Prospects for Fundy tidal power

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The Bay of Fundy area in Canada is one of the few places in the world where tides ranging up to 16 metres occur. Because of the magnitude of this tidal variation and the configuration of the surrounding terrain, the area offers excellent possibilities for the construction of tidal-electric plants to exploit this energy. Figure 1 indicates some of the sites within Canada which have been subjected to various degrees of intensive study over the past half-century.

Although interest in exploiting the energy of the Fundy tides had been expressed early in the century, it wasn't until 1944 that the Governments of Canada and the Province of New Brunswick sponsored an investigation into the exploitation of the tidal energy at the upper end of Shepody Bay. That study indicated that an hydraulically-linked, double-basin scheme, incorporating the estuaries of the Memramcook and Petitcodiac rivers could produce about 1.3 TWh annually but concluded the project was not economically justified. A number of investigations of limited scope were undertaken in the late 1950's and early 1960's in the Chignecto Bay and Minas Basin areas but none of these was sufficiently definitive to establish the merits of development.

Subsequently, comprehensive investigations undertaken during 1966-69, 1976-77, 1981-82 and 1984-85 have :

(i) provided an in-depth background to the potential for tidal power development in the Bay of Fundy;

(ii) identified the most appropriate sites for development;

(iii) defined technically sound designs and construction methods;

(iv) showed that a tidal power development will provide net economic benefits. These in-depth studies and the cumulative operating experience and record of the two modern, tidal power stations, the one at La Rance and the other at Annapolis, have demonstrated that, not only are there now available proven and mature technologies for the exploitation of the energy of the Fundy tides, but also that such exploitation can be competitive to conventional sources of electrical energy in the Maritime provinces. However, notwithstanding the positive results that have been obtained from these preliminary, feasibility and update studies, very little, if any, progress has subsequently been made towards realizing a tidal power project in the upper reaches of the Bay of Fundy. Some research activities relating to environmental and ecological aspects have been undertaken under government sponsorship since 1977, such as the development of a hydrodynamic model which will be useful in predicting, for example, changes in sediment regime, but such research has been sporadic and uncoordinated.

I ■ RESULTS OF RECENT INVESTIGATIONS

To set the stage for a decision on the next phase in the exploitation of the renewable energy source in the Fundy tides, the major conclusions and recommendations of the previous studies are reviewed and examined.

1.1 1966-1969 Investigation

The Atlantic Tidal Power Programming Board (ATPPB)

Perspectives de l'énergie marémotrice dans la baie de Fundy

La baie de Fundy au Canada possède probablement les conditions les plus favorables dans le monde de l'exploitation de l'énergie marémotrice. Les résultats des investigations conduites durant le dernier quart de siècle sont décrits y compris les aspects d'exploitation et d'impact sur l'environnement, pour la centrale d'Annapolis (20 MW) mise en service en 1984. Au départ, cette dernière était destinée au test des unités de turbines de grand diamètre (7,6 m) STRAFLO sur des petits hauteurs de chute.

Les études montrent que le développement d'une centrale de 1400 MW en tête de la baie de Fundy est techniquement et économiquement viable et qu'une telle centrale pourrait être compétitive avec des centrales à combustibles fossiles. L'importance du réglage est discutée, dans le cas où l'exploitation de cette source d'énergie renouvelable et non polluante correspondrait aux besoins des provinces maritimes.

