Canadian manufacturers in several energy-intensive industries face a serious competitive disadvantage by not having the same opportunities as their American counterparts to install cogeneration facilities. Industry and Science Canada (ISC) worked closely with 29 pulp and paper mills to document the potential benefits of enabling Canadian firms to sell excess cogenerated power to utilities at the utilities' avoided cost rates. Assuming that the utilities were in need of additional base-load power, the benefits to Canadian firms would be great (approximately 3% of sales, or about $55 million/mill). In essentially all cases, these benefits could be at-tained without resorting to crosshauling subsidies (i.e., selling power at a high avoided cost rate and repurchasing the same quantity at a lower average industrial rate).

Les manufacturiers canadiens travaillant dans plusieurs industries qui font un usage intensif de l'énergie font face à un désavantage sérieux par rapport à la concurrence parce qu'ils ne bénéficient pas des mêmes facilités que leur équivalents américains pour installer la cogénération. Industrie et Sciences Canada (ISC) a travaillé en collaboration étroite avec 29 fabriques de pâtes et papiers pour documenter les bénéfices potentiels que les sociétés canadiennes retireraient si on leur permettait de vendre l'excès d'énergie provenant de la cogénération aux entreprises de service public canadiennes à un prix qui soit fixé en tenant compte des coûts évités par lesdites entreprises. En supposant que ces dernières aient besoin d'un supplément d'énergie à charge minimale, les avantages que les sociétés canadiennes en retireraient seraient importants (approximativement 3% des ventes ou environ 55 millions par fabrique). Dans pratiquement tous les cas, on pourraient atteindre ces objectifs sans avoir recours à la forme de subsides appelée "crosshauling" (qui consiste à vendre le courant à un prix fixé par rapport à un taux élevé de coûts évités et à racheter la même quantité à un prix industriel moyen plus bas).

This report provides additional information referred to in the above paper by A.C. Harberger.
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Cogeneration: Potential Impact on the Competitiveness of Canada's Pulp and Paper Industry

BRENDAN BURNS, JIM DOUGLAS, DON TATE and NADA VRANY

1. Introduction

1.1 Background

The cogeneration of electricity by manufacturing enterprises is an efficient, environmentally-friendly approach with which Canadian firms can enhance their competitiveness. Being able to produce and sell by-product electricity to electric utilities at the power companies' avoided (or incremental) cost offers the potential of a very profitable additional stream of revenues for manufacturing enterprises. These incremental revenues could, in some cases, enable Canadian firms to expand their operations; in other cases, incremental sales could make the difference between Canadian plants continuing to operate or having to shut down. All of these benefits could accrue to the manufacturing sector without penalizing other consumers of electricity. In summary, cogeneration in high, steam-consuming manufacturing operations offers a natural competitive advantage that Canadians cannot afford to ignore.

Industry and Science Canada (ISC) came to investigate cogeneration as an off-shoot of the

subsidies intelligence work undertaken in the US pulp and paper sector. Early work in subsidies revealed that US pulp and paper enterprises enjoyed two advantages not readily available to their Canadian counterparts:

- First, they had the opportunity to produce and sell electricity in addition to their needs at the utilities' incremental costs for producing this power themselves.
- Second, the US firms frequently benefitted from extensive subsidies. They were able to concurrently sell their power at high rates to the utilities and to buy back the same power at low rates.

In the US, the implementation of the Public Utilities Regulatory Policies Act (PURPA) in 1978 greatly facilitated the implementation of cogeneration in US industries.

The pulp and paper sector has been a principal participant in taking advantage of cogeneration in the US. Given the importance of this sector in Canada, one would expect that proportionately the Canadian industry could obtain even greater benefits.

