ENVIRONMENTAL ASSESSMENT OF
HIGH VOLTAGE ELECTRICAL TRANSMISSION LINES
IN BRITISH COLUMBIA

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INTRODUCTION

Growth and consumption are two functions now synonymous with modern society. While much conjecture and argument arises as to the advisability and necessity for this situation, it remains a fact of life, in particular, in western society. A vivid manifestation of growth and consumption can be seen in the continuing demand for energy despite predicted constraints dictated by price elasticity, conversion to more efficient energy uses and to modified life styles.

A particularly attractive form of clean energy is that of electricity. In a Province such as British Columbia with, until now, abundant hydro power, electric power demand has been increasing at a substained pace and attempts at conservation minimal. As a consequence, electricity demand has and continues to grow at prodigious rates. In 1973, net electric power production in British Columbia was 36,335 million kilowatt hours (kwh). Net production has grown at an average annual rate of 9.1% since 1966. However, supply of electric power to domestic users of power in British Columbia has increased at an average annual compound rate of 6.3% since 1966, less than the 9.1% rate of increase for total power production. (B. C. Energy Commission 1975)

Residential and commercial consumption account for small shares of total electricity consumption in 1971 (20% and 16%), but consumption in both sectors has been growing fast. The 1966-71 average annual growth rate of residential and commercial consumption for example was 9.2% and 9.0% respectively.

Industrial consumption, accounting for 64% of the total in that period has been growing at a rate of 6.1% (B. C. Energy Commission 1975).

It is expected that the Provincial population will continue to grow as will industrial and commercial activity. All of these factors point to the need for more energy in the Province during the foreseeable future. B. C. Hydro's best current estimate of the annual growth of future needs of its B. C. customers over the next 10 years is 5.9% after taking into account expected economic development and factors such as growing public awareness of the need to conserve energy. B. C. Hydro 1980) This does not include any allowance for the export of electricity except for the small amounts to the communities of Point Roberts, Washington and Hyder, Alaska.

The demands on B. C. Hydro are projected to reach 45,065 GW.h by 1985/86. Currently installed generation can assure only 31,690 GW.h per annum (B. C. Hydro 1980). To this should be added the generation under construction at 7 Mile, Peace Canyon and Revelstoke which will increase the total to 44,715 GW.h per annum. Consequently, new and as yet unapproved projects will be required to have an assured ability to satisfy British Columbians of sufficient electricity for 1986/87 onwards.

As load growth increases and more northerly generation sites are developed the need to transmit large blocks of power throughout the Province increases.

There are four primary electric power consuming areas in the Province: the Lower Mainland, Vancouver Island, Kitimat-Kemano, and Nelson-Princeton. Respectively they consume 33%, 17%, 19%, and 12% of the electric power generated in British Columbia. (B. C. Energy Commission 1975)

For the Kitimat-Kemano area and the Nelson-Princeton electrical service areas, the high levels of electricity consumption are explained by the Alcan and Cominco operations. Both these industries are power intensive electro-metallurgical enterprises which largely meet their power demands from their own facilities.

At present, production of electricity on the Lower Mainland is roughly equal to consumption at peak demand. But it is anticipated that this situation is temporary and the area will draw power from northern areas including the Peace, Liard, Stikine and Iskut River Systems in the near future.

Vancouver Island is now dependent on non-island electricity. Peak demand exceeded peak production by more than 50%. Deficits are met by transmitting power from the Lower Mainland to Vancouver Island by submarine cables with a new 500 kv system from Cheekye on the Mainland to Dunsmuir on the Island scheduled for service in 1983.

The central interior, from the Prince George-Bulkley Valley to the Kamloops-Vernon electrical service areas, is dependent on non-area electricity generating facilities for power.

Power is transmitted in the Province over approximately 14,259 km of major transmission lines of which almost 300 km are 500 kv and 3,000 km 230 kv. The backbone of the transmission system are two 500 kilovolt (kv) transmission lines transporting power from the Peace River power plant to the Lower Mainland. Power is taken off this line at Prince George (for Prince George and out into the Bulkley Valley) and at Kelly Lake (for Kamloops and Vernon).

In addition, major transmission lines run from the Bridge River facilities into Vancouver via the Pemberton Valley and the Lillooet River-Harrison Lake-Fraser River routes. There is also a major power line from Bridge River to Powell River via the Pemberton Valley.

Vancouver Island power lines run north from Duncan to Campbell River and south from Duncan to Victoria.

A second transmission network serves the south central interior and the West Kootenays. Power generated by West Kootenay Power and Light and Cominco is transferred from Nelson to Kimberley in the east, and from the Nelson area to Kelowna and Princeton in the west.

With few exceptions, most of the Province is served by an interconnected power transmission system, so that nearly all power consumers have access to the available supply.

Like most large electric utilities, B. C. Hydro has transmission interconnections with its neighbors (the U.S. Northwest and Alberta to reduce the impact of major transmission outages.

