This is a study of the decision to develop hydroelectric power on the Nelson River. An historical account is given of the events leading to the decision to develop the first site andan analysis is made of the economics of the project not only as they affect the public utility but also as they affect the regional and national interests. This study indicates the project to have both advantages and disadvantages. Before evaluating the advisability of the project a review is made of the experience in hydroelectric investment practice in the mixed economy of the United States. Thereafter, consideration is given to appropriate evaluation methods for Canada and the advisability of the project to develop the Nelson River was justified within the terms of reference of the criteria presently employed by the agencies involved, the procedure employed in evaluating such projects should be improved and a broader approach should be taken to regional development generally.

The Nelson River Hydroelectric Development: A Public Utility Investment Affecting Both Regional and National Development -- John A. Cline.

THE NELSON RIVER HYDROELECTRIC DEVELOPMENT: A PUBLIC UTILITY INVESTMENT AFFECTING BOTH REGIONAL AND NATIONAL DEVELOPMENT

John A. Cline

1968

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PREFACE

Scope and Purpose

The decision to develop the Nelson River was taken necessarily in the face of considerable uncertainty upon the outcome of certain trends whose eventual determination cannot be known for some ten or twenty years (such as the actual growth of demand for electric power in Manitoba). The determination of whether the decision to develop the Nelson River at this time was correct or incorrect will not be possible until some time in the far distant future. At this time it is possible to comment only on the advisability of the decision and to recommend certain administrative procedures which would improve the decision-making process. The purpose of this thesis is to study the procedures followed in the decision-making process and to analyse the issues involved in the decision with a view to improving the correctness of decisions made in such large undertakings in the future.

PART ONE

BACKGROUND

CHAPTER ONE

THE NELSON RIVER BASIN

The Nelson River acquired its name at the time of the first recorded contact by Europeans with the territory now known as Manitoba.

Francis Nelson was sailing master of the companion ship on Captain Thomas Button's voyage into Hudson Bay in 1612. In search of the North-West Passage, Button who had sailed with Hudson on the latter's last voyage was forced by cold weather to winter at the mouth of the Nelson on Hudson Bay. Nelson died during the winter and Button honoured him by nam- in the river by which they had wintered after him.

As may be seen in Map 1.1, the Nelson River flows 400 miles from Lake Winnipeg northeast to Hudson Bay and its watershed extends from the height of land adjacent to Lake Superior to the Rocky Mountains. The rivers flowing into the Nelson River watershed include the North and South Saskatchewan, the Red and the Winnipeg Rivers. The adjacent Churchill River basin contributes a watershed area of over 90,000 square miles stretching about 600 miles easterly from its headwaters in Alberta to the point of the proposed diversion of some of its flows in northern Manitoba. At its most northerly point the Churchill River basin reaches to within 50 miles of the Northwest Territories. The combined Nelson River and Churchill River drainage basins encompass an area of slightly more than 500,000 square miles.

For purpose of reference, the Nelson River may be divided into two reaches - the Upper Nelson River and the Lower Nelson. The Upper Nelson is that reach of the river extending from Warren Landing at the

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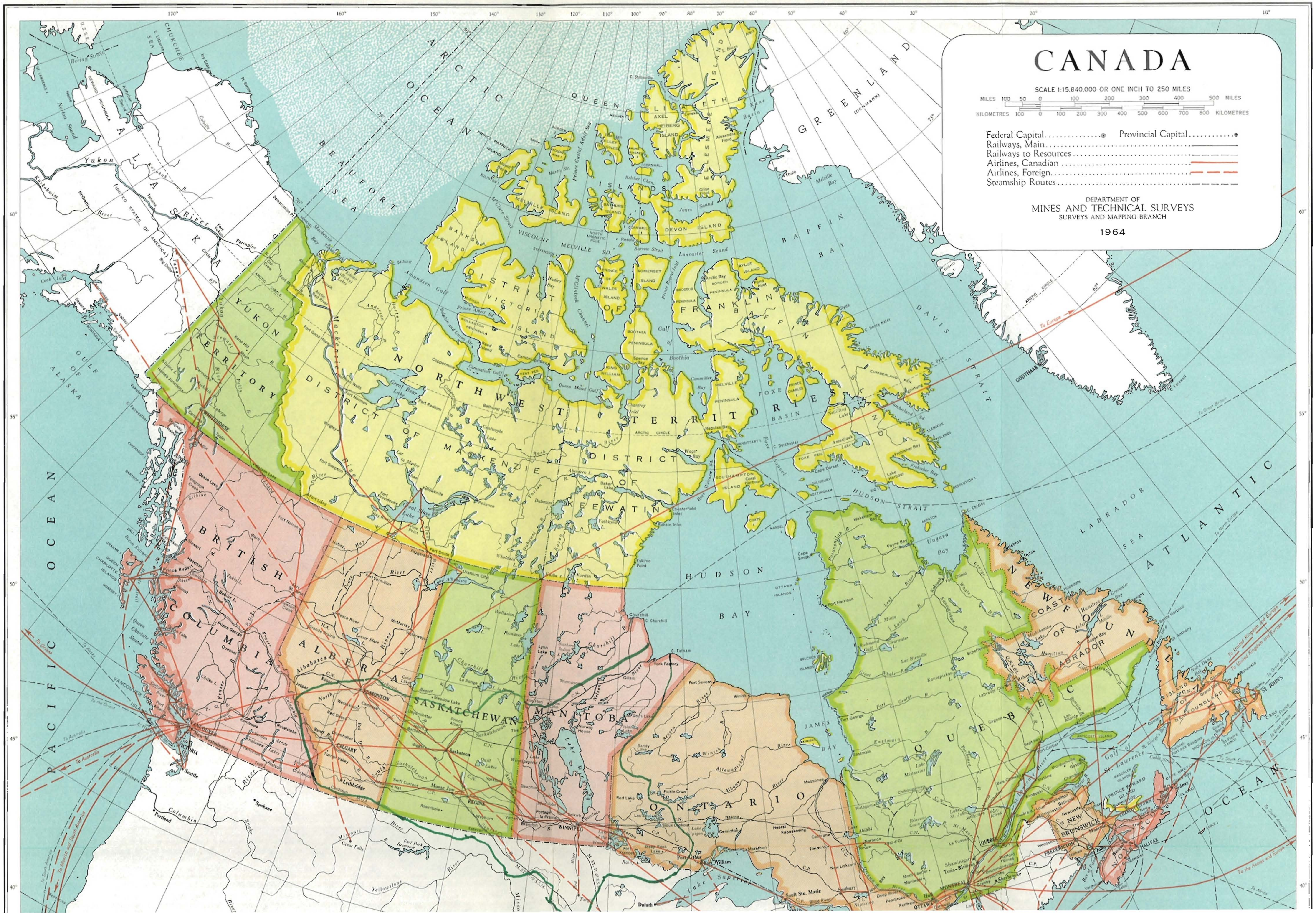
CANADA
SCALE 1:15,840,000 OR ONE INCH TO 250 MILES
MILES 100 50 0 100 200 300 400 500 MILES
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Federal Capital
Provincial Capital
Railways, Main
Railways to Resources
Airlines, Canadian
Airlines, Foreign
Steamship Routes
DEPARTMENT OF
MINES AND TECHNICAL SURVEYS
SURVEYS AND MAPPING BRANCH
1964
ARCTIC OCEAN
BEAUFORT SEA
QUEEN ELIZABETH ISLANDS
GREENLAND
BAFFIN BAY
DAVIS STRAIT
ALASKA
YUKON TERRITORY
NORTHWEST TERRITORIES
DISTRICT OF FRANKLIN
DISTRICT OF MACKENZIE
DISTRICT OF KEEWATIN
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
NEWFOUNDLAND
LABRADOR SEA
HUDSON BAY
JAMES BAY
FOXE BASIN
HUDSON STRAIT
PACIFIC OCEAN
GULF OF ALASKA
ATLANTIC OCEAN
NEW BRUNSWICK
NOVA SCOTIA
PRINCE EDWARD ISLAND

outlet of Lake Winnipeg, to just upstream of Split Lake. The Lower Nelson River is the remaining reach from Split Lake to the river's mouth at Hudson Bay. From the outlet of Lake Winnipeg (where it begins) to the Arctic Ocean at Hudson Bay the Nelson River has a total drop of 712 feet over a length of 400 miles. Such a sharp drop in elevation is attractive for hydroelectric development and the river possesses a number of sites suitable for the concentrations of the great heads necessary for economic hydroelectric development. Including all power sites, a total of 628.5 feet of net head can be developed on the Upper and Lower Nelson out of the total drop of 712 feet from Lake Winnipeg to Hudson Bay.

Lake Winnipeg is the dominant factor of the Nelson River basin. One of the world's largest lakes, 9,400 square miles in area, it is 712 feet above sea level and 400 miles by the run of the Nelson from the Arctic Ocean.

Another feature of the Nelson River system is that it comes into close proximity to the Churchill River which runs to the north. The flows of the Churchill could be diverted into the Nelson River drainage system by either of two routes. One route would be in Saskatchewan, involving diversion of flows from the Churchill River into the Saskatchewan River just above Lake Winnipeg. At that point the flows would be about 850 feet above sea level and the increased flows would augment the output of the Manitoba Hydro hydroelectric plant at Grand Rapids. However, the diversion of flows by this route would drastically reduce the output of the hydroelectric plant at Island Falls, Saskatchewan, belonging to the Hudson Bay Mining and Smelting Company.

Another possible diversion route is by the Rat and Burntwood Rivers from Southern Indian Lake which is part of the Churchill River in

northern Manitoba. The flows diverted from the Churchill River by this route can be introduced into the Nelson at a point just below the present sole Nelson River hydroelectric plant at Kelsey - a point at which the Nelson is still about 500 feet above sea level.

Along this diversion route there is approximately 600,000 kilowatts of capacity that could be developed using the diverted flows of the Churchill that would otherwise flow to the sea providing little or no benefits to the Province.

On the Lower Nelson, 5,000,000 kilowatts could be developed along with 400,000 kilowatts on the Upper Nelson providing a total potential for the system of 6,000,000 kilowatts of capacity. The Nelson River and the Churchill River diversion route represents a potential amount of energy equivalent to the energy that would be derived by burning 36,000,000 tons of coal a year. For a province having no considerable coal deposits or oil and gas fields, the Nelson is the dominant energy fact in Manitoba,

Tributaries of Nelson River

Aside from the local runoff it receives from the immediate vicinity, the Nelson River possesses three major subdivisions of its drainage basin, the Saskatchewan, the Red, and the Winnipeg watersheds.

Description of the Saskatchewan Drainage Basin

The South Saskatchewan River rises in Alberta and Montana, flows into the Province of Saskatchewan, merges with the North Saskatchewan River and proceeds as the Saskatchewan River into Lake Winnipeg in Manitoba. The drainage area above the location of the South Saskatchewan dam can be divided into three parts. The first part consists of the eastern slopes of the Rocky Mountains. The second part consists of the

foothills east of the mountains. Together, the eastern slopes and the foothills produce approximately 92% of the average annual flow at the South Saskatchewan dam site. The third and the largest part consists of the relatively arid prairies.

A predominant feature of the South Saskatchewan River which flows into the Nelson is the South Saskatchewan River Dam. However, a study by the Prairie Farm Rehabilitation Administration found that "full Development" depletions (including irrigation) in Alberta and Saskatchewan would reduce Nelson River power potential by about 3% to 4%. 1 Despite the overwhelming size of the Saskatchewan drainage basin, only 20% of the inflow into Lake Winnipeg is contributed by the Saskatchewan.

Description of the Red River Drainage Basin

The Red River drainage basin can be divided in two parts: 48 thousand square miles drained by the Red River proper, and 63 thousand square miles drained by its major tributary, the Assiniboine River. In spite of its smaller drainage area, the main body of the Red River contributes about 70 per cent of the total average flow of 5,600 cfs. The drainage basin includes the broad, flat and fertile plains that were, at one time, the bottom of Lake Agassiz. The Assiniboine River drainage basin is part of the Canadian Prairies, and ranges in elevation from 750 to 2,700 feet. It has the lowest run-off-per-square-mile of any major river on the North American continent due to the low average annual rainfall of about 16 inches and the low relief of the landscape.

1 W.M. Berry, E. F. Durrant, C. Booy, "Hydrologic Investigations for the South Saskatchewan River Project," page 67 The Engineering Journal, April 1967.

Description of the Winnipeg River Drainage Basin

The Winnipeg River drainage basin, with an area of 52 thousand square miles, is much smaller than that of the Saskatchewan or Red Rivers. However, its average flow of 30,000 cfs. is considerably higher. This is because of the relatively high precipitation in the basin, and because its drainage area consists for the most part of forest-covered Pre-Cambrian formations resulting in a high runoff.

CHAPTER TWO

CHRONOLOGICAL ACCOUNT OF DECISIONS LEADING TO DEVELOPMENT OF NELSON RIVER

From an early date the power potential of the Nelson River was recognized, and hydrologic surveys were conducted on the Nelson as early as 1910. The early annual reports of the Manitoba Hydro-Electric Board contain references to the Nelson River potential. However, not until after the launching of the development at Grand Rapids when Manitoba Hydro had to consider what the succeeding energy source would be, was the Nelson River seriously examined. Consideration of the Nelson River was preceded by developments in long-distance extra-high voltage transmission techniques which made possible the economic transmission of power over much greater distances than previously. As late as 1958 a textbook in electrical engineering held it highly dubious that transmission would ever be economic over greater distances than the few hundred miles then possible.

The decision to develop the first of the potential power sites was taken within a technological continum. On the one hand, the development could not be considered until transmission techniques improved enough to permit such long-distance transmission, on the other hand the comparative economics of the development will some day be profoundly altered when nuclear power is more thoroughly developed.

The high capital costs associated with the extra-high voltage long-distance transmission led to an initial working hypothesis, (later abandoned) which persisted in later misconceptions of what was required on the Nelson. The initial concept of development of the Nelson River

was that, given the long-distances required to transmit the power and the high capital costs of such extra-high voltage long-distance transmission, it was necessary to spread these costs over as many units of output as possible. Accordingly, the concept of development chosen was one of a plant or plants producing at high energy factors of the order of 80% or greater.

An explanation should be given for the term "load factor". With a given flow of water at any given site, the generating capacity can be greater or less depending upon the rate at which the energy obtainable will be required. When the energy available at a specific site is to be required at a long steady rate, the machines installed to generate power at a specific plant operate long hours and are said to be operating at a high load factor. When the energy obtainable at a specific site is to be required in short intense bursts to meet peak demand, more machinery is installed at the plant than could be operated for extended periods. Such a plant, (normally complemented by a reservoir which stores the water for periods of peak demand) is said to be operated at a low load factor.

Not only was the initial emphasis on high load factor development but also large-scale development. This involved the creation of greater capacity than could be absorbed by the Manitoba market alone. The principal export markets of Nelson River power would be located either in Toronto or in Minneapolis. Minneapolis had the advantage of being 500 miles closer than Toronto. However, at the time of the first planning stages of the Nelson River development, export of large blocks of electric power on a long term basis was forbidden by federal legislation. At an earlier stage of Canada's industrial development Canada had permitted Canadian utilities to enter into contracts exporting

electricity to the United States for limited terms which were stated in the contracts. However, when the terms expired; American judges were loath to permit the Canadian utilities to withdraw from their contracts. [1] This led to an anomalous situation. Canadian factories had to pay more for their electricity than American firms which were receiving power from low-cost Canadian hydroelectric sites. Thus American law prevented the Canadian sites from supplying the Canadian factories! Since then the Government of Canada, which controls the export of electric power, had pursued a policy of preventive long-term export of electric power on any large scale to the United States.

At the time that the development of the Nelson was being considered in the early 1960's, developers of the Columbia and of the Hamilton Rivers also were considering export possibilities to the United States. Therefore, arguments were advanced to the federal government by the respective provincial governments at both the ministerial and government officer level.

The first parliamentary indication of a change in the federal policy, came in the throne speech of the Conservative government on September 27, 1962.

On October 8, 1963, the Hon. Mitchell Sharp of the succeeding Liberal administration gave a formal announcement of national power policy. The statement included the opinion that the danger of permanently relinquishing the output of certain power sites as a result of export could be avoided "if export contract is made with a public utility in the United States under reasonable terms and conditions." [1]

1 Page 3300, Hansard House of Commons Debates, First Session Twenty-sixth Parliament 12 Elizabeth II Volume IV, 1963, Queens Printer, Ottawa.

Meanwhile the potential development of the Nelson River had aroused considerable enthusiasm in the Premier of Manitoba. During his second major campaign speech during the election of the fall of 1962, the Winnipeg Free Press, November 20, 1962, carried a front page article "Nelson River Power Roblin's 'Big Pitch'". In his speech Mr. Roblin picked power development as his major theme and dealt with the possibility of export. He informed his audience that his government had already begun studies with American states and with the Province of Ontario to find an export market. The Premier emphsized that the Nelson River development would not only provide cheap power but also give a "tremendous lift" to the economic development of the north and of the province as a whole. He stressed also not only the benefits of on-site employment, but also the national significance of business given to factories across the country and the foreign exchange earnings benefits from power sales.

