands of National Defence), it is unreason-

CANADA'S LARGEST STEAM-ELECTRIC GENERATING PLANT



The Richard L. Hearn station at Toronto. Units - four 100,000 kw turbo-alternator sets, a fifth unit of 200,000 kw is on order for 1958. Capacity may ultimately be as much as 1,000,000 kw. (Ontario Hydro photo)

able to expect that the Arctic and sub-Arctic areas will attract any sizable population, hence the power requirements would largely be dependent upon mineral discoveries. Demands would be moderate unless proximity to tide-water and other favourable economic factors would make a smelting and refining process attractive in such locations in the North. In the forest zone, continuing demands for power by the pulp and paper industry can be envisaged for the next twenty years, probably at a steadily increasing rate. A factor tending towards this is the growing area of forested land that is being managed on a sustained yield basis. Moreover, there is always the chance of further mineral discoveries in the zone that would require additional large amounts of power for development, but unless the economic factors are favourable for smelting and refining of ores and concentrates these demands would not be great. It is in the populated southern zone that the steady upward trend in the demand for power can be expected. The settled

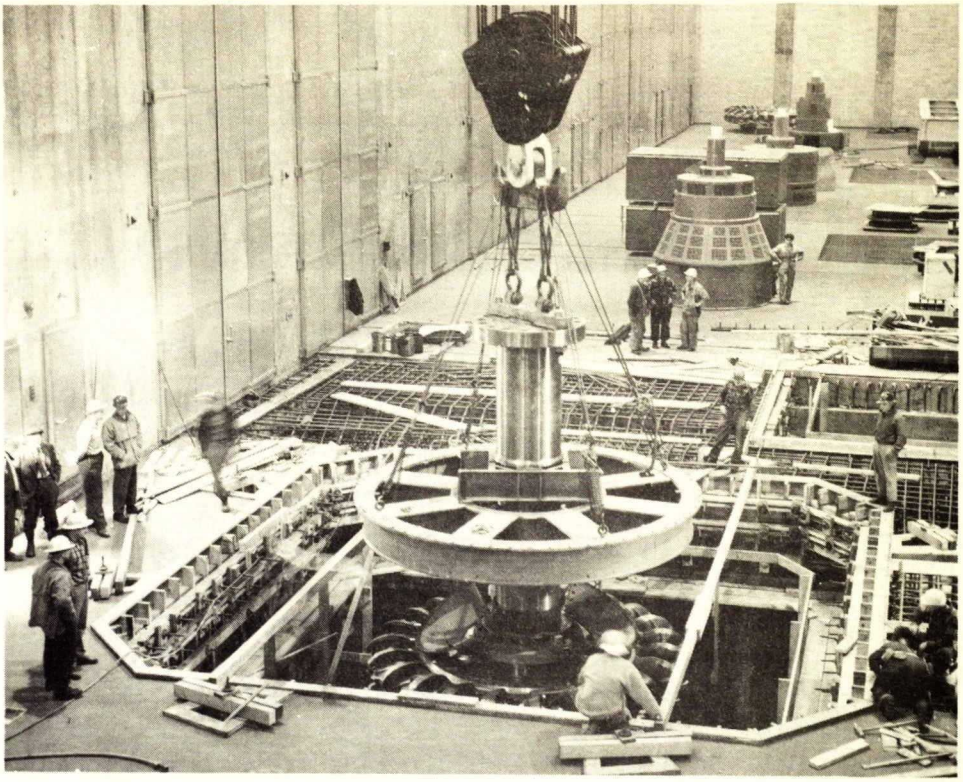
communities will attract more industry and in turn more population will accrue. The large electro-chemical industries cannot of course be expected to be located in this zone at first, because the relatively small population presently provides limited markets, but in the aggregate, and from the future point of view, it is the settled part of Canada that will require steadily increasing amounts of power. Even the heavy power-consuming industries might locate in this zone eventually.

Maritime Provinces

In the Maritimes, assuming a 4 per cent growth rate, the production of electricity should rise in 20 years from the present 3 1/2 billion kilowatt hours to about 8.3 billion kilowatt hours, corresponding to a per capita rise from 2,090 to 3,480 kilowatt hours. The domestic consumption in the area, which has risen very rapidly from a very low figure of 53 kilowatt hours per capita in 1937, should continue to advance, but can hardly be expected to reach the 1975 indicated national average of 1,650 kilowatt hours. Commercial and industrial enterprises should grow, but projection of unusually large increases in power demands would not be warranted unless large mineral deposits containing ores which can be economically smelted in the region are discovered.