The 500 kv transmssion network will be adequate to serve loads to 1990. At that time the Lower Mainland will be served by six 500 kv lines and other regional load centres by two 500 kv lines each. (Ellis, et al 1975)

Rights-of-way for these lines have either been acquired or are in the process of being acquired. The acquisition of additional rights-of-way for load growth beyond 1990, or if required before 1990 by unforeseen shifts in regional load growth, may prove difficult because of the lack of suitable routes and outspoken local opposition to additional transmission line construction.

A point will be reached when the geographically limited number of transmission corridors to B. C.'s main load centre in the Lower Mainland are fully occupied. Existing circuits will then have to be replaced either by double circuit construction or by higher voltage construction. Unless generation close to the load centre is added, the scheduling of future transmission replacement and additions in confined corridors such as the Fraser Canyon will become extremely difficult and expensive.

This situation could develop when power transfer to the Lower Mainland reaches about 10,000 MW--at present growth rates this could occur by the early 1990's. Transmission limitations could, therefore, be critical unless significant generation is installed closer to major load centres in the southwest corner of B. C. More and more environmental constraints are being added to all B. C. Hydro projects and the utility has raised considerable protest, particularly as it applies to the length of time for environmental studies to be completed and projects to come into service.

An indication of the staggering costs for the period 1980 to 1990 is given in Appendix I. For transmission construction alone the estimate exceeds $3 billion.

DISCUSSION

System expansion in order to meet load growth, including new generation attendant transmission and substation facilities is based, in all utilities, on the process of load forecasting. The way in which this predictive approach to planning system needs is reflected throughout a utility system is shown in Appendix II.

B. C. Hydro annually produces a long-range forecast of gross load requirements. Because major new projects require 10 to 15 years' lead time for planning, design, licensing and construction, it is essential that Hydro's forecast not underestimate future demand. Otherwise, lack of available energy could impair future economic development, employment and living standards in the Province. (B. C. Hydro 1979)

B. C. Hydro's latest load forecast estimates that demand for electricity from the utility's power system will grow at an average annual rate of 6.4 per cent over the next 11 years. The forecast reflects the fact that Hydro has undertaken to provide power to West Kootenay Power and Light Co. Ltd. starting in the fall of 1979, when demand from West Kootenay's customers is expected to have exceeded that utility's generating capacity.

The forecasting process involves estimates of electricity sales, gross energy requirements and peak energy demands for Hydro's present 975,000 electric customers, plus the customers to be added in the next 10 years. Clearly the utility must know the energy requirement and the total demand and peak load requirements for each segment of the electric system so that generation, transmission, substation and distribution facilities can be provided to serve each segment adequately.

While projections do become progressively more conjectural with extension into the future, the estimates obtained have provided a fairly rational basis for specific short-range planning and general planning for the longer term.

On this basis and coupled with new generation coming on stream, B. C. Hydro has proposed an expansion of the 500 kv network to incorporate generation at Revelstoke, Hat Creek and East Kootenay, including reinforcements of the interconnection of the Kootenay regional systems with the main integrated system, a reinforcement of the 500 kv network to serve load growth in the Lower Mainland, Vancouver Island and North Coast areas, a new 500 kv transmission interconnection of the Mainland with Vancouver Island with the first circuit of this interconnection scheduled for service in 1983 and the second for service in 1985, and a 500 kv transmission interconnection with Alberta in Crowsnest Pass area scheduled for service in 1982.

A more detailed review of transmission line growth both from 1975 to the present and from now until 1990 is given in Appendix III. Not shown on this projection is the largest single transmission project that will be required to bring power from the proposed generation sites north of Prince George at Liard, Iskut and Stikine as shown in Appendix IV.

Transmission from the Liard and Stikine-Iskut, by virtue of its considerable length, will present serious problems regarding environmental concerns as well as difficult weather and terrain conditions. In addition to local collector lines from the various generating stations, two 500 kilovolt (kv) circuits virtually 500 km long would be required to connect the Stikine-Iskut system to the Province-wide integrated system at Telkwa substation near Smithers. Existing transmission capacity would have to be augmented between Glenannan substation and Kelly Lake substation, a distance of some 420 km.

Even greater technical difficulties would accompany the transmission system for the Liard project than for the Stikine-Iskut, due to greater distances and greater power transfers involved. Transmission from the Liard could be routed down the Rocky Mountain Trench, connecting with the existing system at Kelly Lake - a total distance of more than 1,000 km, with another 200 km for the collector system in the

Liard region. This route would require building about 480 km of new access road alone. Another possible route would run east of the Rockies to G. M. Shrum switchyard at W.A.C. Bennett Dam and then generally parallel the Peace transmission lines to Kelly Lake. Because access would be possible from the Alaska Highway, relatively little access road construction would be necessary.

Whichever alternative were to be adopted, B. C. Hydro would find itself for the first time involved in design and construction of transmission for ac operating voltages above 500 kv and in a climate where environmental concerns are now fully institutionalized and overtly demanding.

This has not always been the case. Today, both the public and public utilities are much more concerned than formely about the environmental and social effects projects can have and much more aware of the need to assess them before construction begins.