In the meantime the federal anc provincial governments had agreed to a cost-sharing of the investigation of the potential of the Nelson River. On Fedruary 18, 1963, an agreement was entered into by the Government of Canada and the Government of Manitoba, under which the former undertook to share with the Government of Manitoba the cost of an investigation of the hydroelectric potential of the Nelson River and the feasibility of its development. The Nelson River Programming Board was set up, composed of representatives of Canada and Manitoba, to carry out the investigations and administer the terms of the agreement with an Administrative Committee responsible to the Board for the overall direction and supervision of the proposed Nelson River studies.

This phase of the studies was carried out at a cost of approximately $1.3 million and was shared equally by the Governments of Canada

and Manitoba. Manitoba Hydro paid the share of the Government of Manitoba.

A report on this work was tabled in the Parliament of Canada and the Manitoba Legislature on March 4, 1964. 1 The report found that more than 4,000 megawatts were available on the Nelson of which 2,000 would be available for long-term export. Based on the studies then conducted, large scale development of power on the Nelson River could provide high load factor, firm power energy on-site at a cost of approximately 2.0 mills per kilowatt hour. High load factor, firm power energy could be delivered to Southern Manitoba at approximately 3.0 mills per kilowatt hour, to Toronto at approximately 4.50 mills per kilowatt hour, and to Minneapolis at approximately 4.25 mills per kilowatt hour. 1

The report recommended further studies in a Phase Three of the investigations which would require a period of two years at a total estimated cost of $3,000,000.

As a result a further agreement was signed on May 27, 1964, extending the studies and investigations to March 31, 1966, and providing an additional $3 million for this purpose. One-half the cost of these studies being provided by the Government of Canada.

By the late summer of 1965, the Manitoba Hydro had arrived at a development scheme on the Nelson River for the Manitoba market alone that was preferable to all other practicable schemes of developing the River and that also was competitive in cost with a lignite-fired thermal scheme. However, given the eventual erosion of the advantages of Nelson

1 Page 4, Nelson River Investigations, Interim Report of the Administrative Committee to the Programming Board Pursuant to the Agreement Between the Government of Canada and the Government of the Province of Manitoba Dated May 27, 1964, Winnipeg November 30, 1965.

1 Page 2, Nelson River Investigations Report of the Administrative Committee to the Programming Board, Winnipeg February 6, 1964.

River energy compared to nuclear energy, an early start on developing the Nelson River was necessary if it were ever to be undertaken. As a result it was felt that federal assistance for development of the Nelson was needed at that juncture rather than deferral via the demand for further investigations.

A report to achieve a policy decision was initially drafted by the Manitoba representatives with approval sought from the representatives of the Federal Government.

The report of the Administrative Committee found: 1

1. The development of capacity in excess of 5,000 megawatts on the Nelson River was economically feasible.

2. The proposed initial development could provide power in time to meet Manitoba's 1970 requirements.

3. The proposed Phase I Development was economically viable on its own and was consistent with the optimum development of the total potential of the river.

4. The Proposed Phase I Development would provide a firm capacity of 855 megawatts and consist of the following elements:

- Kettle site	$143,000.000
- DC Transmission	114,000,000
- Churchill River diversion	20,000,000
- Lake Winnipeg Regulation	28,000,000

5. Compared to a thermal development, Phase I is less favourable in the short-term and more favourable in the long-term, particularly if followed by substantial power developments on the Nelson River.

1 Pages i and ii Nelson River Investigations, Interim Report of the Administrative Committee to the Programming Board Pursuant to the Agreement Between the Government of Canada and the Government of Manitoba, Dated May 27, 1964, Winnipeg, November 30, 1965.

While this relationship is common to most comparisons between thermal power and hydraulic power sources, the initial higher costs of the hydraulic alternative are accentuated in this case by the large element of forward investments. These forward investment are necessary for the feasibility of the first development but impose higher initial capital costs. However, the forward investments would benefit and enhance any further developments.

6. While either an ac or dc transmission medium could be employed, the dc alternative should be adopted.

7. The proposed Phase I Development would accelerate the development of dc technology with its national benefits of enabling the transmission of large sources of low cost power over long distances, would create a readily expandable pool of power for export, and provide an impetus to the evolution of a national power grid.

November 15, 1965, the Premier of Manitoba wrote the Prime Minister that: 1

"The need for energy in the Province of Manitoba has reached the point where I must appeal to you directly for decisions affecting hydro electric power policy in Manitoba." The Premier's letter outlined a proposed "basis of joint federal-provincial collaboration":

"(a) the acceptance by Manitoba of responsibility for the development of the Kettle Rapids generation station;

(b) The qualification under the Canada Water Conservation Act of the Churchill River Diversions works and the works required for the control of the levels of Lake Winnipeg as an when these are put into place with 37½% of the cost being provided by Canada and 62½% being provided by Manitoba.

1 Letter from Premier to Prime Minister included in documents tabled in Manitoba Legislative Assembly Session of 1966.

(c) The financing (and as well putting into place if this should be desired) by Canada of the transmission facilities required; . . . Manitoba would pay for the use of the facilities on a 'wheeling charge' basis designed to limit transmission costs incurred by Manitoba on an actual use basis during the early years but during the service life of the asset should reimburse Canada for its entire investment in the transmission facilities."

The federal government was disinclined to apply the Canada Water Conservation Assistance Act because it might constitute a precedent that would result in a raid on the federal treasury by other provinces. Furthermore, the dc aspect of the development was particularly important to them inasmuch as it constituted a basis for federal participation that other projects did not possess. Thus, the concern of the federal government officers was essentially defensive. Further, the employment-boosting effects of the development were not especially significant to government administrators then in the midst of Canada's longest post-war expansion.

The Report of the Programming Board was completed in December. [1] It echoed the Report of the Administrative Committee in its acceptance of the Phase I Development. It stressed that the peak period of construction would not be reached until the third or fourth year; and also that, while in a comparison with a lignite-fired conventional thermal sequence, the Phase I Development was only very slightly cheaper, the initial capital requirements were much greater for Phase I. It included

1 Front Cover, Nelson River Investigations, Interim Report of the Nelson River Programming Board to the Government of Canada and the Government of Manitoba.

an enumeration of the 1 "indirect and intangible benefits which accrue to the nation and the province . . .

(a) Utilize a renewable resource for the generation of energy.

(b) Provide a source of energy which is better adapted for utility system operation that thermal generation.

(c) Possibly provide an opportunity to advance technology in the field of dc transmission.

(d) Bring within reach the development of several million kw's of hydro-electric power for domestic and export markets over the next twenty years. Investment in Phase I Development economic in itself, has the decided advantage of providing the essential base for the development of additional Nelson River sites.

(e) Make available a large source of low cost energy in a region of mineral deposits and forest resources.

(f) Make power available in Southern Manitoba and play an important role in the export of power beyond the boundaries of Manitoba." The report concluded that the large scale of the Nelson River Phase I Development would be larger than public utility considerations would justify, and, therefore, unless a cooperative basis of development emerged, a pattern of development would be followed which would be less economic over the long term.

Not until February 4 and 5, 1966, was agreement on the proposed development reached by meetings between representatives of Manitoba including the Premier and representatives of Canada including the Ministers of Finance and of Mines and Technical Surveys.

1 Pages 6 and 7 ibid.

The agreement in principle provided for assistance from the Federal Government through construction and financing of the transmission line which would then be leased by Manitoba Hydro. 1 In the interest rate to be employed in the schedule calculating the costs of leasing Manitoba was given the choice of either of two methods. By the first method, a single rate of 5 5/8% would be applied to all funds spent by the Government of Canada or its agency on the transmission line. That was the rate the Government of Canada was charging its Crown Corporations. This was determined by a long-standing practice reflecting the market yield on their long-term issues and the other costs incurred by the Government of Canada in borrowing.

The alternative method of calculating interest costs, would be by a formula that would determine the amount payable on accounts invested each quarter-year, as would be done for Crown Corporations. The rate would be the average rate of yield in the market on actively traded long-term Government of Canada issues in the last five trading days of the month preceding the quarter-year under discussion, plus 0.125 percent for administration, with the total rate then rounded to the nearest 1/8th of one percent.

The first method would protect Manitoba against further increases in the rate of interest during a period of high interest rates; the second would permit Manitoba to take advantage of possible future decreases in interest rates. The Government of Canada refused to consider any combination of the above.

In both cases, although Manitoba Hydro would lease the line

1 Letter, Minister of Energy, Mines and Natural Resources to Premier of Manitoba, correspondence tabled in Manitoba Legislature Session of 1966.

from the Government of Canada or its agency, it would have to assume all the operating costs of the line.

The system of payments of the leasing agreement was to be designed to lessen the financial burden on Manitoba Hydro during the first ten years.

Manitoba was given the option to purchase the tranmission line at any time at the Federal Government's unamortized cost.

The Government of Canada required the assurance that power from the Nelson River would be available on "favourable terms" to other provinces, reflecting the arrangements between the federal government and the Government of Manitoba.

PART TWO

ECONOMIC IMPACT OF NELSON RIVER DEVELOPMENT

CHAPTER THREE

DIRECT BENEFITS AND COSTS

The responsibility of the Manitoba Hydro Electric Board as set out in its Act is "to provide for the continuance of a supply of power adequate for the needs of the province and to promote economy and efficiency in the generation, distribution, supply and use of power". To perform these duties the utility is confronted by a number of basic economic characteristics of the electric utility industry which in sum give capital budgeting and investment planning special significance in the electric utility industry.

Basic Economic Characteristics of the Electric Utility Industry

1. The demand for the product, electricity, is derived indirectly. It performs a whole series of very vital functions in conjunction with electric devices and appliances. When this product is called into service by the flick of a switch, unless the power is immediately available, by and large, the customer is inconvenienced. There is no readily available substitute and no customer inclination to waiting.

2. The product, electricity, cannot be stored economically. As a result, enough power must always be generated in the system in order to meet immediately the total demands of the customers.

3. A long lead time is required to bring new capacity into service - approximately five years.

4. The industry is capital-intensive, probably more than any other industry both with respect to the generation facilities required to produce the energy and with respect to the substantial transmission and distribution facilities required to transport the energy to the final customer.

5. Considerable economies of scale are available.

6. Countervailing the economies of scale is the necessity to hedge against the risk that a major component of generation or transmission capacity will be temporarily out of order. With any generating machine it is known in advance that on occasion it will be out of service, be it for scheduled (and hence predictable) or for unscheduled repair due to failure of one of its parts. This limits the capacity that any particular system can ever entrust to one particular element.

7. Electric generation equipment has a very long service life. Hydroelectric projects, for example, have a full service life of fifty years or more. This makes it necessary to plan far into the future in order to have a reasonably clear view as to how these facilities will perform.

8. The technology of the industry is developing at a very rapid rate. American studies indicate that since the turn of the century the electric utility industry has consistently been one of the most rapid to increase the productivity of its employees, having registered annual increases of about 5½% per man. 1 Studies of the Manitoba electric utility industry indicate productivity per man showing annual increases in the order of 6%.

These facts combined explain the importance of the whole aspect of planning in the electric utility industry. Perhaps relatively more attention is given to planning on a long range basis in the electric utility industry than in any other industry.

1. Page 10 -
National Power Survey.
U.S. Federal Power Commission Part 1.
U.S. Government Printing Office, Washington, 1964.

Sequential Analysis

The attention given to planning in the electrical utility industry has given rise to the development to a very sophisticated level of the analysis of the interrelationships of the proposed capital addition and those succeeding with the present capital assets in the electrical system. The detailed analysis of these interrelationships is called sequential analysis.

For any industry, the addition of a new source of capacity has consequences on the pattern of development of future capital additions. Once the decision has been made to run a railroad through one town, it makes little sense to locate the switching facilities in another lacking a railroad no matter what other locational advantages there may be. And a decision to make a certain capital addition, while it closes doors for some patterns of development, raises the possibility of a wide range of succeeding alternative decisions. Two investment decisions may have consequences that range from completely complementary to completely competitive with a mid-point of being completely indifferent.

In an analysis of such consequences a sufficiently long time period must be allowed to trace such consequences and assess the overall wisdom of the addition. Too short a time period could permit conclusions directly contrary to those which should be drawn. For example, it is possible to derive an immensely profitable return on many investments for repair and modernization. Without this increment of capital, all income stops! Such reasoning would support the gradual reconstruction piece by piece of a railroad that should never have been built in the first place.

How much time is sufficient time? The setting of the time period for examination of the consequences of a decision to add capacity is partly arbitrary and constitutes one of the weaknesses of sequential analysis. Before enlarging upon this weakness a more detailed description of sequential analysis is necessary.

Sequential analysis is a method of comparing the economic merits of alternative sequences of power development. The first step in a sequential analysis is the preparation of a load forecast. The most common method of preparing a load forecast involves the extrapolation of recorded load growth either by a regression equation or by an average of recorded percentage growth rates. Frequently, an upward adjustment is made for large increases in demand that are expected to materialize within the immediate future of four or five years. Generally, the confidence limits of the regression equation or of the average growth rate are drawn. The upper limit of the estimate probably at a 95% confidence level is then treated as the required minimum capacity for each respective year. For each year this amount is regarded as fixed. This load demand must be met. Failure to do so leads to immediate rejection of the plan. On the other hand, any capacity above the load forecast aside from a percentage reserve for contingencies in the system is considered of little value.

An explanation is required of two meaning of "capacity" encountered in public utility economics. In one sense, "capacity" refers to the generalized ability of a plant to produce. In another sense, "capacity" as opposed to "energy" means demand for a rate of delivery of energy. In this sense, the load forecast is prepared for both the demand for energy and the demand for capacity.

Once a load forecast has been prepared, a plan, or where alternatives exist a series of plans, must be arrived at to provide for both capacity and energy requirements. At this stage of the analysis the concern is primarily with the physical factors of what types of machinery and equipment can be installed and with general engineering principles including hedging the risk of unit outages. For hydraulic installations, at this stage it must be ascertained that the proposed pattern of providing for capacity also provides sufficient energy.

After the decision has been made as to what types of plants should be built and what the pattern of their introduction ought to be, the annual costs associated with the chosen assets are estimated for each respective year including both the fixed costs of interest and depreciation and the costs of maintenance and operation as well as the energy costs for fuel or water rentals charged by the provincial authorities.

Once the annual costs for each year have been estimated they are converted for each respective year into their present value as of a specified base year, generally the year of the first addition. The present value of the annual costs are then accumulated for every year of the period under study and the series with the lowest accumulated annual costs would be the most economic barring criteria extraneous to the previous cost compilations.

To an economist, there appear to be two major sources of weakness to the sequential analysis method. First, the prediction of load growth as an extrapolation of past demands for plant does not seem to recognize directly important factors such as anticipated changes in population and economic growth and pricing factors such as the relative prices and availability of alternative energy sources. Secondly, the

reliance on past trends and known technology seems to ignore the fact that both the demand for and the supply of electric power are subject to considerable risk and uncertainty over the usual 20-year period of study. There is always a hazard of the "tail wagging the dog" in that assumed plant additions ten or fifteen years later can alter the economic attractiveness of an addition to be made immediately although no one really knows what type of plant possibilities may then exist. The further into the future the time period under consideration extends, the greater the uncertainty attending the assumptions to be made.