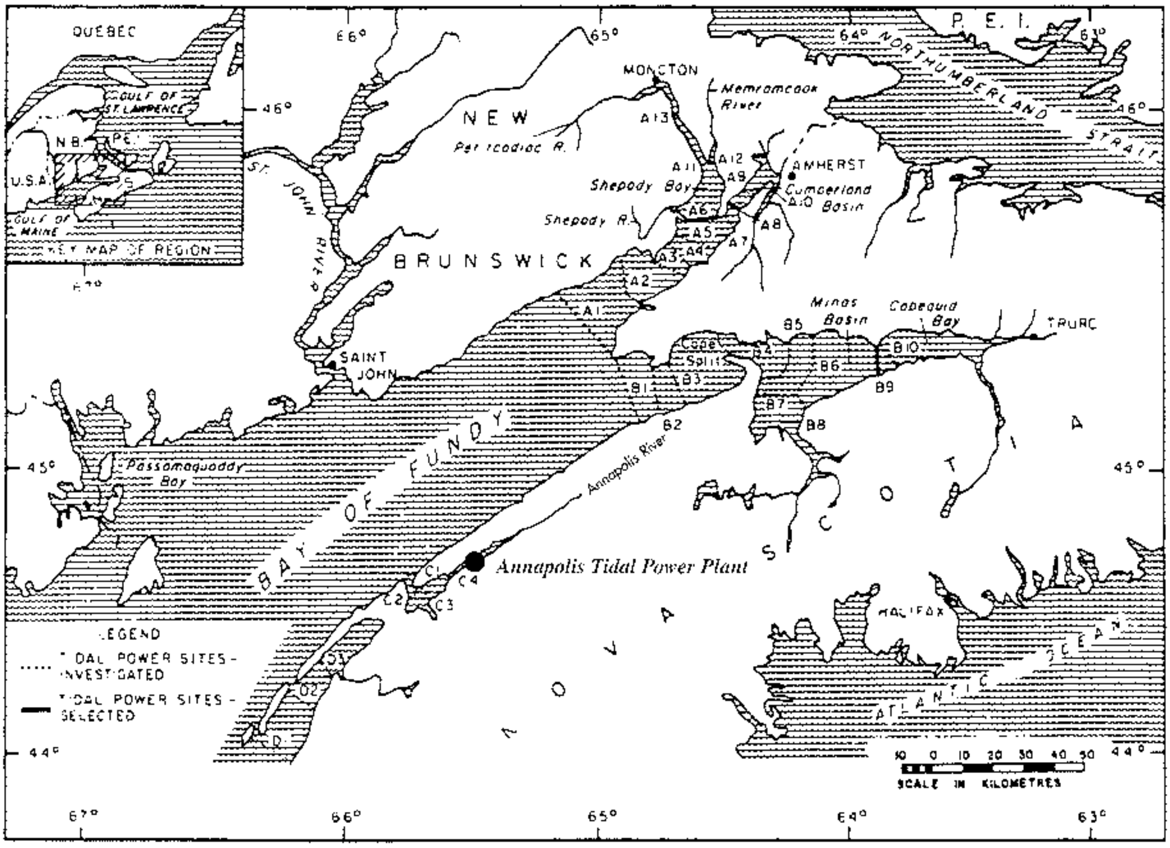
was established by agreement of the Governments of Canada, New Brunswick and Nova Scotia. The Board concluded that economic development of tidal power was not feasible under the then prevailing circumstances. However, it recommended that additional detailed studies be authorized in the event of significant changes in interest rate, construction costs, conventional energy prices, or threatened exhaustion of conventional supplies. Significant changes did occur in both energy prices and supply position within three years of the submission of the Programming Board's report on 31 October 1969 [1].

In the light of those changes, the Federal and the two Maritime provincial governments established, on 29 February 1972, the Bay of Fundy Tidal Power Review Board. After reviewing and updating ATPPB estimates of the cost of tidal power development, examining certain marketing possibilities and comparing market value of tidal power with the value of energy from fossil fuels, the Board concluded that the relative economic merits had converged sufficiently to warrant undertaking more comprehensive studies on a phased basis. In this way, the investigation could be terminated if the results of any phase indicated that tidal power could not become competitive with alternative energy sources.