B. C. Hydro claims (B. C. Hydro 1979) this concern and awareness has led to the establishment of a planning process designed to provide the data necessary to make informed judgements and that this structured process is a natural development of activities Hydro has been undertaking increasingly in recent years, and provides for public involvement.

Prior to 1974 there was virtually no requirement for B. C. Hydro to be accountable for environmental or socio-economic impact of its projects. At that time this writer, in conjunction with staff within B. C. Hydro and the Environment and Land Use Secretariat of the Provincial Government (a coordinating group of professionals, established under N.D.P. auspices) initiated a process through which transmission projects would come under Government scrutiny. A schematic approach evolved initially as shown in Appendices V, VI, VII. Essentially this approach envisaged, as an outgrowth of the load forecasting process, a four part analysis of impacts and consequences. In the first part a broad investiagation would be made of feasible corridors, that is approx. 3 mile wide potential bands in which a route might be determined. Once a corridor approval had been obtained from review agencies and ultimately from the Environment and Land Use Committee of Cabinet then a second, more intensive study would be conducted to determine a specific transmission line route and the impacts quantified. After approval at this level of detail, construction and mitigation would be linked together until commissioning of the project after which the right-of-way system would be monitored and maintained.

It soon became apparent that with the pace of system expansion and the limited number of both B. C. Hydro staff and consultants with environmental expertise, there was no way in which all proposed transmission lines could be exposed to the intensive level of security required. It was, therefore, decided to limit the full study process to lines of 500 kv or particularly sensitive 230 kv projects. This is reflected in the Type I and Type II process contained in Appendices VIII and IX.

By 1977 the ELUC Secretariat had produced detailed guidelines for all linear corridor developments. The Guidelines for Linear Development outlined a comprehensive planning process designed to encourage the careful management of land use and assessment of environmental and social impacts associated with certain types of large linear developments such as major railways, pipelines, transmission lines and industrial roads.

Stage I constituted overall route selection. The objective of the route selection report is the identification of major economic, environmental and social impacts of the proposed route(s) of the development and indication of project planning considerations of these impacts. Specific objectives of the Stage I report were: (ELUC Guidelines 1977)

(i) identification of technical (in engineering terms) and cost feasible route alternatives, which would be capable of containing one or more alignments.

(ii) determination of broad resource capabilities and uses in each route.

(iii) selection of one or more routes with the least possible impact on the quality of the environment and with the least interference with or dislocation to human activities on land at present and in the foreseeable future.

The Guidelines were organized into two parts. Part I descibed a four-stage planning process leading to the granting of applicable permits and project authorization. Part II contained a detailed list of the information essential for the identification and assessment of impacts and an indication of the sources of information available within Provincial and Federal Government Departments.

The Guidelines for Linear Development, which are still in force despite the dissolution of the Secretariat, are administered under the authority of the Environment and Land Use Committee of the Provincial Cabinet. This Committee is responsible for the Environment and Land Use Act which assigns the Committee the duty and power to:

> "ensure that all the aspects of preservation and maintenance of the natural environment are fully considered in the administration of land use and resource development commensurate with the maximum beneficial land use, and minimize and prevent waste of such resources and despoliation of the environment occassioned thereby" (Environment and Land Use Act, 1971, Chapter 17, Section 3 (b))

The Guidelines apply under directive from the Environment and Land Use Committee to all large scale projects, generally defined as those which traverse one or more Resource Management Regions of British columbia, or those which cross or affect areas of particular environmental sensitivity or hazard.

While the Guidelines procedures apply primarily to private and Crown Corporation projects, such as transmission projects they also apply (with minor modifications) to Provincial Government projects such as major public highways and major resource development roads.

A four-step reporting process as shown in Appendix X (i) moves the project assessment systematically from a general overview of the project to more specific definition of impacts and associated plans.

The first report by a proponent is a Prospectus describing the proposed project which is circulated to inform Provincial departments about the project and its timing. Preliminary impact assessment is undertaken in "Stage I" with detailed impact assessment of the project in Stage "II".

Stage I and II reports submitted by the proponent are reviewed, initially by a Project Inter-departmental Steering Committee to ensure that the proponent has met the terms of reference of the Guidelnes; and then by each ministry which makes detailed comments relating to specific ministerial (statutory and program) interests. Comments are then compiled by the Steering Committee (Appendix X (ii)). These offer an opinion(s) on a preferred route(s) and are returned to the proponent for consideration in drafting terms of reference for conducting the next stage of impact analysis and planning.

By the end of Stage II, assuming the proponent has followed the procedures and responded to the comments of the Steering Committee and ministeries it is expected that the final approach to and the handling of impacts will be determined and may be given approval-in-principle. However, this form of approval does not in itself constitute approval or permission to proceed with the development, nor does it replace any existing responsibilities under present legislation. For instance, application for legal land tenure under the Land Act where Crown lands are to be used for a linear development represents a major requirement for B. C. Hydro. Where this or other permits are required, any proponent, through consultation with the appropriate agency and having responded to impact assessment requirements during Stages I and IV, should by the end of Stage II be in a position to proceed with permit applications to that agency.

