A Financial Analysis of Using Sawmill Residues for Cogeneration in Northern Ontario

NAOMI BEKE, GLENN FOX and DAN McKENNEY

This paper investigates the financial viability of producing steam and electricity from forest biomass using a small-scale cogeneration facility (5 MW capacity) in the context of Geraldton, a small municipality in Northern Ontario. Two sources of biomass fuel were considered; sawmill residues and chipped biomass. Results of the financial analysis indicate that, for 100% capacity utilization, using sawmill residues for cogeneration would yield a net present value of over $7 million and an internal rate of return of approximately 17% on an initial investment of $6 million. In comparison, using chipped biomass would yield a net present value of about $2 million and an internal rate of return of 9% at 100% capacity utilization. Calculations based on 80% capacity utilization produced rates of returns of approximately 12% for sawmill residues and about 2% for chipped forest biomass respectively.

Cet article étudie la viabilité financière de la production de vapeur et d'électricité à partir de la biomasse forestière dans une centrale de production combinée (d'une puissance de 5 MW) à Geraldton, petite municipalité du Nord de l'Ontario. L'étude porte sur deux sources de biocarburant: les chutes de sciage et la biomasse en copeaux. Les résultats de l'analyse financière indiquent que, si l'on utilisait la capacité à 100%, le recours aux chutes de sciage dans la production combinée rapporterait une valeur actuelle nette (VAN) de plus de $7 millions et un taux de rendement interne (TRI) d'environ 17% par rapport à un investissement de départ de $6 millions. En comparaison, le recours à la biomasse en copeaux rapporterait une VAN d'environ $2 millions et un TRI de 9% dans le cas où on utiliserait la capacité à 100%. Les calculs effectués sur une utilisation de la capacité à 80% ont abouti à des taux de rendement d'environ 12% pour les chutes de sciage et de 2% à peu près pour la biomasse forestière en copeaux.

Naomi Beke is a former Research Associate with the Department of Agricultural Economics and Business, University of Guelph. Glenn Fox is Professor, Department of Agricultural Economics and Business, University of Guelph. Dan McKenney is Chief Forest Economist, Natural Resources Canada, Sault Ste. Marie, Ontario. Research support under the ENFOR program is gratefully acknowledged.

Introduction

The use of alternative energy sources continues to be a suggested policy instrument for more environmentally benign economic development. However, the burden of costs in relation to direct benefits can be a strong disincentive for independent energy producers. The interplay of relative prices affects the attractiveness of alternative energy. This paper investigates the financial viability of producing steam and electricity from forest biomass in a small-scale cogeneration facility (5 MW capacity).[1] In Northern Canadian communities, forests offer an apparently abundant source of energy. But biomass-based energy production must compete with conventional energy production methods and with traditional demands for forest biomass for pulp and lumber production.

This paper examines the potential of forest biomass energy production that is not directly competitive with traditional demands for fibre. A clear identification of the circumstances required to make sawmill residues a financially

1/ Cogeneration is the simultaneous production of electricity and steam from a single fuel source.

viable method of energy production could help communities assess whether cogeneration is a viable development option. This paper focuses on the profitability of cogeneration using small-scale facilities in Northern Ontario. Rosen and Le (1994) have analysed the potential energy savings from large-scale cogeneration in Ontario. They concluded that cogeneration presents important opportunities for energy conservation in Ontario, and that further investigation of this technology was needed. The present study is a response to this conclusion.

A case study approach is used. The community of Geraldton was selected for several reasons. The community was considering constructing such a facility and the required data and information were more readily available. One of the reasons for this was that Geraldton had been selected as one of four "Community Forests" as part of the provincial government's Sustainable Forestry Initiative. The initiative was designed to test alternative methods of forest management. Local control over resource management has become a widely accepted policy goal in forest management in Canada (CCFM, 1995). Communities with sawmills could, in principle, use excess residues to generate electricity, creating more local employment and income, and potentially alleviating a waste problem. Geraldton is also representative of small Northern Ontario communities with resource-based economies.

Two sources of biomass fuel for cogeneration are considered in this case study; sawmill residues and chipped biomass from the Geraldton Community Forest. A plywood and particle board manufacturer located 38 km east of Geraldton would be a possible source of residue material. Non- and under-utilized species, parts of trees remaining from harvesting operations, and pre-commercial thinning operations represent the other potential fuel source. It should also be noted that Geraldton has an Ontario Hydro transformer, which is necessary to access the provincial electricity grid. For the analyses presented here, the grid is assumed to provide electricity when local demands exceed the capacity of the cogeneration plant, and to absorb surplus production during periods of low local demand. The implications of this assumption are discussed in the concluding section.