1.2 The Central Issue

The Canada-US asymmetry in the acceptance of cogenerated electricity from non-utility sources has resulted in a competitive disadvantage for principal steam-consuming Canadian industries. Approximately 4% of electricity generation in the US comes from cogeneration; recently about 40% of incremental electricity in some states has come from these sources. In contrast, implementing cogeneration in Canada is in its infancy. These competitive disadvantages will continue until there is a significant change in the implementation of non-utility generation in Canada.

1.3 Objective of this Report

The principal objective of this report is to estimate the benefits that would accrue to a broad cross-section of Canadian pulp and paper mills if Canada had a policy requiring utilities to accept cost-effective power from these independent power producers. Through the cooperation of approximately 20 pulp and paper enterprises, ISC has been able to examine the benefits for a sample of about 30 mills.

In this report, publicly available information on utilities' avoided costs provided a basis for estimating the benefits to the pulp and paper enterprises.

2. Cogeneration in the United States

2.1 Potential Benefits of Cogeneration for a Typical US Pulp and Paper Mill

For cogenerators, the natural advantage of generating their own electricity is the difference between their unit production cost and the utility's industrial rate, multiplied by the amount of electricity they self-generate. Before PURPA, potential cogenerators were restricted in the size of the cogeneration facility they could build. As a result, the level of benefit obtained from installing a cogeneration facility was less than optimal.

Once PURPA gave mills the ability to sell utilities excess power, the size of cogeneration facilities increased. Along with the larger generating capacities came significant increases in the advantages of cogeneration. The natural advantage of self generation was now realizable for the entire amount of electricity the mill consumed. Also, the sale of excess electricity, bought by the utility at its avoided costs, provided significant revenues for a cogenerator. These benefits were further augmented by the lower production costs resulting from the economies of scale associated with the larger cogeneration facilities.

In addition to the natural benefits of cogeneration is the potential for subsidization. The subsidization benefit is equal to the difference between the utility's avoided cost rate and the industrial rate, multiplied by the amount of electricity "crosshauled" (electricity sold to the utility at a high (avoided cost) rate and purchased at a low (industrial) rate). The amount of electricity "crosshauled" depends on the contractual arrangement reached between the mill and the utility. The total amount "crosshauled," however, cannot exceed the electric-

ity consumption level of the mill.

2.2 Leading States in Cogeneration

Cogeneration is well established in the United States. In 1990, the 30,500 MW of cogeneration capacity accounted for approximately 4% of the total installed US capacity base of approximately 735,000 MW.

The degree of utilization varies from state to state. Maine is the number one state with 30% of its total electrical generation (2400 MW) coming from cogenerators. California is second with approximately 13% of total electrical generation (44,500 MW) coming from cogenerators. Louisiana, Texas and Michigan follow with approximately 10% of total electrical generation coming from cogenerators.

The amount of cogeneration installed by the pulp and paper mills as a proportion of total state cogeneration is very significant, especially in traditional forest product states. Mississippi is the leading state with almost 100% of cogeneration coming from the pulp and paper sector. Maine and Alabama rank second with over 90% of cogeneration coming from the pulp and paper sector.

3. The Maine Cases

To provide an illustration of the potential benefits from cogeneration, the facilities of four Maine pulp and paper firms were examined.

Information on these mills was obtained through an exhaustive search of numerous public sources. Mill specific operating characteristics were obtained from industry publications; crosshauling arrangements were obtained. Industrial electrical rates and avoided cost schedules were obtained from the Central Maine Power Utility.

Capital and operating cost information was obtained from a Canadian consulting engineering firm that was contracted to perform a technical analysis of each mill.

In all four cases, the mills used cogeneration for the purpose of both load displacement and excess sales. As reported in Table 1, these benefits were further augmented by significant levels of crosshauling.

