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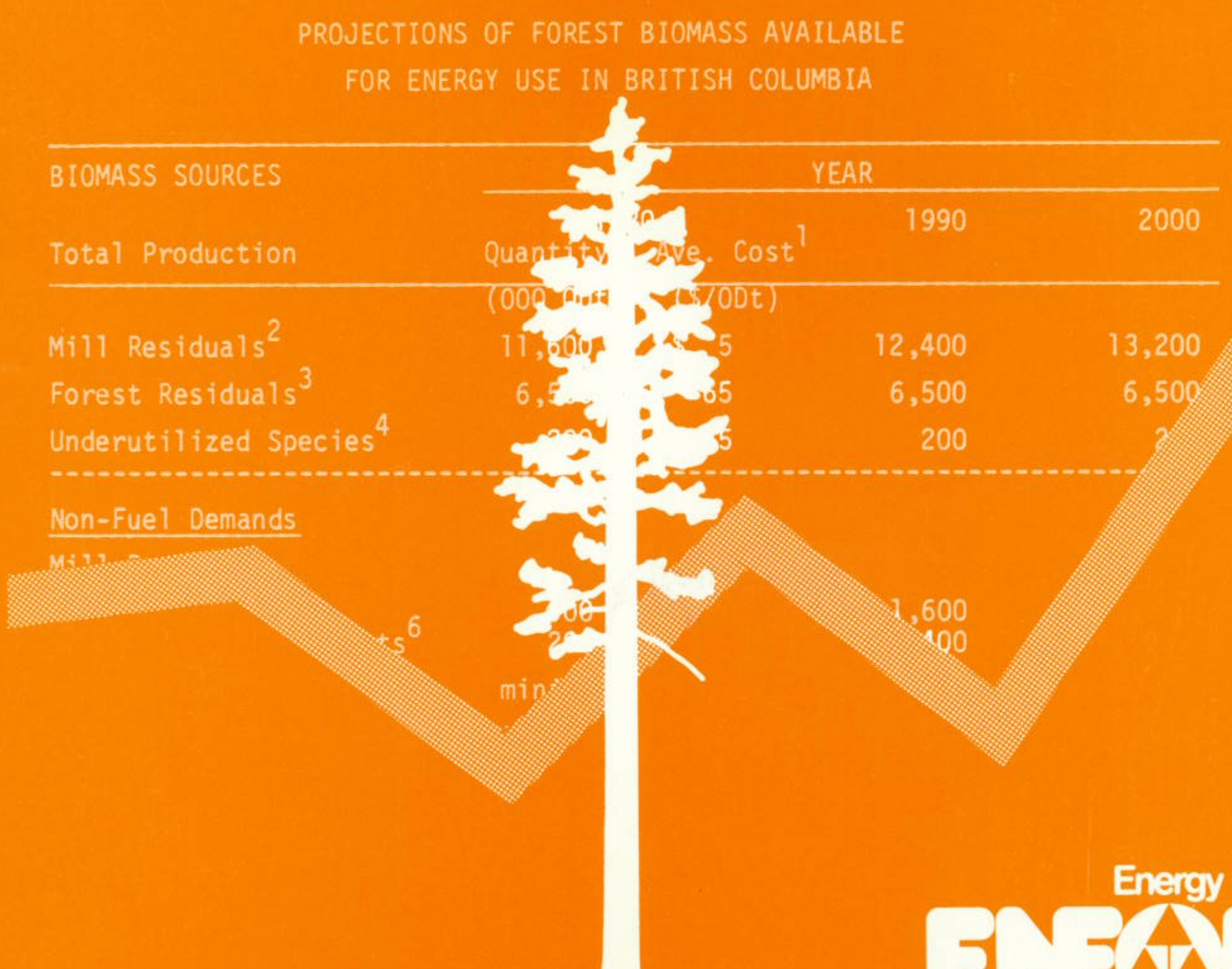
FOREST BIOMASS ENERGY IN BRITISH COLUMBIA:

OPPORTUNITIES, IMPACTS, AND CONSTRAINTS

T.L. McDaniels, McDaniels Research Ltd., Vancouver



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FOREST BIOMASS ENERGY IN BRITISH COLUMBIA

OPPORTUNITIES, IMPACTS, AND CONSTRAINTS

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ABSTRACT

Forest biomass has strong potential as an economically viable energy source in British Columbia. Development of this potential would pose no severe problems for the resource management system. Large positive impacts could be expected upon the forest industry, regional economic conditions, and environmental conditions. At present, a range of institutional factors constrain the realization of this potential; a variety of incentive measures and recommendations are provided to eliminate these constraints.

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RESUME

La biomasse forestière comporte un potentiel élevé en tant que source d'énergie économiquement viable en Columbie-Britannique. Le développement de ce potentiel ne poserait pas de problèmes sérieux pour le système de gestion des ressources. On pourrait s'attendre à des incidences en grande partie positives sur l'industrie forestière, les conditions économiques régionales, et les conditions environnementales. A présent, une série de facteurs d'ordre institutionnel gênent la réalisation de ce potentiel; diverses mesures de stimulation ainsi que dg recommendations sont proposées à l’effet d'éliminer ces constraintes.

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The study team for this project included Professor R. Schwindt of Simon Fraser University, who was the principal author of Chapter III, Section 5.0; and Chapter IV. Section 2.0. K. Cooke, Planning Consultant, was the principal author of Chapter IV, Section 4.0. G. Robinson, Consulting Economist, provided statistical analysis for the pulp mill conversion model. The whole report was read by L. Burdak and R. Yates. Finally, Mrs. L. Burdak deserves thanks for her excellent report preparation services.

FOREWORD

ENFOR is the bilingual acronym for the Canadian Forestry Service's ENergy from the FORest (ENergie de la FORet) program of research and development aimed at securing the knowledge and technical competence to facilitate, in the medium to long term, a greatly increased contribution from forest biomass to our nation's primary energy production. This program is pari of a much larger federal government initiative to promote the development and use of renewable energy as a means of reducing our dependence on petroleum and other nonrenewable energy sources.

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or the director of the establishment issuing the report.

This report, based on ENFOR project P-135, was produced under contract OSB79-00160 by McDaniels Research Ltd., Vancouver, B.C. Readers are reminded that, as the major portion of this report was completed in 1980, some factors may have changed by the time of publication. The conclusions of the report are the sole responsibility of the author and may not correspond to the policies or views of the government of Canada, its departments. or agencies.

CHAPTER I

INTRODUCTION

1.0 OBJECTIVES

Canadians are faced in the 1980s with drastic increases in petroleum prices and dwindling supplies of petroleum fuels. This dismal economic outlook for conventional energy sources has naturally provided an incentive to develop substitutes. To LE considered viable, energy alternatives should LE cost competitive. renewable, and environmentally acceptable. One alternative energy source with strong potential to meet these criteria is forest biomass.

A number of factors make wood biomass an attractive source of energy. Forest materials are available in vast measurable quantities in many parts of Canada. Unlike some other alternative sources. the technology for producing various forms of energy from wood biomass is well established. An extensive industry already functions efficiently by growing and harvesting wood, and large amounts of wastes are produced as by-products from forest industry sawmills. Finally, wood appears to be a cleaner fuel with fewer environmental problems than coal or nuclear energy.

Even though the gross quantities of potential forest energy are formidable, few people would support the view that wood alone could remedy Canada's future shortfalls in energy supply. Rather, wood energy belongs to the growing category of supplementary fuels, which, together, are expected to fill the gap. The proper role for wood energy will be in specific applications that can make use of its particular advantages and avoid its pitfalls. Government initiatives in research and policy development can be expected to help identify the appropriate applications for forest biomass energy.

Although the Canadian government has set an objective of national energy self-sufficiency by 1990, no targets or specific policies for renewable resources, including forest biomass, have been enunciated. But the federal view of the potential for forest energy utilization can be inferred from its FIRE incentive program[1], its reports on forest energy (Love and Overend, 1978). and its research initiatives.

The ENFOR program of the Canadian Forestry Service is a major federal research program aimed at fostering an increased role for forest biomass in national energy production. In June 1979, the ENFOR Secretariat selected McDaniels Research Limited to undertake a study of the implications of increased forest biomass energy use in British Columbia. The focus of the study is to be upon economic and institutional aspects of forest energy use, rather than on silvicultural or technical issues. The research has three primary objectives:

(1) to examine how changes in energy prices would alter wood biomass energy use in British Columbia, and then to trace through the impacts of these changing-use patterns on different aspects of the forest industry;

(2) to identify institutional barriers that could constrain use of foresi biomass energy; and

(3) to consider incentives or other approaches that would eliminate constraints to utilization of this energy resource.

2.0 ISSUES AND ORGANIZATION

Forest biomass energy will play a major role in British Columbia, only if it is economically feasible and is consistent with institutional goals. If forest energy is too costly, relative to other sources, no incentive will exist to develop it. If institutions did not perceive that use of the forest for energy meets their particular goals and provides overall benefits, its exploitation would be slowed. Institutional

[1] **The Forest Industry Renewable Energy Program (FIRE), a capital cost grant for assistance in conversion from fossil fuel to forest biomass, is summarized in W. Wardrop and Associates (1979). Effectiveness of this and other incentive programs is considered in Chapter VI.**

questions are particularly important because there are powerful organizations that have interest in forest utilization and others that have interest in energy development.

Economic aspects of forest energy hinge on the pervasive issue of future prices for petroleum fuels. Expected increases in the *costs* of petroleum sources will effectively enhance the economic value of forest biomass in energy use. In turn, an increase in the value of forest energy holds potential for change in forest resource utilization patterns. The implications of these resource-use changes, in both economic and institutional terms, are the chief concern of this study.

The analysis of the report starts in Chapter II with an assessment of the potential use for forest energy in British Columbia, based on assumed price increases for conventional energy sources. Price assumptions allow us to examine how fast and how much forest biomass energy would substitute for conventional sources, if market conditions provided appropriate signals regarding the relative values of alternative fuels. The purpose is to analyze the potential of wood energy in specific applications under economically optimal conditions.

Greater use of the forest for energy would raise a host of resource management issues. Some of the primary questions would be allocation of: the forest resource between energy use and conventional forest products; markets for mills and forest residuals; and security of biomass supply for energy use. These issues and possible responses by the British Columbia Forest Service are analyzed in Chapter III. The purpose is to show how a new use for forest materials could be affected by the management system.

In Chapter IV, the impacts of increased forest energy use are analyzed. Three perspectives are considered–forest industrial activity, environmental quality, and regional socio-economic conditions. The purpose is to trace through the possible effects of changing forest energy patterns to show the relative advantages and disadvantages from different viewpoints.

Potential constraints to forest biomass energy use are analyzed in Chapter V. Institutional constraints–imposed by the forest industry, energy industry. and other groups–are considered. The possibility that domestic energy prices stay below world prices is posed, and the resulting effects on forest biomass use are assessed. The distribution of benefits and costs from forest energy development is considered to identify organizations that could be disadvantaged in substitution of wood for conventional energy resources.

Possible public actions to speed biomass energy use are analyzed in Chapter VI. Both price changes and incentive programs are considered to eliminate financial constraints. Other methods are discussed to reduce institutional obstades that may impede use of forests for energy. The chapter concludes with a set of recommendations for further research into economic and institutional questions.

CHAPTER II

POTENTIAL FOREST ENERGY USE

1.0 OVERVIEW

Forest biomass appears to be a viable source of energy for a number of specific applications in British Columbia. Both supply and demand factors support this viewpoint. The purpose of this chapter is to assess the potential of wood as a supplementary fuel, based on these supply and demand considerations.

Of course, the optimism toward forest energy use in British Columbia springs from the productivity of its extensive forest and the strength of its forest industry. Forested lands comprise about 55 per cent of the province's 95 million hectare land area. In 1976, about 75 percent of the total forested land — devoted to wmmercial forestry under some form of sustained yield management. It has been estimated that British Columbia contains about 40 per cent of all merchantable timber in the country (Farley. 1979). This tremendous resource supports Canada's largest, and most complex, forest industry. British Columbia's forest conversion plants account for about 25 per cent of pulp, and 70 per cent of sawn lumber, production in Canada. In 1978, over 70,820,000 cubic metres of timber were cut in the province, providing raw material for about 740 wood industry mills and 24 pulp and paper mills (British Columbia, Ministry of Forests, 1978a). Due to this industry's preeminent role in the growth, harvest, management, and utilization of provincial forests, it is a key industrial sector in terms of forest energy use.

Because the forest industry holds the chief potential for greater wood energy utilization in the near term, it receives the primary emphasis in this chapter. The potential stems from the industry's high energy requirements and ready access to wood for fuel. Sawmills and, to a lesser degree, pulp mills produce huge quantities of wood wastes from their conversion operations. To a growing extent, the forest industry depends upon these mill residues as a source of fuel to meet steam and heat require ments. At present, all but three of the province's major pulp and paper mills use mill residues for some portion of their power boiler fuel, which provides steam for the pulping process. Use of residues by sawmills for heat requirements is less prevalent, but still important.

Given that wood energy utilization already occurs in the forest industry*, in what applications could further utilization be expected? To what degree would supply and cost of biomass constrain further energy utilization? On what relative energy prices should analysis of future uses te based? These questions are the topics of concern in this chapter. First, an assessment of wood biomass supplies from various sources is presented. Next, an overview of current energy consumption in the forest industry is provided in Section 3.0. Following, in Section 4.0, is a discussion of energy-pricing issues to determine the appropriate basis for analysis of wood energy utilization. Potential demands for forest energy are considered in Section 5.0. Both near-term utilization in the forest industry and longer-term applications for electrical generation and conversion to liquid fuels are assessed. Finally. this chapter concludes with an integration of the supply and demand analysis of potential wood energy utilization.

2.0 BIOMASS SUPPLY ISSUES

Different types of forest biomass that could be available for energy use in British Columbia include mill residues, forest residues, noncommercial species. and, possibly, plantations. Over the next 15 years[3],

2 More accurately, wood energy use is recurring in British Columbia since dependence upon mill wastes for fuel was much greater before the early 1950s. At that time, falling petroleum prices induced the existing mills to convert their hog fuel or coal boilers to oil.

3 Fifteen years, or through 1995, corresponds to the time frame For the assessment of potential demands in this chapter.

mill residues will provide most of the economically attractive supplies of biomass. Consequently, this source is emphasized in this section, with harvest of forest residues and noncommercial species discussed to a lesser degree.

Although biomass plantations, or "energy farms", are receiving attention and funding in other areas (Mitre Corporation, 1977). the large quantities of waste wood already available in British Columbia make this type of intensive biomass silviculture a iongterm prospect at best.

Energy production could be expected to command supplies of wood biomass if two economic criteria were met.

(1) The costs involved in harvesting, collecting, and transporting forest biomass must be re - covered.

(2) The energy uses of biomass must not preclude alternative applications that are more valuable.

Costs of procuring biomass are affected by such factors as accessibility, harvest technology, tree size. or haul distance–in short, all the variables that affect logging wsts for conventional forest production. Mill residues are the least costly form of forest biomass for energy, since the material has been collected and processed and is available at conversion centres. The opportunity cost of biomass or its value in alternative uses will be a function of technical advances that allow greater use of wastes in conventional forest products.

A comprehensive analysis of biomass supply would require estimates of forest biomass volumes available at different prices in different areas of the province–that is, it would mean deriving regional supply curves. No attempt is made here to estimate supply curves of biomass for energy, since neither data nor resources are available: Factors, such as the price elasticity of su ply, would te particularly difficult to determine! Rather, the approach is to discuss the range of biomass quantities and supply costs derived in other studies, in order to gauge whether biomass supply could be a constraint to full development of forest energy potential in British Columbia.

2.1 Mill Residues

All forest conversion plants–whether sawmills, pulp and paper mills, veneer and plywood plants, or fiberboard plants–produce mill residues. These residues are composed of combustible waste wood fibre in various forms–most commonly bark, sawdust, wood shavings. and trim ends. Proportions of the different materials vary, depending on tree species. manufacturing process. and other factors. Mill residues are usually wet, often dirty, and almost never homogenous. Generally, residues are put through a hammer mill, or "hogger", to make them suitable for fuel use in steam boilers–hence, the colorful term of "hog fuel".

a) Production and Utilization

Relatively good data exists regarding the production and utilization of mill wastes in British Columbia, since the large volume of surplus wastes has prompted surveys to delineate this potential energy source. Table II-1 indicates production of mill wastes by regions in 1976. Total quantity of mill wastes was estimated at 10.92 million oven-dried tonnes (ODt), excluding surplus pulp chip production (Reid, Collins and Associates Ltd., 1978a).[5] A similar estimate was made by the provincial Ministry of Energy, Mines and Petroleum Resources, which placed 1978 production at 11 million ODt (British Columbia, MEMPR, 1980a). By way of comparison, this volume of mill wastes had a potential heat

4 "Price elasticity" refers to the degree that an increase in the price of biamass would bring forth an increase in quantity supplied, i.e., the responsiveness of quantities supplied to price changes.

5 It is important to distinguish, at the outset, between hog fuel and pulp chips. Although both these commodities are derived from wood residuals, they differ in that pulp chips are generally cleaner, more homogenous, and directly useful in pulp production. As discussed later, some components of hog fuel can be used as pulp furnish, but, generally, at a higher cost. Thus, pulp chips have an immediate alternative use, which is assumed to preclude their use as an energy source. All data, in this section referring to wood wastes, excludes chip production.

TABLE II-1
MILL WASTE PRODUCTION AND UTILIZATION, 1976 (ODt)[a]

Region	Production	Utilization		
		Energy[b]	Pulp Furnish	Other[c]
1. East Kootenay	358,700	35,000	------	------
2. West Kootenay	132,000	15,000	------	------
3. Arrow Lakes	351,400	275,000	------	20,000
4. Kinbasket	112,700	80,000	------	------
5. Shuswap	262,800	70,000	45,000	------
6. North Okanagan	435,700	200,000	65,000	10,000
7. South Okanagan	169,700	------	------	------
8. Kamloops	579,900	50,000	65,000	5,000
9. South Cariboo	328,000	15,000	------	------
10. Central Cariboo	470,100	------		------
11. North Cariboo	623,100	238,000	------	------
12. Robson	112,200	5,000	------	------
13. Prince George East	265,100	30,000	------	------
14. Prince George West	1,334,100	210,000	------	------
15. Babine	408,100	75,000	35,000	------
16. Skeena	248,100	5,000	35.000	------
17. Mackenzie	379,300	100,000		------
18. Peace	262,500	------	------	------
19. Fort Nelson	87,700	------	------	------
20. Dease	------	—	------	------
21. North Coast	142,300	110,000	15,000	------
22. Central Coast	17,700	18,000	------	------
23. South Coast	3,819,100	2,765,000	505,000	70.000
Total	10,920,300	4,296,000	755,000	105,000

Source: Reid, Collins and Associates Ltd., (1978a)

[a] For convenience, it is assumed that one gravity-packed unit (GPU) is equal to one ODt. Since a GPU is a unit of volume, the actual weight will vary considerably, depending on wood species, moisture, and other factors. One study found the weight of a typical GPU of hog fuel to be almost exactly one ODt (Corder, 1976). Other sources typically assume .75 to .85 ODt per GPU (Ministry of Forests, pers. comm.). The assumption has little bearing on our overall conclusions.

[b] Includes both pulp mill and sawmill use for steam and electrical generation

[c] Other uses are primarily for particle board.

content equal to about 5 million cubic metres (30 million barrels) of oil6

Data, in a subsequent study based on more accurate surveys, indicates that the South Coast Region had a production of 4.98 million ODt in 1977, or an increase of 30 per cent over the output shown for 1976. The authors of the study suggested that the figure for 1977 was likely more accurate than the previous estimate and that production was unusually high in that year, due to high lumber production (Reid, Collins and Associates Ltd., 1978b). Sawmills are the major producer of wood waste in the area, followed by pulp mills and plywood plants.

When discussing residue use or, indeed, most **aspects** of the provincial forest industry, **it** is necessary to differentiate between Coastal and Interior operations. The Coastal industry developed earlier; its mills are older, its **trees** larger, and its transport costs are lower because of water movement of materials. Also, the Coastal industry is completely developed in terms of available timber and is highly integrated. with primarily large firms controlling timber resources, logging, sawmills, and pulp operations (Pearse, 1976).

Coastal pulp mills are currently the province's largest **users** of hog fuel, which is consumed along with residual oil in their power boilers. Movement of hog fuel by water is common, with sawmills shipping wastes to pulp mills. *As* seen in Table ll-1. 1976 data shows little surplus of hog fuel on the Coast. About 72 per cent of South Coast wood waste produced in that year was utilized for production of steam and electrical power. Data regarding South Coast utilization of hog fuel in 1977 indicated that about 65 per cent of wastes produced in that year were used as energy, 11 per cent for other purposes, and the remaining 26 per cent as surplus (Reid, Collins and Associates Ltd., 1978b). Consensus among industry observers is that planned expansion of hog fuel utilization by pulp mills on the Coast will soon eliminate any surpluses in that region.

A different situation exists in the Interior. The Interior industry has developed more slowly; not all of the sawlog or pulp potential has been utilized. The industry is only partially integrated, with higher transport costs inhibiting movement of mill wastes. Because the Interior industry utilizes smaller diameter logs, residue factors are generally higher, meaning more waste per unit of production. Regions with major accumulations of surplus wood waste include **east** and west of Prince George; south, central, and north Cariboo; Kamloops; and others.

In the Interior. production of wood waste far exceeds use. Table ll-1 indicates that in 1976 only about 22 per cent of residues were utilized for energy purposes, about **4** per cent as fibre input for pulp production, and the remainder was disposed of in landfill or was burned.

As environmental standards have been applied to the forest industry. the ***costs*** of wood waste disposal have risen, according to industry sources. No specific data is available on this trend, although. by way of comparison, OECD (Organization for Economic Cooperation and Development) data shows the cost of pollution control in the U.S. kraft pulp industry **has** risen from about 1.3 per cent of product price in 1970 to about 6.8 per cent in 1975 (OECD, 1978). The **cost** of wood waste disposal by landfill in British Columbia was estimated by Reid, Collins and Associates Ltd. (1978b) to range between $2.25 and $9 per ODt in 1980 dollar terms.

Rising disposal *costs* provide an economic incentive for greater use of wood waste energy. According to Tillman (1978), pollution-control wsts were the primary factor in increased use of wood wastes by the **US.** forest industry between 1972 and 1976. Similarly, a 1976 survey of mill managers in the Pacific Northwest States indicated that the disposal of wastes was the most important feature of energy conversion systems (Moore, 1976). Waste disposal **has** been offered as a primary reason many Interior pulp mills now utilize a portion of wastes for fuel.

b) Costs

Since mill residues are wastes from conventional forest products, the msts of harvest, collection,

Actual heat content would depend on the species of wood, percentage of bark, moisture content, and other factors. One study, of the characteristics of a typical unit of hog fuel delivered to a power plant, measured its heat content at 22 million kj (Corder, 1976). Other studies typically use 17 million to 18 million kj *as* an average measure (Intergroup, 1978)

and transport to conversion facilities are reckoned as zero by operators. The chief advantage of hog fuel is that its acquisition costs are borne by forest products consumers. There is a small cost associated with putting wastes through a hammer mill to produce crushed fuel suitable for steam plant boilers, which is generally viewed as nominal. The only cost of note is, therefore, the cost of transportation from the mill of origin to the mill where it is burned.

Hog fuel is normally moved by barge on the Coast or by truck in the Interior; at present, it is not commonly transported from the Interior to the Coast. Transport costs and hog fuel prices determine the extent to which such movement occurs. Costs of transporting hog fuel should roughly parallel chip transport costs, although a variety of estimates has been made. Reid, Collins and Associates Ltd. (1978b) indicated in their hog fuel survey that transport costs paid by mills in the Interior during 1978 ranged from $0 to $15 per unit, with a maximum haul of about 40 miles. The cost of hog fuel barge transport from the Lower Mainland to Vancouver Island was estimated at $3 to *$6* per unit (Reid, Collins and Associates Ltd., 1978b). Unlike chips, long-range transport of hog fuel by rail is not considered feasible under present conditions because wastes often have moisture content exceeding 50 per cent, meaning they would freeze in open railcars during winter, thus, making handling difficult.

c) Prices

Surpluses of hog fuel cause the price of hog fuel to tend downward. At present, producers of hog fuel receive little when selling residuals, and purchase prices paid by users primarily reflect the cost of delivery; for example, delivered prices for hog fuel in the South Coast Region ranged from $2.50 to $6.75 per ODt in 1978, roughly equivalent to transport costs (Reid, Collins and Associates Ltd.. 1978b). Producers are happy to sell wood wastes at a nominal price, since the cost of disposal by other means is avoided.

d) Future Production

Quantities of hog fuel produced in the future will primarily te a function of the output of con. ventional wood products? The Reid, Collins and Associates Ltd. study (1978b) estimated future wood residuals production, based on projected annual allowable cuts (AAC) and log consumption. These estimates are shown in Table II-2. Mill wastes are predicted to grow to over 13 million ODt by the year 2000. This expansion of residues is due to projected increases in cut levels in certain regions. as well as to more complete utilization of avoidable forest residues. "Avoidable residue" is defined by Reid, Collins and Associates Ltd. as forest wastes that are not now, but could be, extracted as part of the AAC; it is material that falls within current provincial utilization standards.

Reid, Collins and Associates Ltd. did not discuss the basis of their assumption regarding avoidable residues, but the suggestion is that greater utilization (and greater hog fuel supply) will come in response to rising prices for forest products. They further note that their estimates of future forest activity do not completely utilize the potential AAC in all areas. Considering the potential for reductions in AAC as regional supplies are reinventoried, that assumption seems realistic. In sum, the data of Reid, Collins and Associates Ltd. (1978a). as shown in Table II-2, appears to be a reasonable appraisal of future residue production.[a]

2.2 Forest Residues

Forest residues are a potentially large, but high-cost, source of biomass for energy production in British Columbia. The term "forest residues" is

7 Another determinant could be improvements in the lumber recovery factor (LRF) or increased amounts of lumber from a given amount of raw wood. At present, only about half the wood input of a sawmill comes out as sawn lumber. Improvements In the LRF, which would lower residual production, are not expected to change drastically over the next 15 years.

8 The Ministry of Forests' 119801 Resource Analysis *Report* indicates that wood supply "falldowns" may be severe in some regions in coming years. In that light, the production figures of Table II-2 may be somewhat optimistic. On the other hand, the Ministry of Energy, Mines and Petroleum Resources (British Columbia, MEMPR, 1980a) estimates that hog fuel production could reach 15 million ODt yearly in 1996.