Prior to the 1960s, most sawmill waste in Ontario was either incinerated or disposed of in landfills. Since then, rising energy costs, improved technology in sawmills and pulpmills, and the desire for greater forest utilization have all provided impetus for developing alternative uses of sawmill wastes (Tieman, 1986). Some of these uses include agricultural or landscaping mulch, and fuel for the sawmill and other industries. From 1980 to 1990, the Ontario Ministry of Natural Resources reports that Ontario sawmills produced almost 5 million m^3 of sawdust[2] that was either disposed of in landfills, or held in inventory for use in the next year (see Table 1).

Disposing of these residues in approved landfills or simply in piles on the ground could be hazardous to the surrounding ecosystem. When significant amounts of sawmill residues are left for long periods of time, chemicals from the wood leach into the ground. Depending on the soil type, the ratio of wood to bark, and the species of wood that make up the residues, leachate can contaminate ground water (Evans, 1973). Cold water soluble extracts are of principal concern in landfill leachates. Cold water extracts are comprised of mostly phenolic compounds, but sugars, alcohol, resin acids, and various other classes of compounds may also be present. Total water-soluble contents vary, but in Western red cedar, for example, these can be as high as 10% of the wood. Decomposition of piles of sawmill residues depend on aerobic and anaerobic processes. Fungi, which are common organisms of structural decay in wood, are predominantly aerobic. Therefore, the wood residues on the inner layers of a landfill or dumpsite do not break down. The outer layer is subject to aerobic processes. Aerobic fermentation breaks down the sugars, contained within the residue, into carbon dioxide, water, and heat. In sawdust and chip piles, temperatures can reach as high as 185°F. These high

2/ Sawmill residue includes not only sawdust, but also shavings, bark, and hogfuel.

Table 1: Ontario Sawdust Production and Conversion of Sawdust Inventory into Electricity, 1980-1990

Year	Total Sawdust Production (m^3)	Number of Mills	Unutilized Sawdust (m^3)	% of Unutilized Sawdust to Total Production	Potential Electricity from Unutilized Sawdust[1] (MWh)
1980	1,545,770	73	710,180	45.90%	284,072
1981	1,591,773	88	683,457	42.90%	273,383
1982	1,126,173	87	328,209	29.10%	131,284
1983	1,302,491	90	431,675	33.10%	172,670
1984	1,401,664	91	556,213	39.70%	222,485
1985	1,359,824	74	422,451	31.10%	168,980
1986	1,575,450	96	462,010	29.30%	184,804
1987	1,145,905	71	393,969	34.40%	157,588
1988	1,076,190	77	329,140	30.60%	131,656
1989	764,697	74	176,248	23.00%	70,499
1990	1,387,873	n/a	286,982	20.70%	114,400
			4,779,552		1,911,821

Sources: *Ontario Forest Industry Statistical Report* for 1987, 1988, 1989, and 1990; and Beke (1994).
1/ Assuming a conversion factor of 2.5 m^3 of sawdust @ 40% moisture/MWh

temperatures kill organisms that decompose the residues, thereby sterilizing the pile. Thus, difficulties associated with leachates and decomposition make the dumping of sawmill waste a potentially environmentally hazardous method of disposal. Using sawmill waste for cogeneration is one potential method of mediating the problems associated with disposal. Communities with sawmills could use excess residues to generate electricity, possibly creating employment and income in the process.

This paper investigates the financial viability of using sawmill residues for cogeneration from the perspective of a potential independent producer interested in selling electricity to the public utility. Results of the financial analysis for each fuel alternative will be discussed. These results will indicate which fuel source, either sawmill residue or chipped biomass, is the most profitable, since each has different costs associated with its use. Non-utility generators[3] must first seek approval from Ontario Hydro in order to gain access to the Ontario grid system. Current surplus capacity problems of Ontario Hydro limit the prospects for non-utility electricity production in the short run. The latter part of this paper discusses the problem of surplus energy and how this affects the policies and regulations of Ontario Hydro pertaining to the development of cogeneration facilities in the province.