3.1 The Benefits of Cogeneration

The competitive advantage gained from their cogeneration was calculated for each of the four mills. The advantage was broken down into three categories:

i) COST REDUCTION

The cost reduction benefit was calculated as the difference between the state utility's industrial rate and the mill's electricity production cost, multiplied by the amount of self-generated electricity that the mill consumed. The industrial rates were based on published Central Maine Utility rates. The mill's production costs included all operating and capital costs associated with the cogeneration facility. In many cases, boiler capacity became redundant as the mill's steam requirements were being supplied by the new cogeneration facility. Thus, operations were assessed in order to identify any offsetting production costs (and future capital costs) associated with shutting down the redundant boilers.

ii) EXCESS POWER SALES

The excess power sales benefit was calculated as the difference between the utility's avoided cost rate and the mill's production cost, multiplied by the amount of electricity the mill sold to the utility. The amount of electricity available for sale equalled the mill's cogeneration capacity less its electrical consumption requirements. The sale prices used in calculating this portion of the benefits were taken from published avoided cost rate schedules.

iii) CROSSHAULING SUBSIDIES

The crosshauling benefit was calculated as the difference between the utility's avoided cost rate (the mill's selling price for its electricity) and the utility's industrial rate (the mill's purchase price for the electricity it buys back for its processing needs), multiplied by the

Table 1: Four Maine Cases

	A	B	C	D
Annual Paper Production (tons)	490,000	387,000	246,400	457,600
Electricity - (MW)				
Cogenerated Electricity	85	72	75	70
Other Generation	32	5	4	0
Total Electricity Generated	117	77	79	70
Electricity Sold to Utility	85	32	63	45
Electricity Bought from Utility	52	45	32	29
Amount "Crosshauled"	52	32	32	29

amount of electricity the mill is contracted to crosshaul. The amount crosshauled depended on the contractual arrangement with the utility.

As summarized in Figure 1, the benefits from cogeneration at the four Maine mills are significant. They vary from $75 to $250 per ton, or, 7.5% to 22.5% of sales.

4. Canadian Analysis

4.1 Electricity Avoided Costs

The feasibility of cogeneration in Canada depends, to a great extent, upon the avoided (or incremental) costs of supplying power by the provincial utilities. Avoided costs are defined as the levelized capital and operating unit costs that the utility would incur in building and operating a base-load generating station in order to produce the incremental electricity demand. These avoided costs are the benchmark costs for private sector cogenerators to produce electricity for sale at a profit.

Avoided costs vary with the type and size of proposed incremental generating station. Fuel availability is the primary factor in determining the type of station. In many areas of the country where hydro electric potential has already been fully developed; coal-fired stations are the principal alternative. The size of the incremental station depends on the current level of electrical consumption and the expected demand growth rate in each province. The incremental or avoided costs were developed based on the assumed incremental

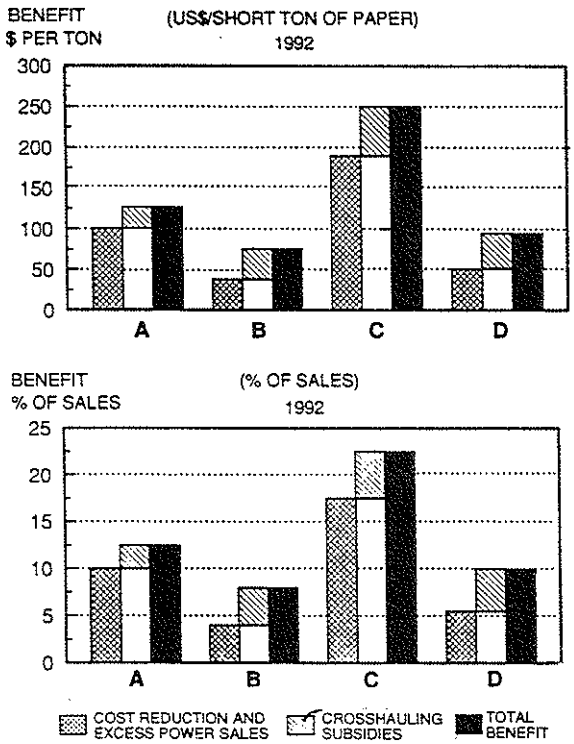

Figure 1: Competitive Advantage: Cogeneration at Four Maine Sites

units illustrated in Table 2.