Relative Cost Structure Alternative Electric Sources

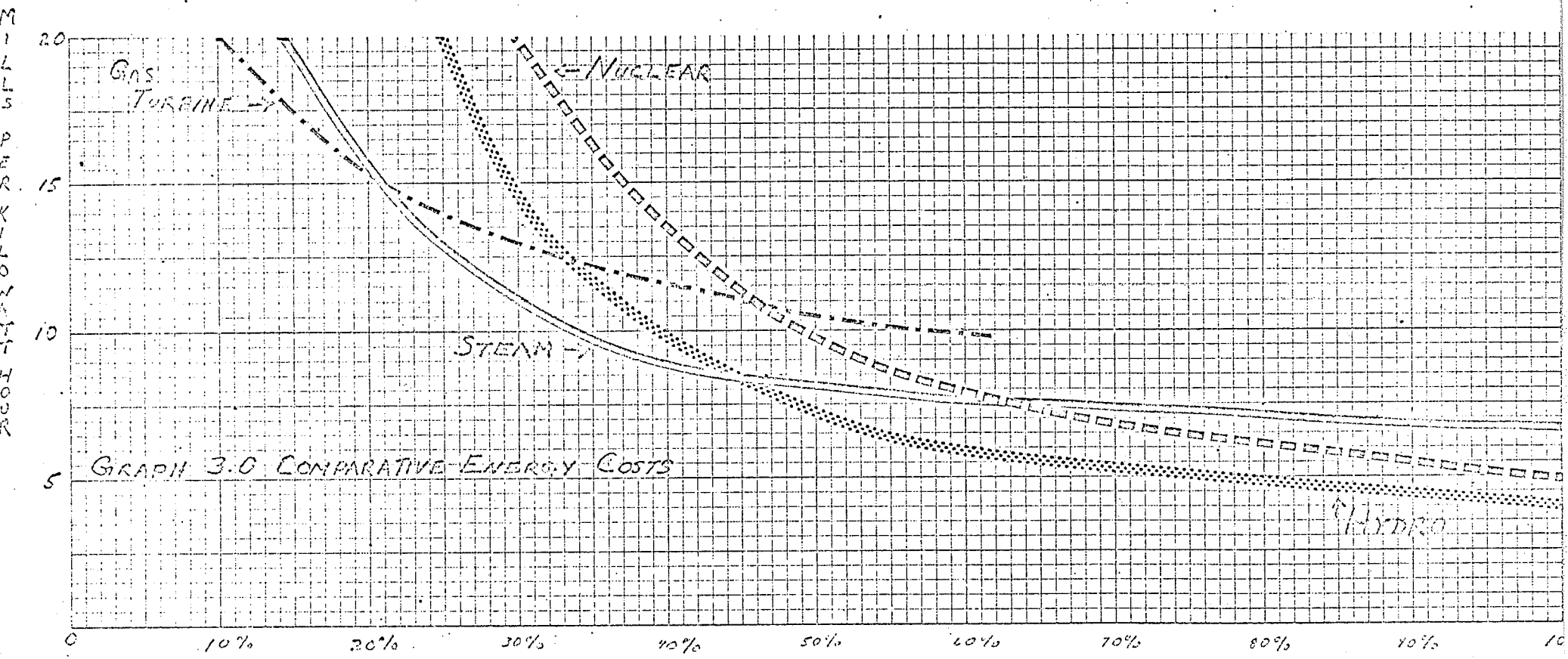
Electric power can be produced a number of ways as far as the study of physics is concerned. Howev r, from the point of view of public utility economics only a limited number of alternatives are open, namely hydroelectric dams, nuclear thermal plants, coal-gas or oil fired thermal plants and gas turbines for large systems (diesel plants can be used for small local service). Table 3.1 shows the comparative cost structure of [1.] hydro, lignite-fired thermal, nuclear and gas turbine electric generating plants. Graph 3.0 shows their comparative cost behaviour at different load factors.

Each source of energy has its own specific characteristics which make it more suitable to certain types of energy requirements than others. High load factors are necessary on nuclear or hydraulic plants to distribute the high fixed costs and realize the economies of their low energy costs. Gas turbine plants are a cheap source of capacity but their high fuel costs make them an expensive source of energy. Hydro plants in dry years do not

1. Pages 309 and 311 - E. Kniper, Water Resources Development; Butterworth and Co. Ltd., London 1965.

	Hydro	Lignite-Fired Thermal	Nuclear	Gas Turbine
Capital Cost per kilowatt	$400 (incl. transm.)	$150	$250 (including initial fuel)	$100
Interest	6%	6%	6%	6%
Depreciation (straight line)	1%	2%	2%	2%
Taxes and Insurance	1%	2%	3%	2%
Operation and Maintenance	$2/kw per year	$3/kw per year	$5/kw per year	$3/kw per year
Fuel replacement and waste disposed			$10/kw per year	
Fuel		4 mills/kwh		7 mills/kwh

Source: see text



have the same amount of energy that they have in normal or wet years. Coal-fired thermal plants are not dependent upon the weather. In fact, thermal plants with their reliable energy can be used to permit hydro plants to operate at higher load factors since water, which would otherwise have to be stored in a reservoir as a protection against years of low flows, could be used to generate electricity. Thermal plants operate most efficiently when they produce heat continuously; indeed, there appears to be objections to shutting a nuclear plant for any appreciable length of time. Coal-fired thermal plants have the advantage of being operable at high or low load factors although at very high load factors the high fuel costs offset their advantage due to their low capital costs. A major advantage of hydroelectric plants is the fact that a hydraulic turbine begins to operate almost as soon as the water begins to flow through it. Gas turbines have the same advantage of requiring little start-up time but the other sources require some advance period of warming up before they can begin generation. Hydro-electric turbines' short start-up time and the fact that once a dam has been built additional turbines can be added at low incremental cost make hydraulic capacity very attractive as a source of potential peaking capacity and the transition from base to peak loading can be accomplished readily in a limited hydro expanding system.

Capital Requirements for Development of the Nelson River

Development of the Nelson River could involve power dams not only on the Lower Nelson and Upper Nelson but also along the diversion route of the flows from the Churchill River. Moreover decisions to regulate the level of Lake Winnipeg and to divert some of the flows of

the Churchill River affect the design and power installation at most of the sites. Therefore, not only are there several potential sites in the Nelson River development, there are also many possible patterns of exploiting any particular site depending upon whether the flows available are those of the river in its natural state or those augmented by the Churchill River, those assisted by the regulation of the lev el of Lake Winnipeg, or those with both flow improvements added. Following is a summary of the costs and capacities as estimated in the late summer and fall of 1965 when the decision to develop the Nelson River was made (estimates are subject to a continuous process of review and revision as further information becomes available):

TABLE 3.2 CAPITAL COSTS OF NELSON RIVER SITES [1.]

	Installed Capacity (megawatts)	Capital Cost ($ millions)	Capital Cost Per Installed Kilowatt ($/KW)
Upper Nelson			
River in Natural State			
Bladder Rapids	317	95.6	301
Kelsey	fully developed for available flow		
River with Lake Winnipeg Regulation and Churchill River Diversion			
Burntwood River Diversion enters downstream of Upper Nelson			
Lower Nelson			
River with Churchill River Diversion, Lake Winnipeg Unregulated			
Upper Gull	251	82.9	330
Lower Gull	291	82.1	282
Kettle	513	105.4	205
Long Spruce	439	108.5	247
Limestone	988	198.9	201
Gillam Island	422	97.9	232

1. page 29, Nelson River Investigations, Interim Report of the Administrative Committee to the Programming Board Pursuant to Agreement Between The Government of Canada and the Government of Manitoba dated May 27, 1964.

TABLE 3.2 (continued)

	Installed Capacity (megawatts)	Capital Cost ($ millions)	Capital Cost Per Installed Kilowatt ($/KW)
River with Churchill River Diversion and Lake Winnipeg Regulation			
*a) Assumed Design Flow - 100,000 cubic feet per second			
Upper Gull	334	98.7	296
Lower Gull	388	97.8	252
Kettle	684	121.5	178
Long Spruce	586	124.9	213
Limestone	1,317	230.1	175
Gillam Island	562	115.2	205
*b) Assumed Design Flow - 100,000 cubic feet per second			
Upper Gull	418	114.7	274
Lower Gull	485	113.5	234
Kettle	855	137.8	161
Long Spruce	732	141.2	193
Limeston e	1,646	261.3	159
Gillam Island	703	132.5	188

*Assumed Design Flow has to do with the turbine capacity installed at a site rather than with the direct physical properties of flow and drop in elevation.

Burntwood River		
Notigi	100	not available
Wuskwatem	226	" "
Manasan	126	" "
First Rapids	138	" "

- Cost estimates do not include provision for spare capacity.

In addition to the cost of the hydroelectric dams, there are substantial capital costs involved in the flow improvement works. Regulation of Lake Winnipeg would require $28,900,000 and diversion of a portion of the flows of the Churchill River would require $20,500,000 for the Burntwood-Southern Indian Lake routing.

Capital Requirements for Transmission

The transmission of power from the Nelson to Southern Manitoba could be done by either of two electrical methods - alternating current or direct current - and by following either of two routes - one east of Lake Winnipeg, the other west of Lake Winnipeg. The Eastern Route would be shorter than the Western (approximately 520 miles from Kettle to Winnipeg compared with 610). However, the terrain encountered by the Eastern Route is quite difficult to approach due to the limited transportation facilities and roads in the area. Moreover the Eastern Route passes across muskeg, transverse water courses, boulder-strewn terrain and sections of little or no overburden for tower footings. Construction along this route would very likely involve resort to helicopter erection methods throughout - an expensive and weather-vulnerable method.

In comparison, the Western Route has readily available access over the greater part of its total length and soil and construction conditions are better known from parallel transmission lines.

Because ac transmission requires intermediate switching stations along the route, it was concluded that the Western Route was superior for ac transmission. For dc, the Eastern Route has a smaller capital cost but the uncertainties of construction in that more difficult terrain and the subsequent difficulties for operation and maintenance would support the choice of the Western Route.

The choice of direct current technology in comparison to alternating current technology was a matter of much more involved considerations. Each technology has its particular advantages and disadvantages. The earliest generating stations employed dc transmission technology but at low voltages the losses in energy were excessive. Employment of ac re-

duced losses at stepped-up voltages to an acceptable level. However, over long distances ac transmission becomes very delicate and instable being subject to disturbances which prevent the power from ever reaching its destination. Furthermore, transmission losses are nill.

There has been a resurgence of interest in dc technology for long-distance transmission at extreme voltages where the excessive losses do not prevail. As of 1965, five major dc installations were in service in the world and three others are in the design or construction stage. With total distances of over 600 miles from the Nelson River to Southern Manitoba, over 1,000 miles from the Nelson River to Minneapolis and over 1,600 miles from the Nelson River to Toronto, the Nelson River transmission requirements were then among the longest known to have been considered in the world. In an electrical sense, dc in effect moves the Nelson River to Southern Manitoba and the delicacy of interconnections with other large systems is accordingly modified. Also, the need for switching stations is removed and maintenance and operation of line and terminal convertor stations is simplified considerably.

In addition to the electrical advantages, dc technology exhibits certain cost savings in long distance transmission. As an example, the tower required to carry the line is smaller and less expensive. On the Western Route, the cost advantages of dc are reflected in the comparative cost per mile of a 500 kv guyed "V" No. 1 line of $75,600 for an ac line and $54,000 for a 450 kv dc line.

TABLE 3.3 COST OF LINE ALONE 1.

EHV ac

Eastern Route

(i) Rigid Towers 478 miles x $86,000/mile = $41.1 x 10^6
(ii) Guyed Towers 478 miles x $76,000/mile = $36.3 x 10^6

1. Source Manitoba Hydro

TABLE 3.3 (continued)

Western Route

(i) Rigid Towers 610 miles x \$70,500/mile = \$43.0 x 10^6
(ii) Guyed Towers 610 miles x \$62,700/mile = \$38.3 x 10^6

For the EHV ac line cost itself the Western Route is about \$2,000,000 cheaper.

AC is also subject to a cost of \$35,700/mile for 75% shunt compensation, 80% series compensation located in stations and switching station facilities.

EHV dc

Eastern Route

(i) Rigid Towers 478 miles x \$71,700/mile = \$34.4 x 10^6
(ii) Guyed Towers 478 miles x \$65,100 mile = \$31.1 x 10^6

Western Route

(i) Rigid Towers 580 miles x \$58,000/mile = \$33.6 x 10^6
(ii) Guyed Towers 580 miles x \$54,000/mile = \$31.3 x 10^6

The Western route is marginally more expensive for rigid towers and marginally less expensive for guyed towers.

For EHV dc the cost of the convertor station would be in effect equal for both routes. You cannot leave out convertor costs in a comparison of ac & dc - this is a major item.

Comparitive Sequential Development

In the actual comparison of the relative costs of developing the Nelson River compared with developing additional coal-fired thermal capacity, many alternative combinations were studied by a large professional staff having access to computer facilities. To attempt to perform the same analysis is beyond the purposes of this paper but it is possible to discuss the results of those studies.

Not only were sequences of development considered that were limited to the goal of providing capacity for Manitoba, but various export possibilities were examined. However, at the time when Manitoba Hydro had to make a decision whether or not to develop the Nelson, the export possibilities were still too indefinite to include them as firm plans affecting the decision. In the end, the decision turned on whether or not Nelson River

power was cheaper for the Manitoba market alone than coal-fired thermal power. (Fortunately, the Nelson River sequence which justified itself on the basis of lowest cost also left open the option to expand capacity for export at a later date.)

As has been stated before, in sequential analysis, the comparison between alternative schemes of development is made on the basis of the accumulated value of the present value of annual costs entailed by each of the respective series of capacity additions. It was found that for two alternative sequences of development of Nelson River power, one utilizing EHV AC and the other EHV DC transmission, there was little cost differencebetween them, as a result the technical virtues of DC technology, in respect to stability, became the basis for selecting DC transmission.

Consequently, a comparison was made between the Nelson River EHV DC sequence and the coal-fired thermal sequence (an oversimplification since there in fact, many Nelson River EHV DC and many coal-fired thermal sequences were considered).

An examination of the best EHV DC Nelson River sequence and the best coal-fired thermal sequence indicates that the comparative sequences of development are as indicated in Tables 3.4 and 3.5 and the comparative sequences of present-valued costs are as indicated in Tables 3.6 and 3.7 and Graph 3.1.

A study of the two alternative sequences of development indicates that in the short-run, development of thermal capacity would provide the lowest cost power and energy to meet Manitoba's forecast requirements, while in the longer term, Nelson River power becomes cheaper.

Graph 3.1 is a comparison of the excess of Nelson River accumulated discounted costs over the corresponding coal-fired thermal costs. It may be seen that the hydro sequence would be more expensive than the thermal sequence for the first eighteen years. Over the first twenty-year period the accumulated present value of the annual costs discounted at $5\frac{1}{2}\%$ interest to 1969-70 would be $372,420,000 for a coal-fired thermal sequence and $361,550,000 for the Nelson River sequence commencing with the Phase I Development. The ratio of

these costs is 1.03: 1.00 which is hardly a marked advantage for the Nelson River sequence particularly when consideration is given to the greater initial capital requirement associated with it and to the assumptions employed in these two sequences.

It should be noted that assumptions employed for the comparison of these two sequences of development generally favour the hydro electric development. For example, the assumed rate of growth of demand in the load forecast is based on a period of rural electrification and higher population growth than appears sustainable in the future. Confidential population predictions of 1980 by the Economic Council of Canada show slower rates of population growth in Manitoba. Moreover, the growth in demand for electricity is more rapid when introduced into an area which has been deprived of it than is the demand for electricity in an area which has had a long time to adjust to its availibility and acquire the appliances and labour-saving devices necessary to utilize it. Historically, the demand for the product of many industries has been observed to grow according to the Lorenz curve - slowly at first but at an increasing rate, then rapidly, and finally at a decreasing rate until it is growing slowly again. Projecting growth from a period of rapid expansion does not recognize such a trend although the period examined extended thirty-five years into the future from the year of the decision. These projected growth rates in demand favour the Nelson River alternative since they reduce the period of initial excess capacity that is required to make construction of a minimum sited generating transmission plant possible. Slower load growth projecting would favour both thermal sequences because thermal plants can be added in smaller units more tailored to slow load growth and because thermal plants have a much smaller proportion of fixed costs relative to total costs so that less must be spent for unutilized capacity.

The assumed interest rate used to discount annual costs in both sequences is $5\frac{1}{2}\%$, a rate lower than that obtainable by the electric utility

during the initial years of the development. Lower interest rates favour hydroelectric projects since they reduce the severity of high fixed costs, particularly during the initial period of excess capacity, and since, as a discount factor, they reduce by a lesser amount the ultimate advantages of a hydraulic source compared to a thermal source in respect to generation of electricity at high load factors. Moreover, it will be argued in another chapter that there are good reasons to believe that market imperfections make the rate of interest on electric utility projects (particularly hydroelectric projects) lower than its actual opportunity cost in the overall economy, say, in relation to housing.

Finally, in the thermal sequence the only allowance for technological improvement is through the use of larger units in the last years and by the ultimate resort to nuclear capacity. But the costs applicable to such capacity are the 1965 costs although rapid technological improvement is likely in the case of thermal energy but only slow technological improvement can be expected from hydraulic energy since it is already a highly developed field with high efficiency rates associated with its generating units.

TABLE 3.4 1

SUMMARY OF SEQUENCE X-32A FOR NELSON RIVER DEVELOPMENT AT 125,000 CFS DESIGN FLOW AND HVDC TRANSMISSION TO WARREN, MANITOBA

Power Year	Forecast Peak Load at Generation MW	Forecast Firm Energy at Generation 10^9KWH	System Additions
1969/70	1260	6148	Capacity and energy purchase
70/71	1370	6626	Kettle (6 units), 2 HVDC transmission ccts Kettle-Warren with one monopolar station at each end, Churchill River Diversion
71/72	1458	7024	
72/73	1545	7445	
73/74	1638	7892	Kettle (4 units)
74/75	1736	8365	
75/76	1840	8867	Lake Winnipeg regulation
76/77	1951	9399	Gas turbines (3-56 MW blocks)
77/78	2068	9963	Gas turbines (2-56 MW blocks)
78/79	2192	10561	Gas turbines (3-56 MW blocks)
79/80	2324	11195	Long Spruce (6 units), 2nd HVDC cct. to monopolar operation
80/81	2463	11867	
81/82	2611	12579	
82/83	2767	13333	Long Spruce (4 units
83/84	2933	14133	
84/85	3109	14981	Gas turbines (3-56 MW blocks)
85/86	3296	15880	Gillam (6 units), 1 HVDC cct. to bipolar operation
86/87	3494	16833	Gillam (4 units)

1 Plates 16 and 17, Nelson River Investigations, Interim Report of the Administrative Committee to the Programming Board Pursuant to Agreement between the Government of Canada and the Government of Manitoba Dated May 27, 1964
Winnipeg, November 30, 1965.