3/ A non-utility generator is an electricity producer that generates electricity using equipment that is not owned or operated by the public utility (Ontario Hydro, 1991).

Methods

The Net Present Value Criterion

To evaluate the economic feasibility of each fuel type, a capital budget was prepared and the net present value (NPV) calculated for both alternatives via the following formula:

$$\text{Net Present Value} = -I + \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} \qquad (1)$$

where I is the initial investment; CF_t is the expected net cashflow in year t; r is the discount rate; and n is the time horizon of the project. Internal rates[4] of return are also calculated.

Data

Canada Light and Power[5] estimates that the

4/ The internal rate of return is the smallest value for r in equation (1) that produces a Net Present Value of zero.

5/ Canada Light and Power is a Geraldton-based company that builds cogeneration and district heating facilities in Northern Ontario.

initial investment for a 5 MW cogeneration facility would be about $6 million. This includes the building and machinery as well as wheeling[6] electricity from the cogeneration facility to the Ontario Hydro grid system, but not the costs associated with establishing the infrastructure for a district heating system. Therefore, the unit prices of heat assumed in the calculations below should be interpreted as sales on site. The buyer would assume the costs associated with transporting the heat. Information pertaining to annual revenues, annual costs, income tax, and machinery and building depreciation was obtained from Energy, Mines and Resources Canada (undated), Ontario Hydro, Revenue Canada, Canada Light and Power, and Meng (1993).

Annual Revenue

Revenue for the cogeneration enterprise comes from heat and electricity sales. The communities of Geraldton and Longlac, as well as the surrounding area, receive their electricity from two distribution stations on the Ontario Hydro grid system. During the peak hours of January 1994, the combined supply of electricity to both of these distribution stations was 3.4 MWhs (Mather, 1994). Therefore, a cogeneration facility with a 5 MW capacity would more than offset the electricity supplied to the community and surrounding area of Geraldton. Results were calculated for 100% and for 80% capacity utilization. Annual electricity production at 100% capacity would be 43.68 million kWhs (Table 2). Given this annual level of production and the prices set by Ontario Hydro, Table 2 shows that the annual revenue from electricity production would be $1.694 million for 100% capacity utilization and $1.355 million if the facility operated at 80% capacity. In addition to revenue from electricity production, the cogeneration facility can also earn income from selling heat. Assuming that the cogeneration plant produces 4.54 tonnes of steam per hour, annual heat revenue is $129 thousand per year at 100% capacity utilization and $103 thousand at 80% (Table 3).

Annual Costs

The cogeneration plant would burn approximately 2.5 m^3 of chipped biomass (approximately 40% moisture) to produce 1 MWh (or 1000 kWhs) of electricity (Canada Light and Power, 1993). Table 2 shows that at 100% capacity an annual production of 43,680 MWhs of electricity would require 109,200 m^3 of biomass annually. Since there are approximately 3.5 m^3 of chipped biomass (40% moisture) in a tonne, annual requirements of biomass would be 31,200 tonnes.[7]

Based on Canada Light and Power estimates, annual operating costs for administration, wages, supplies and chemicals were assumed to be $200,000. Maintenance costs for wages, parts and materials were assumed to be $50,000.00 for the first three years of operation and $200,000 for years 4 through 25. The impact of increased operating on maintenance costs is explored in sensitivity analysis.

Costs associated with each fuel alternative are different. Sawmill residues would not require further processing, however they would have to be transported 38 km from Longlac to Geraldton. Assuming that the rate for hauling biomass is 20¢/tonne/km, then annual hauling costs for sawmill residues would be $213,408.[8] Biomass from the area would have to be hauled from various points within the forest to the community of Geraldton. Estimation of the collection costs for underutilized species and other forest biomass is more complex. The Geraldton Community Forest covers seven townships, or 65,352 hectares (Haavisto, 1993). Assuming that the average distance from various points within the community forest to the town of Geraldton is 10 km, average annual hauling costs for forest biomass

6/ Wheeling is the transmitting of electricity from one location to another over power lines owned by a third party. In this case, the lines would likely be owned by the producer.

7/ 109,200 m^3 of chipped biomass divided by 3.5 m^3/tonne yields 31,200 tonnes of biomass.

8/ Annual hauling costs are determined by multiplying the annual requirement of biomass by the per unit cost of hauling and the distance. Hence, the cost of hauling biomass from Longlac is 28,080 x 0.20 x 38 = $213,408.