TABLE II-2
PROJECTED TOTAL MILL WASTE PRODUCTION (ODt)

Region	Year	
	1980	2000
1. East Kootenay	373,000	409,000
2. West Kootenay	162,000	237,000
3. Arrow Lakes	373,000	418,000
4. Kinbasket	116,000	117,000
5. Shuswap	215,000	223,000
6. North Okanagan	363,000	374,000
7. South Okanagan	164,000	167,000
8. Kamloops	560,000	577,000
9. South Cariboo	322,000	332,000
10. Central Cariboo	410,000	493,000
11. North Cariboo	571,000	578,000
12. Robson	80,000	87,000
13. Prince George East	278,000	293,000
14. Prince George West	1,462,000	1,619,000
15. Babine	590,000	737,000
16. Skeena	244,000	364,000
17. Mackenzie	632,000	678,000
18. Peace	365,000	554,000
19. Fort Nelson	238,000	349,000
20. Dease	-----	181,000
21. North Coast	246,000	312,000
22. Central Coast	18,000	18,000
23. South Coast	3,805,000	4,031,000
Total	11,586,000	13,148,000

Source: Reid, Collins and Associates Ltd. (1978a) broadly defined here to include logging residues, intermediate cuttings, and diseased or dead trees. Logging residues are the most widely available form of forest residues–being essentially waste-tree portions. or "slash", left in the woods or at sorting areas afler commercial operations. Components include wood classed as merchantable in terms of provincial utilization standards and wood too small or too defective to be merchantable–branches, foliage, and stumps. Intermediate cuttings are thinnings of small or inferior trees removed for stand improve. ment. These materials are far less readily available than logging residues, since they are more dispersed, found in smaller quantities. and more costly to obtain. The collection of dead or diseased trees is, in most instances, still costlier than other forest residues. The discussion that follows, therefore, concentrates on logging residues.

Residues could conceivably be utilized by collection during or afler initial logging and then reduction to fuel size by chipping or by "hogging" in a hammer mill. In terms of energy production, the characteristics of forest residues are similar to those of mill residues.

a) Quantities

A number of factors affect the volume of logging residues remaining at a specific location, including stand age and quality, nature of terrain, standards of utilization, market conditions, and mill specifications for wood. In general, the Coastal Region produces more residues per acre. since much of the harvest is from large, overmature timber. These trees are often rotten and subject to breakage on falling or are located in steep terrain where full harvest is awkward.

Because quantities of logging residues are so variable between sites, it is difficult to obtain estimates of the total amounts produced. Published estimates of residues differ in the kinds of materials considered and in the measurement of units. F.L.C. Reed and Associates Ltd. (1978) has estimated that unharvested residues of timber classed as merchantable under current utilization standards amount to about 10 per cent of present harvests for Coastal softwoods and about 5 per cent for Interior softwoods. These estimates indicate that a total of about 5.1 million cubic metres of merchantable residues, equivalent to about 2.25 million ODt of biomass, could be utilized annually with no change in the **AAC.** If wood was harvested beyond the current standards, F.L.C. Reed and Associates Ltd. (1978) estimates that the harvest of Coastal softwood would increase by a further 7 per cent, while Interior softwood would increase a further 24 per cent. Total volumes of wastes that could potentially be recovered, for forest products under higher standards, amount to 16.4 million cubic metres yearly, equivalent to about 7.5 million ODt (F.L.C. Reed and Associates Ltd., 1978).

Another study. concerned specifically with logging residues in British Columbia, was prepared in 1976 by the B.C. Forest Service (1976). It presents preliminary estimates of logging residues in each forest district of the province, based on interviews with their fieid staff. Again, the estimates were concemed only with merchantable residues comprised of either avoidable or unavoidable wastes. Its findings are summarized in Table II-3, which shows that estimated merchantable material, left in the forest, ranges from about 26 per cent of committed annual cut for the Vancouver Forest District to about half that for the Cariboo Forest District. Based on this data, Table II-3 also gives projections of the annual volume of merchantable residues in the province; total wastes falling within the close utilization standards are estimated at around 6.3 million ODt yearly, depending on the timber cut in that year.

This preliminary data indicates that considerable volumes of merchantable residues are produced in British Columbia. Yet. the quantities of unmerchantable residues are even greater. The Mitre Corporation has assessed the quantities of logging residues produced from cut of softwoods in the Pacific Northwest States. They estimate that the ratio–of growing stock wood left as residue (both merchantable and potentially merchantable) to total cut–is 0.074 ODt of wood per cubic metre harvested. Unmerchantable volumes of bark and tops are estimated at 0.126 ODt per cubic metre of cut (Mitre Corporation, 1977).[9]

[9] *As* pointed out in Intergroup (1978), the Mitre corporation ratios are almost equivalent to the quantity of merchantable and potentially merchantable residue estimated by F.L.C. Reed and Associates Ltd. for Coastal British Columbia.

TABLE II-3
PROJECTIONS OF MERCHANTABLE LOGGING RESIDUES
FALLING WITHIN CLOSE UTILIZATION STANDARDS
1978

Forest District	Total Timber[a] Scale, 1978 (m^3)	Estimated[b] Residue Factor	Projected[c] Residues (ODt)
Prince George	13,880,000	.16	980,000
Kamloops	8,920,000	.18	710,000
Cariboo	7,510,000	.13	430,000
Nelson	7,220,000	.21	670,000
Prince Rupert Interior	5,240,000	.17	390,000
Prince Rupert Coast	4,110,000	.25	450,000
Vancouver	28,190,000	.26	3,230,000
Total	75,070,000		6,860,000

Source: McDaniels Research Limited

[a] British Columbia, Ministry of Forests (1978). Total timber scale in 1978 exceeded the 10-year average by about 14,160,000 cubic metres.

[b] British Columbia Forest Service (1976). The factors shown above include those given for avoidable and unavoidable wastes of merchantable timber. The ratios shown for the Prince Rupert District were interpolated from the others, since none were given in the original source

[c] It is assumed that 2.8 cubic metres is equivalent to 1.25 ODt

Another study estimated a total slash-to-harvest ratio of **0.113** ODt per cubic metre harvested in the Vancouver Forest District and a comparable ratio of **0.112** ODt per cubic metre in the Kamloops Forest District. The components of slash were not specified in that report (Pulp and Paper Research Institute of Canada, 1975).

In sum, the volume of logging residues is substantial in British Columbia. Residues that are classed as merchantable, under provincial standards, probably exceed 6.5 million ODt per year, while unmerchantable residues are likely to be at least that great.[10] By way of comparison, logging residues amounting to 6.5 million ODt per year would equal nearly 60 per cent of the biomass now available yearly as mill residues.

Moreover, these estimates do not account for the enormous accumulation of residues from logging operations in previous years. Consider, for example, that merchantable logging residues left in the forest during the last ten years could approach 60 million ODt of biomass. If only half of this merchantable material is available for energy use, it could potentially contain the heat equivalent of 85 million barrels of oil. Despite this potential, it would be precipitous to consider accumulated logging residue as a long-term biomass source, since its supply is fixed, access may be difficult, and its recovery could disturb replanted areas.

b) ***Costs***

More important than aggregate volume estimates are the costs of recovering logging residues in usable form. *Costs* of processing residuals will vary substantially. depending on terrain, volume of material, size of pieces, and method of retrieval. In general, larger pieces can be processed at lower cost. Different methods of residual assembly include: collecting (yarding) all debris at the same time as primary logging; yarding debris in a "second pass" after primary logging; and harvesting whole trees. including merchantable and unmerchantable parts. Each of these methods will yield different costs for a given volume of residuals.

Various studies have attempted to estimate costs of collecting, processing, and transporting residuals and have derived a wide range of figures. Table **II-4** summarizes the results of six different cost appraisals from the Pacific **States** and British Columbia. These data indicate costs to deliver residues to a landing and process them into chips, with neither **an** allowance for transport to the final destination nor a profit return to the operator. Estimates provided by the Northwest Energy Policy project are the lowest, but they haveapparently been derived without the benefit of field tests and are **based** on sources from the mid-1970s. The estimates in Rollert (1976) are **based** on two independent chipping trails in the Prince George area in which small volumes of residue were skidded **to** landings, chipped, and loaded onto trucks. The highest, and likely most credible, estimates are those of P.H. Jones and Associates (1979) and Blakeney (1980), both of which were studies for the ENFOR Program. The range of figures found in these sources reflects the variety of conditions and volumes encountered in harvesting forest residuals, as well as the fact that harvest processes are still under development.

It is concluded that costs of collecting and chipping forest residues in British Columbia could range from below $30 per ODt to over $75 per ODt, depending on conditions and methods. Of course, residues from convenient locations (such as log dumps or sorting areas) would have lower average costs than from other sites. Since a number of studies indicated that larger-size materials can be recovered at lower-average **casts, it** *seems* reasonable to expect they would form the primary materials utilized for energy or other purposes. **A** figure of $50 is **a** reasonable estimate for average costs of recovering larger residues, which, for purposes at hand, can **be** represented by the merchantable residues estimated in Table **II-3,** although far more unmerchantable residues could also be utilized at that cost.

The above estimates are gross costs that do not reflect the potential benefits owing to savings on waste disposal or site preparation afforded by recovery of residuals. One source indicated that possible cost savings of **$3.80** to $7.50 per ODt

10 These figures **are** remarkably **close** to provincial estimates that **place annual** merchantable residues at **6.72** million ODt and nonmerchantable residues at **7.83** million ODt (British Columbla, **1980).**

TABLE 11.4
COST ESTIMATES FOR RECOVERY OF LOGGING RESIDUES
EXCLUDING TRANSPORT

Source and Process	Estimate (1980 $/ODt)
1. U.S. Forest Service . Second Pass Medium and larger-size pieces . Pacific *Coast* States	$34
2. U.S. Forest Service . Unspecified process. California	$23 to **$52**
3. Mitre Corporation . Unspecified process, Pacific Northwest	$48 to $58
4. Rollert . Second Pass, B.C.	$23 to $49
5. P.H. Jones and Associates . Single Pass, B.C. - Second Pass, B.C.	 $38 to **$76** **$50** to **$65**
6. Blakeney . Second Pass, B.C.	$42 **to $57**

1. Grantham et al., **1974.** Their medium "size B" specification is roughly similar to the lower limit of British Columbia close utilization standards. "Single pass" refers to recovery of residuals as part of initial logging: "sewnd pass" refers to relogging afler sawlog Operation.

2. **U.S.** Forest Service, **1976.** This reference lumped transport wsts in with harvest and chip **costs, so $10** per ODt was subtracted from the estimates quoted to allow for transportation.

3. Mitre Corporation, **1977.** This reference **also** lumped transport wsts in with other costs, ***so*** $10 per ODt was subtracted from their estimate range.

4. Rollert, **1976**

5. P.H. Jones and **Associates** Ltd., **1979.** The range **of** cost estimates quoted here reflects the **cost** considerations raised in the Foreword to that report Figures are converted, assuming One cunit equals **1.25** ODt.

6. Elakeney, **1980.**

TABLE II-5
ESTIMATED TRUCK TRANSPORTATION
COSTS FOR FOREST BIOMASS
1980

One-Way Distance (miles)	Average Cost[a] ($/ODt)
5	$ 4.20
10	6.40
15	8.30
20	9.50
25	10.60
30	11.50
35	12.50
40	13.50
45	14.50
50	15.50
60	17.50
70	19.50

Source: P.H. Jones and Associates (1979)

Figures are converted to *ODt* equivalence and 1980 dollars,

(1980 dollars) could be provided by residuals recovery in the Interior, if site preparation steps are not required (British Columbia Forest Service. 1976). Thus, the net costs could be roughly $5 lower than the average gross estimate of $50 per ODt. These disposal credits are considered in Chapte rVI.

Transport costs have also been assessed in a number of studies, with the most comprehensive estimates provided by P.H. Jones and Associates (1979). as found in Table II-5. It is concluded that the average costs for a 50-mile road haul are roughly $15 per ODt.[11]

These relatively high harvest and transport costs are corroborated by the observation that, at present, logging residues are virtually ignored in British Columbia. The large surpluses of mill residuals available at low cost, along with an ongoing over-supply of chips in the Interior, make it unattractive now to recover forest residuals for energy or fibre (Council of Forest Industries [COFI] , pers. comm.).

c) Future Availability

Future availability of forest residues could be altered by a number of factors. The first, and fore-

[11] The figures of Table II-5 correspond reasonably well lo the range of transport costs and haul length for Interior hogfuel cited previously from Reid, Collins and Associates Ltd. (1978b).

more complete utilization of timber for primary products, up to the levels of close utilization set by the Ministry of Forests or ever beyond. This assump tion was incorporated into previousestimates of mill residuals in Table II-2. which hypothesized that "avoidable waste" of merchantablematerialwould **be** eliminated in the future. The second major factor is the onset of intensive forest management. Second. growth stands with uniform age and spacing would produce far less residues than unmanaged old-growth stands. Other factors could be the development of whole-tree chipping or expanding markets for conventional products made from residuals, as discussed in subsequent sections.

Taken together, these forces will certainly reduce the volume of lager residues. However, it can **be** expected that improvements in residue recovery processes would mean that lower-quality material could **be** collected for energy use at *costs* comparable to those currently estimated for larger residues. **It** is, therefore. assumed that the quantities of residue estimated in Table 113 would **be** available in the future at roughly $50 per ODt (1980 dollars) average cost, despite higher utilization and managed forests.

2.3 Underutilized Species

Underutilized tree spedes in British Columbia are predominantly composed of harwoods–such as white birch, trembling aspen, black cottonwood, red alder, or bigleaf maple. In certain areas, smaller softwoods–such **as** lodgepole pine–are, at present, underutilized in comparison to potential cuts. These underutilized spedes could possibly provide quantities of forest biomassfor energy at certain locations in the province, **at** costs parallel to or below those of logging residual recovery.

a) Quantities

In terms of total volume, hardwoods make up only about 2.5 per cent of mature timber volume in the province, but are termed a significant, yet neglected, resource (Manning, 1975). Alder and bigieaf maple are Coastal **species;** trembling aspen and poplar are found in the Interior, while cottonwood grows throughout the Coast and Interior of southern British Columbia. On the Coast, hardwood stands are typically the natural regeneration on logged **areas.** Hardwoods occur either as pure stands or mixed with commercial softwoods.

The distribution of hardwoods vanes throughout the province, with the greatest volumes in the northeast and northcentral Interior. Table II-6 indicates the potential cut of hardwoods within ***each*** forest district; the largest volume occurs in the Prince George District. in which hardwoods comprise over ***8*** per cent of the gross forest inventory. Some 20

TABLE II-6
HARVEST AND ANNUAL ALLOWABLE CUT (AAC)
OF HARDWOODS BY FOREST DISTRICT

Forest District	Hardwood Volume (m3)	AAC for Hardwoods (m^3)	Harvest 1973 (m^3)	Harvest as Proportion of AAC (%)
PrinceGeorge	13,404,000	265,600	10,067	3.8
Kamloops	325,930	6,793	3,940	58.0
Nelson	148,000	3,175	1,745	55.0
Prince Rupert	4,690,000	44,167	28,827	65.3
Vancouver	1,311,000	15,946	12,770	80.1
Cariboo	912,000	13,558	351	2.6
British Columbia	20,790,930	349,239	57,700	16.5

Source: Manning (1975)

different sawmills produced sawn hardwoods for semndaty manufacture during 1975 (Manning, 1975). and 'a limited amount of hardwood chips (primarily black cottonwood) is used in pulp production (Manning, 1976).

Table II-6 also indicatesthat cuts of hardwoods fall far below the AAC, except in the Vancouver Forest District. This shortfall reflects the fact that current market uses of British Columbia hardwoods are limited. Sawn hardwood markets in the western United States are now more economically served by Pacific Northwest hardwoods, while eastern Canadian producers are well entrenched in those markets. One report has identified the local market as, perhaps, the best potential for British Columbia hardwoods, but iis size has clear limitations (Manning, 1975).

Recently, P.H. Jones and Associates Ltd. (1979) indicated that markets for hardwood sawlogs were poor during 1978-1979, with only two or three mills buying logs on the entire coast, along with similarly poor export markets for hardwood logs. Jones also found that, at that time, the market for hardwood chips was practically nonexistent. This lack of markets has caused hardwoods to be sometimes relegated to the status of "weed" trees, with coastal hardwood stands classed as "not sufficiently restocked" in forest inventories.

b) Potential Availability for Energy

Hardwoods could be utilized for energy through logging and chipping to yield a fuel similar to chipped logging residuals. When considering hardwoods for energy, it is important to note that, while mill residuals and forest residuals are viewed as renewable or flow resources, hardwoods are, in many respects, a stock resource. If hardwoods were harvested for energy, most areas would likely be re planted with merchantable softwood species such as fir or hemlock, since these species would provide more valuable returns.[12] Use of existing hardwoods for energy would mean that currently unproductive sites could be regenerated for commercial softwood use without expensive clearing.[13] It would also mean that areas of hardwood growth would diminish.

Vancouver Island and the Prince George Forest District appear to be possible areas where hardwoods could be halvested for energy. The P.H. Jones and Associates Ltd. study for the ENFOR Secretariat estimated that there are approximately 70,500 hectares of pure and mixed hardwood stands on Vancouver Islands east coast–mostly on private land. Based on a 30-year halvest plan, it was estimated these stands would yield about 140,000 ODt of wood biomass annually over that period (Jones, 1979).

Within the Prince George Forest District, eight separate management units have hardwood stands that exceed 10 per cent of their total timber inventory, These units–which together, cover the northeast corner of the province–have a current surplus of unallocated annual cut (beyond that committed to forest operators) exceeding 600,000 cunits; this surplus indicates the low level of forest industry development in this area, as well as high costs in these remote locations. Based on this brief data, it is expected that at least 60,000 ODt of hardwoods, and possibly much more, could be available yearly in the Prince George Forest District's northern units for energy purposes.

c) costs

Casts of utilizing hardwoods or other underutilized species for energy can be expected to vaty. depending upon methods. road access, concentration in stands, and many other factors. P.H. Jones and Associates Ltd. (1979) has estimated the costs of halvesting alder for biomass energy on Vancouver Island to range from $19 to $28 per ODt, depending on the method employed. Another study estimated that harvest and chipping of lodgepole pine (a softwood underutilized in some areas) could be accomplished in the Cariboo Region at a cost of $28 to $32 per ODt without transport (Intergroup, 1978).

12 If forest biomass farms are developed in the province at some point in the future, they would likely grow hardwood Species such as alder or cottonwood on an intensive basis. Within the time frame of this study, biomass farms are not considered a probable development. Consequently, softwoods would, in most cases, be replanted in areas now covered with hardwoods.

13 Jones (1979) reports that, on Vancouver Island, certain companies are clearing alder stands to allow replanting, with no use being made of the alder.

Transport costs, which are likely to be significant in the Prince George area, could be expected to parallel those of logging residues in Table II-5, or about $15 for a 50-mile haul.

Based on these limited data, it is expected that recovery of underutilized hardwoods could occur in certain areas at a cost of approximately $30 per **ODt,** plus transport costs. Quantities available for harvest **are** less than logging residues, with the best potential on Vancouver Island or in the Prince George Forest District. These areas have annual biomass potentials estimated at 140,000 ODt and at least 50,000 ODt, respectively. Over the long term, the availability of hardwoods for energy would decrease as sites are restocked with commercial softwoods and as alternative commercial uses for hardwoods develop, as discussed in the next section.

2.4 Alternative Uses of Forest Biomass

Following the lead of Tillman (19781. it is assumed in this report that energy applications could not outbid the forest industry for sawlogs, pulp chips, or residues demanded for manufacture into forest products.[14] It is, therefore, essential to examine the potential demand for prospective energy biomass by the manufacturers of pulp, particle board, or hardwood products.[15] Wood biomass that will not be used for forest products can **be** considered potentially available for energy uses.

a) Pulp Industry

Technical Factors

Softwood mill and forest residues could potentially be used as fibre for wood pulp. At present, mill residues **are** employed as pulp furnish in British Columbia. Table II-2 indicates that about 10 per cent of mill residue production was pulped in 1976-principally sawdust and shavings. Virtually no forest residues are utilized for pulp at present.

Greater use of mill residues for pulp would require screening to separate bark from other aggre gates in wood **wastes** because bark has been found to lower the quality of pulp output, if it is used as a fibre source (British Columbia Forest Service, 1976). New digestor facilities would also be required for mill residues, since they do not soften in regular chip digestors for kraft pulp. An exception would be the new thermomechanicai pulp (TMP) process, which works well on higher-quality residues such as shavings. In British Columbia, three kraft pulp mills now have sawdust digestors and one TMP mill is in operation.

Bark would also present problems in the use of forest residues for pulp. The most likely method of utilizing logging slash for pulp would be through chipping large pieces or whole trees in the woods without bark removal. Studies indicate that barky chips could produce acceptable pulp, but grade and price would be lower (Keys and Hatton, 1974). Whole tree chips could be "debarked" and then used in the pulp process. but at a higher cost.

In sum, use of residues in larger quantities for pulp production would generally entail either higher input costs or a lower-quality product, or both. compared to standard chips.[16] The important question is, When might the pulp industry expand to such a degree that low-cost, higher-quality pulp chips are fully utilized, and turn their attention to residuals for fibre?

Chip Utilization
and Pulp Expansion

In recent years, there has been a pervasive Oversupply of pulp chips in the British Columbia

14 **Given the current oversupply of pulp chips in British Columbia's Interior at a price of $31 per unit, it could be argued that some of the energy uses Outlined later in this chapter (particularly methanol) might be able to command chips away from pulp production, as supported by Intergroup (1978). In order to narrow the scope of supply questions addressed here, that possibility has not been considered.**

16 **Tillman (1978) also considered the potential demand for wood for chemicals. He Concluded that, in the U.S. where conventional oil and gas feedstocks are less abundant than in Canada, wood biomass Utilization for chemicals would remain relatively low (p. *202).* Consequently, use of biomass for chemicals in British Columbia is not considered a major factor in wood energy use.**

16 **A study by the Pulp and Paper Research Institute (1975) noted the additional capital Investment, production problems, and lower pulp quality associated with using sawdust and shavings in kraft pulp.**

Interior. This oversupply is a result of both the province's dose utilization policy and the fact that pulp capacity has not become fully utilized in the Interior and northern parts of the province. The Reid, Collins and Associates Ltd. (1978a) study conservatively estimated surplus chip production at approximately 780.000 units in 1976.

Supply of chips is largely a function of sawmill activity, since chips are a residue by-product of lumber production, while the demand for chips is the result of pulp market conditions. Consequently, chip production and consumption can be out of phase, with high chip supply when demand is low, or the reverse. The oversupply of chips has, however, persisted through these market cycles, even though sawmills obtain no return for surplus chip production. Some observers believe there is a positive elasticity of supply for chips, meaning that higher prices for chips would induce wen greater supplies (Ministry of Forests, pers. comm.).

The *excess* supply of chips has prompted interest by foreign pulp producers. Although chip exports have occurred for some years, the volumes have increased markedly since 1979. Fibreco Export Ltd., a major exporting firm, has contracts to supply 400,000 ODt of softwood chips annually to Japan. The current excess supply of chips in British Columbia is estimated by Fibreco to range from 900,000 to **1.4** million ODt annually, although there is considerable disagreement with this estimate.[17]

This oversupply of chips will not last-steady growth in world pulp demand, recent increases in pulp prices, and abundant fibre supply make expansion of British Columbia's output a certainty. At present, provincial pulp and paper capacity is about 6.1 million tonnes per year. On the basis of world demand studies, the Ministry of Forests recently reviewed the outlook for expansion in pulp and paper capacity. It concluded that, over the next 20 years, bleached kraft pulp capacity could potentially expand by 1.4 million tonnes (theequivalent of 5 to *6* new mills of minimum size). It also suggested newsprint capacity could potentially expand by a total of 1.1 milliontonnes per year by the year 2000. These increases would place the total provincial production capacity at approximately 8.6 million tonnes yearly by the end of the century (British Columbia, Ministry of Forests, 1980). This forecast can be compared to one by Manning (1976). which placed potential output at 7.2 milliontonnes, or to **an** earlier and more optimistic forecast of about 10 million tonnes by Jegr and Thompson (1975).

Investment activity in the forest industry supports these forecasts. Expansion of newsprint production is underway at three coastal mills, as is expansion of kraft pulp capacity at an Interior mill. A new thermomechanical pulp mill is also being constructed at the Interior town of Quesnel (Ministry of Forests, pers. comm.). The three newsprint expansions will reportedly utilize annually a total of roughly 450,000 ODt of chips. The kraft mill expansion, along with development of the new Interior mill, could utilize yearly as much as 750,000 ODt of chips. These expansions in capacity will apparently absorb all currently available residue chip surpluses in the central and northern Interior.

Outlook for Residue Utilization

It is apparent that the oversupply of chips, experienced at current production levels, will soon **be** eliminated and even further quantities of fibre will be required. There is, however, great scope for expanding chip supply. It has already been pointed out that a considerableamountof merchantable material remains in the forest and is not utilized in British Columbia. Reid, Collins and Associates Ltd. (1978a) has estimated that, primarily by achieving full harvest within present utilization standards, chip production could increase by 2.2 million ODt annually by the year 2000. At the **same** time, they foresee that expanded pulp capacity would utilize a greater portion of mill residues as fibre inputs and have, accordingly, estimated that the use of hog fuel as pulp furnish could increaseannually by 1.6 million ODt by the year 2000. Overall, their data postulates a total expansion in fibre consumption by the pulp sector of roughly 4.5 million ODt by the year **2000.**[18]

17 Financial Post, "Fibreco Scoops World Market in Wood **Chips", September 29, 1979,** p. W.1

18 Reid, Collins and Associates Ltd. **11978s).** This expansion would comprise **0.78** million ODt **of current** surplus chips, **2.2** million ODt **of** expanded chip production, and **1.6** million ODt of mill **wastes. No** discussion of how this increased consumption would occur was provided in the report.

By way of comparison, the level of expansion in pulp capacity, foreseen in the Ministry of Forests' review, would require about 3.9 million **ODt** of fibre input-somewhat less than the increase in supply indicated by Reid, Collins and Associates Ltd.[19]

The results of the Reid, Collins and Associates Ltd. study indicate that British Columbia pulp production capacity could expand considerably and still leave enormous quantities of mill wastes for biomass energy. The predicted requirement of **1.6** million **ODt** of residues for pulp furnish would still leave about 11.5 million **ODt** availablefor other uses in the year 2000, based on the Reid, Collins and Associates Ltd. forecast in Table II-2. Of wurse. the full harvest of material–under provincial dose utilization standards assumed by Reid, Collins and Associates Ltd.-would reduce the future volume of forest residue.

b) Particle Board and Composite Products

Particle board or other composite products **are** a much less significant use of mill residues. About 150,000 **ODt** of residueswere usedfor particle board production in the South Coast Region in 1977, or about **4** per cent of residues available in that region (Reid, Collins and Associates Ltd., 1978b). No other regions contain particle board plants. According to industry sources, provincial particle board production is expected to increase slowly, since British Columbia's major market for this product is eastern Canada, which **has** its own sources of supply.

New products made from pressed mill residuals have been under development by researchers for some time. These products could range from pressed dimension lumber to dewrativetrim. Over the period under consideration, demand for residuals in new products could not keexpected to exceed the quantities currently required for particle board (COFI, pers. comm.).

In sum, particle board and other composite products are not expected to significantly reduce the availability of residualsfor energy use.

c) Hardwood Products

Alternative uses of hardwoods include hardwood pulp, as well as a wide array of applications in wood products. At present, black cottonwood is utilized by one provincial mill for mechanical pulping into tissue paper because its white fibres do not require bleaching. Other hardwoods would **te** less acceptable in tissue manufacture. Technically, hardwoods could **be** utilized for kraft pulp, although two factors inhibit their use in British Columbia. First, hardwood fibres are shorter than softwoods, which reduces the quality of the final product and inhibits mixing of hardwoods with softwoods in pulp processes?[20] Second, the lack of hardwood sawmill activity means that hardwood residual chips are unavailable. ***As*** a result, hardwood chips must be produced from roundwood harvest. This process is more expensive than utilizing residual softwood chips, which are abundant in the province.