In submitting its conclusions to governments, the Board pointed out that there are incentives which might encourage the market area to purchase tidal energy because reductions in fossil-fired energy production would result in : (i) reduced atmospheric and water pollution; (ii) reductions in demand on finite oil and gas reserves, which could be diverted to more critical purposes. Also, the necessary transmission facilities dedicated to a tidal power project would undoubtedly provide opportunities for transmission of power between power systems in eastern Canada. In addition, it is interesting to note that, at that time, the Review Board also expressed its opinion that nuclear, not fossil fuel, power costs will constitute the long-term yardstick for economic evaluation of energy projects.

1.2 1975-1977 Reassessment Studies

The three governments, acting upon the Board's conclusions agreed to finance further investigations and directed the Board on December 3, 1975 to carry out further studies with the object of providing a firm estimate of the cost of tidal energy in relation to its alternatives, on which to base a decision to proceed further with detailed investigations and engineering design. On December 2, 1977, the Review Board reported [2] that the reassessment had conclusively demonstrated the fundamental economic feasibility of tidal power and the technical and economic feasibility of its integration into the projected generation supply systems of the Maritime Provinces and recommended, *inter alia*, that funding be provided to complete detailed engineering, socio-economic and environmental investigations and financial planning for the development of a tidal power project at the mouth of Cumberland Basin, i.e. Site A8. Unfortunately, these recommendations were not acted upon at that time



1. The Bay of Fundy.

1.3 Update '82

With major funding provided by the former federal Department of Energy, Mines and Resources, the Tidal Power Corporation of the Province of Nova Scotia undertook a revision of those portions of the Review Board's work rendered out of date by changes in cost, technology, policies or outlook subsequent to 1977 which the Review Board, at its last meeting, had recommended be undertaken. The Update Task Force [3], set up by the Tidal Power Corporation to carry out this review concluded, *inter alia,* that significant reductions in overall cost could be achieved by shortening the construction period which should be one of the objectives of definitive design. The Task Force also noted that, under a reasonable marketing strategy, which would involve allocating a considerable portion of output to export markets, a tidal power development would be economically viable with a benefit to cost ratio in the 2.4 to 3.0 range. The Task Force also noted that the work done to that time fell far short of providing all the information required to launch a tidal power project and that a pre-committment programme encompassing definitive designs and socio-economic and environmental assessments should be undertaken.

1.4 1984-1985 Feasibility Update

Subsequently, the Federal and Nova Scotia governments agreed to finance a study by a private sector interest, the Aluminium Company of Canada (ALCAN), which would be aimed at determining more closely the technical and economic aspects of Site A8, at the entrance of Cumberland Basin between Nova Scotia and New Brunswick (Figure 1). Based on a review of the activities, results and conclusions of ALCAN's study, the Nova Scotia Tidal Power Corporation concluded [4] that further technical work aimed at reducing development costs could be accorded a relatively low priority. It also concluded that the launching of a Stage 2, pre-committment programme, should await further resolution of the marketing, retiming and transmission questions. However, it was emphasized that if means of re-timing the output of Site A8 could be established, Stage 2 studies should be undertaken promptly and a high priority given to establishing feasibility conditions for the development of that site. In this connection, further studies are required to examine how Compressed Air Energy Storage (CAES) Systems and/or the hydro storage of interconnected systems can be integrated with tidal power to provide a high quality source of generation for electrical systems.

1.5 Summary

The updates of 1982 and 1985 proved useful in that they reflected, in updated costs, the current knowledge of turbine/generator performance and improved construction techniques. Currently, the Site A8 design would consist of 42 single-effect turbines with a rating of 34 MW for an installed capacity of 1,428 MW giving an annual energy (net of transmission loss) of 3,307 GWh.

II ■ THE ANNAPOLIS TIDAL GENERATING STATION

In the late 1970's, it was considered that larger scale development of the straight-flow turbine, as developed by Escher Wyss for its STRAFLO unit, could improve the economics of harnessing undeveloped hydro resources in Canada and enhance prospects for development of major tidal energy sites in the Bay of Fundy. Several units of this design, which featured improved seals between rotor and the water passage structure, had been installed in Europe but they were far smaller than the optimal sizes for Canadian sites, then under consideration.