Table 2: Annual Electricity Production Values for 100% and 80% Capacity Utilization for a 5 MW Cogeneration Facility

Seasonal Values[1]	Price (¢/kWh)	Capacity Utilization 100% Electricity Production (kWh x 10^6)	Revenue ($)	Capacity Utilization 80% Electricity Production (kWh x 10^6)	Revenue ($)
Winter Peak	6.32	10.40	657,280	8.32	525,824
Winter Off-Peak	2.26	11.44	258,544	9.12	206,835
Summer Peak	5.59	10.40	581,360	8.32	465,088
Summer Off-Peak	1.72	11.44	196,768	9.12	157,414
Annual		43.68	1,693,952	34.88	1,355,162

1/ Winter extends from October to March, Summer from April to September. Peak hours are from 7:00 a.m. to 11:00 p.m., Monday to Friday except holidays.

Table 3: Heat Production and Revenues, October to March[1]

	Capacity Utilization 100%	Capacity Utilization 80%
Production (tonnes)[2]	19,830.72	15,864.58
Price/tonne	$6.50	$6.50
Annual Revenue	$128,900	$103,120

1/Full capacity production is assumed to be 4368 hours per year.

2/At 4.54 tonnes/hour.

would be $56,160.[9] Forest materials from the Geraldton Community Forest would require chipping and drying. Currently, the Community of Geraldton is operating a heat processing plant at the Geraldton Airport. From these operations, estimated costs for biomass preparation are $25/tonne (Canada Light and Power, 1993). Using this rate, annual preparation costs would be $702,000.[10]

Environmental benefits brought about by the cogeneration project could reduce costs for parties affected by the externalities[11] of sawmill waste disposal. Suppose that a sawmill deposits its residues near a community and that the residues have an adverse effect on drinking water. Whether the community has to spend money to purify the drinking water or the sawmill has to undertake pollution abatement measures, there is a potential cost associated with dumping residues. With the building of a cogeneration plant, a use for the residues is found, thereby reducing the amount deposited in landfills. This saves money for either the community or the sawmill, depending on whose point of view is considered. Note, however that estimation of the value of the environmental benefits of not disposing of residues in landfill is beyond the scope of this study.

Income Tax and Depreciation

A privately-owned cogeneration plant would have to pay income tax on the net revenue it earns. The base Canadian federal corporate tax rate is 38% (Beam and Laiken, 1992). For Ontario corporations, there is a provincial tax abatement of 10% from the federal government that reduces the federal tax rate to 28%. The Ontario provincial tax rate for manufacturing companies is 10%. In addition to the base federal and provincial tax rates, the federal government charges a surtax of 0.28%. There are two tax reductions for businesses in Ontario; they receive a tax reduction of 10% on the first $200,000 they earn and a manufacturing tax shelter of approximately 6%. Therefore, for the purposes of this analysis the total tax rate is assumed to be 22.84% for the first $200,000 of taxable income and 32.84% for any

9/ Similarly, hauling costs from within the community forest are 28,080 x 0.20 x 10 = $56,160.

10/ Annual preparation costs are determined by multiplying 28,080 tonnes of biomass by $25/tonne to get $702,000/year.

11/ An externality occurs when the consumption or production activity of one individual or firm has an unintended impact on the utility or production function of another individual or firm (Mueller, 1993).

additional taxable income.

Depreciation would reduce the income tax that a cogeneration plant would pay. Tax regulations specify that buildings depreciate at a rate of 4% per annum on a declining balance basis. The comparable rate for machinery is set at 20%. In the capital budget calculations summarized in the Appendix Tables, annual depreciation on machinery was charged at 20% of the undepreciated balance or net revenue minus building depreciation, whichever is less. This procedure was adopted to accommodate the scenario in which chipped forest biomass was used as the feedstock. In this case, taxable income does not become positive until year 7.