Power Year	Forecast Peak Load at Generation MW	Forecast Firm Energy at Generation 10^6KWH	System Additions
87/88	3703	17843	
88/89	3926	18913	Gas turbines (5-56 MW blocks)
89/90	4161	20048	Lower Gull (6 units), 2nd HVDC cct. to bipolar operation

TABLE 3.5 1

SUMMARY OF SEQUENCE X-27A FOR ALL THERMAL DEVELOPMENT IN MANITOBA

Power Year	Forecast Peak Load at Generation MW	Forecast Firm Energy at Generation 10^6 KWH	System Additions
1969/70	1260	6148	Thermal unit (150 Mw at Brandon)
70/71	1370	6626	Thermal unit (150 Mx at Brandon)
71/72	1458	7024	Gas turbines (2-56 Mx blocks)
72/73	1545	7445	Thermal unit (150 Mw at Kemnay)
73/74	1638	7892	Gas turbines (1-56 Mw block)
74/75	1736	8365	Gas turbines (2-56 Mw blocks)
75/76	1840	8867	Thermal unit (150 Mw at Kemnay)
76/77	1951	9399	Gas turbines (2-56 Mw blocks)
77/78	2068	9963	Thermal unit (150 Mw)
78/79	2192	10561	Gas turbines (3-56 Mw blocks)
79/80	2324	11195	Thermal unit (150 Mw)
80/81	2463	11867	Thermal unit (150 Mw)
81/82	2611	12579	Thermal unit (150 Mw), Gas turbines (1-56 Mw block)
82/83	2767	13333	Gas turbines (3-56 Mw blocks)
83/84	2933	14133	Thermal unit (300 Mw)
84/85	3109	14981	Gas turbines (2-56 Mw blocks)
85/86	3296	15880	Thermal unit (300 Mw)
86/87	3494	16833	Gas turbines (3-56 Mw blocks)
87/88	3703	17843	Nuclear (300 Mw)
88/89	3926	18913	Nuclear (300 Mw)

1 Plates 18 and 19, Nelson River Investigations, Interim Report of the Administrative Committee to the Programming Board Pursuant to Agreement between the Government of Canada and the Government of Manitoba Dated May 27, 1964
Winnipeg, November 30, 1965.

Table 3.6

SEQUENCE X-32A Nelson River Development -

Accumulated Annual Costs Present Valued to 1969/70 1

Power Year	Accumulated 1969/70 Worth $106
1969/70	3.25
1970/71	12.16
1971/72	27.95
1972/73	42.98
1973/74	57.97
1974/75	72.89
1975/76	87.81
1976/77	103.42
1977/78	119.43
1978/79	135.88
1979/80	154.82
1980/81	176.14
1981/82	196.60
1982/83	216.28
1983/84	235.51
1984/85	254.45
1985/86	274.81
1986/87	296.74
1987/88	318.09
1988/89	339.35
1989/90	361.55

1 Source - Manitoba Hydro

Table 3.7

Sequence X-27A All Thermal

Development - Accumulated Annual Costs Present Valued to 1969/70 [1]

Power Year	Accumulated 1969/70 Worth $106
1969/70	3.74
1970/71	9.53
1971/72	17.36
1972/73	27.14
1973/74	38.60
1974/75	51.00
1975/76	64.76
1976/77	79.84
1977/78	96.17
1978/79	113.94
1979/80	132.90
1980/81	152.64
1981/82	173.45
1982/83	195.10
1983/84	217.95
1984/85	241.71
1985/86	266.14
1986/87	291.28
1987/88	317.33
1988/89	344.61
1989/90	372.42

1 Source - Manitoba Hydro

CHAPTER FOUR

SECONDARY EFFECTS OF NELSON RIVER DEVELOPMENT

The development of power on the Nelson River would affect not only the power costs of the local electric utilities but also the Manitoba and Canadian economies. The potential effects fall into three general categories:

1. Employment Effects
2. Balance of Payments Effects
3. Long-term and Minor Effects

1. Employment Effects

One of the most immediately apparent effects of construction of dams in northern Manitoba is its employment effect. Further, it should not be forgotten that the construction industry plays a particularly important social and economic role in the community. The construction industry absorbs many members of our society with less than average education or employment skills. Construction is a usual source of employment for new immigrants. And construction, it must be said, accepts many individuals whose social adjustments and practices would not be accepted in other employment environments.

The employment boosting effects of construction of hydro electric dams in northern Manitoba on the Nelson River can be roughly divided into three classes:

1. On-site employment in construction and related activities;
2. Services and supply employment maintaining the on-site labour force and construction activities.
3. Factory and other labour involved in the manufacture of the requisite supplies and materials.

While no great precision can be attained, a rough quantification of the employment generated by Nelson River construction is pertinent to any appreciation of the economic attractiveness of developing the river.

(a) On-Site Construction Labour

All the dams proposed for construction on the Nelson River, as well as all the works for the flow improvements of the Lake Winnipeg Regulation and Churchill River Diversion are of the earthfill gravity dam type. This type can roughly be described as consisting of rock and earth fill piled up in a high dike with a very large base in relation to its width at the top. Such a dam remains in place and restrains the flow of water due to the weight of its massive bulk and the stability of its wide base. All other hydro electric dams in Manitoba power utility construction experience have been of the concrete gravity dam type. While somewhat similar in the engineering principles by which it restrains the flow of water, these dams obviously use proportionately much more concrete in their construction. The remoteness of the Nelson River power sites and the availability of suitable earthfill precluded resort to concrete as a major building material. Despite this one difference in construction materials many of the other steps in the construction process and components of the proposed structures are similar to those employed in the recent concrete gravity dam experience of the Manitoba utilities. Furthermore, each hydro electric development is in many significant respects unique and distinct from all other hydro electric developments. What is applied in the design and construction of these structures is not an assembly-line procedure but a body of knowledge, a catalogue of experience in dealing with similar but not identical conditions. Each hydro electric

development is the product of the application of human intelligence and experience to certain fixed and unalterable conditions of nature. These fundamental phenomena, the flow characteristics, the geology of the river bed, natural falls and potential reservoirs, combine to present a unique and distinct set of premises upon which this body of knowledge must operate to prepare a suitable control of the river to justify installing water turbines.

There will always be a marked variation in labour requirements from site to site even if both of them are of the same construction type. However, there would be a general similarity in the labour types required by either the concrete gravity and the earthfill gravity types of construction. Both types would require labour for roughly similar duties of site clearing, dyking, coffer-damming, excavation, turbine and fixture installation, etcetera. Although an exact relationship between capital costs and labour requirements cannot be found for each specific construction type, given the variability from site to site, employment requirements for a concrete gravity dam would be a serviceable rough guide to the requirements of an earthfill gravity dam although not as good as figures based upon employment at an earthfill gravity dam in Northern Manitoba. But the more comparable figures have not been compiled because no such construction had taken place in Northern Manitoba before.

As a very rough guide, the experience with the Grand Rapids concrete gravity dam should be as acceptable as an indication of the manpower requirements of Nelson River construction as any other information source. Given the uniqueness of each project, no other project can claim to be more directly comparable and the Grand Rapids project was constructed under Northern Manitoba construction conditions.

Each Grand Rapids Generating Station monthly report [1] included figures on how many men were there for the month. By adding the reported manpower for each month, total employment on the Grand Rapids project may be estimated at 3,750 man years. (A man year means that a man would be on-site for twelve months.) The capital cost of the Grand Rapids dam and powerhouse is $102 million. Therefore, 36.8 man years were required per million dollars of construction cost.

Capital costs for the most expensive development at each of the Nelson River sites and the resultant estimated total man years of employment are shown in Table 4.1.

1 Manitoba Hydro

TABLE 4.1 1. ESTIMATED CONSTRUCTION EMPLOYMENT AT NELSON RIVER SITES

Site	Capital Cost[1] ($000,000)	Total Employment (man years)
Kettle	138	5,100
Long Spruce	141	5,200
Limestone	261	9,600
Gillam Island	133	4,900
Lower Gull	114	4,200
Upper Gull	115	4,200
Kelsey Extension	27	1,000
Churchill River Diversion	21	800
Lake Winnipeg Regulation	29	1,100
Total		36,100

Transmission Construction

A survey of working orders of transmission line construction in Manitoba discloses that about 20% of the total cost is for labor. 2. In the opinion of transmission line experts, there is no general reason why this proportion would alter radically for a large EHV line but the proportion for any specific line could vary sharply due to the particular construction problems encountered.

The cost per mile of a 450 kv line was estimated at $70,500 by Manitoba Hydro and a minimum of two lines would be required. Table 4.2 contains the estimated approximate employment due to construction of transmission lines from Kettle Rapids to specific markets.

1 Source: page 29 Interim Report of Administrative Committee November 30, 1965 Winnipeg 1965

2 Manitoba Hydro

TABLE 4.2 ESTIMATED CONSTRUCTION EMPLOYMENT FOR TRANSMISSION LINES FROM KETTLE RAPIDS

Terminus	Capital Cost ($000,000)	Total Employment (man years)
Winnipeg	84	1,600
Toronto	166	3,200
U.S. Border (destination Minneapolis)	80	1,600

(b) Services and Supply Labour

Maintaining the on-site labour force and construction activities will require employment in auxiliary services such as transportation, banking and finance and other industries. The development of auxiliary employment has been a convenient source of justification for various "make-work" projects. The question must always arise whether these workers would not easily be otherwise or elsewhere employed. Clearly, conservatism is desirable in an area so clearly prone to abuse. The Manitoba employment multiplier has been estimated at between 2.0 and 2.2 1.

(c) Manufacturing Labour

Nelson River construction will require manufactured articles both as components of the finished product - the hydro electric dam - and as the tools employed in building the product. It should be noted that much of the employment for such articles would occur in jurisdictions other than Manitoba. This is an area of challenge. A perusal of the requirements for manufactured goods indicates that most, if not all, of the requirements for manufactured goods would be supplied from other jurisdictions. However, many could be produced in Manitoba.

1 page 111 - 2 - 5 Report of the Committee on Manitoba's Economic Future, Queen's Printer, Winnipeg, 1963

2. Improvement in the Canadian Balance of Payments

It has been proposed that export of Nelson River power would be a substantial foreign exchange earner and would thereby improve the Canadian balance of payments on current account. While this could be true during export years there is just as much likelihood that Nelson River power would cause an over-all deterioration in the Canadian balance on current account. Moreover it may be questioned whether balance of payment considerations are a legitimate investment criterion in modern day government with its more immediate and controllable fiscal, monetary and exchange rate tools.

Initial Deterioration During Construction Period

During the years of construction the rise in investment will tend to boost the national income. As the national income rises imports and savings will rise which will limit the rise in incomes. Whether the rise in income will consist only of inflation of prices depends upon whether there is excess capacity or full employment of the national resources. To avoid inflation if the economy is in a state of full employment, all of the resources for the extra investment must be borrowed abroad and the balance on current account will deteriorate by the full $250 or $400 million required to construct the facilities to export the 800 MW or 1200 MW as the case may be. There would undoubtedly be some price inflation which would require greater construction expenditures than estimated. Deterioration in the balance on current account can limit the price increase.

If there is excess capacity in the economy during the construction period the rise in incomes occasioned by the extra investment will provide some extra savings which will be available to finance the investment and thereby limit the amount which has to be borrowed abroad. This

would limit the necessary deterioration in the balance on current account perhaps to as much as half the construction cost. The actual amount by which the balance on current account would be worsened by Nelson River construction depends on a number of dynamic and volatile factors affecting savings and imports. The more rapidly imports rise with income the more the balance on current account will be worsened. The more slowly savings rise with income the more the balance of payments will be worsened. Canadian imports have been observed to rise rapidly with income while savings usually rise slowly during a prolonged period of expansion of incomes. It is probably therefore that the largest part of the construction costs of the Nelson River would have to be borrowed.

On the other hand it should be said that the worsening of the balance on current account during the construction period is largely a cost of attaining full employment and would occur through most employment-creating projects. In comparison to most such projects Nelson River construction would involve a comparatively high proportion of domestic goods and services and would therefore involve relatively less deterioration in the balance on current account. Therefore, if the construction could be accomplished in the five-year period 1967-71, the balance on current account might be worsened neglecting secondary import effects by the full cost of the development by an average of $50 million to $80 million annually. In times of economic slack, the secondary import multiplier effects would raise that figure.) This is not a large part of a forecast deficit of $1,000 to $2,000 million. Thus as an employment-creating project Nelson River construction would have fewer balance of payments problems than most. If the economy were at full employment or fighting inflation, it

would worsen the balance on current account by the full amount but not limit the rise in prices as much as most other projects.

For the purposes of this exercise it is assumed that starting in 1970 power can be sold at $30 a kilowatt in the United States. Two examples are considered.

Case A — The export of 800 MW with $250 million development costs.

Case B — The export of 1200 MW with $400 million development costs.

Trends in the Canadian Balance of Payments

The deficit in Canada's external account on a national accounts basis climbed from $428 million for the year 1964 to $1,101 million in 1966.

In its First Annual Review, the Economic Council projected an increasing deficit due to a faster growth in imports than in exports. The Council predicted a possible $1,500 or $2,000 million deficit in 1970.

Later Improvement in Balance of Payments After 1970

The most obvious benefit of the power export would be an annual revenue of $36 million dollars after 1970. This would represent from 1.2% to 2.4% of the forecast 1970 deficit. Since export would be long-term it would be a stable source of foreign exchange earnings.

If there were not enough investible funds available in Canada to finance the construction of the necessary dams and transmission lines, it will be necessary to increase borrowing in the U.S. by $250 million in Case A and $400 million in Case B. Also after 1970 interest would have to be paid on the debt. At a 5.5% rate of interest this would be $14 million in Case A and $22 million in Case B and would offset the export earnings of $24 million and $36 million respectively. The net effect of export after 1970 would be $10 million of foreign exchange earnings in Case A

and $14 million in Case B. Table 4.3 summarizes the primary effects of large scale export of power to the U.S.

TABLE 4.3 PRIMARY FOREIGN EFFECTS OF LARGE-SCALE POWER EXPORT

Amount Exported	Maximum Annual Borrowing Before 1970 (millions	Annual Gross Earnings After 1970 (millions)	Annual Interest Payments After 1970 (millions)	Annual Net Earnings After 1970 (millions)
800 MW	$50	$24	$14	$10
1200 MW	80	36	22	14

As a summary it may be said that during the construction period the balance on current account could be worsened by an annual $50 to $80 million approximately. Later it will be improved by an annual $10 or $14 million. The initial deterioration might occur in greater severity in any case by any other employment-creating project. The value of the future foreign exchange earnings is problematical.

A consideration of whether the worsening of the balance on current account during the initial period would lead to a foreign exchange problem would depend on the ex ante foreign investment in Canada abroad.

3. Long-Term and Minor Effects

Many of the effects which fall under this category are studied in later chapters but some enumeration is justified at this point to provide for the consideration of what secondary effects apply.

Effects which are considered in later chapters include the contributions of the Phase I Development to the development of dc technology and future evolvement of a national grid, the potential value of dc technology to Canada in the future, the development of the northern Manitoba frontier and its reciprocal benefits to southern Manitoba and the value of low-cost electricity to the development of Manitoba industry.

One effect not examined elsewhere is the possible substitution of a renewable Canadian resource for either an exhaustible Canadian resource or an American import. Hydro sites do prevent the use of coal deposits but with technological improvements in mining and materials usage the value of such an effect is dubious. The value of reducing imports has been questioned in the face of more modern and flexible techniques such as exchange and interest rate variation.

Development of the Nelson River can contribute to future irrigation and navigation schemes on the Canadian prairies. 1. The hydroelectric dams can be utilized partially to control water levels for such purposes. (This possibility is still remote and experience with forecast irrigation and navigation uses on multiple purpose projects in the United States has not been entirely successful.)

Development of the Nelson River could contribute to the employment and advancement of the native peoples in northern Manitoba. However, the numbers of such people are small and the experience with construction projects and native peoples has not been good (cf. Lagasse Report). 2.

1 page 341, E. Kuiper, "The Water Resources of the Nelson River Basin" in Resources For Tomorrow
Volume 1, Queen's Printer, Ottawa 1961.

2 page 823, volume III, A Study of the Population of Indian Ancestry Living in Manitoba, Social and Economic Research Office, Manitoba Department of Agriculture and Immigration under the direction of Jean H. Lagasse, Winnipeg 1959.