Interest in a low-head demonstration project was shared by various utilities across Canada as well as by the Government of Canada and by tidal power investigators. Larger-scale development of a new hydro-electric turbine could improve the prospects for development of major, tidal energy sites in the Bay of Fundy. A causeway which had been constructed across the mouth of the Annapolis River in 1963 was selected for the site since it would minimize the capital outlay as well as offer experience in commercial operation at least cost. The causeway had been constructed to provide better drainage and protection for the dyked lands around the Annapolis Basin and to carry a roadway to replace an old bridge. The causeway was already equipped with a fishway and with sluices containing vertical lift gates. The sluices would be closed against the flood tide when the Annapolis River itself was in flood so as to limit the water level in the head pond to 1.8 m above the mean sea level.

A commitment decision was made on 5 December 1979 when the Governments of Canada and Nova Scotia announced an agreement to construct a low-head hydro demonstration plant at Annapolis. With a $25 million grant by the Federal Government, the former Nova Scotia Tidal Power Corporation, as owner of the plant, undertook to fund the balance of the cost and engaged Nova Scotia Power to design, construct and operate the project. Design was based on single-effect, ebb generation using one single-regulated STRAFLO unit of 7.6m throat diameter – the same size as planned for large tidal power plants in the Bay of Fundy.

2.1 Review of Plant Operation

Construction commenced in 1980 and the plant entered commercial service in August 1984. The Annapolis Tidal Generating Station has been described in detail in papers by DeLory [5] and by Rice and Baker [6]. Much was learned during construction and commissioning of Annapolis Tidal Power Plant, but long service is required to assess such things as longevity, resistance to corrosion and maintenance needs. Comments on the performance, maintenance and environmental aspects are presented hereunder.

2.2 Performance

The unit attained specified outputs at the specified heads, i.e. 17.8 MW at 5m and 19.9 MW (overload with 2-hour rating) at 5.6m. Run-up and synchronization are automated and the facilities proved adequate to surmount difficulties imposed by the large inertia of the runner and the tendency for wicket-gate operation to cause seiches in the headpond.

Annual output has been in the range of 30 GWh per year which is well below the planned target of 50 GWh. This has been due, in part, to changes made during construction of the project and shortly thereafter. Hard strata in the discharge channel had escaped detection in preliminary drilling and, when discovered, it was decided to accept a shallower channel. This resulted in a small increase in the tailrace elevation. However, a larger reduction of available head resulted from a decision during the first year of operation to limit the maximum headpond level to 6 m above mean sea level. The out-of-phase discharge may also reduce the tidal range at the site but the gauging necessary to check this possibility has not been undertaken.

Two start-up troubles were encountered. One resulted from the fact that the field coils of the rim generator had not been sufficiently insulated by the manufacturer who was concerned with heat dissipation and did not encapsulate them as specified. This problem was resolved by applying an epoxy coating. The insulation resistance is still low but outages are avoided by keeping the windings warm when the unit is not running. The other problem arose from the fact that the plant uses sea water for, among other things, cooling the generator through heat exchangers, cooling the bearing oil and lubrication of rim seals. The clearance between the latter and the metal face of the stationary metal is very small, so the intake water is filtered. The filters tend to plug very quickly and back-washing was not effective. A different type of filter with continuous backwash solved this problem.

For a tidal plant, it is reasonable to define *availability* as the ratio of operating time to the total time when head equals or exceeds the minimum operating head. On this basis, the Annapolis unit has consistently achieved an availability of about 99%. Typical availability of hydro units operated by Canadian utilities is in the 95-96% range.

2.3 Maintenance

The wetted surfaces of the intake, the turbine unit and the draft tube have active cathodic protection. With the exception of a spot at the root of one runner blade, this has completely inhibited corrosion. The runner blades are stainless steel and the hub is carbon steel. In its manufacture, five layers of gradually changing composition were welded between the hub and runner to avoid creating undesirable potential at the joint. It is possible that there was some irregularity at the point now subject to corrosion. The affected area is only a few square centimetres and repairs are made every few years when the machine is dewatered for other purposes.