Greater use of black cottonwood for tissue production is possible in the southern part of the province, particularly in the Vancouver Forest District, where the high level of industry development means that other fibre sources besides softwoods are utilized. On the other hand, widespread development of hardwood kraft pulp is not expected in the near future because of the lower cost and higher quality of softwood chips.

Hardwoods could be utilized for wood products ranging from veneers to decorative trim of furniture components. Manning has summarized the priority uses of provincial hardwoods in the wood products industry. as well as the market constraints that impede their development. His assessment points to the provincial market as perhaps the one with the greatest potential (Manning, 1975).

Based on this opinion, it is expected that hardwood utilization in wood products will grow slowly in British Columbia. In total, the use of hardwood in pulp or wood products cannot be expected to infringe upon the amounts of biomass estimated to be available for energy purposes over the next 15 years.

19 **Calculated on the assumption that 1 ODt equals 1 unit of chips, 1 tonne of bleached kraft Pulp requires 2 units, and 1 tonne of newsprint requires 1 unit.**

20 **Small amounts of hardwood can be pulped together with softwood, if the mixture is carefully controlled.**

2.5 Conclusion

British Columbia has vast supplies of forest biomass available for energy use. Table II-7 summarizes potential biomass supplies and their estimated wsts and nonfuel biomass demands in the province. Surplus mill residues are the largest, and by far the most attractive, source of biomass. Forest residuals could provide substantial quantities of biomass, but at a much higher cost, while underexploited hardwood species could provide modest biomass supplies in certain areas.

3.0 CURRENT ENERGY USE PATTERNS IN THE PROVINCIAL FOREST INDUSTRY

British Columbia's forest industry is a formidable consumer of energy. During 1978, the three sectoral components of the industry—iogging, pulp and paper, and wood products—in total, consumed some 290 pj of energy, which comprised about 70 per cent of the province's total industrial consumption (British Columbia, MEMPR, 1980a).[21] This dominance reflects the sectots position as the province's chief employer, as well as the energy intensivenessof its processes. Natural gas, residual oil, wood wastes, and electricity are the energy sources that fuel this industry's activity. Choices between these fuel alternatives have been made by forest industry firms on the basis of relative prices and availability of energy inputs.

Because forest biomass holds a potential for further replacement of fossil fuels and electricity within the industry, it is useful to review the forest sectots patterns of energy consumption. We can, thereby, identify applications in which technical factors indicate potential for expanded wood energy use and also determine how current pricesfor alternative energy sources affect the swpe for substitution of fossil fuels.

As diswssed in following sections, energy uses in pulp and paper mills depend upon technology, age, and output. There are three general methods by which lignin (the bonding agent in wood) is broken down tofreethe cellulose fibres, which, when matted, constitute paper. These three are the chemical, mechanical (or groundwood), and thermomechanical processes. Eachhasstrikingly different energy require ments. We discuss, first, the sulphate or kraft process employed in British Columbia to produce "market" pulp. Groundwood and thermomechanical processes, which producenewsprint, are discussed subsequently.

Energy use in the wood products sector is considered in a subsequent section, emphasizing lumber and veneer dryers. The logging sector is not considered because it does not hold notable potential for use of wood biomass fuels.

3.1 Chemical Pulp Mills

By far the largest energy consumerswithin the provincial forest industry are chemical pulp mills. in 1978, the pulp sector alone accounted for 168 pi of energy use, or over 60 per cent of the forest industry total.

All but one of the province's 19 chemical pulp mills employ the sulphate or kraft process, which depends on heat and chemicals to soften wood fibres. Kraft pulp production is energy intensive, requiring about 48 x 10^9j per tonne on average, although energy consumption varies significantly between mills (British Columbia Energy Commission, 1978). Roughly 85 per cent of this total is needed in the form of process heat. A major proportionof that process heat is obtained by burning lignin that has k e n extracted from wood chips and is contained within recycled process liquors. Recovery boilers, fueled by lignin dissolvedin process liquors, normally provide 50 to 60 per cent of a mill's total energy requirements. Thus, wood energy from recycled chemicals already satisfies about half of the total energy requirements at all provincial kraft mills, through a process that has been termed "a model of recycling efficiency". Remaining requirements for process heat are provided by power boilers.

a) Power Boilers

Power boilers are the chief users of purchased fuels and, consequently, hold the greatest potential for expansion of wood energy within the pulp sector.

21 Forest industry requirements account for roughly one-third of the total energy consumption by the entire province. Petajoules is pj, or 10^{15} j.

TABLE II-7
PROJECTIONS OF FOREST BIOMASS
AVAILABLE FOR ENERGY USE IN BRITISH COLUMBIA

Biomass Sources Total Production	1980 Quantity ('000 ODt)	1980 Avge. Cost[a] ($/ODt)	1990	2000
Mill Residuals[b]	11,600	$ 5	12,400	13,200
Forest Residuals'	6,500	65	6,500	6,500
Underutilized Species[d]	200	45	200	200
Nonfuel Demands				
Mill Residuals				
- pulp[e]	900		1,600	2,400
- composite products[f]	200		400	600
Forest Residuals	minimal		minimal	minimal
Underutilized Species[g]	minimal		minimal	minimal
Available for Energy Use				
Mill Residuals	10,500		10,400	10,200
Forest Residuals	6,500		6.500	6,500
Underutilized Species	200		200	200

[a] Costs for mill residues reflect current average transport costs, as reported in Reid, Collins (1978b). Costs for forest residues and underutilized species include transport costs of $15 for a 50-mile haul.

[b] Reid, Collins (1978a:32). Figures for 1990 were interpolated.

[c] These estimates ignore the potential for utilizing residues from previously logged areas. Figures for 1980 include only merchantable material, while figures for 1990 and 2000 include unavoidable waste of merchantable material, as well as smaller residues

[d] This conservative estimate reflects only the long-term sustainable harvest from existing stands on Vancouver Island and a potential level of sustainable harvest in the Prince George area. Actual harvests could be much larger.

[e] Pulp demands for residuals were taken from Reid, Collins (1978b), which are sufficient to accommodate potential expansion of the industry expected by the Ministry of Forests. It is assumed that pulp producers would prefer to utilize mill residues rather than forest residues.

[f] Estimated maximum potential development of particle board and other composite products.

[g] Utilization of hardwoods for wood products could grow considerably and still have minimal effect on the production levels for enemy indicated here.

TABLE II-8
CONSUMPTION OF ENERGY IN THE
BRITISH COLUMBIA PULP AND PAPER SECTOR
(petajoules)

YEAR	ENERGY SOURCE				
	RPP[a]	Natural Gas	Electricity[b]	Hog Fuel	Waste Liquors
1970	31.757	17.936	14.061	NA	NA
1971	34.184	19.413	15.644	NA	NA
1972	34.752	20.769	17.641	NA	NA
1973	36.751	25.842	15.687	NA	NA
1974	41.875	27.289	15.169	NA	NA
1975	35.265	21.685	14.298	NA	NA
1976[c]	34.250	22.170	16.910	37.03	92.04
1977	34.500	23.820	17.340	37.00	100.10
1978	37.940	24.840	17.820	38.11	99.43

Source: Statistics Canada, Catalogue **57.002** and **57-208,** and B.C. Energy Commission **(1978)**

a Refined Petroleum Products

b To account for annual self-generated hydroelectric power, 2.35 pi was added to the Statistics Canada figures.

c All data for years 1976-1978 are taken from the Energy Commission forecast. No earlier consumption figures are available for hog fuel and waste liquors.

These boilers could be designed to burn residual fuel oil, natural gas, coal, wood wastes, or a combination of fuels. Oil and natural gas were formerly the premier fuels in power boilers, although aggregate consumption of hog fuel has recently surpassed them, according to the B.C. Energy Commission **(1978).** No coal is used at present in British Columbia. Table **118** indicates the historical consumption of purchased fuels by the pulp and paper sector, as well as estimated consumption, including unpurchased fuel, in recent years.

Hidden within these aggregate figures is the fact that the provincial pulp sector has two distinct regions that exhibit different energy use patterns.

Mills on the Coast were generally built before the late **1950s** and have historically depended largely on residual fuel oil for their power boiler energy requirements. This pattern occurs because coastal mills were constructed during a period of low hydrocarbon prices, which made oil attractive, and because natural gas is not available in many coastal locations. Pulp mills in the Interior were constructed in the **1960s** and **1970s** and primarily depend on natural gas for their boiler fuel requirements.

Normally, a mill has more than one power boiler. In a typical mill, one of the boilers burns hog fuel, while the others burn either oil or gas.[22] A

22 Only three of the province's mills, ail in the Interior, do not consume any hag fuel in their boilers

boiler designed to burn oil or gas cannot accept *even* small quantities of wood wastes. On the other hand, hogfuel boilers normally require a minimum of about 15 per cent fossil fuels to maintain **even** burning, or "overfire" them. Most mills with hogfuel boilers now use substantially more than 15 per cent fossil fuels in them to meet the plant's heat requirements,

A firm has three options if it wishes to consume greater quantities of wood wastes in its power boilers. First, it could increase the proportion of wastes consumed in *an* existing hog fuel boiler. Second. it could install a hog fuel burner within a boiler formerly using fossil fuels. In both of these cases, the accompanying reduction in fossil fuel could prohibitively lower the boiler's heat output. or de-rate it, since hog fuel has lower heat content than fossil fuel. The firm may then have inadequate heat for process needs. A third option, and one considered by many firms, is to install a new hog fuel boiler. Since boilers have a long operating life, installing a new boiler in *an* existing mill usually means closing down a useful one that *is* consuming oil or gas. The attractiveness of investment in boiler replacement depends on whether the cost savings, in reduced consumption of fossil fuels, can justify the capital cost and the higher operating cost of a new hogfuel boiler.

The attractiveness of increased hog fuel consumption in power boilers is, therefore, dependent upon the costs of fossil fuels that would otherwise be consumed. Table II-9–which compares the average domestic delivered prices of residual oil and natural gas in British Columbia–indicates that hog fuel conversion would be considerably more attractive for oil.consuming mills. Natural gas is, in 1980, about 40 per cent less costly on a heat-equivalent basis because the provincial government has chosen to keep domestic gas prices relatively low, even in comparison to domestic oil prices.

Investment behavior by the pulp sector supports this observation. Steady oil price increases, Since 1973, have prompted consideration of sub stituting hog fuel for residual oil. At least six of the ten coastal pulp and paper mills are planning, or have implemented, projects to displace oil with hog fuel through boiler replacement. It can be expected that these investments have been prompted by expected returns from saved fuel costs, as well as from some concern about the reliability of residual oil supply, since a portion of provincial needs are met through imports from California. These planned projects would increase current consumption of hog fuel on the Coast by roughly 1.0 million ODt and would mean that only three coastal mills have

TABLE 119
INDUSTRIAL FOSSIL FUEL PRICES
IN VANCOUVER[a]
(cents per petajoule)

Year	Natural Gas[b]	Oil[c]
1977	100.35	NA
1978	128.78	162.05
1979	128.78	210.00

Source: B.C. Energy Commission (1978) and B.C., Ministry of Economic Development (pers. comm.)

a Average price for 1977, estimates for 1978.

b Interruptable gas sales.

c Residual fuel oil, barge lots.

not moved to maximize hog fuel consumption (COFI, pers. comm.).[23]

Interior mills, burning natural gas, face less stringent economic circumstances in fuel costs and have reacted accordingly. Six mills now use hog fuel for a portion of their energy needs-a move based, in part, on a desire to dispose of wastes. Only one interior mill has announced plans to displace gas by consuming larger quantities of hog fuel, according to industry sources. The domestic price of natural *gas* is apparently too low to justify investments to replace gas-fired boilers.

In addition to the economic issues **posed** by prices of alternative fuels, there are other factors to weigh in considering conversion to wood wastes as boiler fuel. One important consideration is that hog fuel boilers are significantly larger than fossil fuel boilers of equivalent heat output. Some firms may not have space available on-site to accommodate such a boiler. Second. pollution control msts are likely to **be** higher than for natural gas because particulate control is a concern for wood fuels (see Chapter IV, Section **3.0).** Third, operating costs for hog fuel boilers are expected to **be** higher than for oil or gas boilers. All of these factors are expected to **be** relatively less important than the comparative **msts** of fuel alternatives in terms of the viability of hog fuel conversion.

Three summary observations can **be** made. In technical terms, power boilers are a direct and promising application for replacement of fossil fuel with wood energy. In economic terms. increasing oil prices make it likely that replacement of oil by wood waste boilers will proceed rapidly, even at domestic oil prices. On the other hand, relatively low domestic natural gas prices inhibit the conversion from gas to hog fuel.

b) Lime Kilns

Lime kilns provide the final requirement for process heat in kraft pulp mills. Constraints posed by accepted technology require that natural gas or fuel oil **be** used in this application. since hog fuel cannot provide sufficient heat. However, MacMillan Bloedel Ltd. is installing in experimental wood-fueled lime kiln at its Port Alberni mill, with the help of joint federal and provincial funding. Successful develop. ment of this technology would open significant new opportunities for wood energy application. since a lime kiln consumes about **7** per cent of in average mill's total energy needs.

c) Cogeneration

Remaining energy inputs of kraft mills are needed in the form of electricity. This electricity could either **be** purchased or self-generated by routing steam from the boilers through a noncondensing turbine before using it in the pulp process.[24] Because the steam is effectively **used** twice–for heat and electricity–spectacular gains can be made in energy efficiency compared to conventional electric systems. Steam cycle cogeneration, as this system is termed, uses about half the thermal input that utility-operated thermal electric plants require to produce a kilowatt of power (H.A. Simons, **1977).** The difference in efficiency is due to the need to condense steam and dissipate low-grade heat in utility operated plants, whereas surplus heat **can** be put to use in a cogeneration facility.

Electrical capacity requirements of the province's major pulp and paper mills have been estimated at roughly **740** Mw. Approximately 220 Mw of cogeneration capacity **has** been installed in provincial mills. Considerable noncondensing electricity potential remains unutilized in these mills.

A series of papers by Cox and Helliwell argues that. while substantially more electricity could be cogenerated by installing more turbines and converting to higher-pressure boilers, most firms now have no economic incentive to do *so.* Cox and Helliwell's **(1978)** calculations indicate that pulp mills could completely meet their own electric needs and become net power suppliers to the provincial grid, at costs below that of new hydroelectric generation by **B.C.** Hydro–the province's major

[23] One mill, at Tahsis, had a power boiler in place that was designed so it could be converted to wood wastes. It could, therefore, increase wood fuel consumption without boiler replacement

[24] A number of alder mills, with appropriate locations, selfgenerate their electrical energy by operating their awn hydroelectric plank. The MacMillan Bloedel plant at Powell River is an example.

utility. However, many pulp mills find it more economical to purchase, rather than to cogenerate, electricity, according to Cox and Helliwell (1978). This is because B.C. Hydro sells power to its consumers at costs below their marginal cost of electric production. Thus, while cogeneration holds potential for greater wood energy use[25], it is partially inhibited by utility pricing policies (see Chapter V).

These arguments are given credence by industry behavior. New cogeneration facilities are only being installed in areas where B.C. Hydro has difficulty meeting power demands on Vancouver Island. One mill has installed oversized boilers in order to have the capacity to increase its electricity production, if it wishes in the future; at present, the firm sees no economic incentive in greater cogeneration. and the potential is unutilized. Conversely, the forest sector in the Pacific Northwest States, which faces higher electric costs, is moving to increase its cogeneration facilities (U.S. Departmentof Energy, 1978).

In addition to utility pricing, other economic and technical factors are considerations when weighing the potential for cogeneration in the pulpsector. One point argued by Cox and Helliwell (1978) is that investment in higher-pressured power boilers by pulp mills could be economically justifiable to produce greater amounts of electricity, depending upon utility pricing policies. Higher pressures mean that more steam is available to produce more electricity for sale to the provincial grid. However, installation of a high-pressure hog fuel boiler would usually mean the company's flexibility and ease of steam operation would be impaired, since its other boilers would be at lower pressures. According to industry sources. managing steam loads would become more complex, but could be accomplished if the economic incentive to install higher-pressured boilers was strong enough (H.A. Simons, pers. comm.). Another consideration is that increased wood burning for electricity could entail higher pollution control costs.

3.2 Newsprint Mills

Energy requirements in newsprint mills are quite different than pulp mills, since the fibre is primarily loosened by mechanical rather than chemical means–either groundwood or thermomechanical processes are commonly used. An average groundwood newsprint mill consumes about 6.7 x 10^9 j of electricity and 15.5 x 10^9 j process heat for each tonne of newsprint production (British Columbia Energy Commission, 1978). Thermomechanical pulp (TMP) mills consume more energy per tonne, with a higherpercentageof electricity. All of the province's four newsprint mills are integratedwith kraft pulp mills. This proximity meansthat newsprint mills can utilize the same energy sources as their respective pulp mill. Electricity supplies are either purchased or self-generated, and process heat is available from the pulp mill steam boilers. thus, providing energy efficiencies. Newsprint mills, therefore, have no internal energy sources and, consequently. offer no added opportunities for increased wood energy use.

3.3 Wood Products

British Columbia's wood products sector is diverse–both in products and facilities. Over 700 different mills inthe province produce lumber, plywood, shakes, shingles, moldings, and particle board. This diversity makes comment (regardingenergy use) difficult, although some aggregate data is available.

Wood product output is not as energy intensive as is pulp and paper, although substantial energy is consumed by the sector. Total energy consumption in the wood products sector during 1978 was estimated at roughly 37 pj, with about 30 pi attributable to sawmill production. Historical consumption of purchased energy, shown in Table 11-10, indicates that natural gas is the primary purchased fuel. However, these data do not include consumption of wood wastes for energy in the sector. Wastes were estimated to comprise 40 per cent of the total energy needs in wood products during 1975, or more than twice the energy provided by natural gas (British Columbia Energy Commission, 1978). Hog fuel consumption occurs primarily on the Coast in larger, older mills that burn wood wastes to produce steam for cogenerated electricity and process heat required in lumber drying, although other hog fuel systems are in use.

The wide range of facilities and products in this sector prevents an overall assessment of energy

25 Increased wood energy use would occur because there is a thermal cost, or heat requirement, in cogeneration over and above the requirements for the pulp process. More heat is needed and, thus, more fuel consumed when cogenerating electricity than if only the needs for process heat are met.

TABLE II-10
CONSUMPTION OF PURCHASED ENERGY IN THE
BRITISH COLUMBIA WOOD PRODUCTS SECTOR
BY FUEL TYPE
(petajoules)

Year	RPP[a]	LPG[b]	Natural Gas	Electricity	Total
1970	3.028	.696	2.796	3.366	9.886
1971	3.292	.780	4.579	3.925	12.576
1972	4.157	.960	6.035	4.484	15.636
1973	4.030	.950	7.227	5.275	17.482
1974	3.976	1.070	6.997	5.075	17.120
1975	2.855	.586	6.143	5.054	14.638

Source: Statistics Canada, Catalogue 57-002 and 57-208, various year?

a Refined Petroleum Products

b Liquified Petroleum Gas

needs in the various process steps. Instead, the approach adopted is to diswss the major energy-consuming applications that show potential for replacement of fossil fuel by wood wastes. Primary applications are in lumber dryers and veneer dryers, which wnsume about 60 per cent of energy used in lumber and plywood manufacture. Cogeneration of electricity also shows potential for Increased biomass energy utilization.

a) **Lumber** Kilns

Lumber-drying kilns are the application with the greatest potential for using wood wastes in place of fossil fuels. Some 375 different kilns dry about 12.9 million cubic metres (5.5×10^9 fbm) of lumber in an average year throughout the province. Heat requirements for drying are estimated at 0.68 million kj per cubic metre, or on the order of 10.5×10^{12} kj yearly. Over 90 per cent of kiln-dried lumber comes from the Interior. Various kiln fuels are employed in the province, including natural gas, propane, oil, and wood waste. In turn, there are various methods for transmitting combustion heat to the kiln, including steam, hot water, direct and indirect hot gas, and others. Steam boilers are the prevalent method of utilizing hog fuel, although direct and indirect hot gas kilns are available (Levelton, 1978). Recent installations have included a Lamb Corgate direct hot gas system and a Konus Kessel hot oil system.

Wood wastes are an appealing fuel for lumber kilns because combustion of residuals reduces the need for waste disposal. Virtually all sawmills produce more wood residues than would be required to meet their energy needs. However, consensus among industry observers is that the domestic price of natural gas has made it more attractive than hog fuel utilization in areas where gas is available. Other obstacles to hog fuel utilization in sawmills include: the large size of a hog fuel boiler, if a steam system is desired; the requirement of a full-time licensed boiler tender, which raises operating wsts; and pollution control wsts for wood boiler?. Table II-11 indicates that some 16 different sawmills operated kilns that used wood waste as their primary fuel during 1979.

The potential for increased utilization of wood wastes in lumber drying is found primarily at interior mills. Many of the wastal mills are older

TABLE II-11
PRIMARY FUEL SOURCES
FOR LUMBER KILNS AT PROVINCIAL SAWMILLS

REGION	NUMBER OF KILNS				
	RPP[a]	Natural Gas	LPG[b]	Hog Fuel	Unknown
Coast	6	5	0	9	12
Interior	3	43	14	8	13
Total	9	48	14	17	25

Source: British Columbia, Ministry of Economic Deveiopment (1979b)

a Refined Petroleum Products

b Liquified Petroleum Gas

and have utilized wood wastes for some years. Greater use of wood wastes in an existing mill would generally mean replacement of existing heating systems. Thus, the attractiveness of this investment is again a function of potential cost savings afforded by reducing fossil fuel consumption. It could be expected that such investments would be more attractive for mills consuming fossil fuels other than natural gas, given the relative prices of fuels.

Industry behavior corresponds to this Obsevation. One interior mill. which formerly used butane for energy, has recently installed a wood-fueled system. Other mills that utilize residual oil, propane, or butane are considered, by provincial agencies, as candidates for conversion to wood wastes. On the other hand, no mills accessible to low-cost natural gas supplies are reported to be planning conversion to wood wastes. One new mill, now in the planning *stages,* is weighing the advantages of natural gas and wood wastes as kiln fuel (COFI, pers. comm.).

b) Veneer Kilns

Veneer-drying kilns, important in plywood production, are similar to lumber kilns in terms of fuels and technology. Plywood production in British Columbia was estimated to be the equivaient of 2.10 million cubic meters of 1 cm product in **1976.** All veneer used in plywood is dried. One source has estimated the heat requirement for drying to be roughly 0.6 million kj per 100 square metres of 0.3 cm veneer, which corresponds to an annual provincewide energy requirement of about 1.83 x 10^{12} kj for veneer drying. This energy requirement is about **one-**fifth of that needed in lumber kilns (Levelton. 1978).

Primary heat sources employed in veneer dryers are natural gas or propane for direct-fired units and steam raised in boilers (in turn, fueled with oil, gas, or hog fuel) for indirectly heated units. Only five veneer dryers now rely exclusively on natural *gas* or propane; the others all utilizing wood wastes to some degree. This information indicates the potential for increased wood energy utilization in veneer drying to be relatively small (Ministry of Economic Development, pers. comm.).

Greater use of wood wastes in veneer dryers generally raises the *same* types of issues as in lumber kilns, with one exception. Levelton indicates that veneer mills generally do not produce enough residues to fully meet their internal energy requirements. Thus, heavy reliance on wastes could require some veneer mills to purchase and transport wastes for pari of their energy needs. This could prove infeasible unless they were integrated with sawmills at the *same* location.

c) Cogeneration

Sawmills or plywood mills with steam boiler systems have opportunities to selfgenerate electricity in the same manner as pulp mills, Only limited data is available on the current extent of cogeneration in the wood products sector. It occurs primarily in older mills on the Coast that utilize wood wastes in steam boilers

Cogeneration in wood products mills confronts the same economic factors as described previously for pulp mills. Given the present prices charged for electricity, there has been a trend away from self-generation. This trend has been hastened by pollution-control guidelines that add costs to wood waste use in boilers, according to the British Columbia Energy Commission (1978). The Commission's forecasts indicate that, as electrical prices rise, the use of hog fuel for electricai generation will increase, despite pollution-control costs.

4.0 ENERGY PRICE ISSUES

The previous section illustrated the importance of the relative prices of energy resources in setting energy-consumption patterns of the forest industry. Major adjustment in the industry's fuel-consumption patterns could not be expected unless the costs of using various energy sources alter. Barring regulatory steps by government, a firm's cost in using various fuels is primarily affected by fuel prices. Thus, the forest industry will likely adjust its energy patterns primarily in response to relative fuel costs.

4.1 An Economic Basis for Energy Prices

The role of prices in affecting fuel choices of the forest sector is actually a problem of resource allocation. Economists maintain that, to obtain the best use of society's scarce resources, the price for a particular good should be equal to its marginal cost. Marginal cost has two chief components–the cost of producing an extra unit of the resource and the value of an extra unit in its alternative uses (i.e., its opportunity cost).

Prices of energy resources should, therefore, reflect the cost to society of obtaining an added amount of the resource and the cost that society bears in foregoing a valuable alternative use.[26] If energy prices were set in this manner, a number of desirable economic objectives would be achieved.

(a) Energy consumers would fully bear the social costs that stem from consumption of various resources. Consumers would have a clear financial incentive to choose the least costly, and therefore the best, energy source for a given application. Users would also have an incentive to fully weigh the benefits from investment in conservation, compared to purchasing more energy. Finally, energy prices would not present obstades to development of alternative sources such as forest biomass.

(b) Only energy uses that are more valuable than all alternative uses of that resource would be economically attractive; thus, redundant or wasteful uses would be eliminated.

(c) Public-resource owners would be fully compensated for the value of their energy resources.

(d) Users of the final products that involve energy inputs would be charged with the full value of resources required to produce their goods.

in terms of the forest sector, marginal-cost prices for energy would require firms to weigh fuel alternatives on the basis of the total cost to society of their consumption. Evaluation on this basis would fully measure the economic benefits of wood biomass in forest industry applications and lead users to consume the most appropriate quantity of wood energy, relative to other fuels.

It can be argued that current prices of energy resources are not set on the basis of these criteria. A subsequent section demonstrates that oil, natural gas, and electricity prices are priced below their apparent marginal costs. Forest industry firms confront prices that encourage them to consume relatively more of these resources and relatively less wood energy than would be the case if marginal costs were paid.

One objective of this study is to weigh the potential of biomass energy in British Columbia from

26 Social costs of energy production should, in theory, include externalities or nonmarketed costs. No attempt is made here to weigh external costs of energy alternatives such as environmental effects. These costs are considered in Chapter VI.

an economic perspective. Since relative prices are so important to the demand for wood energy, the appropriateness of current prices should be considered. What is required is to estimate the economic potential of biomass under prices that fully measure the value to society of fuel alternatives. The analysis of this chapter is, therefore, based not on current prices but on assumptions regarding the marginal costs (including production and opportunity costs) of fuel alternatives. An assessment on this basis indicates what role biomass could play in energy supply, rather than what it will play.