Since ISC does not have access to the internal systems planning analyses of the provincial utilities, the avoided costs used in this report were obtained from publicly available information. Enerfor Corporation, a firm involved in developing biomass fuel power plants, supplied the 1992 avoided cost rates in Figure 2.

Table 2: Marginal Investment by Province

Province	Name	Utility Type	Capacity (MW)
New Brunswick	Belledune	Coal	450
Quebec	Grande Baleine	Hydro	1000
Ontario	Unidentified project	Coal	740
Manitoba	Conawapa	Hydro	1300
Saskatchewan	Shand #2	Coal	280
Alberta	Keephills #3	Coal	375
British Columbia	Peace River 'C'	Hydro	900

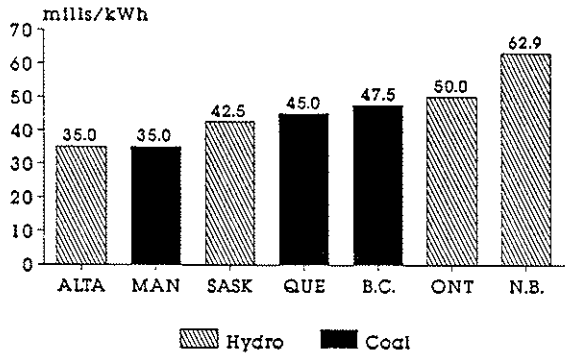

Figure 2: Estimates of Avoided Cost Rates
Source: Enerfor Corporation

A comparison between the avoided cost and the average industrial rate, by province, is provided in Figure 3. The industrial rates were obtained by contacting each provincial utility and asking for the capacity and energy charges applicable to a 70 MW user operating 24 hours per day, 350 days per year. As expected, in all provinces (except Saskatchewan) the industrial rate was below the avoided cost.

On a weighted average basis, the industrial rates were approximately 88% the level of the avoided cost rates.[1] Such comparatively high industrial rates indicate that the avoided costs are likely conservative values.

4.2 The Sample of Canadian Mills

ISC received extensive support in its study

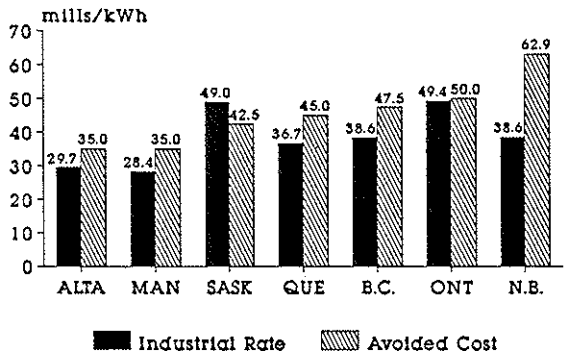

Figure 3: Comparison Between Avoided Cost and Average Industrial Rates

from the Canadian pulp and paper sector. The sample included 29 mills, or approximately 20 per cent of the total industry. The breakdown of the 29 sample mills by mill type is shown in Table 3.

The principal products of the firms in the sample included: kraft pulp, thermo mechanical pulp, newsprint, fine paper, light weight coated and coated groundwood. Annual production levels varied from 121,878 to 598,670 tonnes per year. Mill electrical consumption levels varied from 16 to 200 MW.

4.3 The Canadian Case Studies

The objective of each case study was to determine the mill-by-mill benefits available from cogeneration. This involved two steps:
a) A breakeven electricity generation cost was calculated for each mill. This is the rate where the present value of the after tax cashflows, discounted at the weighted average cost of capital for the firm, equalled the capital cost for the cogeneration project, i.e., where the net present value of the project was zero. Projects were assumed to start in 1995 and run until 2015.