Results

The Capital Budget

Table 4 summarizes the capital budget assumptions for the two alternative sources of fuel. Calculation of annual cash flows is reported in Appendix Tables 1 and 2. For both capital budgets, the real discount rate is assumed to be 5%.[12] The NPV of cash flows of the project using sawmill residues for fuel is $7.143 million at 100% capacity and $3.818 million at 80% (see Table 5). The NPV using chipped biomass from silvicultural thinning for fuel is $2.141 million at 100% capacity but -$1.488 million at 80%. The internal rate of return is 17.06% for sawmill residues and 9.04% for chipped biomass. High preparation costs associated with using forest materials for a fuel source reduce the NPV with this feedstock. These results assume that the biomass is free, except for preparation and/or transportation costs. All else equal, the absence of preparation costs for sawmill residues makes this fuel source a more profitable alternative.

In addition to the cash flows received by the owners of the facility, the cogeneration plant pays corporate income tax. Based on the assumptions about the tax structure enumerated earlier, the present value of income tax paid is $3.767 million for the sawmill residue scenario, and $1.456 million for the case of chipped forest biomass for 100% capacity utilization, and $2.195 million and $0.189 million for 80%, respectively.

Sensitivity Analysis

Sensitivity analysis was performed to investigate how the NPV responds to changes in the initial assumptions (Jog *et al.*, 1990). Elasticities were calculated to measure the rate at which the NPV of the cash flows would respond to increases in the cost of the initial investment, the prices received for heat and electricity, the discount rate, and maintenance costs. These elasticity values are reported in Tables 6 and 7. They were derived as the percentage change in the NPV from a 1% increase in the relevant parameter. Negative elasticity values indicate that the NPV of the cash flows varies inversely with changes in the variable in question. Positive values indicate that increases in the variable increase the present value of the cash flows. The greater the elasticity, the more sensitive the NPV is to changes in the respective variable.

Elasticity values for the chipped forest biomass scenario are higher than the corresponding values for sawmill residues because the base NPV of the cash flows is smaller. In both scenarios, not surprisingly, changes in the price of electricity have a greater impact on cash flows than heat prices, initial investment costs or annual operating and maintenance costs. Indeed, electricity sales generate over 90% of the annual revenue for the cogeneration plant. Increases in the cost of the initial investment and in the discount rate reduce the present value of the cash flows. The effect of increases in the discount rate are negative and large, suggesting that this parameter is critical to the financial viability of the cogeneration plant.

12/ For a discussion on the selection of a appropriate value for the real discount rate, see Kula (1984).

Table 4: Base Scenario Capital Budget Values

	Sawmill Residues		Chipped Biomass
Initial Capital Investment		$6,000,000	
Buildings		$600,000	
Equipment and Machinery		$5,400,000	
Annual Operating Costs			
Operations (administration, wages, supplies, and chemicals)		$200,000	
Maintenance (wages, parts & materials, contracts)			
• years 1-3		$50,000	
• after third year		$200,000	
Sawmill Residue Hauling Costs	$213,408		
Biomass Preparation Costs (chipping and drying)			$702,000
Total Annual Operating Costs			
• years 1-3	$463,408		$1,008,160
• years 4-25	$613,408		$1,158,160
Annual Gross Revenue			
Heat Revenue (refer to Table 3)		$128,820	
Electricity Revenue (refer to Table 3)		$1,538,278	
Total Annual Gross Revenue		$1,667,098	
Depreciation rate (on declining balance)			
Building		4%	
Machinery		20%	
Economic Life of Cogeneration Plant		25 years	
Discount Rate		5%	

Table 5: Internal Rates of Return and Net Present Values for Sawmill Residues and Chipped Biomass

	Sawmill Residues		Chipped Biomass	
Capacity utilization	100%	80%	100%	80%
Internal Rate of Return	17.06%	11.92%	9.04%	1.89%
Net Present Value of Cash Flows	$7,142,869	$3,818,439	$2,141,398	($1,487,628)
Net Present Value of Income Tax Paid	$3,766,651	$2,194,712	$1,456,023	$188,679

The Policies of Ontario Hydro that Affect Non-Utility Generation

Over the last 30 years, Ontario Hydro has produced all but a tiny fraction (much less than one percent) of all electricity generated and sold in the province. During this time, numerous mega-projects were undertaken by Ontario Hydro in anticipation of increases in future electricity demand. Between 1960 and 1975, eleven projects were commissioned with a total expected output capacity of 25,000 megawatts (McKay, 1983). These projects involved substantial capital costs. For example the Darlington nuclear power project alone was estimated to cost $13.8 billion. Ontario Hydro's debt has continued to increase, reaching $38 billion by 1992 (Bradley, 1992). To alleviate some of its financial problems, Ontario Hydro has increased its rates to industrial and private consumers. For example, between 1985 and 1992, real residential rates in Toronto increased by 24% (Solomon, 1992). Non-utility generators have also experienced the effects of Ontario Hydro's debt burden. In 1992, a cogeneration plant using biomass fuel received 8.40¢/kWh for winter peak rates. The same plant only received 7.11¢/kWh for winter peak rates in 1993 (Ontario Hydro, 1992a). During the five-year period ending in 1993, Ontario