4.2 Price Assumptions for Energy Resources

The task at hand is to determine the marginal values of alternative fuels. In the absence of competitive markets, prices for energy resources must be inferred. As will be seen subsequently, government agenaes are chiefly responsible for setting the relative prices of energy resources in British Columbia. It would be under their auspices that changes in relative prices of energy resources could be accomplished.

a) Oil

Domestic crude oil prices are determined in Canada by federal government policy. Roughly 40 per cent of Canadian requirements are filled through imports that supply eastern Canada. Westem Canada (including British Columbia) is primarily supplied by Alberta production. To maintain regional equity, federal agencies administer one domestic oil price (considerably below import prices) throughout Canada, despite the reliance of the east on costly imported oil. A compensation scheme operated by Energy, Mines and Resources Canada provides oil importers with a subsidy to make up the difference between the domestic price and the average cost of imported oil at Toronto refineries. In early 1980, the domestic price of crude oil in British Columbia was about $103.20 per cubic metre ($16.40 per barrel) delivered to the refinery, or roughly 55 per cent of the average imported crude oil price delivered to Toronto (MEMPR, pers. comm.).[27]

Future domestic prices will reflect political judgement, although the three major political parties acknowledge the need to move domestic prices closer to import prices. This escalation is required because tax revenues are now used to subsidize import prices. Canada reportedly has the lowest domestic oil prices among western industrialized countries.

Residual fuel oil prices are relevant when considering forest industry consumption. About 30 per cent of British Columbia's *total* residual fuel oil supplies are imported, usually from California. It *seems* likely that much more than 30 per cent of the residual oil burned in pulp mills is imported because large industrial purchasers are the chief importers. When residual oil is imported, compensation payments reduce its cost to users to roughly the domestic oil price. Canadian taxpayers, thus, subsidize consumption of imported oil by British Columbia's pulp mills. Residual oil prices fluctuate on the basis of supply and demand, since it is a by-product of oil refining that must be disposed of by oil suppliers. As shown in Table II-9, spot-market prices for residual oil have risen sharply in recent years. Provincial residual oil prices have averaged roughly 85 per cent of the domestic crude oil prices (MEMPR, pers. comm.).

A number of factors point to world oil prices as the proper measure of the value of oil for this study. First, the compensation scheme means that Canadians actually pay world prices for added supply, even though they appear lower to consumers. Second, the cost of domestic production is expected to rise as high-cost frontier and oil sands production replaces conventional oil supply. Oil *sands* projects are said to be profitable only if they receive world prices for their production. Finally. oil supplies that could be displaced through the use of wood wastes would be available to reduce imports.

in 1980, there is no single world price for oil. A price of $157.25 U.S. per cubic metre ($25 per barrel) is used here as the minimum import price, although spot-market prices sometimes could exceed $250 per cubic metre. The $157.25 figure converts to about $182 per cubic metre in Canadian funds. Following the historical relationship, $157.25 Canadian should approximate average residual oil price per cubic metre. Adding a delivery charge, $163

27 **Coal is not considered here because it is not now used as an energy source in the British Columbia forest industry and because wood wastes would likely be preferred to coal by this industry in the future.**

per cubic metre (or $26 per barrel) is used as the **1980** value of residual oil delivered to forest industry mills. This price (and others derived in this section) is assumed to remain constant in relative terms in future years.[28]

b) Natural Gas

British Columbia is a major producer and exporter of natural gas. In 1979, provincial wells produced approximately 9.2 billion cubic metres of natural *gas* of which slightly over half was exported to the Pacific Northwest States.

Domestic natural gas prices are set by provincial government policy, while export prices are approved by the National Energy Board (NEB). That the province **has** chosen to keep its domestic gas prices low is illustrated by the relationship between field prices paid to producers and wholesale prices of gas sold to utilities. The provincial Petroleum Corporation, which buys all gas production, paid roughly $4.00 per hm^3 ($1.15 per mcf) to producers of "new" gas in the field in October 1979. The Corporation then sold this gas to utilities at prices ranging from $3.60 to $4.10 per hm^3, realizing losses on some sales when transmission costs are considered (B.C. Petroleum Corporation, pers. comm.).

Provincial utilities sell natural gas to their industrial consumers at rates ranging from $4.80 to $6.70 per hm^3, depending upon location and other factors. On an energy-equivalent basis, the 1980 domestic price of natural gas is roughly 55 per cent of domestic oil prices. This relationship can **be** compared to gas price?. set at about 85 per cent of domestic oil prices in Ontario and Quebec.

Export prices of natural gas are set by the NEB on an energy-equivalent basis at par with imported oil. New **rates** announced in 1980 set the export price of British Columbia gas at $15.80 per hm^3 (or $4.47 **U.S.** per mcf), which is more than four times greater than the domestic wholesale price to utilities (B.C. Petroleum Corporation, pers. comm.).

It *seems* likely that domestic gas prices will increase relative to oil, but the extent of this is unclear. In its 1978 forecast, the provincial Energy Commission assumed the price of gas would increase relative to oil, but did not specify by how much. Similarly, a 1980 provincial energy policy paper supports a reduction in the price disparity, but mentions no specific figures (British Columbia, MEMPR. **1980a).** On the other hand, gas **has** been supported in these reports as a desirable substitute for imported oil and would continue to **be** priced somewhat below oil in order to attract consumers.

It could be argued that the export price of natural gas should **be** used as a measure of its opportunity cost. This view would hold that each unit of gas saved through use of other fuels would be available for export or for future domestic consumption, depending on provincial policy. One objection is that the ability of the province to export increased quaniities of natural gas **has** been limited by lack of available distribution capacity and by lagging gas demand in the Northwest States. Some western **US.** industrial consumers have switched to residual oil in response to recent gas price increases.[29] In 1979, the province had gas available in wells that was not pumped owing to lack of domestic or export markets.

A recent decision by the National Energy Board may have changed the outlook for increased natural gas exports by British Columbia. In December 1979, the Board determined that Canada had adequate gas **reserves** to permit increased exports to the **U.S.,** *so,* increased the rate of British Columbia exports by about 1.7 million cubic metres **per day.**[30] Constraints posed by pipeline capacity can be overcome through new construction, although the elasticity of demand may curtail increased exports in the future.

On the assumption that the opportunity cost of domestic consumption is increased exports, the export price should, in theory, **be** the best measure of the value of natural gas. But considering the uncertainty regarding the potential for increased exports. that assumption may be too extreme. **A** figure

28 This highly conservative assumption is employed to avoid overstating the *case* for wood energy. The sensitivity of the findings to this assumption is discussed subsequently.

29 Vancouver *Sun,* "126 million loss looms if export *gas* price rises", September 29, 1979.

30 Vancouver Sun, "Hike in Gas Sales to U.S. Will Net B.C. $5.3 Million", December 7, 1979.

of 85 per cent of the natural gas export price is employed as the value of natural gas delivered to the mills, or \$15.90 per hm^3 (\$4.40 per mcf). This figure roughly corresponds to 85 per cent of the imported oil price. Subsequently. in Chapter V, the potential for wood energy development is assessed on the basis of a lower value for natural gas.

c) Electricity

B.C. Hydro and Power Authority-the province's major electric utility-operates a primarily hydroelectric system. Like most utilities, its prices are set on the basis of its average cost of electricity production distributed between customer classes, with uniform rates throughout the province. The utility's bulk electricity rates are approximately 1.5 cents (15 mills) per kilowatt-hour (kwh) as of April 1980. B.C. Hydro is willing to purchase power from forestry companies if they have cogeneration surpluses; it pays about 0.14 cent per kwh, slightly less than the selling price because it views cogeneration power as relatively undependable (B.C. Hydro, pers. comm.).

B.C. Hydro is contemplating a number of generation projects as alternatives to meet load growth in the 1980s and 1990s. Virtually all possibilities would entail unit generation costs higher than previous projects. Like most utilities, B.C. Hydro's low-cost generation alternatives are all developed, so it must consider higher-cost, remote hydroelectric sites or thermal coal generation for future needs. The utility finds itself charging 15 mills per kwh to new industrial customers, while planning projects with costs that range from 15 to 30 mills per kwh to meet new demands.

A study undertaken at the University of British Columbia applied the principles of marginal-cost pricing to B.C. Hydro to determine how the utility's rates and future demand would be affected (Osler. 1977). It concluded that marginal-cost prices would encourage efficiency in electrical production and in consumption. The study's simulation model estimated the average marginal cost of meeting future demands to be about 24 mills per kwh.[31]. These calculations assumed capital-cost overruns of 25 per cent on all future projects. Taking a more optimistic approach and assuming future projects can be constructed at B.C. Hydro's estimated wsts, the marginal 32 cost is roughly 20 mills per kwh in 1977 dollars.[32]

B.C. Hydro's system plan changed considerably in terms of project priorities since Osler (1977) conducted his evaluation. However, his results are reasonably consistent with internal reviews of marginal costs conducted by the utility (B.C. Hydro, pers. comm.). Consequently, an estimate of 20 mills per kwh (1977 dollars) is used to represent the average marginal cost of B.C. Hydro's electrical production. Updated to 1980 dollars, the cost is roughly 26 mills per kwh. Cogenerated electrical production by the forest industry is valued at that level, whether it is consumed within the plants as a substitute for purchased electricity or is surplus available for sale to B.C. Hydro.

d) Wood Biomass

If it is argued that the marginal costs of conventional fuels are higher than current prices, one should further consider that the estimated costs of obtaining wood biomass are too low. To the extent that oil and gas wsts are underestimated, so, too, would be energy costs in biomass harvest. [33]

For wood wastes, the total cost of wood hardest and transport to sawmills is paid by pulp and

31 Electrical production is actually measured and sold in two ways-in terms of capacity, or peak requirements, and in terms of energy, or average requirements. B.C. Hydro operates a predominantly hydroelectric system that has substantial amounts of peaking capacity available at any give time, if it chooses to release stored water through its extra turbines. The B>C. Hydro system is, therefore, energy critical, rather than capacity critical. Charges to users should, thus, weigh more heavily on average energy consumption than on peak requirements. The cost figures of Osler (1977) add together both energy and capacity charges.

32 This approach follows Cox and Helliwell (1978).

33 It was previously asserted that energy uses could not outbid the forest industry for wood supplies. Only biomass supplies with no alternative use are considered here as available for energy production. That being the case, opportunity costs of energy biomass are zero.

lumber consumers. One could expect that, if oil and gas were priced at their marginal wsts, the prices of pulp and lumber might increase, but the cost of wood **wastes** available for energy would continue to be calculated as zero. Therefore, the only effect upon mill residues would be transport wsts. Statistics Canada **(1977)** data shows that energy costs comprise about 20 per cent of total **costs** in truck transport. One can assume that these wsts are all for petroleum products that are **50** per cent undervalued at current prices. Then, the marginal cost of wood wastes would be 20 per cent above current transport costs.

For forest residues and noncommercial spedes, both harvest costs and transport costs would be underestimated. Statistics Canada **(1977)** data for logging shows energy costs to comprise less than **10** per cent of total logging costs. Allowing for the undervalued energy cost in transport and for the undervalued petroleum prices, as previously estimated, marginal costs of biomassfrom forest residues and noncommercial species should be no more than **10** percent greaterthan current costs.

These adjustmentswould mean that the average wst of wood **wastes** delivered to mills would be between $6 and **$7** per ODt, assuming the short hauls now prevalent for Interior hog fuel transport. The average costs of biomass from forest residues would rise to about **$70** per ODt, while underexploited **species** could be available at roughly **$50** per **ODt,** assuming a 50-mile haul.

5.0 POTENTIAL DEMANDS FOR BIOMASS ENERGY

5.1 Overview

If alternative fuels were priced on the basis of their marginal **costs,** the demand for energy from forest biomass would grow rapidly in British Columbia. In the near term, forest industry firms would attempt to minimize their fuel costs through increasing reliance on wood fuels. Over the longer term, conversion of forest biomass to other energy forms could prove economically feasible, particularly for electrical generation and transportation fuels.

The purpose of this section is to evaluate these potential demands for biomass energy. The approach followed is to postulate that, in response to increases in energy prices argued in Section 4.0, energy users would act as rational economic units by seeking the lowest-cost fuel alternative. Nothing except direct cost and availability of fuels is considered. Institutional or other nonmarket barriers to wood energy use are addressed subsequently in Chapter VI.

Conclusions drawn previously regarding the characteristics of biomass sources are helpful to indicate priorities for their energy use. First, mill residues are available at minimal cost, in contrast to the considerable extraction costs associated with other biomass sources. This cost advantage means that mill wastes would receive primary attention for energy applications and would be fully utilized before consumers turned to higher-cost wood sources. Second, transport costs for wood fuels are relatively high, sup gesting that local applications would be most attractive. Third, because of moisture content, wood biomass has a relatively low fuel efficiency, with only **50** to 60 per cent of the potential energy actually obtained through combustion. This energy "penalty" suggests that forest biomass could best competewith other energy sources when applied in contexts where high energy efficiencies are obtained.

The following assessment of biomass potential is divided into two time periods. The near term extends through **1985** and is concernedwith applications that have immediate potential. The longerterm extends through **1995** and includes applications that require a more lengthy lead time.

5.2 Near-Term Potential

During the period to **1985,** the forest industry would provide the primary opportunities for increased use of wood biomass **fuel.**[34] The Mitre

34 Rapid increases in domestic energy prices would also encourage greater use of wood biomassfor home heating. Present empirical knowledge of domestic wood heating is minimal in Canada. A greater role for wood energy in the home would raise a few of the same issues implicit in other usesdue to its more decentralized Scale and lack of institutional involvement. Consequently, home heating is not considered further here, even though it has wide potential for growth and few apparent obstacles, other than effects on air quality. It should be noted that expanded domestic use of wood for heat could reducethe supply of readily accessibleforest residues

Corporation (1978) points out that forest sectors have the characteristics needed for successful substitution of wood fuels for conventional ones, including:

a significant energy requirement that is threatened by increasing oil and gas prices;

access to supplies of an alternative fuel large enough to contribute significantly to filling its energy demand; and

technological expertise and equipment required to convert the fuel to usable energy forms.

Increases in energy prices would precipitate major efforts by forest industry firms to reduce energy purchases. Initial moves would likely involve energy conservation through steps such as better 'management of Steam loads, reduced heat loss, and improved operating procedures. Beyond energy conservation. firms would consider the returns on investment in systems that substitute low-cost fuels in place of higher-cost fuels. Greater use of mill wastes by pulp mills and sawmills would be the likely result.

Greater quantities of wood biomass could potentially be utilized in three ways by the forest industry–direct combustion, conversion to gas for combustion, or cogeneration. These three demands are considered below, first for the pulp sector and then for wood products.

a) Pulp and Paper Mills

Direct Combustion

At least three studies have weighed the potential demand for wood as fuel for power boilers by the pulp and paper sector (British Columbia, Ministry of Economic Development, 1979a; Cox and Helliwell, 1978; British Columbia Energy Commission, 1978). These assessments have all adopted somewhat different approaches and price assumptions. Nevertheless, their conclusions all point to greater use of wood wastes as boiler fuel in the sector, depending on prices of alternative fuels and other factors.

The analytical approach adopted here models the decision confronting a firm with efficiently operating power boilers in place and facing substantial increases in fossil fuel costs. The firm could reduce its consumption of fossil fuel to roughly 15 per cent of fuel needs by installing a specially-designed hog fuel boiler. This investment would be economically attractive if the fuel-cost savings implicit in burning wood wastes provided an acceptable rate of return on the expenditures required for conversion. By employing estimates of the capital wsts of boiler replacement and assumptions regarding fuel costs. it is possible to determine the economic viability of hog fuel utilization from both the firm's and public's viewpoint.

Results presented in Table 11-12 summarize the calculations, which are more fully explained in Appendix I. Results are shown on the basis of a 5-year financial life, a 25-year financial life, and net present value. The 5-year financial period corresponds to the investment criterion generally employed by the forest industry. The 25-year period and the net present value calculations are criteria used to assess the economic viability over the full life of the investment, which are more appropriate measures from the public's viewpoint. The data shows that all but three mills would obtain returns on investment over 10 per cent, even at a 5-year payback period and ignoring subsequent benefits. Taking a longer perspective, all investments would have a positive net present value, and ail but one have a return on investment exceeding 20 per cent with a 25-year financial life. It should be noted that these assessments were calculated on the basis of a **$7** per **ODt** transport charge as the cost of hog fuel and with relative prices of energy alternatives assumed constant at the levels outlined in Section 4.0. If the prices of fossil fuels were assumed to increase in real terms in the future, the returns would be proportionately higher.[35] The results also show the maximum long-run prices companies would be willing to pay for wood wastes and still receive a 10 per cent return over the life of the investment.

Because the approach here is to view fuel choices as a problem in using society's scarce resources efficiently, it is preferable to evaluate these conversion projects over their full economic life. Thus, the present value criteria, along with the return on investment over 25 years. are the better measures

35 **A 5 per cent relative annual increase in the price of fossil fuels would increase the percentage return of these investments by an average of 6.5 per cent over a 5-year financial life.**

TABLE 11-12
ECONOMIC RETURNS FROM INVESTMENT IN HOG FUEL BOILERS AT MAJOR BRITISH COLUMBIA PULP AND PAPER MILLS[a]
(Number of Mills)

AFTER-TAX RETURN ON INVESTMENT

Return	5-Year Financial Life	25-Year Financial Life
0 - 10%	3	--
10.20%	5	1
20.30%	5	7
30 - 40%	1	5
above 40%	5	6

NET PRESENT VALUE

Return	Mills
$ 0 - $20 million	1
$20.540 miiiion	7
$40. 560 million	5
$60- 580 million	1
above $80 million	5

MAXIMUM PRICE FOR HOG FUEL

$ 0 - $ 5	0
$ 5 - $10	1
$10 - $15	13
$15 - $20	5
above 520	0

Source: McDaniels Research Limited

[a] See Appendix I for information regarding data and methodology.

of the economic viability of these investments. On that basis, it is concluded that virtually all pulp mills would have an economic incentive to invest in new hog fuel boilers that would allow them to substitute wood wastes for fossil fuels. Conversion of provincial mills to hog fuel boilers is included as a potential use of wood energy over the near term, as summarized later in Table 11-16. Total conversion of boilers would inaease wood waste consumption by approximately 3.1 million ODt yearly beyond the present consumption, which is estimated at 2.4 million ODt (Reid, Collins, 1978a and 1978b).

Beyond utilizing wood wastes in power boilers for 85 per cent of heat requirements, two emerging technologies could further reduce the fossil fuel requirements of pulp mills to nearly zero–hog fuel dryers and hog-fueled lime kilns.

If hog fuel was consistently dry and pulverized, it would be unnecessary to use any fossil fuels in some types of hog fuel boilers. At present, a small proportion of fossil fuel is required in all hog fuel boilers to maintain even burning, especially in winter when wastes are wet. Levelton (1978) indicates that dryers that utilize wood wastes for heat are commercially available to improve the quality of hog fuel for boiler needs. Two coastal pulp mills are planning to install hog fuel dryers, which will eliminate requirements for fossil fuel in the boilers. The planned installations would use boiler exhaust gases to dry wood wastes. Consequently, no extra fuel consumption would be required to provide heat for drying. Further information on the *costs* and benefits of hog fuel dryers is not available, although industry consultants view hog fuel dryers as a cost-effective way to further reduce fossil fuel consumption, even at current energy prices (H.A. Simons, pers. comm.).

Lime kilns directly fueled by wood wastes may be possible in the future, although they are not technically operable now. Because of high temperature requirements, supplies of dried, pulverized wood wastes would likely be needed. Develop ment, in conjunction with hog fuel dryers, may therefore be necessary. An experimental wood-fueled lime kiln, employing a Lamb-Cargate wet cell burner, is being installed at MacMillan Bloedel's Port Alberni mill (British Columbia, MEMPR, 1981).

Complete adoption of hogfuel dryers–to augment use of wastes in boilers and allow waste consumption in lime kilns–would increasetotal wood energy utilization in pulp mills. The potential increase is roughly 15 per cent over the basic requirement in boilers. Given the favorable outlook for hog fuel dryers. this level of consumption is viewed as a potentially viable use of wood energy and is included in Table 11-16.

Gasification

The basic process of converting wood wastes or other organic material into low energy gas (producer gas) has long been recognized. During the first half of this century, a few plants (converting wood wastes to producer gas) operated sporadically in North America. Low-cost natural gas eventually curtailed their activities (Tillman, 1978). Rising gas prices have restored interest in these processes and, at present, there are a number of gasification systems under development.

Wood gasification appears to be best suited for small-scale, local applications, since producer gas cannot be stored effectively and its low energy content makes transport expensive. It could probably be substituted for natural gas in most applications, although the two cannot be mixed indiscriminately because of different burning characteristics.

Some studies optimistically view wood gasification as a commercially available and economically viable technology–for example, the Mitre Corporation (1978) has estimated the cost of wood gas to range from about $2.57 to $3.62 per million kj, depending on plant size, if the costs of wood feedstock is $16 per ODt. These prices would make wood gas economically preferable to natural gas valued at its marginal cost. However, B.H. Levelton's (1978) evaluation of wood energy conversion technology concluded that none of the gasification systems they reviewed was a proven technology. Wood gasification status as an emerging technology can be *seen* in the ENFOR program's support of three different gasifier development projects.

Even if gasification systems are success fully developed, they have only moderate scope in pulp mills. Potential applications in power boilers would be in the same units already identified as candidates for conversion to hog fuel. A mill converting to hog fuel over the next 'few years would have no incentive to later install gasification systems. Lime kilns and overfiring of hog fuel boilers are possible applications of wood gas–for example, the experimental wood-fueled lime kiln at MacMillan Bloedel's Port Alberni plant utilizes a gasifier section. Direct use of wood wastes in these applications has already been considered. Given the capital costs and energy losses associated with wood gasification, direct combustion may be preferable in applications where both would be technically possible.

If successful development of wood gasification occurs, it would likely not expand wood energy use in pulp mills far beyond that already identified for direct wood combustion. Certain plants could select gasification systems in place of direct burning, particularly in lime kilns. However, the total wood energy consumption would not change greatly.

Cogeneration[36]

Cogeneration of electricity is the final application with potential for increased wood energy in the pulp and paper sector. Technically, the quantity of electricity produced by pulp mills in British Columbia could more than double. The real question is the economic attractiveness of this generation.

Investment in further cogeneration facilities can be analyzed in the same manner as boiler conversion-comparing after-tax costs to the benefits from replacement of purchased energy. The view- point is that of a firm that has already decided to install a new hog fuel boiler and is considering investment in a high-pressure one in order to generate the maximum amount of electricity. The extra costs for a higher-pressure boiler and new turbogenerators are compared to returns from electrical generation valued at 26 mills per kwh.

Results are summarized in Table II-13 and are more fully explained in Appendix I. It is assumed that returns over the life of the investment and the net present value are appropriate measures of the social value of these projects. The data shows that all mills but two would receive an after-tax return above 10 per cent over 25 years; similarly, all but two have a positive net present value.

It is concluded that investment in cogeneration facilities could be an economically viable use of wood wastes at 17 pulp mills and is incorporated in Table II-16 as a near-term potential use. These investments would produce roughly 1.6×10^9 kwh of electrical energy and consume about 1.4 million ODt of wood wastes yearly. [37]

b) Wood Products

Direct Combustion

An assessment of biomass energy potential in the wood products sector is complicated by the number and variety of kiln-drying installations in the province. Analysis on the basis of individual mills is impractical, even though it is recognized that site- specific factors are particularly important for wood energy applications for this sector. The only approach is to consider the sawmill sector and plywood sector in aggregate, pointing out the forces that would affect wood wastes use in drying applications.

It should be recognized that, ever at the comparatively low energy prices of the 1970s, a number of sawmills found it advantageous to use hog fuel for lumber drying. Energy prices set on the basis of marginal costs would certainly expand this use of wood wastes. According to the Ministry of Economic Development, potential expansion of wood-fueled drying is largely in the Interior as a substitute for natural gas and propane. Larger mills are more likely candidates for conversion, since smaller mills may not be able to finance the capital costs or accommodate the higher pollution-control costs and operating costs of hog fuel dryers. Complete information on the cost and benefits of wood- fueled lumber dryers is not available.

A rough estimate of the potential for wood energy use in sawmills can be derived from

[36] Strictly speaking, "cogeneration" is not a use of wood fuel but rather a term describing how heat energy is used. Fossil fuel could also be used for this purpose. However, given the current structure of electrical and fuel costs, wood fuel is the only viable energy source for cogeneration.

[37] In a recent energy supply review, the provincial government estimated the potential for new cogeneration in the forest industry to be 2.1 billion kwh, excluding projects now underway (British Columbia, 1980).

TABLE 11-13
ECONOMIC RETURNS FROM INVESTMENT
IN A HIGH-PRESSURE BOILER AND TURBOGENERATOR
AT MAJOR BRITISH COLUMBIA PULP AND PAPER MILLS[a]
(Numberof Mills)

AFTER-TAX RETURN ON INVESTMENT

Return	5-Year Financial Life	25-Year Financial Life
Negative	7	0
0 - 10%	11	2
10 - 20%	0	11
20.30%	0	6
30.40%	0	0
above 40%	0	0

NET PRESENT VALUE

Return	Mills
Negative	2
$ 0-$10 million	2
$10 - $20 million	6
$20. 530 million	5
$30- $40 million	1
above540 million	3

MAXIMUM PRICE FOR HOG FUEL

$/ODt	Mills
Negative	2
$ 0-$ 5	1
$ $5-$10	7
$10-$15	7
$15 - $20	2
above $20	0

Source: McDaniels Research Limited

[a] See Appendix I for information regardingdata and methodology.

aqgregate data. Table II-1 1 previously summarized the number of mills in the province operating drying kilns by fuel type. It is arbitrarily assumed that kiln-equipped sawmills not now using wood wastes–with annual production capacity over 120,000 cubic metres–would be the best candidates for conversion.[38] This category includes about 50 sawmills; of these, it is further assumed that 60 per cent would find it economically viable to convert to wood wastes for kiln fuel, particularly if returns were considered over the operating iile of the equipment.

Thirty kiln-equipped mills, with a total annual production capacity of about 7.6 million cubic metres[39], are assumed as representative of the potential for new wood energy use in lumber drying. Assuming 0.68 million kj are required to dry one cubic metre, the new demand for drying would be roughly 5.1 x 10^{12} kj, or the equivalent of 330,000 ODt yearly. This is in addition to the current consumption estimated at 1.67 million ODt in the whole wood products sector (Reid, Collins and Associates Ltd., 1978a and 1978b).

Beyond the use of wood energy for drying, there are a number of other applications in which process heat–particularly steam-can be employed in sawmills. Aside from cogeneration, these include space heating. log conditioning. general drying, and others. There is no data to estimate the current or potential use of wood energy in these applications, although. according to the British Columbia Energy Commission, consumption of wood for these assorted purposes could be surprisingly high. A figure of 10 per cent of the estimated requiremerits for wood biomass energy in lumber drying is assumed to represent the additional requirement for wood energy in general sawmill applications. These estimatesare included in Table 11.16.