Following ministerial review of the final plans and associated applications submitted during Stage III, a review will take place and a Project Steering Committee report is made to the Environment and Land Use Committee indicating any areas for further inter-ministery action. In addition to these formal procedures, meetings associated with review involving government/proponent consultation the proponent and/or the proponent's consultants and the Steering Committee may mutually agree to hold informal progress meetings.

Stage II provides the detailed alignment and assessment planning for a project. The main objective of the Stage II report is to identify and provide supporting rationale for a preferred route alignment (not necessarily surveyed) within the routes identified as a result of Stage I.

The Stage II report generally parallels the Stage I report in scope but requires more in-depth analysis and planning. Its components are: (ELUC Guidelines 1977)

(i) detailing of the technically optimal route(s) within the selected corridor(s);

(ii) site specific analysis of impacts on the natural and human environments related to both the right-of-way and off-site aspects of the proposed development program;

(iii) detailed description of proposals for preventing, mitigating or compensating for identified impacts on the natural and human environments;

(iv) where applicable, the use of the benefit-cost analysis approach to determine the route with the greatest social benefit;

(v) presentation of public response.

Stage III relates to specific approvals. Before a project can proceed, B. C. Hydro as with any other proponent is required under Provincial statutes to obtain various licenses and permits. Stage III represents the preparation of final plans and the application and granting of licenses and permits. The applications must, insofar as environmental impact related matters are concerned, contain a statement of what steps the proponent must take to avoid, mitigate or compensate for adverse environmental impacts and for the enhancement of the benefits of the project; all of which should have been identified during the impact assessment process and reported in the Stage II report.

This fact was sharply brought home to B. C. Hydro early in 1978 in the case of the proposed McGregor Diversion that would have transferred water from the Fraser River system into the Peace River system. After years of study, the project was shelved when it was discovered that it could pose a serious danger to fish in the northern river system.

The most apparent requirement in the case of B. C. Hydro, for a particular license is the need for a water license before a new hydro project can get under way. The Provincial Comptroller of Water Rights has the authority to hold public hearings on a proposed hydroelectric project, at which Hydro must present its case and answer questions of intervenors. When a water license is issued, it may impose a number of conditions and restrictions. Even at this stage, intervenors have the right of appeal to the Provincial Cabinet, which may add further conditions to the license, or even withdraw it.

Stage IV of the ELUC Guidelines is the final stage encompassing implementation. Some Provincial Government Agencies have specific and continuing responsibilities during development of a project and continue to monitor specific aspects of project initiation. In the case of linear developments, particular attention is paid by Provincial Agencies to the construction process. Environment design specifications which have been identified during Stages I and II and which have been incorporated in permits will in turn be incorporated in construction contract documents to ensure follow through of the necessary impact avoidance and mitigation measures. While the most intensive monitoring can be anticipated throughout the development phase, during which accepted guidelines to mitigate construction impacts are enforced, once operational, normal regulatory functions related to adequacy, safety, etc., apply.

One arguable failing of the Guidelines is that, while Part II of the text of the Guidelines requires detailed information requirements for project assessment it is basically an inventory list and little guidance, if any, is given about methods of assessment or of how to evaluate the information collected. In 1975 Duffy noted that;

"The subject of environmental impact assessment is undergoing refinement as a result of discussion and debate, particularly on the question of what environmental impact includes and what it excludes. A description of environmental impact should cover all obvious and hidden factors, both negative and positive.

Descriptions of environmental impacts are required for an environmental impact assessment, the results of which are given in an environmental impact statement. At present the contents of these statements vary greatly in Canada because the guidelines for their preparation are not yet consistent between the Provincial and Federal Government Agencies which require them."

"Environmental impact assessment is a predictive activity. Some impacts are essentially conjectural, some are partially predictable, and some are almost totally predictable. At the present time there is a need for more objective methods which permit the identification and measurement of all relevant environmental impacts. The importance which is attached to impacts also needs more attention. Ultimately it will be important to understand how to integrate the impacts of an action into an expression which describes the sum of the effects. The methods which are available now fall short of these properties, particularly that of the integration of impacts."

"In recent years there has been an acceleration in efforts to develop adequate methods to assess environmental impacts of different kinds. A number of methods have evolved with specific orientations."

"At the present time the state of the art of environmental impact assessment is in its infancy. Only a few methods are being given wide application. Substantial research and development will be required to support the development of environmental impact assessment on a variety of actions in Canada.

"Methods for environmental impact assessment should possess some or all of the following characteristics:

1. Permit a comprehensive review of a proposed action.
2. Be flexible and, therefore, applicable to a wide range of actions.
3. Be objective and repeatable.
4. Permit the input of available expertise and information.

5. Employ definite criteria and rationale.
6. Permit the assessment of impact magnitude and total effect.
7. Identify environmentally sensitive areas.
8. Permit the integration of different impacts towards a total impact for the action."

"At the present time, there are no methods which fully satisfy all of these characteristics, though some do provide for more integrated and comprehensive assessments than others."