CHAPTER FIVE

INDUSTRIAL DEVELOPMENT

The contribution of the Nelson River development towards the industrial development of Manitoba seem to arise not only due to low power costs but also from manufacturing and assembly operations which would be established to supply demand originating with the project, and from its short-and-long-run effect on the provincial balance of payments. Once the topic of industrial development is considered, however, the likelihood and the advisability of locating the ensuing industrial development in Manitoba must be compared to that of alternative industrial locations.

EFFECT OF LOW ELECTRIC POWER COSTS

One point requiring clarification and restatement is that the electric power produced on the Nelson River will not be markedly lower in cost than that which could have been produced by other alternative sources. It has been observed that the development of the Nelson River is only narrowly superior to a program of developing thermal capacity. Moreover, Manitoba has enjoyed low electricity costs since the earliest years of electric power development. Development of electric power on the Nelson River, therefore, represents, not a transition to a new order of power costs, but merely a continuance of a presently prevailing situation. Despite the low electricity costs in Manitoba, it is difficult to argue

that such low power costs have occasioned any special surge of industrial development.

In industry electric power is primarily a form of motive power. While, most industrial processes require substantial quantities of heat and this is something which electricity, in general, cannot provide on an economic basis. Furthermore, the electric power bill in most industries is only a small proportion of the total costs of operation. Finally, many industries are more market-oriented than supply-oriented, and, whatever the advantages prevailing within a proposed plant, lack of mass markets and high transportation costs to outside markets can quickly submerge any on-site benefits.

In consideration of such factors, it has been advanced that, from the point of view of industrial development, the availibility of electric power on reasonable terms is more critical to industrial development than the particular degree of cost advantage.

An important consideration in examining the impact of power costs on industrial development is the comparative structure of rates between the various classes of consumers (whether domestic, commercial or industrial) particularly in light of the rates prevailing in other areas. Manitoba traditionally has had very low domestic and farm power rates. In comparison with Ontario and Quebec, Manitoba's industrial rates are somewhat higher although lower in most cases than those prevailing in other parts of Canada. This in part reflects the differing relative political powers of consumers in Manitoba on the one hand and those of industrial concerns in Ontario and Quebec, on the other, both urban residential and rural farmers, have been a driving force behing the demand for electric power in Manitoba.

Extending John Dales' thesis that the relative structure of power rates in Quebec (high domestic, low industrial) had led to the development of a social structure favouring an advanced primary industry base with a habitant culture, it may be argued that the prevailing rate structure in Manitoba (relatively low, relatively high industrial) tended to produce an economy that imported and consumed large quantities of appliances and power but not an economy that produced many appliances itself. This trend apparently contradicts a study of the relative economies of operating an electrical manufacturing facility in Manitoba compared to other centres prepared by the Fantus Corporation (an American consulting firm) in the early part of the 'sixties. It indicated operating and transportation advantages for a firm based in Manitoba over any other centre.

(i) Dominion Bureau of Statistics: Electricity Bills - 57203

(ii) Cost comparison study, a comparative study of the ABC corporations operating costs among 12 Canadian cities: Prepared by the Fantus Company, Chicago, Illinois, 1963. Page 9.

Development of the Manitoba Northern Frontier

With respect to Northern development (particularly mining) the development of power on the Nelson River should not be construed as advancing the potential of such development. Northern Manitoba abounds in small power sites awaiting development. The decision to utilize EHV DC makes it very unlikely that Nelson River power will ever be used in any sizeable amount for typical northern developments. The cost of conversion from DC to AC is too great and the cost of stepping down from EHV levels of 900,000 volt-amperes is similarly a factor tending to decrease the likelihood that Nelson River power will be economically feasible for the general type of northern industrial devleopment. Such loads are well below

the hundreds of megawatts required to justify the stepping-down and conversion facilities. However, as stated before, there are many potential power sites in northern Manitoba which have sufficient capacity to service the small industrial power requirements of mining and timber developments although not large enough to justify the expensive transmission facilities required to transfer the power down to southern Manitoba. (See also "Effect on Balance. . . Capability" on page 57.)

Effect of Construction Program on Long-Range Development

The program of construction of the Nelson River will include a demand for many products and services. For some of them demand may be large enough to justify the installation of manufacturing and assembly facilities to produce them in Manitoba. This development effect is in some senses a version of supply creating its own demand or of demand creating its own supply. The electric power industry is a very large and all pervasive industry requiring massive amounts of capital and having a very large and widely dispersed labour force. Moreover, the employees and contractors recipient of payments in the electric industry are inescapably consumers of the electricity, appliances and machinery which they themselves produce.

The potential is there that firms finding it feasible to move into Manitoba on the basis of supplying the demand occasioned by development of the Nelson River would find the economic environment suitable for further expansion and extension into other markets and product lines.

Effect on Balance of Payments of Increased Export Capability

There is a possibility that, while the initial impact on the balance on current account would be to tend to create a deficit, over the long-run there would be succeeding rounds of industrial development which would increase Manitoba's ability to compete in export markets. While much attention has been focussed on the potential developments in electricity-intensive industries, low-cost electricity is nothing new to Manitoba and the development of the Nelson River does not mean that the rate structure of Manitoba Hydro

would be altered. The new dimension that the Nelson River development introduces to the Manitoba economy is the magnitude of its expenditure on Northern Development. There still remains the possibility of electricity. Mining and other resource industries could increase due to improvements in northern roads, communications, industrial aptitude of native people and other elements in the economic infrastructure of Northern Manitoba. These possible developments could increase Manitoba's exports in the future.

Industrial Development and Consideration of Alternative Power Markets

Once the initial expenditure of on-site development and of the DC conversion equipment has been undertaken, the additional cost of transmission is relatively small. Therefore, once the decision to develop the Nelson River has been made, the beneficial industrial development effects of the development could, in principle, as logically take place 500 miles from the sites on the Nelson River or 1,000 miles distant, without effecting things to any great extent. The question may be put then disregarding considerations, such as national boundaries and political subdivisions, what would be the optimal centre for the industrial development occasioned by the development of the Nelson River if it were the clear objective to maximize the industrial benefits of development of the Nelson River.

A comprehensive answer to this question would require an exhaustive comparison of the capacities of the industrial bases of Winnipeg and Minneapolis. Such an analysis is beyond the purposes of this paper. However, barring a sector-by-sector analysis of the demand and increase electricity for electric energy in each of the respective centres, it would appear that (inasmuch as the specifically new aspect of the development of the Nelson River development is the size of the expenditure on Northern Development) the major industrial development effect of development of the Nelson River will be felt in its greatest magnitude in Manitoba rather than Minnesota and Winnipeg is the major population and manufacturing concentration in Manitoba.

Moreover, Minneapolis has the opportunity for achieving the very low electricity power costs for a huge nuclear development and can absorb such a large plant. The potential for capitalizing on the development effects seem to be concentrated in Winnipeg in comparison with Minneapolis.

CHAPTER SIX

EXAMINATION OF THE ISSUES INVOLVED BY JURISDICTIONS

Hydroelectric developments occur in large discrete lumps. The effect of such developments are structural rather than marginal. The commitment of resources is virtually irretrievable and because of size and long service life that commitment requires the foregoing of many other possible sequences of development much more than most other types of investment. The large size of the Nelson River development compared to the Manitoba economy intensifies these general aspects of hydroelectric projects. The consequences of the project are important for the nation, the province and the utility.

The purpose of this chapter is to analyse the various jurisdictional issues affecting the Nelson River development and to assign them to the particular authority or authorities involved. This will be done by describing an optimum outcome and then examining how departures from this optimum would affect the different authorities.

Ideal Result

The success of the Nelson River development, first of all, depends on its success as a provider of low-cost energy. The long service life of hydroelectric projects and the large component of fixed costs in their total costs, imply low-cost power and protection from inflation for long periods for those utilities having a heavy proportion of large blocks of hydraulic energy in their systems. Moreover, those Nelson River power sites that are to be developed do not have to provide energy of lower cost than some other subsequent source of low-cost, high energy source, such as nuclear power, for their entire service lives to justify the decision to pursue development of the Nelson River. This applies not only in a world of imperfect knowledge and uncertainty of the future where a decision need not be ultimately proved right but only the wisest that could be attained with the information which

could be developed. There is also the case in which the Nelson River would be developed for a period of years and then Manitoba Hydro could go to Nuclear (or some other) capacity. It is entirely possible that such a procedure would provide lower ultimate costs for the period overall than would a procedure of "marking time" with coal-fired thermal capacity (of lower relative fixed costs) until nuclear energy eventually became superior (if ever).

Development of the Nelson River will make some contribution towards the strengthening of the industrial base of Manitoba particularly in the field of secondary manufacturing and assembly. The advantages of the Nelson River development from the point of view of industrial development lie not only in the low-cost energy benefits and in the size of the capital commitment but also in the probable long duration of the sequence of development of successive sites. The nature of construction on the Nelson emphasizes earth-moving and there stands to be substantial earth-moving on the Nelson River until the year 2000, approximately. This creates a demand for many types of earth-moving machinery, equipment and supplies and could justify the installation of plants and facilities in the assembly and service of this field. Particularly since many of the demands for such services and equipment are similar to those of the agricultural machinery so prevalent in the wheatgrowing regions of the Prairie Provinces and the Prairie States. A factor to consider in the possible contributions of the Nelson River development to Manitoba industrial development is the location of such energy development relatively close to tidewater.

Development of the Nelson River could contribute to an optimal program of utilization of the water resources of the Canadian Western Plains.

Water presently is flowing down the Nelson River to the sea with only the Kelsey powerhouse making any use of this great natural resource. It appears that it will be some time before any substantial alternative use will materialize for that water. Furthermore, only the minor part of the flows of the Nelson River originate in areas that are likely ever to require any substantial quantities of water for consumptive purposes.

Extra-high voltage direct current technology has some potential as a medium of transmission of large blocks of power from remote northern hydro, Maritime Provinces mine-mouth coal-fired thermal plants or isolated nuclear plants to load-centres across Canada. EHV DC tehcnology has been seen as significantly contributing to a feasible national grid.

Federal Government and the Overall Economy

The Federal Government's participation in Phase I of the development of the Nelson River has committed a portion of the borrowing capacity of the central government to the transmission facilities of the development. Furthermore, it was the enabling factor which permitted the Phase I portion to go forward at this time. The Federal Government thus has an interest and responsibility in seeing the success of the Phase I Project.

Despite the Federal enthusiasm for EHV DC transmission there are some questions associated with it aside from its technical and financial feasibility. The number of remaining northern rivers having sufficiently large power sites to justify the use of DC transmission is small. Development is proceeding on the Peace River and at Churchill Falls without such a system of transmission. The much-heralded national grid may never become of sufficiently large scale to validate the use of DC technology. As in so many forms of transport, the natural lines of flow of electric

power run north and south rather than east and west, the only justification for east-west transmission lines being in the temporary shunting of peak capacity across different time zones (a demand of only limited amount and duration). Otherwise, it will probably always be more attractive for a Canadian utility,other things being equal, to favour any sizeable interconnections with an American utility than with another Canadian utility, simply because of the problem of distance. This will apply particularly in the not-too-distant days of widespread nuclear power.

With respect to the most economic use of water, the Federal Government has some interest in avoiding any situation which will have the danger of irrevocably committing the water resources of the Saskatchewan Basin to the low-value use of electric power generation. There is always the possibility that administrative entanglements and excessively high compensatory allowances towards energy foregone on the Nelson River could forestall valid alternative uses of the water in future times. One possible use for the water would be the North American Water Project Alliance which recommends the sale of substantial quantities of Canadian water in the United States for industrial and municipal purposes. However the cheap alternative cost in the United States of other forms of water purification (such as in nuclear generating stations) tend to indicate that the Canadian receipts for such water will never be particularly great.

The Federal Government with its interest in protecting the long-term welfare of the overall economy must pursue a very conservational approach to the use of water resources. On the one hand, there is the introduction of nuclear power with its greater ease of locating in alternative places.

There is also the commitment of resources for regional development which might better be employed both in other schemes of development and in other regions.

Manitoba

The high fixed costs of the Nelson River development represent a heavy commitment for a long term by the people of Manitoba. There is always the possibility that the power plants developed on the Nelson will represent a waste of resources upon the appearance of other cheaper sources of energy or of the eventual replacement of the central power generating station by some other system such as residential-sized generating units. Since Manitoba Hydro debt is guaranteed by the Province the decline of demand for the output of central electric generating stations would impose substantial debt on the Province. In a hydraulic system, the low annual operating costs of the hydro dams (about 0.4 mills per kilowatt hour) would mean that electricity from an existing hydro plant should be lower in cost than electricity from any other conceivable source in an ex post sense. However, the demand for the output of central generating stations could decline if alternative energy sources permit greater customer convenience, such as appliances with self-contained power units.

The decision to use EHV DC transmission carried with it the inability to drop off loads in the North unless they justify the installation of convertor stations which require very large blocks of capacity to defray their heavy fixed costs.

There is finally the consideration of whether the extra capital commitment required by the Nelson River in comparison to coal-fired thermal might not have more benefits for provincial development if it were channelled

through another undertaking.

Electric Utility

The electric utility planners were confronted by similar considerations than those faced by the other agents. The possibility exists that lower cost sources of power would materialize in the near future. Further, the power planners in Manitoba must have some concern that considerations beyond their direct control could deny the utility sufficient supplies of water at some future time.

There is always the consideration that, while a nuclear plant is beyond the capacity of Manitoba particularly from a system reserve point of view, it need not be so for the combined systems of Manitoba and North Dakota. The location of a nuclear generating plant somewhere between Minneapolis and Winnipeg could provide low-cost on-site energy and minimize transmission costs.

Conclusion

As with many important developments, the justification of the Nelson River project was not a simple open-and-shut case. The decision to develop was taken in the face of considerable uncertainty about its outcome and in the face of many alternative opportunities for accomplishing the same ends.

Before commenting on the desirability of the project a study will be made of the experience with hydroelectric developments by private enterprise in Quebec, by state ownership in the U.S.S.R., and by public action in a mixed economy in the United States. Then an attempt will be made to develop analytical procedures appropriate to present-day Canada.

PART THREE

COMPARATIVE ELECTRIC DEVELOPMENT METHODS IN THE UNITED STATES AS THEY RELATE TO NELSON RIVER DEVELOPMENT

CHAPTER SEVEN

UNITED STATES RESOURCES INVESTMENT PRACTICES

Introduction

As the wealthiest and most advanced mixed economy in history, the United States has led the way in the development of advanced techniques of analysis of various investment proposals. In her recent history, the United States has seen the development of benefit-cost techniques that are particularly applicable to investments by public authorities. With the similarity between the American and Canadian economy, there is a pronounced tendency for an uncritical acceptance by Canadian analysts of the more advanced techniques of the American economists. For example, such embodiments of professional opinion as the Resources for Tomorrow Conference have recommended the technique to Canadian application.

(i) Page 158, Resources for Tomorrow, Volume III, Proceedings of the Conference, Queen's Printer, Ottawa. 1962.

However, the American benefit-cost technique evolved under a particular set of conditions which include some elements of public and some elements of private enterprise. The benefit-cost criterion evolved in a mixed economy for projects having multiple products (benefits) and in the context of a large and comparatively advanced economy. An appraisal is possible after a review of the historical conditions under which the benefit-cost analysis evolved. The Tennessee Valley Authority is also a particularly important practice. The TVA type of administration is charged with sufficiently broad terms of reference to justify its consideration of procedures which "internalize" the external economies typical of large hydroelectric projects. The mechanism is there to examine the relative merits of many development opportunities in the

example of a mechanism of development in a mixed economy.

Historical Background

Despite the predominance of private ownership enterprise in the United States, the federal government is the largest owner of hydroelectric capacity in the United States. From an early stage in the nation's history it was recognized that the federal government had jurisdiction over navigation. In the twentieth centruy as the necessity to conserve natural resources became more widely felt, the "conservation movement", an alliance of intellectual leaders, politicians and public servants, began to affect public policy. In 1920 the Federal Power Commission was created with control over water-power sites on navigable streams on public lands. With the passage of time the jurisdiction of the Commission widened until, during the first term of Franklin D. Roosevelt, it included all electric energy (if the electric current was sold in interstate commerce).

The involvement of the federal government in hydroelectric developments in the United States leads to the rather paradoxical situation that, in the leading free-enterprise nation, the evolution of a policy of examining the feasibility of hydroelectric projects has been conducted in the national political arena. The history of the Tennessee Valley Authority is a case in point.

As early as 1824, a proposal was made to improve navigation on the Tennessee River as part of a broad program of waterways development. Over the next century subsequent bills to develop the Tennessee River were presented to Congress and met much success. Shortly after his inauguration, President Franklin Roosevelt indicated the enthusiasm for the project in a message to Congress and a bill was signed by the President May 18, 1933.

Gordon R. Clapp, chairman of the board of TVA from 1946 to 1954 and associated with the undertaking from 1933, has observed of the TVA act:

That Franklin D. Roosevelt of New York was in the White House in 1933, George Norris of Nebraska was in the Senate, and the country was prostrate with unemployment had almost everything to do with its creation at that time. But the ideas and policies written into the Act evolved from the reflective observations, studies, and experiences of the scientists and the informed concern of laymen who initiated the conservation movement.