The water passage has remained free of marine fouling communities possibly due to the applied potentials or perhaps, although less likely, due to high water velocity. There is a heavy build-up of mussels upstream of the stoplog gains at the intake, but the gains and the areas downstream thereof are clean. The contrast is striking.

After about three years in service, a decreasing trend in the flow of sealing water was noted. By the following year, the flow had dwindled to the point that remedial action was necessary. The unit was dewatered and the seals removed. It was found that the small water passages which delivered high pressure water to the face of the seals had become choked by deposits of manganese. The deposits were removed by scraping and the unit returned to service. It was determined that the deposition of manganese, normally present in sea water, was being triggered by the small amounts of chlorine, used to inhibit marine fouling, in the water taken in for plant operating purposes. Since it was judged unwise to dispense with this protection, the seals are removed and cleaned at intervals of three to four years. No sign of seal wear has yet been detected. This latter problem could have been avoided by using fresh water for plant use instead of the readily available salt water. Although water utility mains run past the plant, the demonstration was designed to uncover the problems entailed in the use of similar machines for large tidal plants where fresh water would not be so conveniently available as well as those in river hydro applications.

Avoidance of corrosion on metal surfaces exposed to air in the turbine pit requires some maintenance effort. The external surfaces of water passages are chilled by sea water so that atmospheric water vapour tends to condense on them, particularly during the intervals between operating periods when there is no stray heat from the generator, and the atmosphere tends to have some salt content as is usual in proximity to the sea. Heat and ventilation are provided but there is no air conditioning. Costs and benefits of including this feature in future tidal plants of this type may deserve careful analysis.

There has been no indication of wear in upstream and downstream rotor bearings. There are no trash racks so that the runner blades are relied upon to deal with any trash or ice and have proved capable of doing so. However, a wicket gate operating link was bent on one occasion when some timbers of 30x30 cm cross-section passed through the machine.

In summary, maintenance requirements have been met by taking the unit out of service for about two weeks every three or four years. This is less than had been expected and significantly less than the allowance used in feasibility studies for large tidal plants at the Fundy sites.

2.4 Environmental aspects

The environmental requirements for the project were supervised by an intergovernmental environmental advisory committee (IGEAC). It was the first instance of unified environmental control and saved the project from the confusion and delays entailed in meeting the requirements of a number of independent agencies. Over 30 studies were carried out dealing with various real or conjectured impacts. The main potential impacts identified by these studies involved either the marine environment or the low-lying farm lands adjacent to the head pond. Potential marine impacts comprised delays imposed on migrating anadromous fish, fish mortality and siltation. Potential terrestrial impacts comprised salt intrusion, impairment of drainage, flooding, erosion and salination of headpond surface water used as water supply for livestock.

A section of the sluiceway, built when the causeway was constructed across the estuary some years earlier, is left open at all times to provide fish passage. The IGEAC considered that it was not close enough to the turbine and ordered construction of a second fishway immediately adjacent to the intake. Limits were also defined for the release of sediment during construction and these were not exceeded. In the headpond area, aboiteaux were constructed in the drainage outlets of low-lying dyked lands and water supply from small streams was provided where needed. Provision was made in the station operating logic for strategies that would avoid exceeding the target maximum headpond level, based on tidal and river flow data.

During the construction and commissioning periods there was a good deal of concern about impacts. This concern reached a crescendo when operations commenced and the headpond elevation was gradually being changed to its intended final level. The concern was fanned by the media and, since it was new and clearly visible, the plant was blamed for any real effects that had existed for decades as well as for imagined new impacts. The environmental authorities received many complaints. One such complaint concerned a yellow dust observed on water surfaces in the area which turned out to be pollen from spruce trees which has fallen on Nova Scotia in the month of May since time immemorial.