"Environmental impact assessment is based on the analysis of field studies and background information. The assessment statement is reviewed for its implications for decision-making on whether to proceed with an action, modify it, or stop it. Through the sequence of study, assessment, and review there is a need for methods to identify, measure and evaluate the impacts which accompany a given action."

To date, however, the methods used for transmission line impact analysis have been less than satisfactory. This is well shown by an analysis of such studies conducted up to 1979 (ELUC 1979).

At Stage I of the ELUC Guidelines the proponent is required to identify feasible route (corridor) alternatives, determine the broad resource capabilities, uses and potential impacts in those routes, and select one or more routes on the basis of the best balance between environmental and economic cost of the development. When completing the Stage II report, the proponent must detail the alternative alignments within the corridor(s) selected at Stage I; analyze the specific environmental impacts associated with the alignments; provide proposals for mitigating environmental impacts and for using the proposed development for enhancing the environment; present public response regarding the proposed development; and choose the most environmentally and economically feasible alternative alignment.

There are, therefore, four obvious steps in assessing impact at either Stage I or Stage II: (1) alternative identification, (2) impact identification, (3) impact measurement, (4) impact evaluation. In the first step alternative corridors (Stage I) or alignments (Stage II) should be identified in the study area.

Although the same basic steps are taken in the impact assessment, Stage I examines the overall impact of the various corridors while Stage II examines the specific impacts associated with the alignments within the preferred corridor selected at Stage I.

In the ELUC study (1979) of all the reports reviewed, only those assessing the impact of power transmission lines contained an adequate identification of alternative corridors. Most of the other reports evaluated were inadequate in that they compared and selected corridors or alignments without explaining the rationale for selection.

Engineering factors, of course, influence the search for an optimum route (corridor). The greatest range of alternatives is usually associated with transmission lines, while fewer options are availabe for pipelines and even less for highways and railways.

In the study reports, alternative corridors were identified for the various transmission lines in basically the same way. All transmission reports employed an overlay approach to delineate alternatives regardless of whether they used an overlay or checklist approach in impact identification or measurement. The criteria for corridor selection were primarily associated with the geotechnical feasibility and existing land use in the study areas.

A number of reports employed a preliminary screening phase in which the least feasible alternatives were eliminated before an in-depth analysis was conducted. The utility of this approach is that no time and energy need to be spent examining corridors that are unfeasible and may be devoted to a more intensive study of fewer options.

The methods employed for impact identification in the various reports reviewed were of either the checklist - or overlay-type approach. Although none of the methods employed a formalized checklist, eleven of the fourteen reports examined were based on a description of environmental impacts or parameters put forward by either the proponent or consultant and hence, should be considered cheklist-type approaches. The remainder of the reports employed an overlay technique although generally a series of maps rather than overlays was used in depicting environmental characteristics that may affect a development.

It was concluded in the report (ELUC 1979) that checklists tended to be more successful for impact identification than the overlay technique for the Stage I report because they were more comprehensive and flexible for presenting data.

The graphic data requirement for the overlay approach, however, can be considered an advantage in impact evaluation where, if high standards of data procurement are attained, better comparison of alternatives is possible. However, overlays, being heavily dependent upon the spatial extent of features, do not well represent many socio-economic factors.

On the other hand, many secondary and tertiary impacts are often neglected where the checklist approach is used in identifying interactions between environmental factors.

However, interactions between factors may be even more difficult to represent in the overlay approach and are perhaps better analyzed through such methods as biophysical mapping.

(Rees, 1976) Suggests that checklists generally have a greater tendency than overlay methods to double count impacts where, for instance, the secondary impacts of one factor are the primary impacts of another. If a more sophisticated checklist approach is employed for Stage I analysis, there is a relatively high probability of double counted impacts entering the evaluation stage and hence affecting results. Where sophisticated checklists employ models or indices to quantitatively determine total impact scores, caution must be exercised to minimize the double counting of impacts.

The ELUC report (1979) noted that list approaches appear more capable of identifying the nature of impacts than the overlay methods. They tend to consider both positive and negative impacts more often than overlays, largely because of their flexibility. The ELUC report also makes the important observation that there was a general lack of a systematic and hence comprehensive consideration of the timing, duration and direction of impacts in the Stage II reports examined regardless of the methodology employed. The report also noted that as the spatial unit of analysis decreased between Stage I and II, more precise types of data were required for impact assessment. As smaller scales are employed it becomes increasingly difficult for an overlay approach to handle detailed and dispersed features while this is not the case with the checklist method.

Once the actual environmental impacts of a transmission line development are identified, there should be an estimate of the magnitude of these quantitative impacts. Impact measurement can be approached in either a qualitative or quantitative way. The primary advantage of a qualitative approach is its conceptual simplicity. The determination of magnitude is usually based upon professional but subjective judgement with the magnitude of impact often expressed in simple, non-numerical terms (for example, low, medium, high). A simple qualitative approach tends to be much more easily understood by the public than a complex, quantitative method and hence tends to yield higher public acceptance of the study conclusions. The main disadvantage of a qualitative approach to impact measurement is the lack of uniformity in approaching a number of similar environmental concerns since no explicit benchmark exists as a common thread throughout each environmental component. Consequently, the determination of magnitude is often based heavily on subjective judgement, as different analysts may well produce dissimilar results. Even a team will have different members with varied backgrounds and consequently differing perceptions of various environmental components.