(i) Page 8, Gordon R. Clapp, The TVA, an approach to the development of a region University of Chicago Press, Chicago, 1955.

The multiple purposes of TVA are indicated in Section 23 of the Act which provides that:

. . .general purposes (1) the maximum amount of flood control; (2) the maximum development of said Tennessee River for navigation purposes; (3) the maximum generation of electric power consistent with flood control and navigation; (4) the proper use of marginal lands; (5) the proper method of reforestation of all lands in said drainage basin suitable for reforestation; and (6) the economic and social well-being of the people living in said river basin.

It should be recognized that these objectives are not always mutually compatible. To quote from the first technical report, The Norris Project: A Comprehensive Report on the Planning, Design, Construction, and Initial Operations of the Tennessee Valley Authority's First Water Control Project:

(i) Page 32 Tennessee Valley Authority, the Norris Project: A Comprehensive Report on the planning, design, construction, and initial operations of the Tennessee Valley Authoritys first water control project. Technical report No. 7 United States government printing office, Washington, 1940.

The federal government had previously carried out projects for the development and use of water power, for navigation, and for control of floods. The distinction of the TVA was an administrative device. Previous bills had addressed themselves to the special advantages and applications of particular sites. President Roosevelt in a message to Congress directed their attention to the first (Norris Dam site) and recommended a comprehensive program for development of the

resources of the entire Tennessee drainage basin in these terms:

"The continued idleness of a great national investment in the Tennessee Valley leads me to ask the Congress for legislation necessary to enlist this project in the service of the people.

"It is clear that the...(initial site)...is but a small part of the potential public usefulness of the entire Tennessee River. Such use, if envisioned in the entirety, transcends more power development: it enters the wide fields of flood control, soil erosion, afforestation, elimination from agricultural use of marginal lands, and distribution and diversification of industry. In short, this power development ...leads logically to national planning for a complete river watershed involving many states and the future lives and welfare of millions...

"I, therefore, suggest to the Congress legislation to create a Tennessee Valley Authority - a corporation clothed with the power of government but possessed of the flexibility and initiative of a private enterprise. It should be charged with the broadest duty of planning for the proper use, conservation, and development of the natural resources of the Tennessee River drainage basin...This Authority should also be clothed with the necessary power to carry these plans into effect.[1]

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1. House Document 15, Seventy-Third Congress, First Session, printed in full text at 77 Congressional Record 1423 quoted in J.S. Ransmeier The Tennessee Valley Authority 1942 Vanderbilt University Press, pp. 135 - 138.

From its origin, therefore, the Tennessee Valley Authority was conceived and constituted with broad administrative concerns and powers. An example of the comprehensive approach it took to resource development planning is its extension of low-cost electric power via the mechanism of publicly owned distribution organizations. The rates that these organizations could charge were set by TVA in its power contracts with them. The rates charged by the TVA contractors were, generally, about 50% or more lower than those of the private power companies in

the region for residential and commercial customers and about 30% lower for industrial power customers.

Moreover, as indicated in the Ransmeier study, lower rates appear to have increased consumption of electricity enough to increase the financial return to the local publicly and privately owned distribution organizations. [1]

One aspect of the TVA multiple purpose approach to water resources development is that it is conducted in an environment that is hospitable to joint use of dams. Generally the potential power sites in the United States occur in areas that (compared to Canada) are nearby to concentrations of population desiring the potential services of improved navigation, irrigation or recreation. The TVA in the United States, for example, has participated in projects as various as the research and development of chemical processes to develop fertilizer and munitions from mineral deposits in the area. This arose from the prior erection of nitrate munitions plant in the region during World War I.

The experience in the United States of the multiple-purpose development of river basins by public agencies subject to different financial constraints than private firms has led to the development of a new feasibility evaluation technique, benefit-cost analysis.

Benefit Cost Analysis

Until very recently most of the literature on benefit-cost analysis consisted of official American documents or of summarizations and critiques of these documents. The overall benefit of costs of a project are examined under this method:

1. Pages 146and 164 Joseph S. Ransmeir, The Tennessee Valley Authority Vanderbilt University Press, Nashville, 1942.

This viewpoint is the view from Washington, D.C., surveying the whole of the United States and taking the algebraic sum of gains and losses in the various parts of the United States; that is, taking the net gains and losses regardless of their regional incidence. [1]

The method consists of making provision, in water resources projects, not only for "primary benefits" but also of "secondary benefits". The practical effect of such a method has been to obtain permission from Congress to proceed with hydroelectric projects which were not financially competitive with thermal electric options if they were built as single purpose projects. Intangible benefits generally are recognized by means of a qualitative statement of the nature of the particular advantage involved and the weighting of such advantages is left to political authorities.

Costs are divided into primary or direct, secondary, and associated. Primary costs or direct costs are those necessary to make project services available. Secondary are those necessary to realize secondary benefits. Associated costs are those incurred by the primary beneficiaries to realize the full value of its benefits. These costs are deducted from gross primary benefits in deriving the value of anticipated primary benefits. In general, "The economic costs of a project are considered to be the value of the benefits as represented by other uses of the resources that are foregone as a result of the development. They also include any adverse effects that result from the project. [2]

There is some divergence as to the criteria for selection of the best project. Some authorities prefer the project with the highest

1. A. Scott in Water Workshop B, Resources for Tomorrow, Vol. 3, Queens Printer, Ottawa, 1962.

2. R. A. Spargo, "Benefit-Cost Analysis and Projext Evaluation" in Resources for Tomorrow, Queens Printer, Ottawa 1962, Vol. 1

benefit-cost ratio while others lean to selecting the project with maximum net benefits (sometimes stated in terms of the project with an incremental benefit-cost ratio of 1 in relation to alternative projects). [1]

The division in opinion on the basis of selection of projects is primarily a division on the various jurisdictions as to proper aims. In general, if there is some precondition imposed such as providing a particular service, develop a region, or give employment, then the project achieving that aim with the highest benefit-cost ratio is to be selected. If the aim is to develop a particular site fully where labour and capital supplies are reasonably elastic then the incremental benefit-cost ratio of 1 applies. [2]

One problem which has been considered is the availability of capital. Governments can borrow for hydroelectric projects with greater ease than for other undertakings. In the United States, the opportunity exists to issue tax-exempt bonds in the money market. The possibility exists, therefore, that despite the financial feasibility of the project, capital might be better employed in other sectors of the economy. It has been observed that:

"It seems likely that any increase in government borrowing under circumstances where the total volume of funds is limited would affect mainly investment areas, such as housing, where the return was low." [3]

Therefore, it has been recommended that, in computation of interest costs or of discount rates, a moderately higher interest rate be used than the government's borrowing rate for the benefit-cost eval-

1. E. Kuiper, Water Resources Development, Winnipeg 1963, p. 498.
2. cf., Scott, page 155, Resources for Tomorrow, Vol. III, Queens Printer, Ottawa, 1962.
3. C. L. Barber, "Water Resource Development", CJEPS, November 1961, p. 535.

uation of such government projects.

Such a technique might have been justified in the case of the Nelson River Project because the increase in debt for the province to undertake the development might deny the province the opportunity to take on debt to finance various other government programs.

One difficulty in the application of the technique to Canadian problems is the necessarily subjective aspect of predictions about the value of various benefits due to important intangible benefits and the developmental aspects predominating in most large Canadian projects. [1]

A fundamental criticism of benefit-cost analysis has been made in questioning its merits due to its sole concern with efficiency of allocation of resources. It has been objected that projects do not come to light in an environment in which alternative uses of the resources are known for the whole economic system.

"In fact, projects of varying degrees of merit usually come to light say because of crises, the existence of unemployment, or through the activities of energetic groups or politicians or by submissions by provincial or local governments. As such, the analysis may be pertinent only in determining within very narrow limits whether the resources invested could be better used in connection with some other purpose or project". [2]

In the case of the Nelson River development, the institutions did not then exist to evaluate its attractiveness relative to other developmental efforts (such as education and manpower services or as in residential expenditures). It was not exactly pertinent since the oppor-

1. cf A. Scott, 3b and 3c, page 155, Resources for Tomorrow Vol. III, Ottawa, 1962.
2. "Benefit-Cost Analysis and Project Evaluation", R. A. Spargo, in Resources for Tomorrow, Ottawa, 1962, Vol. 1, p. 300.

tunity to pursue these alternative courses of action could not have been exploited without some radical transformation in the institutional arrangement.

The benefit-cost analysis is not free of its own institutional bias. A distinguished resources scholar, John Krutillo, has remarked that in the development of the Columbia River the most economic sites are located in Canada but the Corps of Army Engineers was unwilling to pursue alternatives beyond its areal jurisdiction. [1] Further, an examination of flood damage in the twenty years following 1936 indicated that "mean annual flood losses increased over the period of record and at a rate that has not declined notably since 1936". [2] All this despite the expenditure of $4 billion over the period on the Corps of Engineers flood-control program.

Damage rose despite discounting for higher prices and despite the program because industry, commercial enterprises and residential housing persisted in building on flood-prone property and the flood protection merely served to extend the flood plains. Marshall observed that it may be that flood plain zoning and a flood warning system is what is required "But over the years the Corps has shown no interest in these alternatives. [3]

1. J. Krutila, Sequence and Timing in River Basin Development, Washington, Resources for the Future, Inc., 1960.
2. Reported in Readings in Resource Management and Conservation, ed. by I. Burton and R. W. Kates, article "Rational Choice in Water Resources Planning", H. Marshall, p. 533, University of Chicago Press, Chicago, 1965.
   G. F. White et al., Changes in Urban Occupance of Flood Plains in the United States, Dept. of Geog. Research Paper No. 57 (Chicago: Dept. of Gepg. University of Chicago), 1958.
3. Marshall, Ibid.

Applicability to the Nelson River Development

As with the Soviet experience, the American approach is still evolving and developing. It does appear to have some direct applicability to Canada with the benefit-cost analysis and their practice of using a large multi-jurisdictional agency to achieve comprehensive development of a resource or region. It may be seen that the validity of benefit-cost analysis is limited by the range of alternatives that it is permitted to examine. There is a danger in large public agencies that the alternatives examined will only be those that aggrandize the agency.

A more serious defect of the benefit-cost analysis for Canadian conditions is its emphasis upon the multiple purpose aspects of a development to the neglect of the sectoral and structural nature of the investment. In Canada, the structural aspects of the investment are at least as important as the multiple purposes of the benefits. [1]

But despite its defects, the American approach as represented by the TVA entity and the benefit-cost criteria represents a considerable improvement of existing Canadian practice. The TVA type of administration is charged with sufficiently broad terms of reference to justify its consideration of procedures which"internalize" the external economies typical of large hydroelectric projects. The mechanism is there to examine the relative merits of many development opportunities in the resources field on the basis of the multiple criteria typical of large public endeavours. The criticisms of the benefit-cost approach which we have examined may be reduced to criticisms of the approach for not properly considering the important objectives of an ideally constituted administrative agency.

1. cf A. Scott, op. cit.

PART FOUR

EVALUATION OF THE DECISION TO DEVELOP THE NELSON RIVER

CHAPTER EIGHT

CANADIAN STRATEGY OF RESOURCE INVESTMENT AND REGIONAL DEVELOPMENT

> These two salient aspects of Canadian growth - narrow channelling of investment and centralized organization - are, in turn, closely related to the long-range planning we usually identify as national policy. We can, in fact, review Canadian history in terms of a succession of national policies - first French, then British, finally Canadian - in which these characteristics of historical constants may be discerned. The strategy of investment in basic resources has been a dominant theme; these resources have played their role as growing points, and attitudes to resource exploitation have shaped our national policies at every turn. [1]

The involvement of government in the structural evolution and development of the national economy has been a predominant fact in the history of Canada. The investment in the development of the Nelson River has both of Easterbrook's "salient aspects". The purpose of this chapter is to identify the most important factors which would guide a strategy of investment in resource development.

Nelson River Development as it Affects National Policy

It must be clearly recognized that the decision to develop the Nelson River is a proper subject to be considered within national economic policy.

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1. W. T. Easterbrook, "Resources and Growth in the Canadian Economy", Resources for Tomorrow, Vol. 3, Ottawa, 1962, p. 18.

The justification for development of the Nelson River was predicated upon its proposed contributions to the development of Manitoba. The development of the Nelson River must be appraised primarily as an attempt to develop Manitoba. Its advantages as a source of electricity are marginal at best.

As has been discussed above, there are potential cost advantages of Nelson River electric power over the coal-fired thermal electric power which was the other alternative source of power available to Manitoba Hydro at the time of the decision. But as has also been discussed above Manitoba Hydro representatives maintained that other considerations such as the massive capital requirements of Nelson River development prevented Manitoba Hydro from developing the Nelson River in the absence of federal government support. In other words, development of the Nelson River was not justified on the basis of its potential cost advantages. Certain other considerations such as the massive capital requirements and the potential improvement of thermal costs - whether coal-fired or nucleat - should have led to the choice of a coal-fired thermal plant at that time if the considerations of electric power utility economics alone were to prevail.

The decision to pursue a policy of developing Manitoba and the method chosen to go about it is clearly a matter of national and provincial policy and transcends simple public utility economics. Therefore, the advisability of the decision to develop the Nelson must be examined on the basis of its contributions to the development of Manitoba and in the light of the other possible courses of action that could have been taken to develop Manitoba at that time. First of all however, we must establish that there is some need to develop the Manitoba economy via government policies.

The Economy of Manitoba

The economy of the Prairie Provinces has been changing in the fifteen year period ending in 1966. The population of the cities of Regina, Saskatoon, Calgary, and Edmonton have almost doubled while the population of Winnipeg has increased by about only 45%. The focal point for Manitoba, Winnipeg had grown at a rapid rate prior to 1961 as the post-war boom and farm consolidation concealed the fact that the four other entres were replacing Winnipeg as a service centre.

In recent years the Manitoba economy has experienced only limited rates of population growth, as may be seen in Table 10.1

TABLE 10.1 POPULATION OF MANITOBA AND CANADA AS OF JUNE 1

Year	Manitoba	Canada
1961	922,000	18,238,000
1962	936,000	18,583,000
1963	949,000	18,931,000
1964	959,000	19,290,000
1965	965,000	19,644,000
1966	963,000	20,015,000
1967	963,000	20,405,000

Even before making allowances for net in-migration, Manitoba has been losing population at a rate of from 10,000 to 15,000 annually in recent years. It will be noted that the growth in population halted sharply in 1965 when a decline of 2,000 was experienced in the twelve months from June 1965 to the beginning of June 1966. During the same period other regions of Canada registered substantial increases.

Labour income and personal income in Manitoba are generally lower than those of other provinces with the exception of the Maritimes

Source: DBS Annual Population Estimates: 91 201

and in some instances Quebec.

Apparently, therefore, some more rapid development would benefit a laggin portion of the national economy.

Basis for an Interpretation of Growth

Statistical measures of incomes, population, investment, production called "Manitoba", aside from problems of collection, are relatively simple and uncomplicated concepts. However, when we want to comment on the overall behaviour of these and other measures we tend to speak of the "Manitoba economy". The question arises, just what is an "economy"? This question is particularly urgent if we wish to plan activities which in some sense will "improve" the behaviour of these measures we spoke of above. The question might be redefined to be, "In what sense does it appear to be intuitively meaninful to speak of the "Canadian economy", and the "Manitoba economy", but somewhat awkward to refer to the "Fort Rouge economy" and especially inconvenient to refer to the "Fleet Avenue economy". Certainly one characteristic which appears to justify the term "economy" has to do with the joint participation in production of the humanly controllable factors as albour, management skills and capital. Furthermore it seems necessary that there be some internal consumption of the production of the factors. This theorem become apparent when you consider some remote regions of the province whose inhabitants are only temporary prospectors. Areas which are entirely dependent on the export of their product do not appear to qualify as "economies" although they quite definitely appear to be "regions".

Therefore, the characteristics of an "economy" appears to include not only the division of labour among human participants but also some degree of mutual consumption of the products of the participants. Some

means of transfer payments could be designed to increase the incomes and population in the territorial jurisdiction of Manitoba without particularly increasing the Manitoba economy, depending upon the attendant circumstances. Thus, an economy is not defined by statistical measures of income, investment, population or production. The definition of an economy appears to require both an interaction of production and consumption between the participants and also some degree of continuity of the total numbers of participants. Since it is unlikely that totals could remain unchanged although individual participants change annually (for any large category) it appears that some degree of factor immobility of labour is a characteristic of an economy.

To assess a proposal to develop the Manitoba economy a definition of the word "Manitoba" is necessary. It serves little purpose to consider Manitoba purely as a geographical area. The beneficiaries of a development scheme should be people not georgraphic boundaries and expanses. The population of Manitoba consists of a constantly changing group of individuals due to births, deaths and migration. Moreover, any program of large-scale northern construction would attract a large amount of transient labour that would contain few recent or future residents of the province. Finally, it may be in the interest of particular residents of the province to go elsewhere - for how many, might be a question for fundamental nation-wide research. Therefore, "Manitoba"should be defined in terms of the population which could best maximize its welfare by living in Manitoba with an informed knowledge of and capability of migrating to opportunities elsewhere.