In New Brunswick, there are the large lead-zinc deposits in the Bathurst area and the manganese deposits in the Woodstock area that will undoubtedly require much additional power in years to come. If smelting and refining of the metals in addition to mining and concentrating operations are undertaken, and if, in addition, chemical manufacturing, including fertilizers, develops, much larger amounts of power will be required. Similar conditions could arise if the less

SIMPLICITY
- slow speed operation
- massive costly construction
- low operational cost



Four hydraulic powered generators of 105,000 kw each in the underground power house at Alcan's Kemano station, British Columbia. (Aluminum Company of Canada photo)

explored north country of Labrador yields large mineral deposits, leading possibly to harnessing the great potential power of the Hamilton River. But all these potential demands are contingent on investors finding economic feasibility in converting ores and concentrates into metal at or near the mine sites. Undoubtedly the Maritimes should offer attractive geographical locations for metallurgical and other industry where advantage can be taken of the great Atlantic sea routes to world markets. However, the great competitor to the Maritimes, within the Canadian domain, is the St. Lawrence River with its proximity to large hydro-electric installations and as yet unexploited sites on the Quebec North Shore giving an advantage powerwise over the Maritimes.

Quebec

This province leads all others in potential and harnessed hydro-electric power. Approximately 40 per cent of the potential hydraulic power of Canada and

about 47 per cent of the capacity of hydro-electric installations are found within its boundaries.

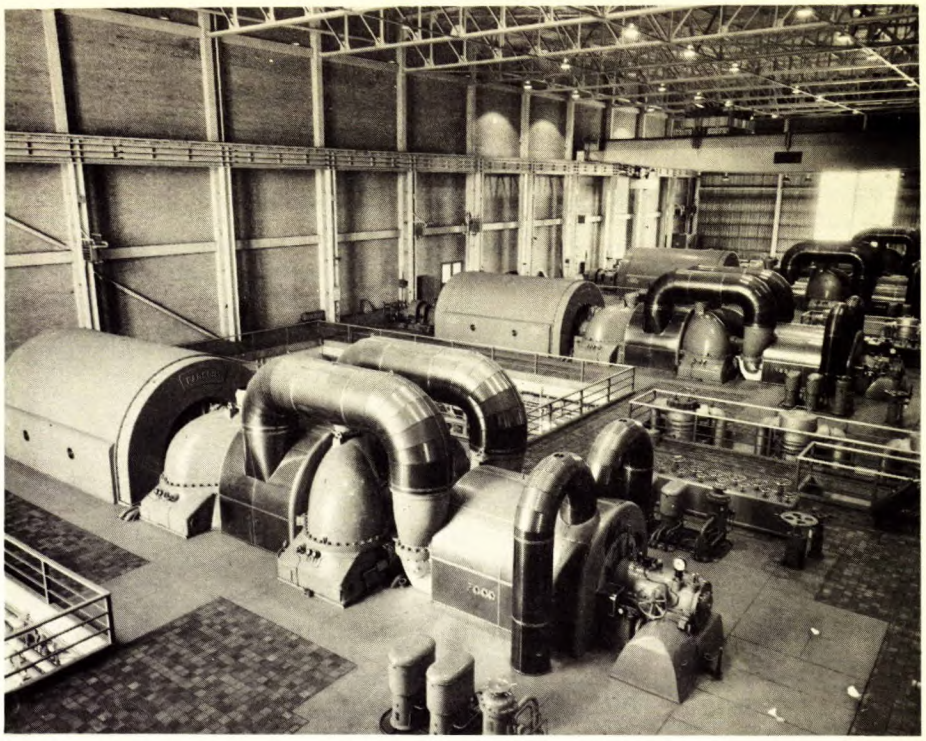
It is noteworthy that 34 1/2 billion kilowatt hours of the 1953 total of 70 billion for Canada was produced in Quebec, yet the domestic per capita usage at 458 kilowatt hours was substantially lower than that of Ontario, Manitoba, and British Columbia. The ratio of industrial and commercial to domestic use was about 16 1/2 to 1, which emphasizes the importance of availability of cheap electric power to industry in this province. The Aluminum Company of Canada, it will be recalled, was first located at Niagara. It moved to Arvida when the cost of power in the first location became unattractive to this heavy consumer.

Quebec possesses the advantage of the relatively undeveloped North Shore country fronting the St. Lawrence River for some 1,000 miles. New hydro-electric sites (for example three on the Bersimis River capable of 1 3/4 million kilowatts ultimate installation and shortly to deliver one million kilowatts of new power to the province) will probably encourage industry to locate along this important waterway. The industrial future of Quebec, particularly if it is coupled with the discovery of minerals, is indeed a bright one.