1/ It is realized that some customers have negotiated industrial rates more favourable than those quoted.

Table 3: Sample Mills by Type

Mill Type	Number of Mills	Total Production (%)
Pulp Mills	11	45
Newsprint Mills	12	37
Paper Mills	6	18
	29	100

b) The actual cash benefits to each mill were calculated. These benefits were derived by comparing the mill's total breakeven electricity production costs with the appropriate provincial electricity rates. In this section, the benefits are presented as before tax profits.

As in the analysis of US mills, the benefits were broken down into three categories:
i) The cost reduction was calculated as the difference between the unit production cost and the provincial industrial rate times the amount of electricity the mill consumed.
ii) Sales revenue for any excess power was calculated as the difference between the production costs and the avoided cost rate.
iii) Subsidies revenue was calculated as the difference between the utility's avoided cost and its industrial rate times the total amount of electricity the mill consumed. Assuming 100% of the electricity consumed was crosshauled allowed for calculation of the maximum potential benefit.

The results in Figure 4 indicate that pulp and paper mills would receive significant benefits from cogeneration. In 28 out of the 29 case studies, the mill would benefit from self-generation; profits ranged from $14.42 to $164

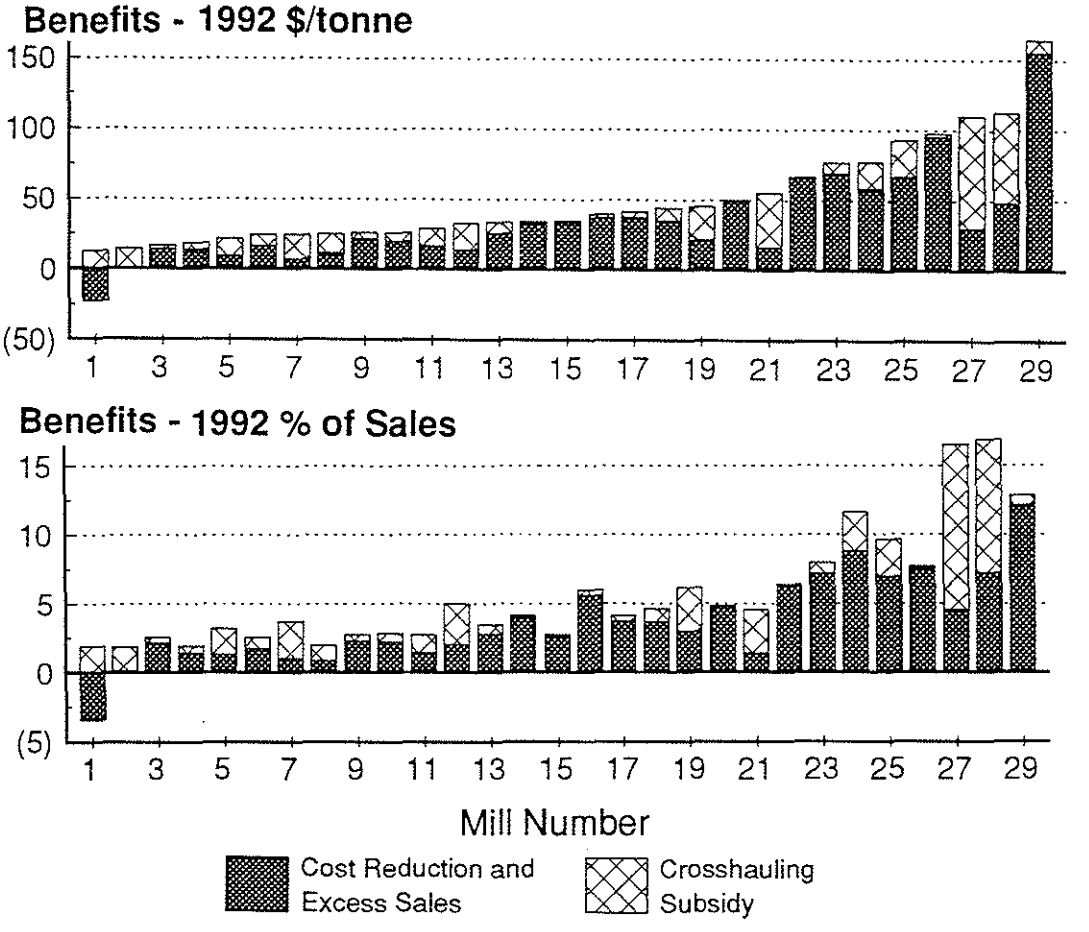

Figure 4: Cogeneration Benefits Based on Non-Tax-Paying Utilities

per tonne, or from 1.9 to 16.8 as a percent of sales.

On a weighted average basis the mill-by-mill analysis of benefits from cogeneration provided the results reported in Figure 5.

5. Cogeneration: Economic Analysis