The major advantage of a quantitative technique is its uniformity in approaching the evaluation of impacts. The disadvantages of this approach include cost, complexity which yields low public comprehension and acceptance of results, inability to adequately handle intangible and social-community discontinuities between segments or regions.

Another major problem with a quantitative approach is the problem of comparing impacts and using various scaling techniques. An approach for comparing impacts that was employed in the Cheekey to Dunsmuir transmission report, for which this writer was a team member, is where the magnitude score given to each impact is normalized. The highest impact score was given a value of 10 and each score below was prorated, thus providing a common base for comparison between impacts. Different types of interval scales can be used. Another recent B. C. Hydro consultant report, the Cranbrook to B. C.-Alberta Border Study measured impact on only one scale, a linear interval scale. In the Cheekye to Dunsmuir report we employed both linear and non-linear interval scales in impact measurement. Where advanced quantification of environmental impact is attempted, in regions of varying importance this approach is more desirable since the magnitude scales reflect the relative impact upon each sector. In this way a distinction can be made between the situation where a slight alteration in one factor may have a large impact and one where a change of similar magnitude in another factor results in only a slight impact. Admittedly this further complicates the method and thus reduces comprehension.

Actual impact evaluation is a critical phase in environmental impact assessment for it is here that the relative importance of impacts and resource values are determined and routes, (corridors or actual alignments) are compared and selected. The difficulty with which some linear corridor route assessments encounter this problem is seen in this quote from the ELUC evaluation of the effectiveness of the Guidelines in 1979.

> "The evaluation of environmental impacts revolves around two rudimentary problems. Firstly, what is the relative importance of biophysical, social and economic impacts? Secondly, what is the relative importance of environmental versus economic cost? Although the general goal in the various reports reviewed was to select the alternative that had the lowest economic cost and environmental degradation, only one report (Cheekye to Dunsmuir) explicitly answered the two foregoing questions. Unless the reader is informed of how the impacts were evaluated then it is very difficult to assess the analyst's judgement in selecting a preferred corridor or alignment. Since this is one of the primary purposes of completing an environmental impact statement, it is essential that a description of the tradeoffs (i.e.

answers to the two questions) be provided in the text. The lack of such a description was the greatest weakness found in the reports reviewed.

A wide variety of authors have attempted to generalize on the various techniques available for actual impact comparison and evaluation. Newkirk (1979) for example recognizes two basic methodologies for transmission line studies. These may be conveniently divided into general environmental impact assessment methods and path-finding methods. Newkirk suggests that there are many different techniques used or proposed to perform the former while the latter is relatively poorly developed with respect to its integration with environmental impact assessment. Most path-finding development has been associated with network analysis, critical path studies and operations research. Very few attempts have been made at combining general environmental impact assessment methods and path finding.

Newkirk notes nine major methods that may be identified for general environmental impact. They include "Expert Committee" assessment, checklists, matrix methods, benefit/cost analysis, descriptive land unit analysis, input-output analysis, overlay techniques (both manual cartographic and computer-based), information system transformation analysis, and analysis by mathematical surface approximations.

Hilborn (1977) has divided the techniques into three major types, roughly in order of frequency of use. First is the intuitive "list and discuss" approach, this technique generally consists of experts considering the likely consequences of some project. Second is the frequently used Leopold Matrix and its numerous variations. The third technique are numerical models, usually used on a digital computer.

Hilborn (1977) notes that several techniques proposed for use in impact assessment seek to predict system dynamics without requiring the detailed description of processes or functional relationships that is characteristic of quantitative simulation. The simpler of these methods actually utilize less information than that contained in a Leopold Matrix. The more complex methods are essentially specialized programing languages for quantitative computer simulation.

Reese (1979) counters that if we have learned anything about the effects of 'modern' technology on complex systems, it is that the most important impacts may simply be unknowable and, therefore, unpredictable before the fact.

Reese considerably broadens the concept of impact evaulation - "determination of the significance of the ecological impacts to society. This should include consideration of:

(a) the direct and indirect monetary costs and benefits of the project attributable to impacts on the natural environment,

(b) intangible values,

(c) the attitudes of society toward risk and uncertainty;"

and suggests that while it is arguably the weakest in the chain, impact evaluation is potentially the most important. Since it contributes to the overall benefit/cost analysis, impact evaluation should be able seriously to affect final decisions on the fate of a project.