The plant was also blamed for the disappearance of clams on one tidal flat about 5 miles westward of the plant and clam fishermen demanded closure of the plant. Investigation showed that the immediate causes were the failure of new clam spat to settle on the flat coupled with the effects of a predatory marine worm. Before the investigation was completed, a new generation of clam spats settled and the flat was repopulated. Obviously, this event had nothing to do with the plant which was operating throughout this whole period.

Now, after more than 12 years of operation, the real impacts can, in most cases, be assumed to have become readily observable so that it is possible to make a fairly reliable assessment. The following summary is based on published and unpublished research as well as the presence or absence of technical or public concern.

2.4.1 Fishery Impacts

Fish species frequenting the river include Atlantic salmon, striped bass, shad and blue back herring. Among these, shad have been used from the outset as the marker species because of their numbers and the associated sport fishery.

A 1995 survey of the shad population found that the individual fish size, age and estimated number of spawning fish were somewhat lower than in 1985. This would be consistent with moderate turbine mortality but it could also be part of the general malaise which has affected most species of commercial importance in the Atlantic fishery. In any case, the population is still large and it is reasonable to conclude that any effects due to the plant had stabilized by that time.

There is a fall salmon run but it is not fished. Many years before the tidal plant was built, salmon were adversely affected by river hydro developments. The local, striped bass fishery has varied over the years with the success or failure of each year class. Data are not available but the fishery still exists. The productivity of the headpond, which supports juvenile anadromous fish, has improved since the plant went into operation and exhibits more biological diversity.

Efforts made to develop behavioral means of diverting fish from the vicinity of the turbine to the original fishpass met with only limited success. In the course of this effort it was found that about two-thirds of the adult fish making a downstream passage use the sluice rather than the turbine.

In summary, the impacts on important fish species have, at worst, been only moderate and do not threaten the demise of fish stocks.

2.4.2 Sedimentation

Single-effect ebb-generation imposes conditions more favourable to deposition of sediments in the headpond than the prior regime under which at least two of the three sluice gates were normally open throughout the tidal cycle. The rate of sedimentation has, in fact, increased in the lower reaches of the headpond. This implies that, in the absence of any increase in the rate of upstream erosion and the concentration of suspended solids, the discharge through the barrage must carry less sediment than under prior conditions.

2.4.3 Erosion

The rate of erosion in the estuarial section of the river between Annapolis Royal and Bridgetown increased when the causeway was built in the early 1960's. This is attributable to decreased salinity in the headpond and a corresponding decrease in the energy required to cause scouring. It was conjectured that plant operation would increase salinity and, if anything, reduce erosion. Transects of the shoreline taken after about three years of operation were compared with similar data taken before start-up. The comparison tended to show that there had been some slumping but that there had been little overall loss of material. However, erosion does not proceed in those soils at a steady rate and the results were not regarded as conclusive. The author is not aware that any more recent data exist.

2.4.4 Protection of Agricultural Soils

Extensive piezometer measurements taken before and after start-up in the most sensitive areas of the dykeland surrounding the headpond failed to record any indication of saline penetration as a result of the new headpond regime. The soils have extremely low permeability and surface runoff is the usual form of drainage, although some 'mole' drainage is also used. The aboiteaux which had been installed as part of the remedial programme, function as intended so that the pre-existing drainage conditions are unaltered.

The plant operating logic provides computerized control of headpond levels and controls the surface elevation with an error of not more than about 5 cm. The turbine is available to augment discharge capacity, if necessary, in the event of floods. Level control before the plant was built was based on human judgment and exercised through manual control of sluice gates. At times, the headpond rose nearly 3 m above the intended level.

In summary, the plant has increased the accuracy of control and has enhanced the quality of dykeland protection.