In Professor Arnold Harberger's paper, 'The Cogeneration of Electric Energy: The Case of Pulp and Paper Mills,' the economic efficiency effects of crosshauling were considered from the perspective of the firm and society. Based on this work, Table 4 illustrates that crosshauling can be beneficial to society only when the firm's cost of cogeneration energy exceeds the industrial rate.

ISC's analysis of the 29 mill sample indicates that in only one case was crosshauling needed to ensure that the social optimum was reached.

From Professor Harberger's economic analysis it can be concluded that cogeneration could be implemented in Canada with no crosshauling and in the vast majority of cases the social optimum would be approximated.

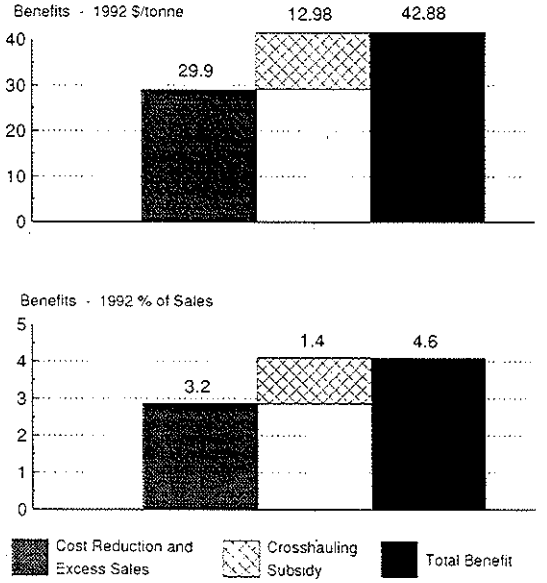

Figure 5: Average Benefits from Cogeneration

However, without crosshauling Canadian firms would continue to be at a disadvantage relative to mills in those US states where crosshauling is permitted.

Table 4

Firm's Electricity Cost with Cogeneration and Crosshauling	Plant Production Exceeds Plant Demand	Plant Production Less Than Plant Demand
Less Than or Equal to Industrial Rate	▸ reduces social gain from no crosshauling case ▸ increases private gain ▸ private energy use does not equal social optimum	▸ reduces social gain from no crosshauling case ▸ increases private gain ▸ private energy use does not equal social optimum
Greater Than Industrial Rate (Crosshauling May Be Desirable)	▸ private gain ▸ social gain ▸ private energy use does not equal social optimum	▸ private gain ▸ social gain ▸ private energy use does not equal social optimum

Table 5

Firm's Electricity Cost With Cogeneration	Plant Production Exceeds Plant Demand	Plant Production Less Than Plant Demand
Less Than or Equal to Industrial Rate	▸ 22 Mills (76%)	▸ 6 Mills (21%)
Greater Than Industrial Rate (Crosshauling May Be Needed For Social Optimum)	▸ 1 Mill (3%)	▸ 0 Mills (0%)