Davies (1979) in presenting a state-of-the-art review of environmental impact assessment methods notes Canter (1977) found more than 50 impact methods have been developed in response to the requirements of the U. S. National Environmental Policy Act. Again, this number of methods can be reduced considerably when it is considered that most of them are variations about a general theme. Warner and Bromley (1974), for example, have divided impact methods into five main classes: ad hoc procedures, overlay techniques, check lists, matrices and networks. Davies (1979) also discusses five major types of methods but these include:

(i) environmental matrices;

(ii) environmental overlay mapping;

(iii) environmental impact indices;

(iv) the systems approach and systems analysis;

(v) benefit/cost analysis

Davies observes that there are few reviews, (Coleman 1977 is an exception), which analyze the merits of these methods in relation to the environmental assessment process and it is important to note that it is not possible to discuss a framework for assessment prior to consideration of assessment in terms of the broader planning process. This processs, and hence a framework for assessment, varies considerable from one province to the other.

Davies also makes the often forgotten point that in the case of linear facilities the most important measure in minimizing environment disruption is corridor or route selection.

While the methods described by most writers are valuable in evaluating the environmental problems associated with routes they generally do not play a direct role in corridor or route selection. The exception to this would be methods derived from the overlay mapping approach.

The ELUC Study (1979) examined four basic approaches used in alternative comparison; general discussion, matrices, overlays and networks. Evaluation of some comparison of corridors in some reports took the form of a rather loose and unsystematic discussion of construction and environmental factors. This type of approach tended to produce repetition in examining some factors and omissions in studying others.

The alternative corridors in one report were compared in terms of the sensitivity, occurrence and stability of eight environmental factors in an environmental impact assessment matrix. Each cell contained a very brief description of the severity of impacts (or problems) associated with a particular environmental factor and alternative route.

This writer feels that The use of written description rather than numbers, enhances the application to areas where only general, qualitative data are available. The difficulty of this approach lies in handling those factors that vary considerably throughout a potential corridor and interact extensively with a large number of other factors. When many environmental factors are included in one matrix, each has an equal (implicit) weighting with all the other factors in the matrix unless some effort is made to highlight the differences between these factors. Thus, the use and presentation of matrices must be carefully planned in order to overcome these limitations.

In reports that employ an overlay approach as an analytical tool for evaluating and comparing alternative corridors the sensitive environmental areas are delineated on a number of separate maps and then combined to determine which alternatives contained the fewest sensitive areas and hence were the most desirable. A liability of this approach is that by aggregating all factors on the same map, each factor assumes (implicitly) an equal weighting with all others on the map regardless of the relative importance of each. This can yield a somewhat misleading representation in areas where one or two factors are of extreme importance. Unless impacts are explicitly weighted when they are combined in graphic, tabular of any other form, they often assume equal weighting. The advantages of this overlay approach are its simplicity, low resource requirements and the ease with which the rationale for selecting the preferred corridor can be communicated.

The network analysis approach was employed in only three of the fourteen reports examined in the ELUC (1979) study The various identified corridors were divided into a number of links or segments and evaluated on the basis of the number of relatively explicit criteria. Values for each link were aggregated in various ways to yield totals for the impact of groups of environmental factors. A disadvantage of this approach is that it is possible for one or two very important impacts to be combined with a great number of low impacts to yield an average low impact for all the factors. It was found that important qualitative impacts were often not emphasized in reports that employed quantitative comparison, unless a special effort was made to "red flag" them. A "red flagging" technique that has received much attention is that developed by Norbert Dee and others at the Battelle Memorial Institute (Dee et all, 1972). When a relatively sophisticated quantitative approach is used, it is possible for severe impacts to become buried, thorough numberous calculations and transformations, among a multitude of low impacts.

In one report, a matrix was presented which showed how the values for various factors associated with agriculture combined to yield an aggregate rating for impact upon the farming sector. This type of matrix could be used to demonstrate the rationale employed for deriving total impact classes or scores in virtually any situation where impacts are aggregated.

A more complex approach to aggregating impacts was employed in our Cheekye to Dunsmuir report. An impact hierarchy was established where each environmental factor was given a weight according to its relative importance to others in the hierarchy. A pitfall of such an approach is to assign environmental weights that are too fine. Differences in total impact scores of alternative corridors should really be tested for their significance, however, we were not able to do this due to fiscal limitations on our computer time.

The ELUC Study (1979) notes that in the Cheekey Dunsmuir report, the relative importance of economic and environmental cost is well portrayed. None of the other reports reviewed contained an explicit presentation of the relative importance of these two factors.

In examining alternative selection the study found only one report presented the method of evaluating environmental impacts and hence the criteria and rationale for selecting the preferred corridor. Many of the reports provided the criteria for corridor selection but lacked a description of the method and rationale of evaluation. It is clearly once the basis for impact evaluation is presented that it is then possible to assess the analyst's judgement and rigour in selecting a particular corridor or alignment.

Davies (1979) in examining the various methods used by utilities for linear corridor evaluation found that Calgary Power Limited (1976) published a check list of Standard Impact Assessments of Electric Transmission Lines. The publication is more than a check list in that it provides a means by which the impact of a transmission line on one route can be compared with the same line on another route.

Davies also found that Ontario Hydro (1975) used a modified matrix to assist in the evaluation of a power line system to Prince Edward County. Using a data weighting system, the routes were compared on the basis of economics, supply characteristics, property impact, natural environment impact and visual impact.