Table 6: Sensitivity Analysis for Sawmill Residues (Base NPV of Cash Flows of $7,142,869 at 100% Capacity Utilization)

Variable	Elasticity[1]
Initial Investment ($)	-0.60
Heat Price ($/tonne)	0.16
Electricity Price (¢/kWh)	2.14
Discount Rate (increase to 6%)	-16.20
Annual Operating and Maintenance Costs	-0.47

1/ Defined as the % change in the Base Net Present Value of Cash Flows for a 1% increase in the relevant variable.

Table 7: Sensitivity Analysis for Forest Biomass (Base NPV of Cash Flows of $2,141,398 at 100% Capacity Utilization)

Variable	Elasticity
Initial Investment ($)	-2.16
Heat Price ($/tonne)	0.57
Electricity Price (¢/kWh)	7.48
Discount Rate (increase to 6%)	-30.80
Annual Operating and Maintenance Costs	-1.60

Hydro real buyback rates for non-utility generators have decreased by 18.3% (Brooks, 1993).

System-wide over capacity has also diminished the prospects for growth in non-utility generation. In 1993, Ontario Hydro predicted a surplus supply of three GWhs (Brooks, 1993). As a result of that estimated surplus, 66 non-utility generation projects were put on hold in December 1992 (Ontario Hydro, 1992b). Fifty of these projects eventually received new in-service conditions in May 1993 and the remaining 16 projects, totalling an expected 1200 MWhs were to be offered new in-service dates and capacity limits in the future (Ontario Hydro, 1993a). At present, Ontario Hydro is no longer accepting contracts for non-utility generators because, "[p]urchasing non-utility power before it is required would add needlessly to system costs and to the price of electricity" (Ontario Hydro, 1993b, p. 14). However, under some circumstances, non-utility generated electricity will be required to service remote communities and transmission constrained areas. When non-utility generated capacity is required, preference will be given to those producers that use renewable resources and more efficient energy technologies (Ontario Hydro, 1994).

The financial benefits of a small- to medium scale cogeneration facility of the type investigated in this study hinges on the terms of access to the provincial distribution grid for electricity. The location of sawmill residuals in Northern communities and the renewable nature of residuals as a feedstock open a narrow window of opportunity for this type of installation as a vehicle for regional development. Unless the conditions of access to the provincial distribution grid are relaxed, however, these potential gains will not be realized. Ontario Hydro seems to be continuing to resist development of small-scale cogeneration facilities (Weber, 1996).

Conclusions

The results of this study indicate that using sawmill residues for cogeneration can be a profitable venture. In addition, potentially harmful environmental effects can be mitigated. In the case of the Geraldton Community Forest, the after-tax NPV of the 25-year project was found to range from $3.8 million to $7.1 million, and to generate an internal rate of return in the range of 12-17%. Sensitivity analysis showed that these returns are reasonably robust with respect to variations in costs and revenues.

To appreciate the potential of sawmill residual as a source of electricity production on a provincial scale, the cumulative volume of unutilized sawdust produced at sawmills in Ontario between 1980 and 1990 was almost 5 million m^3 (see Table 1). At an annual average consumption rate of 45 kWhs/day, this feedstock could satisfy the electricity needs of 116,397 homes for one year.

There are two issues that may limit entry of non-utility generators into the Ontario electricity market, and thus affect the financial viability of cogeneration projects. First, excess capacity problems of Ontario Hydro force the public utility to confine the purchase of non-utility generated electricity to circumstances of remote needs and transmission constraints. Second, the financial problems of Ontario Hydro force the public utility to set buyback rates that have decreased in the past and could further decline in the future. However, using sawmill residues for fuel could be an advantage in light of these problems. Sawmills are generally located in remote areas where the need for non-utility generated electricity could arise. Also, the profit margin with the use of sawmill residues leaves room for future decreases in Ontario Hydro buyback rates.