Ontario

This province has been the closest in power consumption pattern to the United States. The high standard of living is reflected in the high proportion of domestic power consumed, at 1,055 kilowatt hours per capita in 1953. The ratio of domestic to industrial and commercial consumption in 1953 was about 1 to .3. However, there has been considerable diversification in the use of power. In

COMPLEXITY
- high-speed operation
- light, less costly construction
- heavy operational cost



Three of the four steam turbo-alternators of 100,000 kw each in the Richard L. Hearn station in Toronto. (Ontario Hydro photo)

the forest and mineral belt of the north a great mining, smelting, and refining industry has been developed, as well as power-using paper industries. In the populated south the greatest concentration of diverse industries in Canada has been built up. Cheap hydro-electric power has played an important role in the industrial development of the province, but the end of economically exploitable hydro power is in sight. After completion of the St. Lawrence Seaway-Power project, which will give Ontario almost one million kilowatts of additional installed capacity, The Hydro-Electric Power Commission of Ontario will seemingly have to turn to thermally generated power, using fossil fuels, probably mostly imported coal from the United States, and eventually nuclear fuel. Already the Commission depends on the Toronto and Windsor steam stations for 664,000 kilowatts of its installed power, and to some extent to importation of steam-generated power from the states of Michigan and New York.

For many years to come the production of hydro-electric power in Ontario should be sufficiently large to ensure that higher costs for other supplementary power would not seriously affect the average cost. However, a rise in power costs relative to other provinces adequately supplied with hydro-electric power must be expected. This rise need not be serious except to industries which are heavy consumers of hydro-electric power, because technical advances now make it possible to build thermal plants of 40 per cent efficiency, as against the general average of under 25 per cent for thermal power generation in Canada today. With the continuation of development of industrial facilities and growth of population, the power requirements of Ontario should more than double by 1975.

Prairie Provinces

This region, the bread-basket of Canada, has had mainly an agrarian economy up to the present, but it is unmistakably developing primary industry of great importance to the nation, with a wealth of base metals, uranium, and other valuable minerals in the sub-Arctic. The forest belt is also being actively explored for minerals and any day another Flin Flon may be discovered. At the western end of this region there is, of course, the rapidly growing petroleum and natural gas industry. The area is experiencing growth in industry based on petro-chemicals, and as and when these provinces become more populated and have greater market possibilities, they may well become established as one of the metallurgical areas of Canada.

The power economy of this region must of necessity be mixed, owing to the varied character of the energy resources. At the eastern end, in Manitoba,

Northwest Territories

In a sense, this very large part of Canada is an enigma in regard to its future. With a population of less than 20,000 in an area of about one-third of the whole country, it is difficult to predict what will happen so far as power requirements are concerned in the next twenty years. Unless reasons for migration arise, such as the discovery of great mineral wealth, it seems reasonably certain that these territories will remain comparatively dormant for many years to come. Here, for strategic reasons, might be the region where small nuclear power plants could be established and tried out.

British Columbia and Yukon Territory

British Columbia has been a power-minded province for the last three decades or so. Next to Quebec it possesses the largest hydro-electric potential in the country. The great mining, smelting, and chemical industries at Kimberley and Trail, the great industrial centre of Vancouver, and now the aluminum industry at Kitimat, are all heavy consumers of power. It is interesting to note that the domestic consumption at 734 kilowatt hours per capita in 1953 was the third highest in the country, indicating the high standard of living enjoyed, on the average, in the province. The northern part of the province and Yukon Territory awaken speculation as to the future. In a sense that region resembles Labrador, as in the event of discovery of large mineral wealth the proximity of the seaboard will offer opportunities for smelting and refining of metals which can find foreign markets. The current discussion of the potential energy that might be developed from the Yukon River watershed points in this direction. Cheap, plenti-

ful power and proximity of ocean trade routes could very well also attract the smelting and refining of imported ores.

Canada in Summary

In summary, the prospect for utilizing the still plentiful Canadian energy resources is bright. Hydro-electric power will continue to play its very important part in attracting and developing industries consuming large blocks of power. The northern sub-Arctic and the forest zones of Labrador, Quebec, British Columbia, and the Yukon will make the largest contribution to hydro development. The populated southern regions in the Maritimes, Ontario, and the Prairies, will increasingly turn to fossil fuels and, in the more distant future, to nuclear fuel if the economics of its use become favourable.

With such a large proportion of electric power being supplied by large utility systems that can balance higher-cost fuel power with the lower-cost hydro-electric power, costs should remain reasonably attractive and such as to encourage use in the domestic as well as in commercial and industrial fields. This will be especially the case if, in comparison with other commodities, the increase in electricity cost is slow and modest. Long-distance transmission will be a factor of growing importance in this country, as will be the development of inter-provincial integration of power systems. The latter may well be a major development in the next 20 years in Canada so far as the southern populated belt is concerned. Only a major world cataclysm could interfere with the expected more-than-doubling of the Canadian electric power consumption in the next 20 years.