However, in comparison with the Canadian economy, the factors in the Manitoba economy are more prone to out-migration. The Manitoba economy differs from a national economy also in respect to the degree of export of

its production, not only beyond national borders but also beyond the borders of the economy which in the case of Manitoba is its provincial borders. This is also true for imports.

While we shall refer to regional growth it is important to recognize that the central concept - that of a region - has not been specifically and uniquely defind. Tinbergen and Bos define a regiona as a "geographical unit". [1]

It is more important at this stage to recognize the important Characteristics of a "region". To return to Tinbergen and Bos, "A georgraphical subdivision of the economy introduces movements between regions, of both products and factors of production . . . The crudest approach is to distinguish between products or factors which cannot move on the one hand and which move freely on the other hand." [1]

The mobility of both product and factors of production within the economy, provides an important clue towards the proper concern of regional economic development policies. Drawing a boundaries for an economic region is a process which has not been clearly defined and generally degenerates into the acceptance of the legal boundaries of some particular jurisdiction for which statistics have been compiled. However, by directing attention to the mobility not only of products but also of factors it is possible to identify proper areas of concern for policy makers.

A region consists of many factors some of which could readily be employed elsewhere. A policy of maximizing employment within a particular set of regional boundaries, could well involve lower incomes for some of the mobile resources, particularly labour. Some resources are relatively

1 page 100 Jan Tinberger, Hendricus C. Bos, Mathematical Models of Economic Growth McGraw-Hill, New York, 1962.

immobile. Natural resources, land and most real estate and building property are the readiest examples. Other resources are more or less immobile according to the limits of time and alternative incomes which you select. Of the human resources, the professions are very mobile with the exception of law (which significantly is the vocation of a very high proportion of politicians and the most vocifierous proponents of regional development).

Definition of a region in terms of the mobility of factors and products would justify rejecting schemes to develop in depressed regions of relatively affluent nation industries which typically require such cheap labour that their long-term future in the absence of tariff protection is with nations that are in more backward stages of economic growth. Unless the laws of comparative advantage and the virtues of the international specialization of industries are recognized and cultivated there is a danger of constructing regional pockets of technological backwardness in high mass consumption societies as a consequence of regional development policies. One of the essential aspects of growth in an advanced economy is the process of reallocation of resources towards their most efficient use. Mobility of resources, not only between industries and firms, but also between regions is an essential part of maximizing behaviour and a characteristic distinguishing an advanced economy from a traditional society. A program which would decrease mobility of resources by developing marginal industries while employment opportunities existed in other regions would appear to be a non-maximizing behaviour.

Defining a region in terms of its most immobile factors - such as stagnant industrial operations or immobile professions - can discriminate against more mobile resources. This would be particularly true

for a program aiding local industrialists at the expense of labourers having an imperfect knowledge of employment opportunities in other regions.

Therefore, it is important to remember that a region consists of factors, whose best development may be elsewhere. Therefore development policies should be designed that recognize this alternative.

The Opportunity Cost Approach

Appraising different alternatives to develop Manitoba involves a consideration not only of whether or not there would be any positive results from a particular scheme but also of how desirable one scheme would be relative to another. This is especially important in a scheme involving a structural change in the economy because the selection of one scheme most probably would preclude doing another, at least at the same time.

The first consideration that must apply is the opportunity costs of the particular porject. The most relevant conceptual approach to opportunity costs for policy-makers, is less a matter of the trading value of one bundle of goods and services compared to another (as is common in international trade), so much as the decision to cancel or delay other programs. Joseph A. Kershaw and Roland N. McKean have stated it in these terms:

"Every Decision is a Choice Among Alternatives.

When a school board decides to add a psychologist, it is by that act deciding not to do many other things that cost the same . . . (Such as) . . . repairing the gymnasium, buying typewriters, raising custodial salaries or replacing worn-out band instruments . . . whenever a positive decision is made a decision not to do an almost infinite number of other things is made with it." [1]

One proviso should be added, however, that in the case of

1. J. A. Kershaw and R. N. McKean, "How to Make School Decisions", in Perspectives on the Economics of Education, C. S. Benson ed. Houghton Mifflin Company, Boston, 1963, p. 393-4.

opportunity costs, attention must be directed, not only to the demand side, but also to the supply side of the potential opportunities. Money can be made available more readily for certain types of porjects than for others. There is something about the concreteness (no pun intended) of a hydro-electric project that inspires investor confidence and permits the issue of debt that might not otherwise find acceptance in the Capital market at tolerable rates of interest. Therefore, some projects constitute more realizable projects than others regardless of their potential contribution to the commonweal. It can be argued that more capital would be forthcoming for a project involving massive amounts of fixed capital than for an investment in intangible social capital. This despite the proven profitability of investment in such intangibles as education or health.

Therefore, one of the aims of decision-makers should be the recognition not only of exploitable opportunities, but also of foregone opportunities due to specific project decisions. Moreover, an evaluation must be made between opportunities in regard to the potential funds forthcoming to enable their realization. The capital market is a collection of men sho operate no more rationally than policy-makers in developing areas. The money-managers of the capital market are as disposed to be overly impressed by physically impressive projects such as hydroelectric projects as are development planners. It has been remarked by W. Arthur Lewis that developmental authorities in underdeveloped countries devote too much attention to investment in concrete things and too little attention to investment in persons. [1] He observed that ". . . vast resources will be poured into controlling a single river, where the same money would yield much more if spent on a great number of wells, tanks, and small streams." [2] Lewis'

1. W. A. Lewis, The Theorgy of Economic Growth; Richard D. Irwin, Homewood, Illinois; 1955, p.395
2. Ibid., p. 394.

solution was greater decentralization of the planning process. The evaluation might be broadened to consider the relative merits of investment in education, particularly since many studies such as those by the Economic Council of Canada, indicate that the rate of return on investment in education is particularly high. [1]

Examining both the demand side of opportunity cost (the alternative uses to which the particular resources might be devoted) and the supply side of opportunity costs (that capital is forthcoming for certain concrete types and categories of projects that would not be forthcoming for other projects, such as better social workers), some consideration should therefore be given to opportunities in terms of potential capability to carry out certain programs. This leads to the necessity of carrying out an actual analysis of the physical capabilty of the economy. Such an analysis will disclose certain "fre goods" and also certain "bottlenecks".

One of the predominant bottlenecks in a developmental investment program is the capadity of the construction industry to increase its output. The Nelson River Development at its inception put a sharply increased demand for construction labour, managers and machinery on the national scene at the same time as the Economic Council of Canada had observed in its Fourth Annual Report that the housing shortage was serious in large metropolitan areas. (While not all the construction activities pursued on the Nelson River Development would have equivalent demand in southern canada, a substantial portion of the resources devoted to the Nelson could be alternatively directed to improving urban conditions.) An examination of investment by type of

1. page 90 Economic Council of Canada Second Annual Review Queens Printer, Ottawa, 1965.

expenditure discloses that the largest category of expenditure is not on machines and tools but instead in buildings and public works. General civil engineering services are the major item in investment and during periods of high investment constitute a major production bottleneck.

As has been discussed above market imperfections tend to make capital available more readily for some types of projects than for others. While on small categories of expenditure the market imperfections may cancel out, on large and structural expenditures the imperfections of the market must be remedied by some consistent form of comprehensive planning or else the economy is prone to massive misallocations of resources just as incorrectly planned economies are. The "invisible hand" of free markets has not been justified by economic thinkers as an end in itself but as a means to an efficient allocation of resources. When inefficient allocations of resources appear some alternative means needs to be developed.

Given the considerable degree of uncertainty prevailing in large investment projects, one of the most immediate benefits a planning authority could provide would be a general forecast of future demand both by industrial sectors and by geographical regions. Such forecasts are necessary for the effective operation of a program of manpower deployment. Therefore, to asses the relative priority of need of different investment propositions, some forecast of probably future growth is necessary.

The devlopment of such a forecast is beyond the purpose of this paper as would be the development of an estimate of the rate of interest to be applied to the Nelson River Project which reflected the relative opportunity cost of the required capital. However, if such a forecast had been developed and if such a rate of interest had been estimated, it would be much easier to appraise both the probably future demand for

electricity in Manitoba and the profitability of the development in relation to other structural priorities of other sectors and in other regions.

An approach to the opportunity cost of capital for such projects has been made by G. L. Reuber and R. J. Wonnacost in The Cost of Capital in Canada, With Special Reference to Public Development of the Columbia River. 1.

The opportunity cost approach provides a method for rationally considering the desirability of the development of the Nelson River. It goes without saying that the expenditure of a great amount of money in Manitoba will have some beneficial development effects on the province. The question is whether these beneficial effects are sufficient to justify the projects costs and the developmental effects foregone from other potential development projects.

It is necessary to consider the criteria which should be used to choose between alternatives. In other words, we need some method of measuring the opportunity costs of different programs. Tinbergen and Bos propose for their model, "Different programs may lead to different development patterns. In order to be able to choose between alternative programs, a criterion is needed which summarizes the development patterns. As such a criterion, we could choose the discounted value of the future total national product. . . " 2.

We shall accept such a criterion although it should be admitted that there are other attractive criterions besides the simple economic efficiency criterion. One such approach has been suggested by A. M. Freeman III, which dealt specifically with public investment in water

1. Resources For the Future, Inc., Washington, D. C., 1961.
2. A recent article "Income Distribution and Public Investment", American Economic Review June 1967.

resources projects with the view to improving inequalities in income distribution.

This approach is notable in its determination to work out the operational considerations that should apply in a policy of explicitly using public investment projects to improve the equality of the distribution of income. Freeman's approach is laudable in that it gives a basis for examining the advisability of using public investment projects as a means of improving the distribution of income.

Freeman's approach makes very explicit the consequences of a use of publi investment projects to improve the equality of the distribution of income. A thorough exploration of the consequences of this approach is beyond the purposes of this paper but a preliminary justification for the rejection of an income redistribution criterion for a public investment program is hinted by Freeman in his comment that the "optimum scale of project for redistribution purposes is . . . the efficient scale of project as well . . . But this happy result stems from the lack of a constraint on . . . (the repayment obligation which) . . . must be able to take on negative values, if need be to assure that incomes are raised or lowered to the optimum level." [1] It would appear that any process of income redistribution that would be followed by means of a public investment to avoid the need of specific transfer payments at the first instance but which could very well require substantial transfer payments at some secondary stage would violate its motivating principle. If tranfer payments are objectionable on a specific basis at any one stage of production or consumption, they should in

1. American Economic Review, June 1967, p. 504.

principle be equally objectionable at another stage. We are left with the conclusion that, other things being equal, the best investment project is the one which maximizes national income. It is important to note that this approach is analogous but not identical with the investment principles of maximization now followed for a private firm. These principles concentrate on maximization from the standpoint of an individual input-output unit in the income flow process. This present criterion focusses on the total income flow process and therefore comprehends the contribution of sectors such as the electric power industry that provide their product at less than that which market power alone could command and which also discounts the contribution of sectors which because of market imperfections are able to command a greater return than their competitive market valuation would command.

One qualification is justified at this stage. The choice between things which maximize national income is a choice between selections of projects which maximize the total return. The literature of capital budgeting abounds with examples of procedures of selecting among combination of projects given a budget constraint on the total size of the capital commitment. This approach is therefore an explicit opportunity cost approach. In maximizing the planner would choose among particular combinations of projects on the basis of their foregone opportunities compared to other projects.

We have previously rejected the use of public investment projects as a means of income redistribution. This should apply not only between groups but also between regions. The danger of poorly conceived regional devlopment programs is that they may merely construct a future "Springhill Nova Scotia's". Furthermore, we as a consequence must reject anyppeference to live in Manitoba as a policy variable, as opposed to a consumption variable. Individuals may well desire to remain in a region but if they do

so they should be willing to pay for this rigidity if the Manitoba economy was not capable of maintaining the level of economic prosperity equal to those of other regions.

THEORECTICAL JUSTIFICATION FOR REGIONAL DEVELOPMENT

The aim of this section is to arrive at a regional development theory that will build on the previous observations of an investment evaluation procedure for regional investments in Canada. Recognizing that the single most important criterion for any development scheme is its effect on national incomes (particularly on a per capita basis), the manner by which regional development contributes to maximizing national incomes must be investigated.

The explanation of the growth of provincial economies is often phrased in terms of a "staple theory" concentrating on the export of some product or products to a foreign market. This theory can be contrasted with the general explanation of economic progress which focusses on the growth of population, the accumulation of capital, technological advancement and the discovery of new resources.

These two approaches appear to be partly the result of the degree of disaggregation used in the analysis. For the world as a whole, the growth of income is clearly the result of the growth of investment, population, technical knowledge and known resources. But for any individual, (except a self-sufficient hermit) the growth of his income is dependent upon what he can earn (export) from the sale of his services to others. The policy implications of these two analytical approaches are more or less different. In the staple theory approach the most immediate attention should be focussed on means of increasing export possibilities and increasing efficiency in the export sectors. In the "domestic Production" approach the most

immediate attention should be directed to improving investment prospects, increasing savings, advancing technical progress, increasing the size of the market and, probably most important, realizing fuller employment of the productive factors.

Analyzing the Manitoba economy, it does not appear that changes in Manitoba can be studied without including the interaction of decisions that occurs in a national economy. At the same time, with the high mobility of labour out of Manitoba and the substantial expenditure by Manitobans on non-Manitoba products, it appears that macro analysis of the income-expenditure type would not explicitly comprehend significant factors contributing to the explanation of the levels of economic activity attained. Moreover, the composition of Manitoba totals is subject to variation different from the variation experienced by the Canadian economy. Therefore, the growth of Manitoba's economy must be analyzed by some means between those in partial equilibrium analysis and those in national elements as income-expenditure analysis.

As a result of the large out-migration, the supply of labour in Manitoba is larger than would be immediately apparent by studies of the Manitoba unemployment rate. Therefore, it appears justified to consider labour as a surplus resource better than to consider it as a scarce resource.

An investment commitment of the scale of the Nelson River is large enough to involve a structural change in the Manitoba economy (a 10% to 20% increase in the construction labour force and is concentrated in the northern region) but not large enough to qualify as a structural change in the Canadian economy. Structural change therefore involves not only the size of the change but also the relative composition of the sectors affected.

Canadian economic historians have tended to explain the development of Canada in terms of a staple theory generally associated with the name of H. A. Innis. Recently Professor Anthony Scott has explored the relevance of such a theory to the regional development of Canada in the mid-sixties and found it preferable to any other approach. [1]

"The staple or export-community approach, . . . , offers an explanation both of regional growth and of decline, chiefly in terms of factor migration." [2]

Regional growth occurs in the first place not because of regional savings or population increases arising from natural increase but from migration resulting from employment and investment opportunities in the export sector. Once the region is settled the staple "base" as it continues to grow provides a basis for a cluster of manufacturing, trades, services and governmental and institutional facilities called residentiary industries. ". . . the residentiary industries may not only impart the air of being independent of the base, but may, through the development of internal and external economies, become exporters themselves. Should this happen, and should the region have grown to sufficient size, the area may now take off into self-sustained growth, in the Rostow sense." [3]

The region will have attained self-sustaining growth if it can continue to expand even if the export staple industry's growth "falters or ceases". If growth does not continue this will lead in time to the emigration of labour or capital, unless another staple appears. ". . .

1. "Policy for Declining Regions: A Theoretical Approach", W. D. Wood, R. S. Thomas eds. in Areas of Economic Stress in Canada, Industrial Relations Centre, Queens University, Kingston, 1965, pp. 73-92.
2. Op. cit., p. 79.
3. Ibid.

the decline of a region can be ascribed to the decline of a staple." [1]

In Scott's formulation of the staple thesis, the decline of a region is not necessarily a misfortune.

"The main lesson from the model is almost a truism: regional incomes need not decline below the national average if labour is at least as mobile as capital, and if both inputs emigrate at the rate dictated by the rate of decline of the staple industry's market (while it pays national wage and interest rates) and by the associated decline of the residentiary industries." [2]

This version of the staple theory has a lot of guidance to provide for policy-makers particularly in the field of goals and of manpower measures. However, it may be difficult to determine whether a particular decline is directly attributable to a decline in the staple industry or to the failure of residentiary industries to attain the necessary levels of efficiency to enable the economy to achieve self-sustaining growth. In the latter case the appropriate policy solution would not be the migration of factors so much as the promotion of efficiency and alternative opportunities. If a region declines it is possible for historians at a later stage to explain the decline in terms of a staple theory. If the region continues to expand a self-sustaining growth theory can be employed. But for regions experiencing a retardation in growth it is difficult to determine which set of circumstances apply. The fundamental merit of this approach is its relevance to the rejection of a large number of subtle subsidization policies as unjustified except for a strictly limited transitional period.