Veneer dryers were previously mentioned as holding small potential for further use of wood wastes. Moreover, veneer mills may require additional hog fuel supplies, beyond their own production, to fully utilize wood energy for drying. Consequently, no quantitative assessment of potential use in veneer dryers is made.

Gasification

Two factors make wood gasification an interesting technology for lumber dryers. Sawmills have a ready supply of wood wastes, and wood gas could be directly used in natural gas dryers with little alteration of burners. This interest is evident in the prototype wood gasifier that has been installed at a sawmill in Chasm, B.C.

For the purpose at hand, however, wood gasification is only of moderate importance. If the technology was successfully developed, it would be most appealing to larger sawmills that could afford the initial capital cost and also capture the scale economies of wood gas production. These are the same group of mills that were previously identified as candidates for use of combusted wood energy in lumber drying through steam systems or direct heating. Availability of wood gasification systems would mean that some firms might select gasification over direct wood use. depending on relative costs. However, the total use of wood energy for lumber drying would likely expand only to a modest degree. A figure of 10 per cent of the potential direct energy use of wood wastes in kiln dryers is assumed to be representative of the net increase in wood energy use attributable to future development of gasifiers for sawmills.

Cogeneration

Cogeneration in wood products could be expanded in situations where a firm uses boilers to mise stem for kiln drying. According to the British Columbia Energy Commission (1978). cogeneration in the wood products sector can be expected to increase after electricity prices rise to the point where costs of pollution control for hog fuel boilers can be recovered. With the prices of natural gas and electricity posed in this analysis, firms contemplating replacement of gas burners in lumber kilns could

38 The smallest sawmill now using hog fuel for drying has an annual production capacity of roughly 110,000 cubic metres. Ministry of Economic Development, unpublished data, is the source of information on the number and capacity of dryers in this section,

39 Calculated as 60 per cent of the total production of kilnequipped mills above 120,000 cubic metres capacity not now using wood wastes for energy.

opt for a **steam** system based on hog fuel, which would permit greater self-generation of electricity. It can be argued that the economic attractiveness of cogeneration in the pulp sector, as shown in Table 11.13, would **suggest** that **some** mills producing steam would find it profitable to self-generate more electricity.

Only limited data is available from the Council of Forest Industries or the provincial Ministry of Energy, Mines and Petroleum Resources regarding current cogeneration in wood products. Further, there appears to be no way to evaluate the potential expansion or the economic returns from new cogeneration facilities. This is particularly true because one cannot predict the extent to which new wood-fueled lumber kilns would utilize a steam system instead of direct firing or gasification.

Potential consumption of wood for electrical cogeneration is arbitrarily assumed to be 20 per cent of the potential wood energy requirement for direct combustion in lumber drying. This figure, assumed to be the additional wood consumption for Cogeneration, is less than 5 per cent of the estimated wood requirement for new cogeneration in pulp mills.

5.3 Longer-Term Potential

Over the period to 1995, potential applications of forest biomass energy could expand beyond uses in forest industry to include conversion to other energy forms. Electrical generation and liquid fuels are the **two** uses with significant long-term potential, as discussed in subsequent sections.

a) Electrical Generation

Thermal electric plants fueled with wood biomass are technically straightforward, using a steam cycle much like coal- or oil-fired plants. A number of wood-fueled electric facilities are under consideration in North America. Wood-fueled plants have two main characteristics that set them apart from fossil-fueled thermal generation.

> Because wood biomass is bulky and relatively expensive to transport. the distance over which fuels can be carried is limited. As Tillman (1978) observes, these transport costs constrain the maximum fuel supply of a power plant. Wood-fueled power plants must, therefore, be much smaller in scale than conventional thermal plants. Tiliman indicates that wood. fueled plants could not exceed 150 Mw (megawatts), in comparison *to* a minimum optimal scale of pehaps **1000** Mw for coal plants.
>
> Wood-fueled power plants must be located near their fuel sources, which are normally forest industry conversion centres. This proximity means that there may be thermal applications for the plant's steam after it has passed through the turbines, such as district heating or in the industry's process-heat requirements. In other words, cogeneration of electricity and heat is possible, raising the thermal efficiency and economic viability *of* the plant.

Electricity generated from forest biomass can be expected to have other advantages over coal-fired thermal facilities. If mill residues are burned, fuel costs will be considerably lower. Air emissions can be more easily controlled, since removal of particulates in wood smoke is less costly than sulphur removal from coal-stack gases. Finally. environmental benefits would be obtained from wood waste disposal, while coal mining could entail environmental costs. The major disadvantage of wood-fueled plants is that their small size would not provide the considerable economies of scale obtained from larger thermal facilities.

A recent study by H.A. Simons (International) Ltd. (1978) has assessed the cost and feasibility *of* a wood-fueled cogenerating 50 Mw power plant at Quesnel, British Columbia. After comparison of different scales, boiler pressures, locations, and cogeneration options, the study concluded that the most attractive plan was a 50 Mw plant producing electricity for the provincial grid and Steam for use in kiln drying at six nearby sawmills. It was assumed that the six firms would be willing to purchase the steam at a price equivalent to the cost of natural gas they would otherwise consume in their kiln dryers. The plant was scaled to consume 350,000 **ODt** of hog fuel yearly. an amount equal to the projected surplus hog fuel production in the vicinity.[40] Fuel

40 **According to B.C. Hydro, the thermomechanical pulp mill, now under construction at Quesnel, would not adversely affect hog fuel supplies.**

was assumed to be available at zero cost, other than allowances for transport and "hogging".

Based on these assumptions, the study indicated the preferable pian would entail generation costs of about 13.5 mills (1.35 cents) per **kwh** afler the revenue from steam sales was considered. A natural gas price of $6.20 per cubic metre–as prevailed during 1978 in that area-was used to measure the value of gas consumption saved because of steam-kiin heating.

Naturally, the expected revenue from gas replacement is sensitive to natural gas prices. If the higher natural gas prices (assumed as appropriate in this study **[$15.90 hm^3]**) were employed in the analysis, the value of revenue from steam sales–that is, value of gas replacement–would more than double. This revenue credit against project costs would effectively reduce the cost of electrical generation to about 10-11 mills per kwh.

B.C. Hydro has commissioned more detailed engineering studies of the Quesnel plant and is considering it as a possible alternative for future development.[41] The utility now has two hydroelectric dams under construction and another planned hydroelectric project ready for licence hearings. After these projects are in action. new electrical generation could **be** required in the late 1980s or early **1990s.** depending on load growth.

Comparative financial costs and environmental wsts are the factors considered when the utility selects the best project from its potential developments. Interviews with B.C. Hydro indicate that. at 10-11 mills per kwh, the Quesnel thermal hog fuel plant has financial costs below other projects. More over, the Quesnel plant would provide significant environmental benefits in terms of waste disposal. While the utility's other alternatives ail pose significant environmental costs, it is important to bear in mind the scale of the Quesnel plant. It would provide only 50 Mw of capacity in comparison to the potential 2,000 Mw coal-fired plant at Hat Creek. However, the small size of the plant is not as significant as the fact that its costs are likely to **be** competitive with other alternatives, if marginal cost prices are used to measure the value of gas savings.

Other small-scale hog fuel-fired electric plants could also **be** feasible, particularly if they exhibited the **same** combination of cogeneration potential and abundant low-cost fuel. Vancouver Island is, at first glance, an appealing location, since the cost of providing new power there is very high as a result of transmission costs from the Mainland. However, the lack of surplus hog fuel supplies on the Island would iikeiy require that a biomass-fueled plant depend on forest residues and noncommercial **species** of energy. P.H. Jones and Associates ltd. (1979) assessed the potential for such a plant on Vancouver Island. Based on capital costs estimated from the previously-mentioned Simons (1978) study, Jones concluded that a 50 Mw plant would involve capital, and fuel-supply, costs of approximately 37 mills per kwh. This figure is high in comparison to B.C. Hydro's other alternatives on Vancouver Island. The increase in costs of a Vancouver Island plant over the Quesnel site is due to the cost of fuel supply (about 20 mills per kwh) and a lack of revenue from sale of steam. This comparison shows that low-cost wood supply and applications for steam heating are critical in making wood-fueled electric power viable in British Columbia.

It is concluded that a 50 Mw hog fuel-fired thermal electric and steam plant at Quesnel is a potentially viable long-term application of forest energy. No other plants of this nature are included as subsequent developments. Although other sites with the prerequisites of low-cost fuel and uses for steam may **be** available, they have not been identified in feasibility assessments.

b) Liquid Fuels

Using available technology, forest biomass can provide the hydrocarbon building blocks for conversion to an array of energy and chemical commodities. Among the most attractive candidates for biomass conversion processes are liquid transportation fuels, which comprise the bulk of Canadian petroleum demands. A recent study by Intergroup

41 **Preliminary results from the detailed engineering Studies indicate costs of roughly 22 mills per kwh. Even at that level, the plant has *costs* comparable to other B.C. Hydro alternatives, if the value of gas savings is calculated on a marginal-cost basis.**

Consulting Economists Ltd. (1978) assessed the feasibility of producing liquid fuels from renewable resources in Canada. Its findings show that alcohol fuels. particularly methanol, are the most versatile, economically attractive, and technically operable option for conversion of renewable resources into liquid fuels.[42] The study also pointed to a strong potential for methanol production in British Columbia, using wood biomass and natural gas as feedstocks.

Technology and Economic Potential

Methanol is a hydrocarbon liquid with a variety of potential fuel uses-as a blend with gasoline for direct use in conventional automobiles, as a "dual fuel" with diesel fuel[43], as a primary fuel in specially designed vehicles, and as a substitute for middle distillates such as homeheating oil, in retrofitted furnaces[44]. At present, methanol is produced exclusively from natural gas feedstock.

Production of methanol from biomass resources requires that the feedstock be first con. verted to synthesis gas with medium energy content. The gas would next be modified so that it is similar to natural gas, and then synthesized in methanol. The Intergroup report argued that a workable oxygen-fed gasifier producing synthesis gas from biomass could readily be adapted from existing pilot units. It, therefore, anticipated no technological difficulties in methanol production. Their assessment indicated that a methane-hybrid process using large quantities of natural, gas, as well as biomass for feedstock. is the most economical conversion path, until the price of oil exceeds $156 to $189 per cubic metre ($25 to $30 per barrel).[45]

Market values for methanol depend upon oil prices and government tax regimes, since it is a substitute for refined oil products. A weighted average market value of about $0.154 per litre at the production site was estimated for methanol, assuming a $25 per barrel oil price.[46] The most valuable application of methanol would be in gasoline-alcohol blends, where market values would exceed $0.20 per litre at that oil price.

Costs of producing methanol in the methane-hybrid process are expected to be sensitive to feedstock costs and scale of production. Since this process utilizes natural gas as the primary feedstock with biomass as a supplement, its price has the largest effect on production costs. Economic effects of increasing biomass supply costs are, however, more interesting for our purposes. Table 11-14 indicates estimated production costs for plants with annual capacity of 414 million iitres (1,000 tonnes per day)

42 Technological barriers have until recently, inhibited the production for ethanol from wood biomass. New findings indicate that this process may well be viable, which would be a major boost for alcohol fuel applications (G.R. Gregory, pers comm.).

43 This source (Intergroup, 1978) notes that transportation fuels are a particularly attractive application for biomass conversion because of premium prices charged, which now place gasoline at more than twice the price Of an equivalent volume of crude oil, and because substitutes for liquid fuels are difficult to obtain. "Gasohol" blends now available in the United States contain 10 per cent ethanol for direct use in today's automobiles. The "dual fuel" concept for diesel applications is distinct from a blend in that the two fuels remain separate in the fuel tank. The engine would use Only diesel fuel for certain operations such as starting or idling: at other times, the engine would consume an effective "blend" of the two fuels. Modifications required for this methanol use are expected to be minor enough to justify adapting existing machines, particularly for commercial applications. Used in this manner, methanol could comprise over 40 per cent of one dual.

44 Other uses for methanol could include turbine fuel, boiler fuel, and fuel cells (Love and Overend, 19781.

46 The $25 figure was derived, assuming the cost of gas was set at 83 per cent of oil on an energy content basis. Lower pricing of gas. relative to oil. would mean the methane-hybrid process is the most attractive approach at even higher ail prices.

46 Also, assuming oil prices grow by $1 per year after 1977 and a "case 2 scenario" in which methanol is taxed on the basis of "input Btu" equivalence to diesel fuel (Intergroup, 19781.

TABLE 11-14
COSTS OF METHANE-HYBRID PLANT METHANOL-
(cents per gallon)

Biomass Feedstock Cost (per ODt)		
	414 million LPY	1.24 billion LPY
510	50	45
30	53	48
50	56	51
70	59	54
80	62	57

Source: Adapted from Intergroup Consulting Economists Ltd. (1978)

Assumes gas priced at **83 per cent** of oil. **at $157.25 per cubic metre.**

TABLE 11-15
COSTS OF SIMPLE GASIFICATION PLANT
(cents per gallon)

Feedstock Costs (per ODT)	Plant Scale	
	414 million LPY	1.24 billion LPY
$10	48.1	39.1
30	66.3	57.3
50	84.5	75.5
70	102.7	93.7

Source: Adapted from Intergroup Consulting Economists Ltd. (1978)

and 1.24 billion litres (3000 tonnes per day). These costs were calculated by Intergroup (1978) with an allowance for a 10 per cent real rate of return on investment over a 20-year plant life. Comparison of these production costs with the market values noted earlier indicates that methane-hybrid methanol production could be economically viable with forest biomass supply costs of $80 per ODt or even higher.[47]

Feedstock requirements for a 414 million LPY plant using the methane-hybrid process are about 138,000 ODt of wood biomass and 8.37 bcf of natural gas per year. The 1.24 billion LPY plant requirements are three times greater.

Two other routes outlined for methanol production from biomass are the simple gasification and hydrogen-hybrid process. Simple gasification is based on conversion of biomass feedstocks only. Consequently, about six times more forest biomass per tonne of methanol is required than for the methane-hybrid process. Costs of wood supply are, therefore, extremely important in the simple gasification process. The hydrogen-hybrid process requires large amounts of electricity along with biomass and is viewed as a more long-term alternative than either of the other choices.

The Intergroup (1978) study indicates that, if natural gas prices are set at 83 per cent parity with an oil price of $157.25 per cubic metre, the methane-hybrid process has lower costs than simple gasification in cases where wood costs exceed about $15 ODt. Moreover, the much lower biomass requirements per unit of output indicate that the methane-hybrid alternative is more likely than simple gasification to capture scale economies associated with largescale production. According to Intergroup's work, the methane-hybrid process is the most viable for methanol production from biomass during the period under consideration.

Other observers have not been so optimistic regarding methanol from wood biomass. A report undertaken for the Ontario government concluded that conversion of wood and solid waste into methanol was not economically justifiable. It recommended against any demonstration programs for liquid fuels from waste?.. Federal agencies are reportedly taking a cautious view of the potential for methanol from biomass by continuing research, yet not making commitments to largescale development. Factors mentioned as impeding methanol development are the current lack of substantial retail markets and the possibility that synthesis gas may be more economically attractive for wood conversion than methanol.[48]

It should be recognized that the Ontario methanol study and the Intergroup report are not strictly comparable. The Ontario report considered the potential for methanol production with wood and solid waste as the sole feedstocks. The methane-hybrid process advocated by Intergroup employs natural gas as the primary feedstock supplemented with biomass. Previous tables indicated that the methane-hybrid process is more economically attractive. Moreover, a combination of natural gas and wood as feedstocks appears well suited to methane production in British Columbia. given the abundance of these fuels.

The growing role of methanol as a liquid fuel can be seen in the production increases expected in coming years. Recent forecasts predict world methanol production capacity to increase by 72.94 billion litres per day by 1990. In Canada, a major facility is planned for Red Deer, Alberta. by Alberta Gas Chemicals Ltd., and one methanol plant is under construction at Kitimat, British Columbia. it is notable that the methanol facilities in Westem Canada would employ natural gas as the only feedstock. According to the Ministry of Energy, Mines and Petroleum Resources, no methanol facilities-based on biomass feedstock–are in commercial operation anywhere in the world.

Despite these factors, oil price increases make the potential for methanol production from

47 It should be recognized that these calculations assume the investor is willing to use all economic rents available in conversion of gas to methanol in order to buy wood feedstocks. In other words, they assume an objective to maximize payments for wood, while only requiring a minimum rate of return on investment for the whole operation.

48 Canadian Renewable Energy News, "Ottawa still hesitant about potential of methanol.., November 1979, p. 10, citing officials of Environment Canada and Energy, Mines and Resources Canada.

biomass in British Columbia reasonably good. The commitment of the United States to encourage production of alcohol fuels from biomass should open markets for alcohols in gasoline blends and should spur interest in Canada. The US. alcohol fuel program is expected to emphasize ethanol from agricultural wastes; however, methanol would be more feasible in British Columbia because of the abundance of natural gas and wood biomass sources. Based on the Intergroup (1978) work, there is a potential for viable methanol bioconversion in British Columbia.

Potential Demand

Intergroup (1978) provided estimates of the maximum potential demand for methanol in British Columbia on the basis of National Energy Board forecasts of regional liquid fuel energy requirements in 1995 and on assumed penetration rates for methanol into these markets. This data shows that, in 1995, potential methanol demand could range from 0.81 billion litres yearly (if methanol penetrates only the market for gasoline blends) to 5.8 billion litres yearly (if methanol penetrates the gasoline, diesel fuel, and middle distillate markets).

Methanol consumption in gasoline blends of 0.81 billion litres yearly would displace roughly 540,000 cubic metres of gasoline yearly. That figure can be compared with a forecast of total motor fuel gasoline consumption of about 3.8 million cubic metres in British Columbia during 1992.[49] Assuming constant gasoline consumption between 1992 and 1995, the Intergroup estimate would see methanol acquiring roughly 14 per cent of the gasoline market by 1995.

Considering further penetration into gasoline, diesel, and middle distillate markets, Intergroup's maximum figure of 5.85 billion iitres of methanol yearly would displace roughly 3.4 million cubic metres of refined petroleum products annually by 1995. This can be compared to the Energy Commission's estimate of 12.08 million cubic metres as total provincial demand for refined petroleum products in 1992. Assuming a 1 per cent annual increase in consumption of petroleum products between 1992 and 1995, the highest Intergroup estimate envisions substitution of methanol for about 27 per cent of total refined petroleum products in British Columbia. These figures consider only the demand for methanol within the province. Intergroup postulates that, with its supplies of biomass and natural gas, the province could readily produce much more methanol to meet demands elsewhere in Canada or the United States.

The question that remains unanswerable is, At what rate may production grow in the province to meet this potential demand? Factors affecting this rate include the speed of market development, technology refinement, and policy formation. Forest resource management issues may also affect the rate of methanol development.

Given these uncertainties, the best approach is to pick a representative level of develop ment and trace out its effects. it is assumed that three 414 million LPY plants (or one 1.24 billion LPY plant) producing methanol from natural gas and wood biomass could beoperating in British Columbia by 1995. At that scale, annual methanol production would be the equivalent of about 880,000 cubic metres of refined petroleum products. If this methanol production was entirely consumed within the province, it would substitute for approximately 7 per cent of projected total refined petroleum consumption in 1995.[50] Assuming methanol was marketed only in gasoline blends and as a "dual fuel" with diesel, that level of production would replace about 11 per cent of the 1995 provincial consumption of these fuels.

Three 414 million LPY methanol plants would require about 400,000 *ODt* of wood biomass and 705 million cubic metres of natural gas yearly. In terms of energy content, roughly four times as much gas as wood energy would be consumed. This level of wood energy consumption is comparable to the hog fuel requirement of two large pulp mills

49 British Columbia Energy Commission (1978). Note that this forecast predicts failing gasoline Consumption after 1980, on the assumption that diesel-fueled autos would begin to reduce gasoline demand. No allowance vias made in this forecast for displacement of gasoline by methanol.

50 Interpolating from the British Columbia Energy Commission (1978) forecast.

making maximum use of biomass energy for process steam. The level of gas consumption is roughly equal to 30 days of provincial gas exports at the currently permissible rate, or about 6 per cent of the 1992 natural gas production forecast for British Columbia.

c) Other Uses

Beyond the applications already discussed, wood biomass could be converted into a variety of other energy commodities. Most of these would involve conversion of wood to gas, although various other conversion processes are technically possible. In this section, we can only briefly discuss these options and, where possible, can suggest their potential in British Columbia.

Through gasification, wood biomass is converted into producer gas with low energy content or synthesis gas with medium energy content. Outside of the forest industry, producer gas could conceivably be used as a substitute for natural gas in large industrial applications or as fuel for electric power generation. Because producer gas cannot be stored or transported effectively, it would have to be used at its place of production. Moreover, it would likely have to be produced from mill residues in order for the wsts to be reasonably competitive with natural gas. On that basis, it seems unlikely that there are many available opportunities for industrial use in mining or other nonforest sectors, since these facilities are not usually located near supplies of wood wastes.

Use of wood producer gas for electrical generation is under consideration by Saskatchewan Power Corporation (1979) and has been assessed in studies funded by the ENFOR program. The producer gas would be used to replace diesel fuel in small-scale electric generators. which supply remote communities. There is some swpe for the use of wood gas in this capacity in British Columbia, since B.C. Hydro operates diesel-fueled generators in certain remote communities.

The real question is, What source of electricity has least costs to serve remote locations, given that diesel fuel is valued at the world price in this study? The Saskatchewan studies have considered the relative costs of wood gasification and diesel for remote areas, but results of that research are not available. Other possibilities are that, in forest-based communities. there may be scope for direct combustion of wood wastes in boilers for electricity and process steam. Alternatively, small-scale hydroelectric Sites may be available. Finally, B.C. Hydro is also testing small-scale wind-powered generators for remote locations. It is, therefore, impossible to generalize on the relative merits of wood gasifiers for remote electricity generation in British Columbia until more information is available on the costs of alternatives.

Synthesis gas from wood could readily be augmented into synthetic natural gas and then manufactured into other petrochemicals. Synthetic natural gas has been mentioned as a potentially attractive use of wood biomass in Canada, particularly in regions without natural gas reserves. In British Columbia, which has substantial gas reserves, production of synthetic natural gas is, at first thought, redundant. However, the real issue is not the volume of gas reserves available, but the cost of producing synthetic natural gas (SNG) compared to its marketvalue.

The Mitre Corporation (1977) has estimated that the selling price of SNG must be at least $27.20 per hm^3 in order to cover all production costs. These calculations were based on a small-scale plant of 250,000 ODt biomass capacity and biomass feedstock costs of roughly $25 per ODt. With a large-scale plant processing one million ODt of biomass yearly, the costs would fall to roughly $15.00 per hm^3. These cost estimates indicate that SNG could possibly be viable at current export prices. if mill residue feedstock–with costs well below $25 ODt–was available in sufficient quantities or if biomass required for a largescale plant could be obtained at costs of $25 per ODt.

Aside from methanol, the most attractive product that could be produced from synthesis gas is probably ammonia. The Mitre Corporation (1977) and the U.S. Jet Propulsion Laboratory (1978) suggest that ammonia production from synthesis gas was economically competitive at the relatively low natural gas prices of 1977. These calculations were based on a smaller-scale plant consuming 250,000 *ODt* yearly and a biomass cost of $25 per ODt. At the higher natural gas prices of 1980, ammonia from biomass would appear even more attractive.

Finally, many other potentially attractive processes for conversion of wood biomass are under development. These include pyrolysis to produce fuel oil-type liquids, wood gas and charcoal.[51] Liquefaction or hydrogenation of wood biomass could produce a liquid fuel similar to residual oil. Hydrolysis could be employed to produce ethanol; anaerobic digestion could produce methane gas. Except for charcoal from pyrolysis, these processes are Still in the research and pilot plant stages for wood feedstock (Jet Propulsion Laboratory, **1978).**

To summarize, other studies show that ammonia production could well **be** viable and SNG could possibly **be** viable in relatively small-scale production if biomass costs are below **$25** per ODt. Smallscale gasifiers for electrical generation in remote areas could possibly **be** economically viable, although no comparative data is at hand. Other conversion technologies are too poorly defined to speculate on their ewnomic attractiveness. Nevertheless, it can **be** stated that the cost of biomass supplies would be the critical factor in their comparative cost to conventional fuels.

6.0 CONCLUSION

In this final section, the assessments of potential supplies and potential demands for forest biomass are integrated. Supplies and demands are considered on a regional basis to identify areas where shortages of biomass could occur. The willingness of biomass users to pay for long-distance transportation of wastes is **assessed.** Finally, the potential for competition between biomass energy users is discussed and the effects of price increases for forest biomass are considered.

6.1 Demand and **Supply** of Biomsss **Energy**

a) Demands

Table **11.16** summarizes the potential demands for forest biomass energy that hold ewnomic promise. It is possible to differentiate between potential demands on a near-term. longer-term, and technological-development basis. Near-term biomass demands for direct use in forest industry boilers are based upon proven technology. Near-term demand for dried hog fuel in boilers and for use in lime kilns is based on emerging technology. Gasification of wood for use in lime kilns and wood products kilns is an emerging technology.

Over the longer term, direct combustion demands for electricity and steam are based upon proven technology. Potential demands for producer gas, methanol, SNG. and ammonia are based upon emerging technologies. Potential biomass demands for pyrolysis, hydrogenation, hydrolysis, and anaerobic digestion all involve technologies still in the development stage.

The table shows present demands for wood energy in the forest industry and potential demands by specific use. **As** noted previously, no incremental demand is considered for wood gasification in the pulp sector since that application would overlap with direct combustion and not provide significant added biomass consumption.

All of the estimates provided in Table **11.16** should **be** viewed as rough approximations that could be subject to error–particularly in the wood products sector. Nevertheless, the data indicates that, if conventional energy resources are valued on the basis of their marginal costs, there is enormous scope for increased substitution by wood biomass energy.

This is particularly true in the pulp sector, which would account for roughly **75** per cent of the potential forest energy use. Complete adoption of biomass fuel in pulp and paper mills would sub stitute for approximately **635,600** cubic metres of oil and **565** million cubic metres of natural gas and provide 600 Mw of electrical production capacity.[52] Wood energy could allow the pulp sector to **be** almost completely self-sufficient in energy production, other than hog fuel needs.

b) Potential **Shortages** of Mill Residues

Estimates of potential demands must be con. sidered in light of the potential supply of low-cost

[51] Gasification hone type of pyrolysis.

[52] **These figures** only consider **fuel** savings **in** existing **mills.**

TABLE II-16
POTENTIAL ANNUAL DEMANDS FOR
FOREST BIOMASS ENERGY IN BRITISH COLUMBIA BY 1995
(ODt)

Present Use[a]:	
. Pulp industry boilers	2,400,000
. Wood products boilers and dryers	1,670,000
Near-Term Potential (to 1985):	
. Pulp industry boilers[b]	4,800,000
. Added consumption in boilers' and lime kilns due to hogfuel dryers	720,000
. Wood products boilers and dryers[d]	430,000
. Gasification in wood products[e]	30,000
Longer-Term Potential (to 1995):	
. Expansion in pulp sector[f]	1,900,000
. Electricity and steam generation	350,000
. Methanol production	400,000
Total	12,700,000

Source: McDaniels Research Limited

[a] Reid, Collins and Associates Ltd. (1978a), with South Coast consumption taken from 1918b. Consumption of waste liquors in rewvery boilers is not included.