References

Beam, R.E. and S.N. Laiken (1992) *Introduction to Federal Income Taxation in Canada* (Waterloo, Ontario: CCH Canadian Limited).

Beke, N.L. (1994) *An Economic Analysis of Small-Scale Cogeneration using Forest Biomass and Sawmill Residuals in Northern Ontario,* M.Sc. Thesis (Guelph, Ontario: University of Guelph).

Bradley, N. (1992) 'Borrower Profile: Ontario Hydro,' *Euromoney,* Nov.: 14.

Brooks, J. (ed.) (1993) 'Hydro Discards its Own NUG Policy–Again,' *IPPSO FACTO,* 7:1:1, 5.

Canada Light and Power (1993) Telephone interviews with Taisto Makivirta, Canada Light and Power, Geraldton, Ontario. October and November, 1993.

Canadian Council of Forest Ministers (CCFM) (1995) *Defining Sustainable Forest Management: A Canadian Approach to Criteria and Indicators*. (Ottawa: Canadian Forest Service, Natural Resources Canada).

Energy, Mines and Resources Canada (undated) *Class 34 Accelerated Capital Cost Allowance.*

Evans, R.S. (1973) *Hogged Wood and Bark in British Columbia Landfills.* Information Report VP-X-118. (Vancouver: Department of the Environment).

Haavisto, V.F. (1993) *The Geraldton Community Forest Implementation Plan: Managing Nature's Resources 'The Geraldton Way'*. Compiled for the Project Steering Committee Geraldton Community Forest, Geraldton, February.

Jog, V., A. Riding, H. Levy and M. Stewart (1990) *Principles of Financial Management: Canadian Edition.* (Scarborough, Ontario: Prentice-Hall Canada Inc.).

Kula, E. (1984) 'Derivation of Social Time Preference Rates for the United States and Canada,' *Quarterly Journal of Economics,* 99:4:873-82.

Mather, N. (1994) Telephone interview with Neil Mather, Ontario Hydro, Toronto, April.

McKay, P. (1983) *Electric Empire: The Inside Story of Ontario Hydro*. (Toronto: Between the Lines).

Meng, Y. (1993) *The Economic Potential of Thinning Jack Pine for Bioenergy Production in Northern Ontario.* M.Sc. Thesis, Guelph, University of Guelph.

Mueller, D.C. (1993). *Public Choice II: A Revised Edition of Public Choice.* (Cambridge: Cambridge University Press).

Ontario Hydro (1991) *Working with Industry to Generate Electricity*. (Toronto: Ontario Hydro).

—(1992a) *Non-Utility Generation in Ontario.* (Toronto: Ontario Hydro).

—(1992b) 'Ontario Hydro Reduces Existing and Future Electricity Supply,' *News from Ontario Hydro*. December 17.

—(1993a) 'Hydro to Make New Offers for Large NUG Projects,' *News from Ontario Hydro,* May 10.

—(1993b) *Ontario Hydro Annual Report 1992* (Toronto: Ontario Hydro).

—(1994) *A Strategy for Non-Utility Generation* (Toronto: Ontario Hydro).

Ontario Ministry of Natural Resources (1987) *Ontario Forest Industry Statistical Report for 1987* (Toronto: Queen's Printer for Ontario).

—(1988) *Ontario Forest Industry Statistical Report for 1988* (Toronto: Queen's Printer for Ontario).

—(1989) *Ontario Forest Industry Statistical Report for 1989* (Toronto: Queen's Printer for Ontario).

—(1990) *Ontario Forest Industry Statistical Report for 1990* (Toronto: Queen's Printer for

Ontario).

Rosen, M.A. and M. Le (1994) 'Assessment of the Potential Cumulative Benefits of Applying Utility-based Cogeneration in Ontario,' *Energy Studies Review* 6:2:154-63.

Solomon, L. (1992) *The International Trend Toward Electricity Privatization* (Toronto: Energy Probe).

Tieman, T. (1986) *Sawmills in Ontario.* (Toronto: Ministry of Natural Resources).

Weber, T. (1996) 'Ontario Hydro Fighting Cogeneration,' *The Financial Post*, Thursday, May 2, p. 6.