1. Op. cit., p. 83
2. Op. cit., p. 85

One short-coming of this theory is that it provides only a sketchy basis for appreciating the growth of many nations which have several interacting regions. One of the aims of Confederation and the National Policy was the development of a complementary industrialized East and an agricultural Western Prairies. This theory has difficulty in dealing with such cases.

The special relevance of this theory to the development of the Nelson River is that since there has been some retardation in the growth of Manitoba the potential development benefits for Manitoba arising from the construction program might better be derived from a policy to encourage emigration.

W. Arthur Lewis in Development Planning [1] advocates an approach of "regional balance". Regional disparities are seen as natural due to the different growth potential of different areas and the economies of geographical concentration. However, Lewis perceives clear advantages of outlying areas as well:

Economies of scale are a powerful force making for concentration of population; . . . there are also dis-economies of concentration which grow as population increases, and which sooner or later catch up with the economies to produce a state of balance: it pays to grow, but only up to a certain point. Moreover, some economies are exhausted faster than others, so the general picture is a string of towns of different sizes." [2]

Lewis' approach appears to be particularly promising providing as it does a consistent economic explanation of the causality of complementary regional growth and a consistent set of aims for economic policy-

1. Harper and Row, Publishers, New York, 1966.
2. Op. cit., p. 71.

makers upon the basis of maximizing the efficiency of the total national economy by optimally distributing population and productive resources throughout the regions. This is a very important concept. If Scott's staple approach provided a consistent theoretical basis for rejecting proposals of subsidization to declining regions with small growth potential, Lewis' regional balance approach provides a consistent basis for weeding out undesirable proposals of subsidization to the areas of concentration that are experiencing excessive growth. Lewis has suggested as a provisional approach the very stringent examination of development proposals for towns whose populations either exceed 500,000 or are less than 5,000. The economic rationale for a program of limiting excessive concentration Lewis explains in these terms:

> In a free competitive economy, where prices truly reflected social costs, a town or region could not outgrow its "proper" size, in economic terms. As population increases, the marginal yield of resources decreases. Rents rise. The cost of supplying the city with food, water and other necessities from further and further distances increase. The cost of travelling to work increases. The streets and other facilities become congested. The cost of living rises, and this is reflected in wages. Despite the economies of concentration, the region becomes, for some purposes, a high cost area. Some industries move out; others stay out. If the price mechanism worked perfectly a balance would be achiev ed where only those industries remained for whom the special advantages of the area exceeded the high cost of labour, land and congested facilities. 1

Lewis is well aware that the price mechanism does not work perfectly. The virtue of his approach is the manner in which it casts proposals for relieving urban problems into an opportunity cost context with those of regional development since they are now seen as means of achieving the same aim - remedying urban sprawl and congestion while maintaining an optimal level of production and efficiency. By way of an aside he states:

In most countries of the world nowadays, people complain about the excessive explosion of cities, and excessive development of some regions

1. Op. cit., p. 71.

to the neglect of others; yet most of the measures which are taken to deal with this explosion, since they mainly diminish the differential disadvantages of living in the congested areas, merely make the problem worse. [1]

Procedures for Selecting Investment Projects

The first issue to be considered in the selection of investment programs is the degree of decentralization of the decision-making process. We might consider the American benefit-cost approach and the Russian national policy approach as the consequences of two degrees of decision-making decentralization, the American approach representing a decentralized approach, the Russian approach representing a centralized approach. The need for centralization has been described by Tinbergen as:

> . . . we may expect planning to have a larger positive impact on the economy in situations where (1) there is a more pronounced need for forecasts; (2) there is a more pronounced need to stick to some aims; or (3) there is a more pronounced need for coordination. [1]

The need for coordination is particularly important in economies where there is not a highly developed entrepreneurial corps. The United States attachment to individual benefit-cost analysis is therefore partly a result of the lesser need for centralization of decision making in their society. John Krutillo has expressed his preference for partial benefit-cost analysis in these terms:

> . . . any meanin gful evaluation of a regional development program requires intimate knowledge of the many activities which it represents. Furthermore, an approach which attempts to evaluate each program activity individually for its impact on the sector of the economy toward which it is directed is more promising than one which attempts to determine justification for the entire package of development programs by analyses conducted at levels several stages removed from the area of direct program impact. [2]

1. Jan Tinbergen, Central Planning, Yale University Press, New Haven, 1964, p. 65.
2. John Krutilla, "Criteria for Evaluating Regional Development Programs", American Economic Review, Vol. 45, (May 1955), p. 610.

On the other hand it is apparent from our discussion that in a nation of regional disparities investment criteria for projects in which there is significant government participation must make some provision for large and structural projects with respect to their macroeconomic impact on the evolution of the economy. The Economic Council of Canada has stated as a "guideline for action . . . the taking of decisions in respect of investments in social capital in accordance with an adequate consideration of the economic and social benefits to be obtained in relation to costs." [1]

The determination of a consistent regional investment evaluation must await further research. Even Jan Tinbergen and H. C. Bos after developing a number of regional growth models assert in a concluding chapter that in the splitting up a a national investment program into regional programs". . . the distance between practical possibilities and theorectical models is considerable still." [2] Tinbergen and Bos do address themselves to problem of regional development in the last paragraph of their Mathematical Models of Economic Growth:

> To begin with a distinction between regionalsectors and sectors the products of which can move to other regions can be made. Next, differences in production costs between regions can be ascertained. Thus, some regional distribution of production can be made without having recourse to details about transportation

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1. Annual Report, 1965, p. 176.
2. Jan Tinbergen, Hendricus C. Bos, Mathematical Models of Economic Growth, McGraw-Hill, New York, 1962.

> costs. As a third step, transportation costs can be brought into the picture for such sectors as show high - but not prohibitive - transportation costs. This seems to be the most practical approach to regional planning at the moment. Further refinements, along the lines of the model discussed. . . may be the next step. Here, however, we are clearly on academic rather than practical ground." 1

Despite this lack of convenient manipulative mechanisms, a common sense approach to the consideration of the desirability of regional investment programs can be stated in terms of a small number of principles. Our investigations have indicated that a conceptual framework for the organization of the various trends, influences, goals and criteria of regional investment programs does exist, and despite the statistical difficulties and mathematical complexities that remain to be resolved certain principles of special importance do appear to be justified:

1. The proper aim of regional development programs should be maximization of total national income. There are some difficulties here in defining a desirable time pattern but the rate of interest deals with most of these problems. At present the constraints placed upon decision-makers representing bodies such as the Province of Manitoba are such that maximizing national income is not necessarily their objective. But, the possibility of out-migration to other provinces tends to show that Canadians (including Manitobans) would generally be better off if national income were chosen as the aim.

2. The existence of alternative opportunities for the use of the resources that are required to support the program must be recognized and the use of these resources to achieve development benefits in alternative ways must be evaluated.

1. Op. cit., p. 117.

3. There may be bottlenecks in the productive process that if they exist could alter the wisdome of the program.

4. The export staple of the region should be identified and the potential for expansion of the staple should be appraised. For Manitoba the relative decline fo the export of wheat must be replaced by a growth in another staple if the region is to continue to grow unless it has already reached the level of self-sustained growth.

5. Some attention must be directed to the relative advantages and disadvantages of concentration of edonomic activity and the regional advantages of low-cost and high-saving regions.

6. One consideration that must be kept in mind is the physical strategy of the placement of facilities.

7. Probably the most difficult part of the problem of assessment is to appraise the advantages of the project in terms of contributing to the development of a new staple export project or the potential it has towards advancing the prospects of long-term self-sustaining growth. The profitability or financial feasibility of the project is a fundamental guide. But it would appear that in the absence of a consistent well-designed mathematical model a process known in marketing research as sensitivity analysis is an alternative approach. By this method the desirability of the project is examined by predicting its outcome in terms of several logical outcomes for the basic determinants of the feasibility of the project such as cost behaviour, market growth, competition from alternatives or changes in tastes. An appraisal can thereby be made of the "sensitivity" of the project to alternative outcomes. While precise mathematical probability estimates may not be feasible, an appreciation of the potential of

the project and its vulnerability may be attained. In deriving an appreciation of the potential contributions to future self-sustaining growth or the evolution of a staple industry, a sensitivity analysis of the project would indicate whether or not the success of the project depended upon possible but unlikely events both within or without the region, and the contributions of the project to that likelihood.

CHAPTER NINE

CONCLUSION:

THE ADVISABILITY OF DEVELOPMENT OF THE NELSON

The decision to develop the Nelson River was taken in the face of considerable uncertainty upon the outcome of certain trends whose eventual determination cannot be known for some ten or twenty years (such as the actual growth of demand for electric power in Manitoba). The determination of whether the decision to develop the Nelson River at this time was correct or incorrected will not be possible until some time in the far distant future. At this time it is possible to comment only on the advisability of the decision and to recommend certain administrative procedures which would improve the decision-making process.

As has been discussed, there was an intensive analysis of how best to develop the Nelson River and some investigation of its advantages in comparison to coal-fired thermal plants. However, there was little overall analysis of its relative attractiveness in comparison to other schemes of developing the Province of Manitoba.

Moreover, as has been seen, once the Premier of Manitoba had embraced the project and had shown such enthusiasm for it, it became very difficult for people studying the project (particularly in Manitoba) to dismiss it. This is not to criticize Premier Roblin. Some indication of political enthusiasm was required to obtain federal government cooperation in the costs of field work and office studies required to assess the project. Furthermore, the massive capital requirements of the Nelson and the attendant uncertainty necessitate a political decision in choosing it over other alternative schemes of developing the Province

of Manitoba. However, the political decision should have been made after all engineering, and economic considerations had been examined, not before their examination had proceeded beyond preliminary stages. Because of the large political overtones in hydroelectric development decisions, there are tremendous advantages to separating political examination of the project from the economic of the project by some mechanism such as was employed in the examination of the South Saskatchewan Dam Project where a Royal Commission was charged with that responsibility.

The advantages of a Royal Commission are considerable but one difficulty of Commissions is that they are set up for specific studies and once that study is completed their existence ends. As we have seen many of the necessary studies need to be done on a continuing basis. Perhaps some type of Royal Commission on project evaluation could be set up to conduct a continuing evaluation of the relative merits of various projects on the basis of their contribution to national growth and the long-term optimum growth of the regions of Canada. Such a commission or council could not, in itself, remove the evaluation of projects from political debate but it could ensure that such debate be conducted in a more educated and informed context with a recognition of relative costs and opportunities foregone. The commission could develop consistent Canadian methods for assessing the desirability of projects and policies according to their costs and benefits.

Undoubtedly, the Nelson River development had aspects over and above its purely economic aspects. However, the seven points outlined in the previous chapter can provide some guidance as to the advisability of the Nelson River project.

1. It remains to be proved that the Nelson River Development is the best investment from the point of view of the maximization of the national

income. The examination of the project by the electric utility (on the basis of electric utility economics) indicated only marginal (if any) advantages over thermal electric capacity. The Nelson River Phase One Development will require an additional $200 to $250 million over a comparative thermal electric development. No comprehensive analysis has been conducted to indicate whether the Phase One Development provides sufficient benefits to offset the opportunity costs of the additional capital requirements.

2. No analysis has been conducted of the alternative use of the extra capital requirement (particularly in education). Even if as a result of imperfections in the capital market there is some restriction on the additional capital forthcoming for non-hydroelectric developments, there is still reason to believe that the investment in education (with its 20% return)[1] would be more advisable than the achievement of marginal advantage over a thermal development.

3. The Phase One Development would require substantial amounts of civil engineering services for which there are high priority alternative needs for housing, highway, transportation and other requirements (particularly urban services). Furthermore, the direct labour requirements would be for the most transient element in the national labour force. From the point of view of the Province of Manitoba, few would be Manitoba long-run tax-payers. Furthermore, the Phase One Development might require some worsening in the balance on current account and an import of capital and benefit only slightly (if at all) the marginal efficiency of capital compared to labour since the less capital intensive thermal source is so competitive.

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1. Page 90 Economic Council of Canada, Second Annual Review, Queens Printer, Ottawa, 1965

4. Despite fond hopes to the contrary, it is extremely unlikely that the electricity developed on the Nelson River will be exported in large quantities or at a particularly profitable selling price. The potential export markets already all possess alternative sources of energy of low cost.

5. Although the definition of an optimal regional development policy would require a rigorous investigation of all facets of the economies and diseconomies of concentration as it affects regional development and its interrelationships with different regional saving propensities, it does appear that there are clear national advantages in stimulating economic expansion in low cost regions that are not faced with the wastes of congestion that are confronting rapidly growing urbanized regions. Stimulating balanced growth in Manitoba is a logical method of remedying housing problems in Toronto. However other schemes of developing Manitoba would also have this virtue with perhaps less diversion of resources into the logistics of remote frontier development.

6. The Phase One Development would provide power relatively close to tidewater and contribute to the evolution of direct current technology. Both these facets have some value although mainly of an intangible and problematical character.

7. A consideration of the sensitivity of the Nelson River Phase One Development to alterations in basic determinants indicates the vulnerability of this proposed scheme of developing the Manitoba economy. Of the many possible determinants of the future success of the Nelson River Development, the most important basic determinants are the growth of the Manitoba economy as measured by the growth in population and incomes and the progress in competitive energy sources, particularly nuclear energy. A review of the probably alternative outcomes of these parameters indicate the following consequences for the development of the Nelson River:

a) If electricity demand grows as rapidly as projected then the development of the Nelson River would provide the required capacity and energy. The preceding six points are mainly directed to the other considerations which affect the advisability of this development.

b) If electricity demand grows more rapidly than projected, then no federal support would have been required and the development of the Nelson River would be superior to the development of thermal capacity but perhaps inferior to nuclear capacity. It might be noted that the appeal for federal support carried with it the implication that this alternative was uncertain if not unlikely.

c) If electricity demand grows less rapidly than projected, then federal support would be required but it would not be sufficient to justify the choice of the Nelson River development compared to a development of thermal capacity. In this case the Nelson River development would not have triggered the necessary growth in the Manitoba economy and the effort to develop the Manitoba economy would have been a failure.

d) Irrespective of the growth of the Manitoba economy, the development of nuclear technology might be such as to replace hydraulic generation as a source of cheap energy. In such a case the development of coal-fired thermal clearly would be justified since the savings of nuclear over the Nelson River would clearly justify waiting until it had so progressed and in the meantime coal-fired thermal capacity could meet the required demand for capacity and energy without committing the Manitoba government to so great a deal.

e) If nuclear technology, irrespective of the growth of the Manitoba economy, does not grow as rapidly as expected, conditions are unaltered from those in Cases a) and c).

From a review of the potential outcomes of the Nelson River Development, it is apparent how vulnerable the justification for the Nelson River development is upon the most fortunate outcome of the basic determinants. Reviewing the outcomes of these determinants it is unlikely that Manitoba population or incomes will grow more rapidly than projected, especially since the project was in large part justified on the basis of its stimulus to the Manitoba economy. The decision to develop the Nelson River electric capacity is very vulnerable to the most fortunate outcome of the basic variables. An investment in an alternative development (for example) education would be far less vulnerable from the point of view of the national economy. Moreover, such an investment could be more flexible since it could be altered without large inconvertible fixed capital resources.

To the policy-makers involved, the decision to develop the Nelson River was the only reasonable decision for them to make. Any other would have been a dereliction of their responsibilities by ignoring the constraints placed upon their maximizing objectives. The development of the Nelson River represented a realizable method of advancing economic progress in Manitoba. None of the administrative mechanisms explicitly provided for optimizing that progress. The prevailing arrangements of the decision-making process provided for a division of responsibilities between a separate electric utility, a separate provincial entity and the separate federal government. The sum of the parts is not equal to the whole. No independent commission was charged specifically with the responsibility of considering the overall welfare of the nation and of discovering

and evaluating development schemes within such a framework. This could be the virtue of a Royal Commission if it were charged with sufficiently broad terms of reference so that it could affort to consider the welfare of the nation as a whole. The American benefit-cost analysis has this advantage although it is difficult to apply in cases of structural change. The American experience indicates the advantages of charging the agency considering the development with sufficiently broad terms of reference that it can assess all the significant elements involved.

Although there is substantial uncertainty associated with the eventual feasibility of the Nelson River Development, more certain conclusions can be reached on the advisability of the procedure followed in considering the desirability of the project. The Quebec experience indicates the desirability of an intense program of industrial load development to ensure the eventual profitability of the investment in hydroelectric resources. Preferably such a program might be formulated in advance of the project. The Russian experience indicates the advantages of planning for structural change-both for the relative merits of expanding one sector compared to another and also the procedure whereby the required inputs for a developmental sector are explicitly scheduled so that the planning authority can capitalize upon the developmental potential of the project.

The decision to develop the Nelson River appears to have been premature although an accurate assessment can be made only after some twenty or thirty years. Analysis indicates the vulnerability of the project to slight changes in assumptions. A review of the public announcements and official papers does not indicate that a study was made of alternative development projects or policies. Without such studies we cannot be sure the Nelson River decision was the best

available alternative and the most advantageous to Manitoba's priorities. An independent national development commission would be able to develop the data and techniques to arrive at a optimal regional development policy.