[b] Includes requirements for both steam and electricity.

[c] Assumed to be 15 per cent of potential boiler requirements

[d] Comprised of 330,000 ODt for drying, 33,000 ODt for general heat requirements, and 66,000 ODt for cogeneration, as discussed in the text.

[e] Assumed to be 10 percent of drying requirements.

[f] Assumes that capacity in the pulp and paper sector expands by 25 per cent by 1995 and that the total wood energy consumption increases proportionately. Expansion of the pulp sector is discussed in Sedion 2.4,

wood waste biomass. Interpolating from Table **II-7,** it is expected that by **1995** roughly **10.3** ODt of wood wastes would **be** available for fuel use. In other words, the demands for low-cost hog fuel could significantly exceed supply. It would **be** preferable to calculate regional estimates of demand and supply of mill residuals to identify areas of potential shortage. Unfortunately, there is no way to accurately gauge where expansions of the pulp sector may occur, which is likely to be the biggest influence upon the scope of potential shortages.

Nevertheless, it is possible to conjecture about potential shortages in key areas on the basis of current consumption patterns. If complete utilization of wood wastes by pulp mills occurs in the South Coast Region, regional demand would grow by 2.3 million ODt yearly. This increase would place total demand at roughly 4.65 million ODt, in comparison to a projected **1990** hog fuel supply of **3.3** million ODt.[53] Moreover, three of the potential expansions of pulp and paper capacity are located in the South Coast Region, exacerbating potential demands. Shortages of wood wastes for fuel in the South Coast Region are very likely.

Another region that **has** been identified as potentially short of supply is the North Coast. Conversion of the existing mill to maximum use of wood wastes would increase potential demands by roughly 600,000 ODt over the present level of 1,000,000 ODt. These demands can **be** compared to a **1990** supply estimate of **280,000** ODt. Oepending on the locations of pulp mill expansion, other regions should exhibit closer correspondence between supply and demands for mill wastes with locaiized shortages or surpluses possible.

6.2 Effects of **Mill** Residue Shortages

Growing tightness in the regional supply of mill residues would affect the price of biomass for energy. The market value of mill residuals would rise as suppliers found themselves with more buyers than could **be** accommodated. Increasing prices would encourage longer-range transportation to move hog fuel from areas of surplus to areas of shortage, although persistent shortages could develop. Supplies of mill residues could increase if higher prices induce firms to bring more low-value wood to mills for energy use.

As the price of biomass **rises** because of competition and longer transport, the viability of some wood energy **uses** could **be** affected. Recalling the previous section, a number of potential energy uses were evaluated. assuming zero price and minimum transport cost for wood waste. Table **II-17** summarizes the effects of increases in biomass fuel cost upon certain energy applications.

Among the applications for which the effects can **be** quantified, electrical generation in a central plant is shown to **be** the most sensitive to price increases. Raising the cost of fuel to $10 per ODt would mise the cost of power from the Quesnel plant to about 20 mills per kwh. **A** cost increase of this scale would likely render the plant unattractive in comparison to other alternatives. Cogeneration by pulp mills is the next most vulnerable **use** of wood waste. According to our data. a fuel cost of **$15** per ODt would **nearly eliminate** the potential for viable cogeneration production.[54]

Use of wood energy for pulp mill steam requirements is also sensitive to price changes. The price of wood wastes would. however, have to increase to over **$15** per ODt to seriously impair this use. It should also **be** recalled that the willingness of pulp producers to pay for hog fuel in steam production is a function of the price of other fuels. The data in Tables **II-12** and **II-17** were calculated assuming that the prices of oil and gas do not increase in real terms beyond their **1980** values, as determined in Section 4.0. If, instead, the values of oil and gas are assumed to

53 Based on the 1976 consumption of 2.35 million ODt and the projected increase in pulp mills. It is assumed that no incremental increase in consumption by wood products mills occurs in the South Coast Region. Supply estimates are based on the 1990 forecasting of mill residues and the forecast of nonfuel residue demands by Reid, Collins and Associates Ltd. (1978a).

54 Recent calculations done for Programme in Natural Resource Economics at the University of British Columbia are more optimistic. They indicate that, at a fuel cost of $15 per ODt, a substantial amount of cogeneration is still viable, assuming marginal-cost prices for electricity.

TABLE 11-17
PERCENTAGE REDUCTIONS IN POTENTIAL
FOREST BIOMASS DEMAND DUE **TO** INCREASED **HOG** FUEL COSTS

Application	Fuel Cost $10	$15	$20
Pulp Mill Boilers:		-29%	-100%
. steam requirements	nc	-29%	-100%
. cogeneration	-27%	-95%	-100%
		unknown	
Hog Fuel Dryers		unknown	
Wood Products Boilers and Dryers		unknown	
Electrical Generation	- 100%		
Methanol	nc	nc	nc

Source: McDaniels Research Limited

Note: nc = no change

increase in real terms, the amount that pulp mill operators could pay for hog fuel would escalate and the sensitivity to price changes would fall—for example, a 5 per cent real annual increase in oil and ***gas*** prices would mean that a 520 charge for hog fuel only reduces potential demand for wood wastes in boilers by about 20 per cent.

Although there is no specific data, one could expect that the sensitivity of demand for biomass energy in the wood products sector would **be** roughly parallel to the sensitivity of demands for boiler fuel by the pulp sector. Sensitivity of demand for wood energy, **as** a result of hog fuel dryers, would also parallel the sensitivity of pulp boiler demands, since that is where the dried hog fuel would primarily **be** consumed

Those sensitivities indicate which potential **uses** could afford to pay significantly higher transportation costs for wood energy and which could outbid others in situations of wood biomass scarcity. **It** could **be** expected that transport costs of $15 per **ODt** would correspond to a truck haul of perhaps 50 miles. All biomass supplies for electrical generation or cogeneration would have to be drawn from sources much closer than 50 miles for economical use. Because *of* its higher value, demands for hog fuel in boilers could be filled from larger areas. These figures also indicate that, unless a low-cost method of transporting wastes over long distances is developed, there will be difficulties in meeting biomass demands in some areas, particularly the South Coast Region.

6.3 Economic Priorities for Biomass Energy Uses

It is possible to speculate on which energy uses would take precedence if there is competition for biomass supply. Judging from Table 11-14, it is expected that methanol production employing the methane-hybrid process could outbid all other potential uses for wood biomass energy. If Intergroup's (1978) calculations are accurate. it would be economically attractive for pulp mills and sawmills to **sell** their wood wastes to methanol plants and buy coal for their own energy requirements, rather than burn the wastes themselves.[55] However, the Scale of development for methanol, envisioned previously, is not sufficient to preclude other energy uses. It could be further argued that methanol is the only potential use capable of paying the cost of forest residuals harvest for its biomass supply. It is assumed that biomass supplies for methanol are provided from forest residuals and do not forestall other less valuable uses of mill residues.

Use of hog fuel in pulp boilers for steam requirements is, in general, the next most valuable biomass energy use. This application could be expected to bid biomass supplies away from other users in situations of biomass scarcity. Use of wood wastes for drying in the wood products sector can be expected to be nearly as valuable as pulp boilers. Also, lumber-drying utilization would benefit from the fact that sawmills produce more than sufficient quantities of wood waste to meet their own energy requirements. Mill operators could be expected to fill their own needs for wood energy before supplying pulp mills or other uses. Also, there would be no transportation wsts for wood wastes when used on-site for lumber dryers.

Cogeneration of electricity by pulp mills and sawmills is generally a less valuable use of biomass energy. Shortages of supply, which bid up prices, would mean that firms find it less attractive to wgenerate power, particularly in pulp mills where wood wastes must 12 trucked from distant areas.

Finally, electrical generation at Quesnel would be very susceptible to increases in the price of hog fuel and could possibly be outbid by other biomass energy users. However, it should be recalled that the Quesnel plant would have six sawmills nearby from which it would draw fuel and to which it would provide process steam for lumber drying. Thus, any biomass user, figuratively attempting to bid supplies of wood waste away from the Quesnel plant, would be effectively taking valuable energy from the saw mills' lumber kilns.

55 Intergroup argues that methanol could offer to pay all opportunity costs for biomass supplies, including the value of biomass as fuel in the pulp sector.

CHAPTER III

RESOURCE MANAGEMENT ISSUES

1.0 INTRODUCTION

Greater use of forest biomass for energy would essentially mean fashioning a new type of product from British Columbia's wood **reserves.** This added utilization would have implications for, and be affected by, the extant resource management system. **It** is therefore necessary to trace through the effects of increased forest energy exploitation upon the goals and procedures established by the Ministry of Forests to administer forest resources. Our concern in this chapter will be with the management system, rather than with the environmental aspects of resource management (which are addressed in the subsequent chapter.

To discern the effects of forest energy use upon the management system, some knowledge of the system itself is required. This background is provided in Section 2.0, which reviews the major goals and procedures of forest resource management in British Columbia. In Section 3.0, the implications **of** increasing use of forest energy for the rate of harvest are addressed. Next. potential issues in distribution of forest biomass between buyers and sellers are discussed. Finally, in Section 5.0, effects upon the value of forest resources are analyzed.

2.0 EXISTING FOREST MANAGEMENT SYSTEM

British Columbia's system of forest manage. ment is described by its initiates as exceedingly complex. Comprehensive rules are needed because, although the province owns roughly 95 per cent of the forest lands, **it** is not in the business of logging or manufacturing wood products to any significant extent. The result is a- elaborate set of contractual arrangements that allow private industry access to the resource while protecting provincial interests.

Beginning with management goals from ***an*** economic perspective, the salient features **of** this system are reviewed in the following section. Ministry practices in meeting these goals are discussed, including the sustained yield system. provincial utilization standards, tenures, and stumpage.

2.1 Forest Management Goals

In 1978, British Columbia's Legislative Assembly passed its "Ministry of Forests Act" and, in so doing, set forth purposes and functions to **be** followed by the Ministry. These purposes can bcviewed as a statement of goals for forest management in British Columbia. The Ministry is directed:

(a) to encourage the attainment of maximum productivity of the forest and range resources in the province;

(b) to manage, protect, and conserve the forest and range resources of the Crown, having regard to the immediate and long-term economic and social benefits they may confer on the province;

(c) to plan the use of the forest and range resources of the Crown, so that the production of timber and forage, the harvesting of timber, the grazing of livestock, and the realization of fisheries, wildlife, water, outdoor recreation, and other natural resource values are coordinated and integrated in consultation and cooperation with other ministries and agencies of the Crown and with the private sector;

(d) to encourage a vigorous, efficient, and world. competitive timber processing industry in the province; and

(e) to assert the financial interest of the Crown in its forest and range resources in a systematic and equitable manner.

From' economic and resource management perspectives, the first **two** purposes are pehaps most important, These objectives imply that forest management should be designed to secure the full potential contribution of the public forest to economic well-being—in other words, the forest's economic rents, which basically comprise the *excess* of forest economic benefits over the **costs** incurred to obtain them. should be maximized. Economic rents could be derived from the forest in all its potential uses as a source of timber for commercial use, as a watershed, as wildlife habitat, as a recreational resource, and so on. The essential goal for forest management should, thus, be to maximize these diverse benefits and minimize costs (including opportunity costs) for all potential uses.

To achieve these objectives, the Ministry of Forests administers a complex system of tenures, rules, and administrative practices. The key features of this system are briefly outlined in the following section.

2.2 Forest Management Practice

a) Maximum Sustained Yield

Management to obtain "maximum sustainable yield" has been the basic tenet of forest policy since the late 1940s.[56] In simplest terms. sustainable yield is "a forest management regime that involves more or less continuous harvesting, balanced by growth, over specific forest units". This regime is achieved by selecting the constant harvest rate for a forest management unit that will harvest all growth over a complete cycle—in other words, "sustainable yield" means harvesting the greatest annual cut in perpetuity. Implicit in this approach is the assumption that regeneration occurs steadily *so*, at the end of one growing period or "rotation", there will be an evenly graded distribution of age classes in new timber stands for orderly harvest by future foresters.

In his report on the Royal Commission on Forest Resource?, Pearse outlines the purposes, biases, and anomalies in the sustained yield approach, which need not be detailed here. Suffice it to say that the basic rationale for planning steady long-term harvests is to bequeath our forests to future generations in an undiminished state and to promote regional economic stability. In response to these goals, the Commissioner argued that there is no reason to expect that the interests of future generations would best be sewed by a harvesting regime "based on a rather mechanical formula that ignored likely trends like technology, economic values, and tastes". He also argued that neither short-term nor long-term stability in regional employment would be helped by steady harvest rates (Pearse, **1976**).

The sustainable yield policy nevertheless forms the basis of harvest regulation in British Columbia. Relatively steady harvests are administered through a system of cut-control accounts. Each holder of cutting rights has its actual cut tallied in comparison to its allowable annual cut. *As* a general rule, a forest company must harvest within 50 per cent of its allowable cut each year and within 10 per cent of its allowable cut in *each* 5-year period.

The primary effect of sustainable yield regulation upon forest energy use is that it sets the overall rate of harvest. This rate of harvest determines the quantity of material that is processed in conversion mills, which, in turn, govems the amount of mill residues produced in a given year. Constant harvest rates dictate that the flow of raw materials is relatively steady, meaning that production of wood waste is more regular than would otherwise occur.

b) Utilization Standards

Utilization standards are even more important than harvest rates for the supply of forest biomass energy. These standards are set by the province to delineate the quality of timber that must be removed from the forest to ensure full use of timber resources.

Until the **1960s,** the provincial forest industry operated to a standard of timber recovery that corresponded to the lowest quality of timber suitable only for lumber manufacture. This recovery level, known as the intermediate recovery standard, meant that all timber not within the manufacturing capability of sawmills was left in the forest and that most mill wastes were burned.

During the **1960s.** expansion of the pulp industry and improvement in sawmill technology offered opportunities to use much of the wood formerly wasted. A revised *close* utilization standard was

56 **Sustained yield policy was introduced by the province's 1945 Royal Commission on Forest Resources, headed by G. Sloan. At present, all but the province's Crown-granted lands and "Old Temporary Tenures" (outside TFLs) are regulated to obtain sustainable yield (Pearse, 1976).**

initiated in 1966 in the Interior, where it became well established and then was gradually introduced on the Coast, With few exceptions, the dose utilization standard is now the rule throughout the province. It requires that all trees–living or dead, with a breast height diameter of 18 cm or larger in the Interior and 23 cm or larger on the Coast–be recovered. Ail of the stem between a stump 30 cm high and a 10 or 15cm top (dependingon location) must be utilized.

Contractual arrangements usually call for penalties of twice normal stumpage rates[57] on timber that falls within the specified limits, but is not utilized. In addition, there is an overlapping set of controls governing logging **wastes.** These controls define certain material left on the logging site as "avoidable waste" for which the industly licencee may also be penalized.

In practice, penalty billings have not been rigidly applied to enforce utilization standards. The Ministry **has** been flexible in their use, particularly during *adverse* market periods which mitigate against the processing of low. quaiity materials. Nevertheless. attempts to control waste to uniform standards have created friction between the Forest Ministry and industry licencees, particularly on the Coast. Table 113 shows that the forest industry requires considerable improvement before all merchantable material within dose utilization standards is taken from the forest.

Certain criticisms of close utilization standards were levelled by Pearse. The Royal Commission report argued that application of a single standard ignores the complex physical and economic factors that actually determine the optimal degree of use at a given time. Because the standards rigidly specify extent of harvest for high-cost, low-valued material, they sometimes require firms to process submarginal timber at a loss. Inclusion of submarginal material lowers the average value of timber removed, while increasing average costs. This perverse effect means that a smaller harvest, with relaxed utilization standards, may actually increase the value of the forest crop and stumpage paid to the Crown. More over, present arrangements may blunt the incentives of licencees to recover marginal wood. The stumpage system attempts to charge operators the average net value to timber. In that case, the forest company will be penalized in removing logs of below-average quality. since these logs incur the average stumpage rate but provide below-averagereturns. In some *cases,* companies have been charged full stumpage rates on timber they voluntarily use that falls below the utilization standards. **A** potentially greater disincentive, however, is that marginal and submarginal logs removed are charged against an operator's quota. This will restrict his harvest of high-quality timber.

According to Pease, a more rational approach would be to allow economic self-interest to dictate the degree of utilization by companies. This could be accomplished by changing the basis of stumpage charges. **He** presents ***an*** alternative method, which is to base the charge on ***an*** appraisal value of standing timber, rather than on the basis of a fixed charge per cunit scaled.

Despite these criticisms, dose utilization standards are actively administered in the province. By mandating fuller harvests. the standards increase the quantity of mill residues and lower the quantity of forest residues. Close utilization, therefore, lowers the cost of wood waste supply for energy conversion.

c) The Tenure System[58]

Timber harvesting rights, or "tenures", are the **means** employed by the province to permit access by the forest industry to forest resources. The tenure system is complex, since **it** contains a number of tenure types, each with different responsibilities and duration. We need only briefly summarizethe system for our purposes.

An initial distinction should be made between the regulated and unregulated harvesting rights. "Regulated" **means,** in this instance, committed to sustained yield management; the most important regulated tenures are the Tree Farm Licences and the rights within Public Sustained Yield Units **(PSYUs).** Together, the regulated tenures provide over 80 per cent of annual harvest. "Unregulated" harvests

67 "Stumpage" **is** the price **for** standing timber collected **by** the province as owner *of* the forest. The **system is** discussed **subsequently.**

58 This sectiondraws heavily on Schwindt **(1979).**

are taken from Crown-granted lands and the Old Temporary Tenures.[59] These holdings are relatively small in size but provide a disproportionately large amount of recent provincial harvests.

The unregulated tenures are the oldest, and in many respects the most desirable, form of cutting rights. Crown grants were made in the late 1800s to induce settlement and stimulate economic development. Although the policy was sholt-lived, it is responsible for putting some of the province's finest timber in private hands. Old Temporary Tenures were created when the province moved to a policy of alienating harvest rights rather than forest lands. A major distinction between Old Temporary Tenures and Crown grants is that, upon harvest, tenures revert to the province, while granted lands are privately-owned.

Regulated tenures differ in the degree of control and property rights invested in the holder. Tree Farm Licences were established to bring large areas under sustained yield management by giving one company the exclusive right to harvest and manage a given area. These licences are desirable in terms of security, since they extend for long periods and are renewable. However, they place, on the licence holder, the chief responsibility for forest management.

In the PSYUs, the Ministry is directly responsible for forest management. *As* originally envisioned, cutting rights were to be allocated for a short term on the ***basis*** of competitive bidding. The Pearse Commission, instead, determined that competition for timber sales, within the PSYUs. had gradually been eroded owing to procedures established by the Ministry that entrenched the rights of established operators.

The most important feature of the tenure system, in terms of energy use, is that it grants a measure of control over the forest resource and, consequently, over the supply of forest biomass to private firms. Moreover, this control has become increasingly invested in the industly's largest firms. This concentration of economic power is documented in Chapter IV.

d) The Stumpage System

Because there is little competitive bidding involved in allocating timber, the province must determine the value of its resource by other means. A system of stumpage appraisal has, therefore, been developed to estimate the net value of a given amount of timber, in terms of the *excess* of revenues over all costs. This net value is the return attributable to the scarce timber resource and, thus, is the price paid to the timber owner–the province.

To describe the stumpage system in practice, it is again necessary to differentiate between the Coast and the Interior. The appraisal system west of the coastal mountains is based on logs as the final product. This approach is made possible by the existence of the Vancouver log market, from which the selling prices of logs are established. In the Interior, a recognizable log market has never developed; consequently, the appraisal system must go beyond the logging stage. It instead uses lumber and chips as the end products for appraisal.

Once the market value of end products is established, it is necessary to determine the costs borne by forestry companies to produce these products. The stumpage appraisal system estimates all costs of harvest, transport. and imposed management (and in the Interior for sawmilling) on the basis of the "average efficient operator". These cost appraisals include allowances for profit and for risk borne by the operator. Other writers have discussed the specific operation of the system in greater detail.[60]

The stumpage system could possibly affect forest energy use in two distinct ways. One point, mentioned earlier, is that charges based on the average value of timber may create a disincentive for use of low-quality material. Another implication is that the province could, in the future, include the value of mill residuals for energy as part of the end-product appraisal, a point explored later in this chapter.

59 More precisely, unregulated harvests are derived from old tenures and grants that have not been Voluntarily included in Tree Farm Licences by the licence holders. These harvests are unregulated in terms of sustained yield, but the tenures are, nevertheless, subject to certain provincial controls–for example, old tenures ultimately revert to the Crown.

60 See, for example, Task Force on Crown Timber Disposal (1974) or McKillop and Mead (1974).

3.0 EFFECTS ON HARVESTS

Exploitation of forest biomass for energy could have significant effects on the harvests of forest materials. These effects could entail changes in the extent of utilization, the rate of harvest, and the harvest fluctuations.

3.1 Utilization

The previous chapter demonstrated that energy uses could potentially consume all wood wastes produced by British Columbia forest industry mills. Energy consumption of this magnitude would constitute the final increment in total utilization of the current timber harvest. Virtually all material extracted from the forest would be put to use, with the highest-quality material allocated to lumber, the intermediate-quality used for pulp and paper, and the lowest-quality for energy conversion.

Even more important than full utilization of today's cut is the incentive for a greater overall harvest, since energy use would give an economic impetus to remove lower-quality material from the forest. The nature of this incentive is shown in Figure 111-1. The horizontal axis of the graph represents the volume of wood harvested from a given area in cubic metres, while the vertical axis indicates dollar-value for both costs and revenues. Line AA indicates the marginal revenue to the company of harvesting an extra cubic metre of wood, assuming the firm harvests the highest valued timber first and progressively cuts timber of declining quality. This curve fails, indicating that, as the company expands its cut in a particular *area,* it must take more small and defective material that has a lower marginal value. Curve MC shows the marginal cost of harvesting an extra cunit in the area; this curve slopes upward, indicating that small and defective timber is harder and more costly to extract, per cubic metre.[61] Distance along axis OV measures the volume harvested, going from highest- to lowest-quality timber.

The intersection of the AA and MC curves indicates the economically optimal level of harvest in a given area. This optimum occurs at the volume of harvest, shown as Volume 0, where marginal revenues equal marginal costs and the net benefit (shown as the area between the two curves) is maximized.[62] By comparison, Volume R represents the regulated level of harvest as set down in provincial close utilization standards. If, as shown on the diagram, Volume R lies to the right of Volume 0, some low-quality material is harvested at a loss.

A number of exogenous variables could affect the costs of and revenues from wood harvests. thereby shifting the location of these curves as time passes. For example, increases in the value of forest products–whether lumber, pulp, or energy–would move the marginal revenue curve AA to the right; *so,* too, would improvement in conversion technology. On the other hand, the marginal cost curve would shift to the left as the costs of labor, energy, or capital inputs increased or as more remote sites were utilized. Alternatively, costs could fall because of improvements in harvest efficiency, shifting the curve to the right.

One such shift in the revenue curve–resulting from rising fuel prices, which increase the value of wood energy–is illustrated in the graph. Curve BB indicates the marginal value of an added unit of harvest when energy value is considered along with the value of conventional forest products. An important factor is that, if mill residues are the only biomass source under consideration, there is no added harvest cost to the firm, meaning no shift in curve MC.

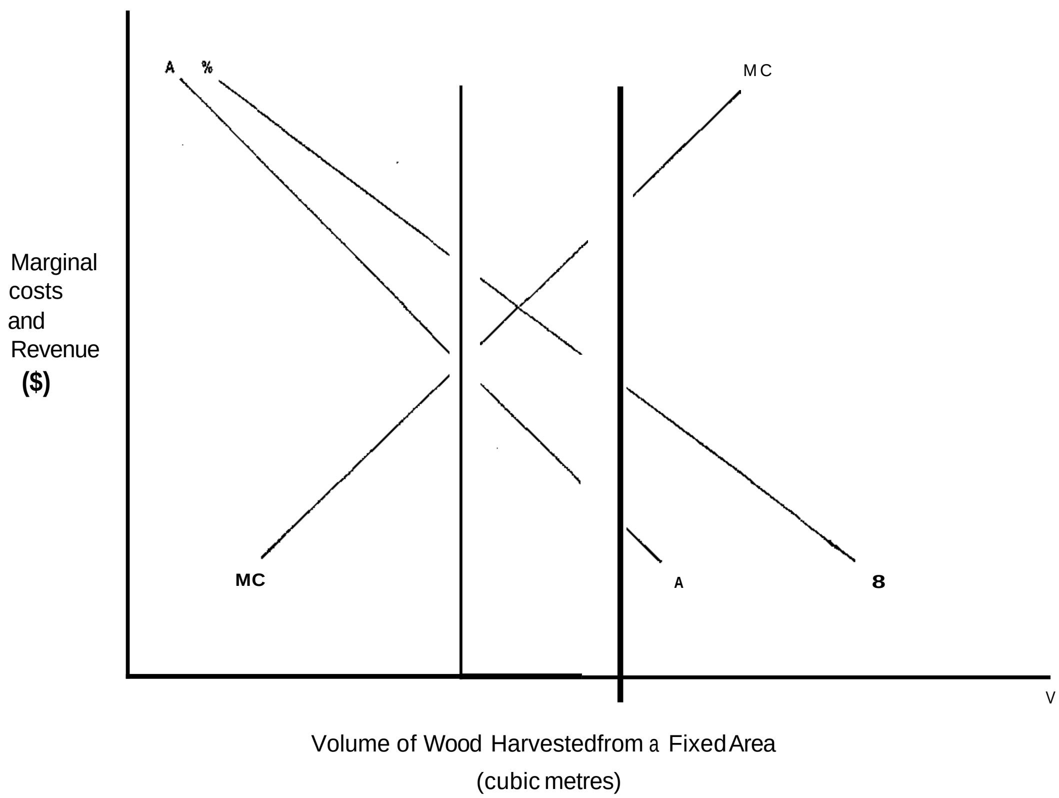
The consequence is that curves BB and MC intersect at a higher volume of harvest from a given area, The recognition of energy values by the company means that fuller Utilization of the forest is economically justified on a given site. Wood energy, therefore, provides an economic opportunity to more fully comply with close utilization standards.

How large would this economic incentive be, relative to the value of conventional forest products? Specific data is not at hand, but some observations can be made. First, the economic value of wastes for

61 Pearse (1976) makes reference to a study of small wood recovery, which indicated that marginal costs increase significantly when recovering low-valued material.

62 The graph ignores stumpage, which would be shown by a parallel shift in the MC curve upward and to the left, reducing the optimal harvest.

FIGURE III-1
MARGiNAL COSTS AND REVENUES OF INCREASED HARVESTS



AA = Value to the company of harvesting an extra cunit from **a** given area

BB = Value to the company of harvesting an extra cunit, recognizing the energy value of **wastes**

MC = Marginal costs of harvesting **an** extra cunit from a given area energy will be greatest in situations where they ran be consumed at the mill site, since transport wsts are avoided. Companies, with integrated sawmills and pulp mills or with wood-fueled lumber kilns at their sawmills, would reap the highest net economic benefits. Net benefits of biomass energy will be greatest if the full wsts of harvest are attributed solely to lumber and pulp production, with residuals viewed as a costless by-product. Forest industry companies meeting these conditions could value residuals for fuel at roughly $10 to $20 per ODt, assuming no increase in the price of oil beyond 1980 levels (see Appendix I). We can assume $15 per ODt to be a representative value of wood wastes to forest industry firms, under these circumstances.