Appendix Table 1: Capital Budget – Sawmill Residues (100% Capacity Utilization)

Year	Net Revenue	Depreciation		Taxable Income	Income Tax	After Tax Income	Cash Flow
		Building	Machinery				
							($6,000,000)
1	$1,359,491	$24,000	$1,080,000	$255,491	$63,903	$191,588	$1,295,588
2	1,359,491	23,040	864,000	472,451	135,153	337,298	1,224,338
3	1,359,491	22,118	691,200	646,173	192,203	453,970	1,167,288
4	1,209,491	21,234	552,960	635,297	188,632	446,666	1,020,859
5	1,209,491	20,384	442,368	746,739	225,229	521,510	984,262
6	1,209,491	19,569	353,894	836,028	254,551	581,476	954,940
7	1,209,491	18,786	283,116	907,589	278,052	629,537	931,439
8	1,209,491	18,035	226,492	964,964	296,894	668,070	912,597
9	1,209,491	17,313	181,194	1,010,984	312,007	698,977	897,484
10	1,209,491	16,621	144,955	1,047,915	324,135	723,780	885,356
11	1,209,491	15,956	115,964	1,077,571	333,874	743,697	875,617
12	1,209,491	15,318	92,771	1,101,402	341,700	759,702	867,791
13	1,209,491	14,705	74,217	1,120,569	347,995	772,574	861,496
14	1,209,491	14,117	59,374	1,136,001	353,063	782,938	856,428
15	1,209,491	13,552	47,499	1,148,440	357,148	791,292	852,343
16	1,209,491	13,010	37,999	1,158,482	360,445	798,036	849,046
17	1,209,491	12,490	30,399	1,166,602	363,112	803,490	846,379
18	1,209,491	11,990	24,319	1,173,181	365,273	807,909	844,218
19	1,209,491	11,510	19,456	1,178,525	367,028	811,497	842,463
20	1,209,491	11,050	15,564	1,182,876	368,457	814,420	841,034
21	1,209,491	10,608	12,452	1,186,431	369,624	816,807	839,867
22	1,209,491	10,184	9,961	1,189,346	370,581	818,765	838,910
23	1,209,491	9,776	7,969	1,191,746	371,369	820,376	838,122
24	1,209,491	9,385	6,375	1,193,730	372,021	821,709	837,470
25	1,209,491	9,010	5,100	1,195,381	372,563	822,818	836,928

Appendix Table 2: Capital Budget – Forest Biomass (100% Capacity Utilization)

Year	Net Revenue	Depreciation		Taxable Income	Income Tax	After Tax Income	Cash Flow
		Building	Machinery				
							($6,000,000)
1	$814,739	$24,000	$790,739	$0	$0	$0	$814,739
2	814,739	23,040	791,699	0	0	0	814,739
3	814,739	22,118	763,512	29,108	6,648	22,460	808,091
4	664,739	21,234	610,810	32,695	7,468	25,228	657,271
5	664,739	20,384	488,648	155,707	35,563	120,143	629,176
6	664,739	19,569	390,918	254,252	63,496	190,755	601,243
7	664,739	18,786	312,735	333,218	89,429	243,789	575,310
8	664,739	18,035	250,188	396,517	110,216	286,300	554,523
9	664,739	17,313	200,150	447,275	126,885	320,390	537,854
10	664,739	16,621	160,120	487,998	140,259	347,739	524,480
11	664,739	15,956	128,096	520,687	150,994	369,693	513,745
12	664,739	15,318	102,477	546,944	159,617	387,328	505,122
13	664,739	14,705	81,982	568,052	166,548	401,504	498,191
14	664,739	14,117	65,585	585,037	172,126	412,911	492,613
15	664,739	13,552	52,468	598,719	176,619	422,099	488,120
16	664,739	13,010	41,975	609,754	180,243	429,511	484,496
17	664,739	12,490	33,580	618,670	183,171	435,499	481,568
18	664,739	11,990	26,864	625,885	185,541	440,345	479,198
19	664,739	11,510	21,491	631,738	187,463	444,275	477,276
20	664,739	11,050	17,193	636,496	189,025	447,471	475,714
21	664,739	10,608	13,754	640,377	190,300	450,077	474,439
22	664,739	10,184	11,003	643,552	191,342	452,209	473,397
23	664,739	9,776	8,803	646,160	192,199	453,961	472,540
24	664,739	9,385	7,042	648,312	192,905	455,406	471,834
25	664,739	9,010	5,634	650,095	193,491	456,604	471,248