III ■ PROSPECTS FOR DEVELOPMENT

The foregoing brief review of conclusions/recommendations and comments from the investigations/reassessments/updates which constitute the feasibility or Phase 1 study of a potential project, and the experience gained in the operation of the Annapolis Tidal Power Plant with its large diameter STRAFLO turbine, make it abundantly clear that a tidal power development at Site A8 is technically and economically feasible. Moreover, contemporaneous discussions also reveal that, more than likely, its output would be competitive with that of fossil-fired plants, particularly if a 'green' accounting technique, i.e. putting a dollar value on all environmental costs, were applied to all electrical energy sources. Therefore, it seems obvious that there is sufficient information on which to base an authorization for the necessary pre-investment activities that would lead to a definitive proposal, i.e. definitive designs and specifications for development of Site A8 (Phase 2), which would be a pre-requisite for a comprehensive 'environmental impact assessment'.

There is a great deal of work to be carried out during a Phase 2 investigation before any decision could be made to construct. For Site A8, some of the required data and activities are :

(i) additional seismic profiles as well as four to six bore holes to investigate overburden and rock;

(ii) additional basic data on sedimentation and ice conditions;

(iii) refinement of the closure method to relate it to construction staging and schedule and lunar tidal cycles;

(iv) additional wave climate data and storm surge modelling is required as well as more detailed generation-supply and generation planning studies, etc;

(v) some hydraulic model studies will have to be undertaken since there are several areas/problems for which only physical models would be capable of adequately simulating the physical phenomena to produce the required information with sufficient accuracy – such models would also be of assistance to the construction and eventual operation of the various structures, should a construction decision be made. Although some isolated environmental studies have been undertaken by research agencies, more comprehensive, intensive and coordinated environmental investigations are required, based on a definitive design. The foregoing are only a few of the essential activities encompassed by a Phase 2 - Pre-investment Design Program.

In view of the capital-intensive nature of tidal-electric, hydroelectric and nuclear projects, a primary concern is project financing. Since a high, real interest-rate environment distorts the perception of the long-term value of the project, the 1984-85 study suggested that this difficulty could be resolved if project financing could be arranged at an index-linked interest rate consisting of a real component of approximately four per cent plus an inflation component equal to the current year's inflation rate. At the present time, the Bank of Canada rates are at a four-decade low of less than 3.5 per cent.

Tidal power would seem to have a unique feature which hasn't yet been explicitly acknowledged. There seems to be a consensus (at least since the 1973 world oil embargo) that the project would have been economic if embarked upon on earlier occasions but never on the current one. This characteristic was intimated during the preparation of the preliminary reassessment report of September 1974 and it was also expressed in the January 1987 issue of International Power Generation under the heading «Tidal power; is it all a question of timing?».

Timing is of the utmost importance. A Phase 2 programme would require about 3 years to complete and, if its conclusions were positive, the construction of an A8 project would take an additional 6 to 8 years. Thus, there would be a period of 10 to 12 years, at least, before a plant at A8 could be fully operational. Even though the installed generation capacity of the Maritime Provinces is sufficient until after the turn of the century, when capacity additions will become necessary, the development of A8 could not be undertaken unless the necessary investigations and environmental studies were initiated in the very near future.

In the 1988 publication, *Into the Mainstream: Strategies for a Secure Environment*, issued under the authority of the Minister of Environment Canada, it is clearly stated that :

«For the first time in the history of this planet, people have the capacity to significantly affect and alter the global environment. Acid rain, accidents involving nuclear energy, or the release of chemicals can threaten air, land and water halfway around the world. Consumption and production practices which are seemingly insignificant at the individual level are now understood to have profound immediate, long-term and cumulative harmful effects on the health of our planet. Massive deforestation, burning of fossil fuels, and use of certain chemicals in ordinary household products are leading to potential long-term global changes.»

«The true costs of some resources may need to be brought onto the conventional balance sheet.»