Based on average lumber conversion factors, one cubic metre of average softwood harvested in the Interior will yield roughly 0.063 ODt of mill residue in addition to its lumber and chip outputs.[63] In other words, the yield of mill residues from one cubic metre of roundwood could be valued by the company at roughly $1, assuming the $15 per ODt energy value. This added "revenue" is obtained at no incremental cost, meaning it is profit that improves the viability of low-quality timber harvest.

3.2 Rate of Harvest

How might forest biomass energy use affect the rate of harvest in provincial forests? In general, it could slightly alter the rate of cut, although the extent would be minimal.

Recalling that provincial hatvests are set on a sustained yield basis, it *seems* that forest energy use would have little effect on the parameters that govern cuts under that regime,[64] although it is true that increased utilization, which is implicit in forest energy use, has affected cuts in the past. The movement from intermediate to close utilization standards in the late 1960s and early 1970s greatly speeded the rate of cut–on a sustained yield basis-because the volume of timber, defined as "mature", increased and the rotation age dropped.[65] But that change is not wmparable to the increase in forest utilization offered by biomass energy, so a similar increase in cut would not result. Close utilization standards were adopted because the province perceived the opportunity to enwurage a new, economically viable use of provincial timber–namely, the pulp industry. The new standards reflected the fact that smaller, formerly useless wood could be manufactured into pulp and paper without affecting sawmill production.

Full scale wnversion of biomass to energy in the applications discussed in Chapter II would mean complete utilization of mill residues produced from the current cut. It could also mean a somewhat expanded volume of harvest from a given area, more closely meeting provincial utilization standards. However, the analysis of Chapter II showed that harvest and shipment of forest biomass *solely* for energy purposes would generally be uneconomic, with the possible exception of methanol. The competitiveness of biomass energy in British Columbia depends largely on the fact that mill residues are readily available at a low cost. Energy conversion will generally be a by-product, rather than a primary product, of forest operations. In that case, its use has no direct bearing on the rate of harvest, as determined by sustained yield calculations.

If the rate of harvest was set to maximize economic benefit rather than to achieve sustained yield, forest energy use would slightly alter the annual cut. The effects of forest energy use would depend on the future value of energy. If it is expected that energy from waste wood is more valuable to society today than in the future, the cutting rate would be somewhat faster than otherwise. Conversely, if biomass energy is expected to be more valuable in future years than at present, the rate of cut will be slowed.

Aside from these effects, it is possible to identify a specific situation where forest energy use could affect the allowable cut allocated to firms in

63 Dobie and Wright (1976). Table 30 shows hog fuel yields of 0.13 to 0.22 ODt per 2.8 cubic metres of logs processed, depending on species and mill type and assuming that 1 GPU = 1 ODt.

64 Ignoring the possibility of biomass plantations.

66 Close utilization essentially means that smaller trees were defined as mature which, in turn, meant the growth period to maturity–that is, the rotation age-was reduced.

certain areas. There are sizable areas in some Interior forest districts where hardwoods constitute a major portion of timber in mixed stands. In recent years, forest administrators have generally not made mixed stands with a major hardwood component available for harvest in **PSYUs.** This practice was adopted for conservation purposes to avoid wastage of large hardwood volumes. The wnsequence **has** been that significant amounts of valuable softwoods in mixed stands have not been utilized, despite growing soft. wood shortages in **some** areas.[66]

Forest energy exploitation would increase the economic viability of harvest in mixed stands by providing a return on the harvest of hardwoods in the absena? of alternative markets. Use of hardwoods for energy would also allow companies to harvest the softwoods in mixed stands and clear hardwood areas for replanting with more valuable softwood **spedes.** The result would te a larger softwood forest crop.

Finally, energy uses could affect the rate of haNeSt on unregulated tenures. Recall that these tenures are not subject to provincial sustained yield regulations[67] but are, instead, cut at the discretion of the tenure holder. Since lands in unregulated tenures are effectively harvested in response to economic factors. the cutting rate would te influenced by the value of energy utilization. Cuts would be marginally increased or reduced, depending on the value of energy biomass today, relative to future energy values. The important consideration regarding unregulated tenures is that they are largely located in the South Coast ara of the province, where future shortages of wood wastes could be severe. If competition for supply **makes** the price of wood biomass in the South Coast, companies controlling unreg ulated tenures would have the freedom to harvest more biomass for energy purposes. if they desired. The obstacles posed by the stumpage system and the steady harvest rate for supply of biomass do not apply in these areas, leaving the operators free to follow economic signals and adjust their harvest. These firms may not find it attractive to undertake a sewnd ps harvest but could include more low quality material during the initial cut.

3.3 Fluctuation in Harvest and Sectoral Demand

Coordination between different processing activities is an interesting feature of integrated industries. The two main activities of the forest processing sector—sawmilling and pulping—are sometimes out of synchrony because the processes serve relatively unrelated markets.

Lumber demand is, at certain times, low owing to reduced home construction, which slows sawmill production and contracts the supply of residual chips. At the same time, the demand for pulp and, therefore, the demand for chips could be high. The converse situation could also occur. This lack of coordination between chip production and chip demand is of concern here because the same type of situation could arise for wood wastes.

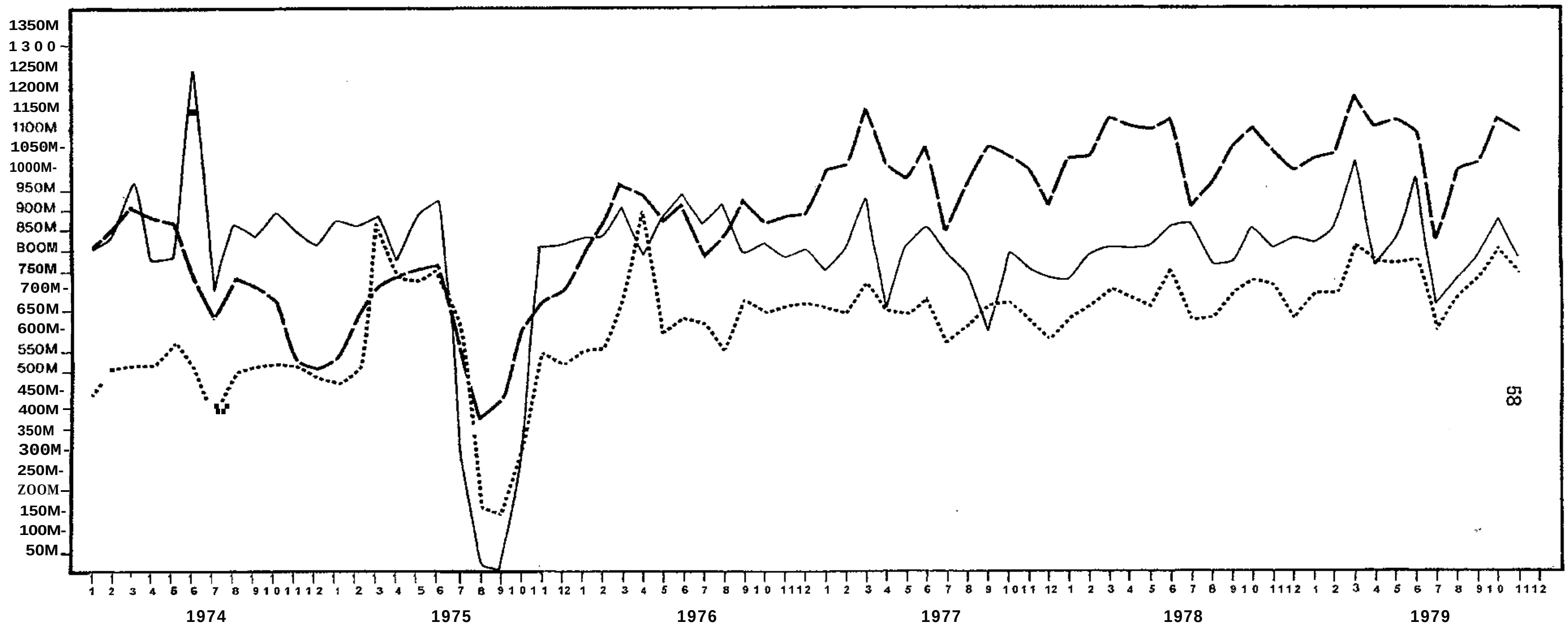
Figure III-2 illustrates the fluctuations that have occurred in timber harvest, chip production, and pulp mill activity in recent years. Lumber production is taken here as a surrogate for the monthly timber harvest. The figure indicates the degree to which fibre requirements of pulp mills lack coordination with fibre production from timber harvests and sawmill activity. While the absolute size of shortages or surpluses in pulp fibre cannot be accurately determined from the graph, it does indicate the variability in these three activities: it illustrates, for example, the period of high fibre consumption and low chip production that occurred in 1974 when pulp mills were constrained by lack of fibre.

Greater reliance by the pulp sector on mill residues for energy would involve the same type of cycles in production and consumption, although one could expect that use of residuals for energy would slightly reduce the disparity between sawmill and pulp mill production—that is to say, the price paid by pulp mills for energy residuals would provide a small incentive to maintain higher sawmill activity, despite depressed lumber markets. Conversely, the consumption of residuals for energy by pulp mills would

66 The Ministry of **Forests'** policy toward allocation of hardwoods and mixed stands is under review during **1980.** improving markets for hardwoods may mean that Commercial exploitation of these species is viable, which would eliminate the administrative constraint on cut in mixed stands.

67 Exceptions are Crown-granted lands included in **tree** farms, which must be managed according to approved plans.

FIGURE 1112
FLUCTUATIONS OF BRITISH COLUMBIA
PULP, CHIP, AND LUMBER PRODUCTION



Source: MeDaniels Research Ltd., based on Statistics Canada, catalogues 35-003 monthly and 25-001 monthly

.... Chip production by sawmills (ODts)

________ Wood fibre consumption by pulp mills (cunits)

— — — Lumber production (l,000 board feet) likely remain relatively constant, wen if chip requirements are low owing to poor markets. Effects of these mildly stabilizing forces could not be expected to greatly dampen the cycles in residual production and consumption. *As* a result, significant disparity in supply and demand could occur.

The consequences of such variations in supply and demand have been illustrated in statements by MacMillan Bloedel Ltd. (1975):

> The hog fuel market is the most volatile, in terms of supply and demand, of all wood residuals. Most of the hog fuel produced is used by the forest industry for power generation, but some must be disposed of by burning and dumping.
>
> Hog fuel is a bulky, difficult, and expensive commodity to handle. It deteriorates and poses a fire hazard during extended storage, and large inventories are not commonly carried. Pulp mills, the major users, normally hold as little as 1 week's supply in inventory, and any disruption in usage or supply quickly reflects on the market demand. Often these disruptions occur across the industry at the Same time, so the surpluses or shortages can become acute in a matter of days.

In other areas, instability in fuel supply and demand has posed some problems for forest energy use. A cogeneration facility in Eugene, Oregon, has recently been forced to utilize its back-up fuels because the plant's normal supply of hog fuel was interrupted. The recent slowdown in US. lumber demand has caused the area's sawmills to reduce their lumber and produce more chips, leaving the plant with a shortage of wood waste fuel (Eugene Water and Electric Board, pers. comm.).

Such occurrences emphasize the need for an efficient mechanism to bring forth reserve supplies of residuals in time of shortage and cut back on residue distribution in times of surplus. Of course, the best mechanism for equating supply with demand is a viable market for residues. Competitive market activity would mean that, in times of shortage, prices for residues would be bid up, rationing the available supply to firms willing to pay higher prices and attracting additional supply from higher-cost sources. In times of surplus, low prices would create an incentive to consume more residues for energy, wherever possible, and discourage any incremental supply. Distribution of wood biomass through markets is the topic of concern in the following section.

4.0 ISSUES IN DISTRIBUTION OF BIOMASS

The resource management issues discussed to this point bear primarily upon the supply of forest energy. Sustained yield policy will place constraints upon the volume and rate of supply. Through the stumpage system, the province will "price" biomass wood fuel and this, in turn, will influence quantity supplied. However, provincial forest policy not only impacts upon physical resource management but is also instrumental in the distribution of wood fibre to processors. This influence is brought to bear primarily through the tenure system.

The purpose of this section is to discuss the effects of existing resource management policies upon the distribution of biomass energy. The method of analysis is posit the type of allocation system that would evolve in the absence of existing policies; to show why such a system cannot operate; and finally to suggest how distribution will be realized within the context of current forest policy.

4.1 Competitive Allocation

If the province assumed all responsibility for forest management (for example, inventorying, roads, cutting plans, reforestation), set out sites to be harvested, and took bids from logging enterprises for the timber, and if the industrial forest sector was unintegrated and populated by a significant number of independent enterprises in each of its component industries, wood fibre would most likely be distributed by means of market allocation. Logging firms would appraise the offered timber stand, taking cognizance of all potential values, including lumber, plywood, pulp, and fuel; would calculate the private costs of extraction; and would bid accordingly. After the harvest, the logging firms would, in turn, offer the wood fibre to the processors. Lumber firms would bid for sawlogs, while plywood mills would compete for peelers. Pulp and paper mills would bid for pulp wood, and all processors would compete for forest residuals, insofar as this material constituted a viable energy source.

After this initial allocation of fibre, additional markets for mill residuals would develop. Sawmills and plywood/veneer operations would offer their residuals primarily to the pulp and paper industry, which would then bid on the basis of its requirements for pulping fibre and wood fuel.

In the absence of constraints on international trade, foreign enterprises would also enter the various markets–in most *cases* as buyers, not sellers.

Allocation of fibre through markets would ensure "highest value and use". Those firms that could extract the greatest return on wood inputs would outbid all others. Inefficient mills would be unable to command resources and would exit from the industry. If forest biomass developed into the most efficient energy source, those firms adopting the appropriate technology would enjoy lower wsts and, thus, a competitive advantage over firms that continued to rely on traditional, more costly fuel types.

4.2 Real-World Situation

a) Forest Tenures

This simplistic scenario will not hold primarily **because** the forests, although "owned" by the province, have largely been committed to individual firms for long periods of time. These commitments to private industrial forest enterprises are lodged in the tenure system.

Resource management is tied to resource allocation through the tenures, although, hypothetically, this link need not exist. In the late **1940s. as** the province moved to the policy of sustained yield, a decision had to be reached as to who-government or industry–would be responsible for the forest management required by this policy. The problem was resolved by creating two broad **classes** of tenures: those where private firms had responsibility for management (mainly the Tree Farm Licences); and those where the Forest Service retained this responsibility (mainly the Public Sustained Yield Units). However, to induce private firms to assume resource management obligations, the province had to offer these firms long-term control over the forest areas they were to manage. Moreover, as the system has evolved, management in the PSYUs has not remained in the hands of the Forest Service. Tenure forms within the PSWs have gradually changed so that firms that practice management can maintain greater control over the timber harvest.

What has emerged is a complex system of property rights whereby industrial forest products companies hold claims to a large proportion of the province's timber, for varying lengths of time, in return for the discharge of varying forest management obligations. In view of these property rights and the resultant industry structure, **it** is clear that the majority of fibre, including wood fuel, will not be allocated through markets.

b) Vertical Integration

The British Columbia forest sector is characterized by pervasive vertical integration from logging through processing and. in some **cases,** up to retail marketing. in **1975,** the ten major forest products companies all maintained logging, saw. milling, and pulp operations. Together, they accounted for **57** per cent of the annual allowable cut of the regulated haNesis and the acreage of the unregulated forest; **37** per cent of sawmilling capacity; **92** per cent **of** pulp capacity; **94** per cent of paper capacity; and **63** per cent of plywood and veneer capacity (see Table **III-1). AS** has been argued elsewhere, concentration of control of processing capacity has, in large measure, resulted from concentration of control over harvesting rights (Schwindt. **1977).**

Assuming that an enterprise's supply of forest residuals is directly related to its control over the timber harvest and that its supply of mill residuals corresponds to its share of processing capacity, **it** is evident that the ten major integrated firms will also be the major producers of wood fuel. Moreover, these very **same** enterprises can be expected to wnsume the bulk of biomass energy.

Recall from Table **11-16** that, currently, the pulp industry acwunts for **59** per cent of forest biomass energy wnsumed and that this share **is** estimated to rise to **79** per cent by **1985.** Assuming that concentration in ***the*** ulp and paper industries remains at its **1975** level[68], by **1985** the ten major

68 This is already an understatement, since documented concentration in the sector has increased since **1978.**

TABLE III-1
DISTRIBUTION OF
TIMBER RIGHTS AND PROCESSING CAPACITY
TEN LARGEST B.C. FOREST PRODUCTS COMPANIES
1975
(% of Provincial Total)

Company	Committed AAC	Unregulated Harvest	Lumber Capacity	Pulp Capacity	Paper Capacity	Plywood and Veneer Capacity
1. MacMillan Bloedel	12.8	24.4	7.2	28.4	56.6	11.8
2. Crown Zellerbach	4.5	13.3	3.4	5.5	15.2	9.0
3. Canadian Forest Products	5.7	2.0	3.6	10.9	5.1	14.4
4. B.C. Forest Products	8.8	4.9	6.4	11.5	12.2	6.1
5. Weldwood	3.6	2.8	3.4	4.1	------	19.7
6. B.C. Cellulose	8.1	0.1	3.1	10.4	4.9	2.2
7. Northwood	5.2	4.2	4.3	4.4	------	------
8. Weyerhauser	1.6	1.1	2.2	6.8	------	------
9. Rayonier	4.2	2.9	1.8	5.5	------	------
10. Tahsis	2.4	1.0	1.3	4.1		------
Total 12	56.9	56.7	36.7	91.6	94.0	63.2

Source: Pearse (1976:B-17) and McDaniels Research Limited integrated firms would, in their pulp and paper operations alone, use roughly 73 per cent of all forest biomass energy consumed. Add to this their potential consumption in wood products operations and the share **rises** to over 90 per cent.

4.3 Consequences of Structure

This industrial structure implies several important consequences. First, a significant proportion of the allocation of forest biomass energy would be carried out through intra-company transactions and not by means of a market. Second, a small number of integrated firms would be consuming a relatively large proportion of this form of energy. These companies, however, would often not be able to supply all their needs and would therefore rely. especially with relation to mill residuals, upon a large number of small, independent sawmills for supplementary supply. Third, and corollary to the second point, the major integrated companies would be extremely sensitive to security of supply of biomass energy to the extent that they rely upon external sources. They can be expected to go to great lengths to avoid risk in this area.

a) Lack of Market Prices

By definition. vertically integrated companies rely upon internal transfers. rather than external transactions, for key inputs. The major integrated forest products firms, for the most part, depend on captive sources of fibre–either owned or held in long-term tenures–to supply their processing operations. Similarly, one would expect that the integrated mills will rely upon their controlled sources of biomass energy, insofar as possible. This, in turn. raises several issues. First, with no broad market for biomass energy, it will be extremely difficult for the province to set appropriate values for wood fuel. This is analogous to problems encountered in setting stumpage for merchantable timber on the Coast and in the Interior. Stumpage on the Coast is tied to the Vancouver log market–an institution, according to many. that does not approximate a true market.[69] Stumpage in the Interior is based upon the value of processed fibre (lumber and chips) and involves the application of a specific formula. In both cases the value of timber is based upon somewhat mechanical measures rather than market values; so, too, will be the *case* for biomass energy, as long as no real market for the material evolves.

The lack of a marketgenerated price will also complicate internal allocation of resources by the integrated company. mese companies will have to rely on internal "transfer" prices between divisions; to the degree that these deviate from "true" or market prices, distortions will be introduced into resource allocation within the firm, which will compromise the attainment of "highest value end use" from the fibre. A detailed discussion of this issue will bedeferred until the next chapter.

b) Unequal Market Power

The large integrated companies will not be able to extract all of their total biomass energy requirements from captive sources. Since emphasis lies on mill residuals as the most viable source, they will have to purchase wood fuel from smaller, unintegrated sawmills. Herein lies a problem because there will be a much higher level of concentration amongst buyers than sellers of noncaptive mill residuais.

In 1975. the ten largest, integrated companies held 37 per cent of provincial sawmilling capacity, while the remaining 63 per cent was distributed unequally among some 230 other enterprises (Pearse, 1976). Thus, ten companies, potentially accounting for 90 per cent of the consumption of biomass energy, will be securing a portion of their requirements from more than 200 suppliers. In technical terms, such a market is defined as oligopsonistic–that is, a few buyers confronting many sellers–with disproportionate market power held by buyers. In such situations, theory predicts buyers will exert their market power to reduce prices and thereby cause a misallocation of resources.

That such a situation may emerge in the distribution of biomass energy is not idle speculation because an analogous one has developed in the market for Interior wood chips. in the early **1960s,** the provincial government encouraged the develop.

69 The nature and workings of the Vancouver log market are discussed in Task Force on Crown Timber Disposal 119741 and Juhasz, "Methods of Crown Timber Appraisal in British Columbia", McKillop and Mead (1974).

TABLE 111-2
COMPARATIVE CHIP PRICES IN DIFFERENT LOCATiONS
1979

Area	Average Price Per Unit (1979 $, f.o.b., sawmill)
British Columbia	39
Ontario	50
Quebec	55
US. Pacific Northwest	50
U.S. South	*50*

Source: Widman Management Ltd. (1979)

ment of pulp mills in the Interior through **a** number of policy innovations. Pulpwood Harvesting Area Agreements were **set** up to enwurage the use of sawmill residuals, which, **at** that time, were under-utilized. Contingent upon the construction of pulp mills, wmpanies were given rights to the residuals of independent sawmills operating within **a** specific area and, if this supply fell short of their **needs,** were directed to harvest pulpwood. The sawmills, in turn, were given increased cutting rights contingent upon **a** movement from "intermediate" to "close" utilization standards.

Up to 1974, there was general dissatisfaction among chip suppliers that the pulp wmpanies were paying too little for chips. In 1974, the government of the day responded to these complaints by passing the Timber Products Stabilization Act, which enabled the Minister of Forests to **set** minimum chip prices. This, the Minister did. Predictably, the pulp companies argued that the floor was too high, and from 1974 **to** the present, they have generally treated the government-set minimum as the *only* price for Interior chips. By late 1979, fragmentary evidence, provided in a report by Widman Management Ltd., indicated that Interior chips were significantly underpriced, **as** seen in Table III-2.

While the Widman (1979) study does not provide substantiation for this data, other evidence does reinforce its findings–for example, in November 1978, Fibrew Export Ltd., **a** consortium of over 40 interior sawmills, claimed that export prices for British Columbia chips were between $58 and $62 per unit (Hathaway, 1978).

c) The Drive for Security of Supply

The inability of the integrated wmpanies to obtain all of their biomass fuel needs from captive sources will also incite those firms to ***seek*** guarantees for the external supply of their requirements. Traditionally, the integrated processors have placed paramount importance upon security of fibre supply (whether it **be** logs or pulp chips), and it is expected that the same attitude will **be** held with respect to biomass energy.

The history of, and the explanation for, the drive for control over fibre sources **has been** documented elsewhere (Schwindt, 1977). Suffice it to say that, if the pulp wmpanies make the significant capital invesments necessary to utilize biomass energy and subsequently become dependent upon this energy source, they will certainly avoid supply interruption. The Interior chip experience again provides insights into this issue.

To induce investment in Interior pulp mills, the province guaranteed ***an*** exclusive fibre supply to each pulp operation. Evidently, it was not enough to ensure that aggregate supply was adequate to meet aggregate demand and then **to** allow market allocation of fibre. Instead, the province gave the pulp companies rights over forest tracts by means of the Pulpwood Harvesting Area Agreements (PHA). These agreements gave to the pulp mills the right to harvest timber, which, at the time, was not usable by the existing sawmills. However, with the advent of improved technology and the emergence of customers (the pulp mills) for residuals, the sawmills moved to "close" utilization and began harvesting what hitherto had been wasted. Because this lower-quality timber had already been implicitly allocated to the pulp companies, the province shored up their "security of supply" by imposing the "chip direction" program. In simple terms, the sawmills that increased their cut within the PHA had their chips "directed" to the pulp mill holding the agreement. Effectively, these chips constituted a captive source of supply for the pulp companies. So great was the production of sawmill residuals as a result of the move to close utilization that the pulp mills rarely invoked their right to actually harvest from these areas and came to rely solely upon the chips directed to them.

In the absence of a wide market for biomass energy (which, of course, ensures supply to any buyer willing and able to pay the market price), the pulp companies can be expected to petition the government for supply guarantees similar to the chip direction policy. The pulp firms can also be expected to extend indirect control over fibre supply through the tenure system or through the further absorption of independent sawmills.

Interestingly, the province has now altered its Interior wood chip policy. The change results from hearings held in early 1980 over the allocation of chips from a newly created pulpwood area. Integrated companies vied for allocation from the area, and in the process, it became clear that the long-standing chip surplus situation had come to an end. The Minister of Forests was asked by several of the contenders to continue the chip direction policy and, not surprisingly, to direct the chips to them. Other participants asked for market allocation. Evidently, the Minister opted for the latter suggestion, as the newly announced policy abandoned both the chip direction and the regulation of price. The predicted result of this decision is higher chip prices followed by increased supply, which, according to some, will be adequate to meet the demands of all those seeking additional fibre. Additionally, at least one pulp company has intimated that it views acquisition of independent sawmills as an appropriate response to this policy change.[70]

4.4 Prescription for Distribution

It is has been argued in this section that, when biomass energy becomes a primary energy source for the British Columbia forest products industries, its allocation will not be determined by open markets because of the existing property rights, the structure of the market, and the general industry preoccupation with security of input supply. The Interior chip market has been briefly described because of similarities between it and the potential market for biomass energy. If the experience of Interior chip allocation teaches anything, it is that a clear policy should be drawn up before the granting of property rights. Once allocated, these property rights would tend to restrict and distort future policy decisions.

When formulating a distribution policy for biomass fuel, the province will have to confront and resolve the competing demands of all participants, one of whom is the province itself. As resource owner, the province has a vested interest in ensuring that maximum value is extracted from the fibre it controls. To this end, it should seek to encourage the use of biomass fuel and facilitate the allocation of the material to those best able to use it.

The pulp and paper sector will demand an assured supply of wood fuel before converting to biomass energy systems, and understandably, they will prefer to pay as little as possible for this input.

The nonintegrated mills and logging operations with surplus residuals will seek the freedom to dispose of their surpluses to whoever will pay the maximum price.

In mediating between these varied and, at times, conflicting demands, policy makers should keep several factors in mind. First, the integrated firms already have succeeded in reducing the risk of insecure fibre supply. The Forest Act of 1978 went a

70 Vancouver *Province*, "Forestry-vested interests at stake as Victoria decides fate of chips", January 23, 1980, p. D10.

long way in assuaging fears that the province was going to renege on long-term tenure commitments it had made to the major enterprises (Schwindt. 1979). Control over harvesting rights, combined with control over a large portion of the sawmilling industry, is adequate assurance of raw material availability.