Davies notes that overlay methods have been used in a number of recent studies of the environmental effects of electric transmission lines. Prominent among these are studies by Ontario Hydro (1974 and 1978) and Manitoba Hydro (1976).

A number of approaches are being developed which attempt to derive one overall rating or index for evaluating a project as a whole. Two well-known examples of these methods are the Environmental Evaluation System proposed by Dee et al (1971). This latter method is essentially a linear combination of component values (e.g. amount of urban land disturbed, relative safety of a route, cost, etc.) multiplied by a weighting factor giving the relative importance of the particular component values. Values for component and weighting are scaled or normalized so that results are kept within reasonable bounds. For each set of component values, two weights are used: (a) a "present" weighting factor and (b) a "future" weighting value. Ontario Hydro (1975) has also developed weighting methods for use in evaluating the impacts of electrical transmission lines. These could be incorporated into most overlay or index methods.

A systems approach is one way of ensuring that all these viewpoints are considered in the analysis of a linear corridor selection problem. Systems analysis is used routinely in management science, systems engineering or operations research. The basic method involves four steps:

(i) define the objective needed to overcome the problem;
(ii) define alternative ways to achieve the objective;
(iii) place these alternatives into a mathematical framework, e.g. simulation model, linear program, etc.;
(iv) developing the optimal solution.

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System analysis usually uses mathematical modelling in order to provide a solution for a problem. Unlike input-output methods, the systems analysis approach incorporates time as an independent variable.

There are two types of models that can be used to describe real world systems:

(i) analytical or deterministic models used where mathematical statements can successfully approximate the real life system;

(ii) simulation models used to investigate the response of a system when one of its parts is changed.

Most, if not all Canadian utilities, use the systems approach today when conducting environmental studies. However, Davies (1979) found that a superficial literature search failed to reveal examples of environmental studies sponsored by Canadian or American utilities which have used a <u>comprehensive</u> systems analysis.

Newkirk (1979) has, however, recently published a planning system which integrates most significant steps involved in performing a detailed environmental impact analysis and associated least impact route finding. Steps include determination of the major environmental factors for consideration through data collection, data bank building, developing factor assessment modules, combination of assessments, and actual route selection. Included in the process is the generation of mapped and tabulated results as well as provision for input of public and governmental concerns, knowledge and attitudes. Data acquisition to support data bank development is apparently automated by using digitizing equipment and special computer programs. Factor assessment modules are developed in the Newkirk system based upon the data bank and implemented by special computer routines. The combination of factor assessments, assessment mapping and route selection are also performed by a series of computer procedures.

The system integrates all study steps from impact factor and data base development through to actual routing analysis. This is done in a modular way to facilitate iterative development of study segments.

A computer procedure to interpolate grid area data directly from source map sheets has been designed.

A new Cascade Algorithm has been developed to permit combination of multiple assessments into one total assessment on a stacked or cascaded threshold basis.

A multistage route identification and analysis procedure has been designed. Using graph contraction, a modified Dijkstra route-finding algorithm, route straightening, and corridor assessment it effectively processes large problems. The author claims that the procedure guarantees the location of least-impact routes and provides alternates, and it removes path irregularities consistent with path impact restrictions.

CONCLUSION

There is no universally acceptable environmental impact assessment method for utility route selection. Any one, or combination, of the approaches discussed here can effectively be used to assess the impact of a linear utility project. However, the method(s) selected must be applied with professional judgement and the results must be interpreted using professional judgement.

In general it can be seen that methods exist which ensure that the impacts of a project will be identified but there stil remains substantial problem in the areas of impact measurement and evaluation. Most of the techniques currently used are directed towards the evaluation of primary impacts. It is equally important to develop approaches which will predict the secondary effects of project implementation.

There is also a need to develop a comprehensive environmental impact assessment process and show how it relates to the planning process. Impact assessment methods should be evaluated as to their function in this process. To what extent the Newkirk system responds to these needs remains to be seen.

In the meantime the situation in British Columbia is once again one of flux and change. Bill 52 introduced and passed in the Provincial Legislature in 1980 has now established a Utilities Commission with specific powers to hold hearings including the examination of transmission line projects. See Appendix XI.

A specific procedure of the process is the application for an Energy Project and Operation Certificate. See Appendix XII. This section of the Act now has a schedule in which the proponent is specifically required to provide:

> identification and preliminary assessment of any impacts by the project on the physical, biological and social environments; and proposals for reducing negative impacts and obtaining the maximum benefits from positive impacts"

Moreover the hearing procedure for the certificates will allow intervenors to specifically challenge both project need and environmental impacts methodology - something that has not happened in this Province before.

It remains to be seen if the systems so far devised will stand the test of vigorous cross-examination when clearly there is much yet to be learnt about linear corridor assessment.

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APPENDIX I

APPENDIX II

APPENDIX III

APPENDIX IV

APPENDIX V

APPENDIX VI

APPENDIX VII

APPENDIX VIII

APPENDIX IX

APPENDIX X

APPENDIX X (i)

APPENDIX X (ii)

APPENDIX XI

APPENDIX XII