The true cost of energy from fossil-fuelled power plants is not revealed when comparing energy sources for electric power generation, such as price supports/constraints or the 'real' costs of large oil spills which are not reflected in the cost of fuel for power plants, nor are the costs arising from the destructive effects of acid rain. Nuclear energy costs do not include the 'real' costs of decommissioning a nuclear power station or the costs of disposal of its waste products. How are the costs of nuclear 'accidents' or of massive oil spills to be factored into the costs of energy from these energy sources ? It must be kept in mind that all forms of electrical energy production have some environmental effects. The advantages of renewable energy sources must be recognised, particularly with respect to greenhouse effects, diversity of supply and fuel price increases[7].

It is often argued that conventional power plants have fewer uncertainties because of the extensive experience which is readily available but this is not necessarily so. For example, although nuclear power has reached a state of maturity, there was a serious incident at Three-Mile Island in 1979. Tidal plants do not pose an extraordinary risk. Trade-offs have to be confronted and decisions made in everything that is done and constructed with resulting disadvantages and advantages to society.

There are few important disadvantages in exploiting tidal energy. Paramount, of course, is the effect on fish, fowl and wildlife. Such effects resulting from the operation of the La Rance and Annapolis plants are now fairly well known and it would appear that the disadvantages can be overcome or are outweighed by the many advantages of tidal energy [8] :

A large tidal power development in the Canadian Bay of Fundy could have an international aspect since its location and operation would affect the resonance of the Bay and the Gulf of Maine. Hydrodynamic numerical modelling predicts that a barrage at Site A8 would change the natural period of the Bay/Gulf system so as to increase tidal amplitudes. The change in tidal range at Boston would be about 3 cm as a result of the operation of a plant at Site A8. The lower Bay and Gulf would experience increased currents. More nutrient-rich water from below the ocean thermocline would be brought in and fish spawning and larval distribution would be affected. Cold water species, which form the majority of the fishery, would benefit. In view of the foregoing international, environmental effects, there would be an obligation to give United States authorities a voice in environmental regulation and control, particularly if output from the tidal plant were to be exported to the United States.

Tidal power development must be a multi-government effort in view of the far-reaching environmental considerations and the significant regional socio-economic benefits as well as the financing of the project. The current uninterested or wavering attitude of governments to this economic, non-polluting electrical energy source, resembles the 'French Wavering' described by Dr. Robert Gibrat [9].

The next step will involve the preparation of a development or framework plan for the pre-investment investigations of Phase 2, including a critical path analysis to identify those items which are sensitive to time constraints in logistics planning, and which would provide the definitive designs and specifications, including the environmental impact assessment, for a tidal power development at Site A8, that is, the requirements necessary for a clear and informed decision to construct or forget the project.

Acknowledgement

The author is indebted to Dr. G. C. Baker for the text summarizing the operation and effects of the Annapolis Tidal Power Plant.

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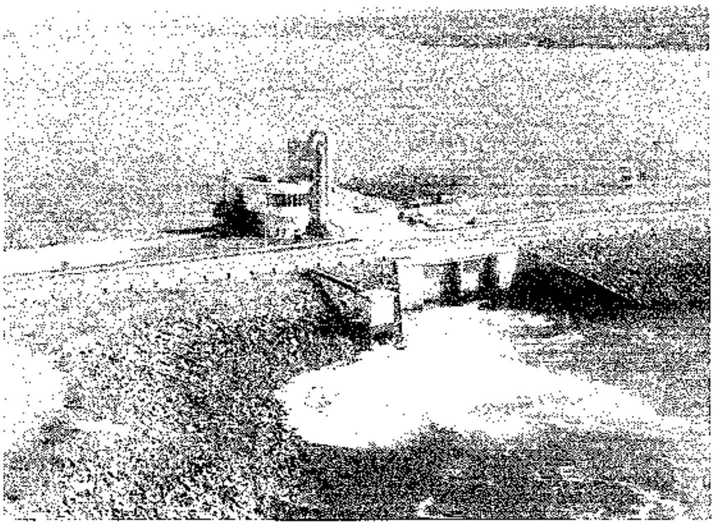

Courtesy : Nova Scotia Tidal Power Corporation

2. The Annapolis Tidal Power Plant.