Second, given the extent of existing constraints on fibre allocation, the province should not further encumber the distribution system–in other words, fibre, which is not already captive. should be traded as freely as possible. The province should strongly encourage the evolution of wood fuel markets. except where evidence indicates that market allocation involves *significant* hardships–for example, regional dislocation.

Third, the development of such markets would help the province realize its interests in the allocation process. A market-determined price will aid the province and industry in achieving ideal allocation. It will also help in determining the province's share in the value of this resource.

Our suggestion here is consistent with the recommendations of the Pearse Royal Commission (Pearse, 1976):

> Thus my proposals to invigorate log and chip markets are also designed to ensure that "The marketing arrangements for timber products permit their full value to be realized and are consistent with an efficient economic structure .. ..."

5.0 EFFECTS ON THE VALUE OF FOREST RESOURCES

As the prices of fossil fuels increase, the value of forest biomass for energy purposes is enhanced. Such a change in relative value for one forest output has effects on the overall economic benefits derived from forest resources. For the purposes at hand, we define "value" as the net economic rents, or gross benefits less all costs, involved in all types of forest utilization. Net economic benefits derived from forest resources could be affected by biomass energy development in three ways–increased competition between alternative users, increased payments as rents to the Crown, and increased value of future forest crops.

5.1 Competition Between Alternative Uses

Perhaps the most controversial result of biomass energy utilization would be increased competition for forest resources. The 1980s are expected to provide steadily increasing demands for British Columbia's fibre supplies by domestic pulp manufacturers and by export markets. Concurrently, increased demands for wood biomass as energy are assured. It is therefore necessary to assess this increasing competition, to consider its overlap, and to determine its effects on the value Of forest resources.

a) Dimensions of Competition

One car find strong indications that competition for the forest industry's fibre residues is stiffening in British Columbia. Most dramatic is the recent vying for control of pulp chips by pulp mills in the central Interior. In late 1979, the Ministry of Forests called for submissions and then held hearings on the allocation of wood chips and residue produced by sawmills in the Cariboo area?' Three different companies actively sought chips from this area to provide fibre for expansion of their pulp activities. These planned expansions would, in total, considerably exceed the current production of chips in the area. Competitive quests for fibre supply to this extent may be indicative of future conditions in other parts of the province.

Another dimension of increased competition for provincial pulp chips is the growing export market, expanded in 1979 by Fibreco Export Inc. Long-term contracts, held by this firm for export of chips to Japan, have been viewed as a potential threat to chip supply by the provincial pulp industry.

Competition for supplies in a different arena-that of wood energy users-is less pronounced but certainly growing in some locations. Approaches have been made to provincial agencies by companies seeking biomass supplies for prospective wood

71 Vancouver Province, "Wood Chip Allocation Contested", January 17,1980, p. C-4.

conversion projects to produce energy or chemicals in the South Coast and elsewhere (Ministry of Economic Development, pers. comm.). In Chapter II, the South Coast was identified as likely to have shortages of low-cost biomass supplies. The potential for export is also a facet of competing demands for energy biomass. In March **1980,** Siocan Forest Products Ltd., **a** sawmill operator in the southern interior, announced an agreement to export up to 150,000 ODt of wood wastes to Washington Stale for fuel in an electric plant.[72]

This talk of growing competition for forest materials must, however, be tempered with the knowledge that, at present, oversupplies of chips and wood wastes are found in many parts of the province. That the province has approved the export of chips and wood wastes is a good indicator of its perception that excess supplies are available. Moreover, there are large areas in the far northeastern part of the province where the forest industry is not even close to the cut capacity of forest resources. Any anticipated overall shortages of pulp chips or wood wastes are, therefore, **based** upon the expectation of future expansion in conversion capacity rather than on current capacity.

b) Quality of Fibre as a Factor in Competition

In terms of physical structure, there is no sharp distinction between wood fibre suitable for fuel and that appropriate for pulp furnish.[73] On that basis, one could say that the two uses draw on the *same* pool of material and that allocation between the two would be determined by the value of the input in the production of the respective output—for example, energy and paper. There is, however, a difference in the quality of fibre suitable for the two uses, as shown in Table III-3.

The table illustrates the descending order of residual quality, with white softwood chips leading the list. High-quality softwood chips are, in fact, the source of strength in British Columbia's pulp sector, since they produce a better product and require less bleaching than other chips. Other potential fibre sources for pulp include chips from convenient forest residues[74], as well as hardwoods in limited quantities. At the other end of the spectrum, material suitable for energy includes all types of wet **or** dirty wastes (including bark). Where the two uses overlap is in clean wastes like sawdust and shavings, which require digestors if used for kraft pulp.

Because of the cost of a sawdust digestor, one would expect only pulp mills to utilize higher proportions of sawdust or shavings in place of chips, if their available supplies of chips were depleted or if chips became costly relative to mill **wastes.** Even in that *case,* a company has the abovementioned alternatives to augment its fibre supply. One Interior mill is expanding in the Prince George area (where tight chip supplies are expected) and plans to utilize a limited amount of hardwood and cedar chips, along with recovery of chips from convenient forest residuals. to make up deficits of conventional chips. The amount of mill wastes this company could utilize is limited by its lack of a sawdust digestor (Northwood Pulp and Timber Ltd., pers. comm.).

Given the long-term potential to supplement conventional chips with other fibre sources. it is expected that extensive use of sawdust and shavings by pulp mills will be slow to develop. There is, moreover, a large class of low-quality wood waste, such as bark and dirty aggregates, expected to be of no interest to the pulp sector unless significantly lower-quality pulp bewmes acceptable. Consequently, competition between pulp and energy users is likely to be segmented as to quality of wastes and not widespread for **some** years, as was previously concluded in Chapter **II.**

c) Possible **Increases** in Residue Supply

It is interesting to observe that growing competition for fibre by pulp mills may possibly increase the supply of residues available for energy use. Such

72 **Vancouver Province, January 27, 1980, p. F-4.**

73 **Pulp** is used **here to represent all direct** uses of **wood** wastes **in manufacturing.**

74 **Fibreco Export Ltd.** is **undertaking a Chip recovery program based on log yard residues. Vancouver *Sun,* "Chip Consortium Plans Three Plants", March 13, 1980, p. D-2.**

TABLE 1113
QUALITY AND SUITABILITY OF
FIBRE SOURCES FOR PULP PRODUCTION

Highest Valueand Quality	Best For Pulp Production
White Softwood Chips Softwood Chips from Convenient Forest Residues[a] Clean Sawdust and Shavings[b] Cedar and Hardwood Chips[c] Small Trim Ends and Slabs Dirty Mixed Wastes Bark	
Lowest Valueand Quality	Worst For Pulp Production

Source: McDaniels Research Ltd

[a] Includes chipping of log yard residues or landing residues only. Recovery of convenient residues is expected to be mud, less costly than recovery from logging sites, which was discussed in Chapter II

[b] Only kraft pulp mills with sawdust digestoncan utilize these residues, Without such a digestor. hardwoodchips may be preferable to sawdust.

[c] Small quantities of hardwood fibre can be mixed with softwoods without reduction in quality of the final product.

an increase in mill residues could stem from more complete utilization of available forest resources. A pioneering example is the plan by Fibreco Export Inc. to construct three chipping mills in the Interior, intended to process log yard residue from the consortium's 42 sawmills. Since these operations will involve debarking of timber residues before chipping, they will produce their own wastes suitable for energy.

More broadly, one can expect that increased competition for fibre would encourage more complete utilization through higher recovery of forest material. Better recovery would entail an increase in sawlogs and pulp logs; as a result, sawmill outputs would increase in volume and mill residues would increase. Such an increase in mill residues, owing to better utilization, was a major factor in predictions of expanded hog fuel production by Reid, Collins and Associates Ltd. in their studies (Reid, Collins, 1978).

Moreover, one could expect that increased demand for chips would encourage chipping of usable residues in the forest. This further step in utilization has already been suggested as a viable solution to prospective chip shortages.[75] If the technology is developed to chip large tree pieces in the forest, it would then be a relatively small step to extend the chipping to other tree parts not suitable for pulp but excellent for energy purposes. Joint recovery of chips and fuel biomass could reduce the recovery costs to competitive levels.

Finally, long-term improvements in forest management, which increase yields, are a good possibility.[76] When coupled with future innovations in transportation, which is now perceived as a major obstacle to efficient residue utilization, increasing yields could significantly expand the volume of biomass available for energy.

Despite these mitigating factors, one could expect that pulp producers may, in the long-term, compete with energy conversion for waste supplies in certain areas. Competition for biomass between various energy users in a given area is also a distinct possibility, as is competition between domestic energy use and export.

d) Consequences of Competition

The initial consequence of increased competition for wood fibre, whether by pulp producers, would be higher prices. These price increases would be a function of the growing opportunity costs and the increasing marginal revenue products of the fibre resource.[77]

Price increases would have beneficial market effects by restraining demand and encouraging greater biomass supply. Increasing prices would serve to ration the available supply to those uses that value biomass highly and that could, therefore, pay more for it. Price increases would also encourage prudent use of biomass resources, as companies would attempt to marginally reduce their consumption and, consequently, reduce their biomass costs. Effects of higher prices on biomass supply would initially occur in longer transport of biomass from areas of surplus to areas of shortage. Price increases would also stimulate greater production of wastes from marginal sources such as chipping of log yard residues or marginal increases in the volume of low-quality material brought to sawmills. Table III-4 summarizes the changes in production- and consumption-associated price increases for biomass.

In short, competition would bring forth the market responses that tend to equate supply with demand. Such market behavior would be neutral, in an economic sense, in its effects upon wood

75 **Vancouver *Province,* "Forestry-Vested Interests at Stake as Victoria Decides Fate of Chips", January 23,1980, pp. D-10, 11.**

76 **For a discussion of increased long-term yields, see Intergroup (1978).**

77 **This statement, and the discussion following, presupposes the existence of active regional markets for wood biomass, as argued in Section 4.0 of this chapter. "Marginal revenue product" refers to the increase in total revenue afforded to a company by an incremental increase in one input. The marginal revenue product of wood biomass stems from the value of the final products-e.g., energy and pulp—and the productivity of the input in the conversion process.**

TABLE III-4
EFFECTS OF INCREASING PRICES ON
SUPPLY AND DEMAND OF FOREST BIOMASS ENERGY

Effects on Demand:

- reduction in quantity of energy demanded
- conservation of energy
- consideration of alternative energy sources

Effects on Supply:

- increased movement of biomass between regions
- increased harvest of low-quality materials at initial logging
- efforts to increase mill residual production where possible
- consideration of recovery of forest residuals for energy

waste consumers. It is possible some marginal biomass energy projects could not afford to purchase wood wastes if competition in their area increases prices (see Chapter II, Section 6.0). But rationing of this type is simply the result of market forces that allocate scarce resources to their more valuable applications and thereby contribute to wise resource management.

Intensified competition would also help achieve the most desirable distribution of biomass between alternative uses. Companies that control biomass supplies would naturally allocate them to the uses that provide the best return, either internally or to buyers outside the company. Manufacturing or energy production would then command fibre if justified on the basis of market prices.

Overall, increased competition would enhance the value of forest resources by raising prices, expanding supply, and encouraging efficiency. Such beneficial results are, however, only obtained if this competition is manifested in an effective wood biomass marketplace.

e) A Possible Source of Misallocation

This positive picture must be qualified by raising a possible, albeit unlikely, context in which competition could fail to properly allocate biomass. Outside of regulatory constraints, the chief obstacle to efficient utilization of biomass could be the forest industry's own investment strategy.

Investment in pulp capacity expansion or biomass conversion facilities requires large financial sums, involves significant lags between decision and start-up, and has a relatively long life. Thus, once an investment is made, the enterprise is committed to a rather inflexible strategy. Unfortunately, the history of forest industry investment policy has been flawed.

> It must also be acknowledged that investment planning in the industry itself has not been faultless. According to last year's President of the Canadian Pulp and Paper Association, "... strategic planning of the industry has been singularly inept ..." This is not inconsistent with the finding of an independent study of general investment behavior that reported, "... a striking (and, to me, surprising) difference between the strenuous efforts to forecast capital expenditures correctly and the rather careless methods used to forecast the cost and revenue consequences of the same projects." Certainly, some large forest products ventures in this province appear to have been poorly planned or poorly managed (Pearse, 1976).

TABLE **III-5**
BIOMASS ENERGY CONVERSION PROJECTS
THAT PROVIDE MINIMUM ACCEPTABLE RETURNS
WHEN OPERATED FOR DIFFERENT TIME PERIODS[a]
(Number of Projects)

	Length of Operation				
	5 years	10 years	15 years	**20** years	**25** years
in Pulp Mills	18	18	18	18	19
Cogeneration Facilities in Pulp Mills	0	3	**5**	10	14

Source: McDaniels Research Ltd.

[a] **Calculated as projects that provide above 15 per cent net after-tax returns on investment when depreciated over the time period. See Appendix I for details of calculations.**

Misallocation of investment resources could eventually result in misallocation of fibre inputs, especially when allocation is based on intra-firm transfers rather than market transactions. For example, if the industry invests simultaneously in both pulp capacity expansion and conversion to biomass fuel without taking cognizance of potential supply and demand factors, especially at the regional and subregional level, distortions could result. Mills attempting to maintain capacity operation might commit fibre to uses that did not reflect its highest value.

The point here is that it is conceivable the industry will invest in a capital stock that requires an inflexible allocative mix of wood waste as fuel and as pulp furnish. If changes in the relative values of these two uses are incompatible with the input mix mandated by current investment, misallocation could result.

One could express this notion more succinctly by saying that a firm could misallocate biomass resources if its private assessment of the most valuable resource use differs from a public assessment. A relevant example would be an energy producer that needs to operate its biomass energy plant for a certain period of years in order to recoup the original investment, despite the possibility that pulp is a more valuable use. It is therefore worthwhile to consider the payoff periods for the potential biomass energy investments discussed in Chapter II.

Table **III-5** indicates the number of biomass conversion projects that provide a minimum acceptable rate of return on investment, when capitalized over different periods. It shows that nearly all of the 19 potential pulp mill boiler replacement projects provide at least a minimum rate of return if operated for only **5** years. Cogeneration investments at pulp mills are less productive; the figures show they must operate at least 10 years before any yield a minimum return and must operate **25** years before all viable projects provide minimum returns. Although no data is at hand, it can be expected that investments at wood products mills would show similar patterns to pulp industry boilers. The investment with the longest term of return is likely the Quesnel thermal electric plant, although it is impossible to calculate comparable return figures.

The upshot is that, although inflexible investment strategy could possibly be a barrier to efficient allocation of biomass supplies, such an occurrence is unlikely. Nearly all the power boiler conversion projects would provide minimum returns if operated for only **5** years, and since these projects comprise over **90** per cent of the potential wood energy use in the forest industry, companies would be unlikely to feel constrained by their energy conversion capital stock when contemplating alternatives in biomass utilization problems.

f) Final Observations

There is little reason to fear that increased competition for biomass supplies would adversely affect the value of forest resources. By increasing prices and promoting efficiency, competition would enhance forest values. So long as regulations or other factors did not impede their decisions, forest industry companies would allocate their biomass supplies to uses that provide the highest return. The bulk of their investments in biomass energy conversion would be repaid in 5 years, so forest companies would have little private incentive to forestall changes in utilization that would bring public benefit. The cost associated with not utilizing biomass energy at present, when there are enormous surpluses of wood wastes in the province, seems to be much greater than the potential cost that could result from forestalling more valuable uses in the distant future.

This is not to suggest that a laissez-faire role is appropriate for provincial resource managers. Considerable dislocation and economic waste could result from too many wood residue consumers in a given area, no matter whether they are energy or pulp producers. Implicit property rights to residues could also become entrenched, limiting the degree of competition and creating the potential for misallocation of biomass supplies. Provincial agencies should, therefore, encourage competition in biomass markets and should also undertake planning studies to identify the best pattern of residue utilization in a given area. Of course, the best pattern, from the provincial viewpoint, could be determined from a number of different criteria, including economic rents to the province, regional development, fossil fuel substitution, or others. The point to emphasize here is that regional planning of residue utilization should accompany, but not replace, a viable market to allocate supplies.

5.2 Stumpage Payments

a) Concepts

Forest biomass energy would have its most direct influence upon resource values through payments to the Crown or stumpage. Stumpage is basically the price paid to the Crown for wood fibre. The objective of the stumpage system is "to appropriate for the Crown the full net value of public timber after due allowances for necessary costs of operating operations and profit to the operators" (Task Force on Crown Timber Disposal, 1974). Logically, if wood waste has a value as fuel, this value should be incorporated into the stumpage calculation. At issue is how these stumpage charges should be imposed to ensure that the province's manifold interests are protected.

Foremost among these interests is the province's role as landlord. Since the stated goal of the stumpage system is to extract the full economic return from the exploitation of public timber, charges should be levied accordingly. This, however, is not a simple task as the province employs a dual stumpage system. On the Coast, the Forest Service bases its calculations of the value of harvested timber upon prices generated in the Vancouver log market. Notwithstanding the fact that this "market" has been the subject of considerable controversy, it is possible that the energy value of mill residuals would automatically be reflected in log prices. It is difficult to see, however, how these log prices would capture the energy value of biomass sources that may become viable in the future, such as unmerchantable species and forest residuals.

The value of timber harvested in the Interior is based upon the prices of final products. With a functioning market for wood fuel, there would be little problem in ascertaining values for this resource. As lower-quality material came to be marketed, its value could be determined and appropriate stumpage imposed.

Appropriation of economic rent is not the sole object of forest policy, and therefore the imposition of stumpage must be made consistent with other policy objectives. Also important among policy objectives is the stimulation of raw material processing and the encouragement of regionally dispersed industrial activity. These goals were important in the framing of the Interior chip pricing policy, which was revealed in Section 4.0 of this chapter.

A relevant question here is, If the province seeks to encourage the adoption of biomass fuel use, what role should the stumpage system play? Pearse, in his Royal Commission report, suggests that no stumpage levy at the outset would provide the greatest encouragement.

> Marketing of hog fuel, sawdust, shaving, and like products should also be encouraged . . . It is important, therefore, that public policy in no way impedes the recovery and use of these residual products. Apparently, incentives for development of new markets are now blunted by apprehensions that this may result in their being included in stumpage appraisal calculations (under the Interior end product appraisal formula) and, hence, in increased timber prices. This concern should be allayed. I, therefore, recommend that the government make an explicit policy statement to the effect that residual products, other than pulp chips, not be included in stumpage appraisals for a period at least sufficient to assure producers that the government will not appropriate the returns from new investments undertaken to develop the use of these products. Such a commitment should be for at least five years (Pearse, **1976).**

The problem with this suggestion is that **it** implies a temporary subsidy at some point in the processing chain. If stumpage is not to be collected, are all rents to accrue to harvesting operations?–that is, Will sawmills pay nothing for the fuel value of the timber they process but be allowed to charge freely determined prices for their residuals? Or will the province insist that pulp mills share in the subsidy, and does this, in turn, mean control of wood fuel prices? And, once these distortions are introduced into the system, how can **it** be guaranteed that they will be withdrawn in an equitable fashion, if at all? The Interior chip policy teaches that, while subsidization did stimulate residual use, **it** also left a legacy of allocative distortions that are only now being removed and, evidently, with considerable problems.

This topic is discussed further in Chapter VI. **It** is sufficient to say at this point that a simplistic policy of stumpage waivers is not a cost-free solution.

b) Practice[78]

Assuming a decision is eventually made to incorporate wood fuel values into the stumpage system, we can briefly review how the move would be practically implemented and how much stumpage charges would increase. First, only in the Interior would overt inclusion of the market value of wood wastes appear in appraisals. On the Coast, the value of wood wastes for energy should, in theory, be registered through the Vancouver log market. Second, previous practice suggests that the value of wood energy would only be incorporated into appraisals when its utilization is widespread in the industry. The Ministry of Forests would likely avoid placing cost burdens on sawmill operators who are not in a position to utilize or market their wastes.

The revenue or market value of wood wastes could be most accurately assessed through reliance on market prices from actual biomass transactions. When assessing the value of biomass, appraisal officers would have to be cognizant of the influence of transport costs upon the return to producers. Since mill wastes would provide revenues without any attendant increase in costs, their market value would directly increase the "conversion return" or excess of revenues over operating costs, which is divided between the province and the forest operator.

An interesting feature of the stumpage system is that the provincial share of the "conversion return" progressively increases as the selling price of outputs increases. In poor product markets, when the price of lumber is depressed, companies pay only minimum stumpage charges of 3 per cent of the selling price per cubic metre. Under those conditions, appraisals incorporating the market value of wood wastes at **$15** per ODt would have little or no effect on stumpage paid.

During periods with normal lumber prices, the province receives roughly **50** per cent of the conversion return. On that basis, a market value of **$15** per ODt for wastes would increase stumpage by roughly **$0.45** per cubic metre, assuming that one cubic metre yields **0.06** ODt of marketable waste.

The provincial share increases during periods of high lumber prices to the extent that **it** receives a maximum of about **80** per cent of the conversion return. Under those conditions, sales of biomass at **$15** per ODt would increase stumpage charges by roughly **$0.75** per cubic metre, again assuming an output of **0.06** ODt of wastes per cubic metre processed.

78 **Information in this section is based upon interviews with the Valuation Division, Ministry *of* Forests.**

TABLE III-6
POTENTIAL COST SAVINGS
RESULTING FROM RESIDUE UTILIZATION
(Estimated Savings in 1980 $ Per Hectare)

Activity	Forest Type		
	Spruce-alpine	Fir-pine	Dry-belt Douglas-fir
Slash Burning	$115 to	$152	---
Windrowing	$115 to	$228	---
Scarification	$115 to	$152	---
Slashing			---
Landing Clean-up	$42.50		$42.50
Total Savings Per ODt of Residues Recovered[a]	$4.50-$9.00		$4.50–$6.00

Source: B.C. Forest Service (1976), citing Mr. A. Vyse

[a] Assuming 30 ODt of residues per hectare in S-B-PL forest types and *8* ODt per hectare in **PL** forest types.

5.3 Increased Values of Future Harvests

To complete this section on forest values, we observe that there will be positive externalities–that is, nonpriced benefits–associated with forest energy use that could increase the value of future harvests.[79] One type of externality could stem from reduction in the costs of fire prevention, site preparation, and reforestation as a result of decreased forest residuals remaining at logging sites. Table III-6 summarizes data presented in a report by the provincial Forest Service, estimating possible cost savings in fire prevention and site preparation that could result from increased residue utilization. These figures should be viewed only as rough estimates.

A second type of externality would be the benefits associated with harvesting noncommercial species, diseased wood, or thinnings for energy use. Each of these activities is a desirable step in forest management but often too expensive to be undertaken. Energy use of the biomass would subsidize these activities and effectively reduce the costs. Again, lack of data precludes an estimate of these potential savings. It is reasonable to say that the value of these associated silvicultural benefits is a topic needing further research.

6.0 CONCLUSIONS

The multiple effects of forest biomass energy use upon resource management have been explored in this chapter. After initially reviewing the resource management system, we have considered the effects on forest harvests, issues in biomass distribution, and effects on the value of forest resources.

The most pronounced effect of forest energy use upon harvests would lie in an incentive for

79 Other externalities, associated with environmental effects of forest energy use, are discussed in the following chapter.

greater utilization. The value of wood wastes for energy would provide an impetus for fuller recovery of the forest crop, more closely in line with provincial utilization standards. Modest effects would also occur on the rate of forest harvests. Forest energy use would marginally reduce the tendency for fluctuation in forest harvests and processing demands; however, the potential for significant disparity in regional supply and demand for wood wastes exists, pointing to the need for viable, effective biomass markets.

Issues in distribution of biomass were thoroughly explored, beginning with an ideal competitive market system. Reasons why this ideal could not be achieved were discussed, emphasizing the industry structure, as reflected in the tenure system and the extent of vertical integration. Next, the probable consequences of this structure for biomass distribution were considered; these centered on the tendency for the major companies to rely on intra-firm transfers where possible, the probable unequal distribution of power between buyers and sellers, and the impetus to obtain security of supply. The section concludes with a prescription for biomass distribution that stresses the need to maximize the degree of competitive market activity.

Our concern in the last major section of the chapter is with the effects of biomass energy use upon the overall value of forest resources. Recognizing the present concern over the adequacy of forest resources to meet industrial demands, we provided a lengthy discussion of the effects of increased competition for wood residues resulting from biomass energy use. The chief conclusion is that, with effective markets, competition would increase prices and efficiently allocate resources to their most valuable uses. Next, we discussed the significance of the stumpage system and its likely role in collecting provincial rents attributable to energy values for wood wastes. Finally, certain positive externalities that could increase forest values by reducing costs were considered.

Some aspects of the forest management system could constrain the adoption of forest energy use; on the other hand, the management system could also be employed to provide incentives to speed the use of biomass for energy. Both these subjects have received only passing mention here but will be explored fully in later chapters.

CHAPTER IV

IMPACTS OF FOREST ENERGY UTILIZATION

1.0 INTRODUCTION

Increased utilization of forest biomass energy would create a wide range of impacts on various aspects of British Columbia's economy and environment. The purpose of this chapter is to identify these impacts by analyzing forest energy use from three perspectives–forest industry activity, environmental quality, and regional socio-economic conditions.

2.0 IMPACTS ON THE FOREST INDUSTRY

2.1 Introduction

In economic textbook terms, a move from conventional to biomass energy sources entails the adoption by the forest industry of a modified production function in response to changes in the relative prices of inputs. In the rarified world, which these textbooks describe, models can be constructed that will show the effects on costs and outputs resulting from the altered input mix. Unfortunately, the world is far more complex than that portrayed by such models; it is complicated by heterogeneous inputs, heterogeneous participants, external authority, entrenched property rights, and the like.

The intent of this section is to present, in broad brush strokes, the probable effects of conversion to forest energy sources upon the structure of the British Columbia forest products industries. When speaking of market structure, the industrial organization economist emphasizes the: absolute and relative size of the enterprises that populate the industry, barriers to entry into the industry, degree of vertical integration, cost structures, and structure of the markets into which producers sell.

Our interest in the probable impacts of a conversion to biomass energy upon the structure of the British Columbia forest products industries is not based upon idle curiosity. Industrial structure, in large measure, determines market conduct and, subsequently, market performance in such areas as production efficiency, allocative efficiency, and progressiveness. The links between structure and performance, although documented in the industrial organization literature, have only recently been applied to renewable resource industries in general and the British Columbia forest products industry in particular. In fact, up to the Royal Commission on Forest Resources, which reported in **1976,** the structure of the industry had not been thoroughly researched. The Commission was explicitly directed to report on the impacts of forest policy on:

> the structure of the forest industry, having regard to its pattern of integration, concentration, ownership, and control; and for the structure of markets for forest products produced in the province . . .

The Commission fulfilled this directive and produced considerable data relating to the structure of the industry (Pearse, **1976).**

Interest in the impacts of forest policy on the industrial organization of the British Columbia forest sector did not end with the Commission report. Recently, the issue was raised again by the Minister of Forestry with respect to the chip direction policy.[80] Policy makers have come to clearly understand the effects of forest policy on industry structure and, consequently, upon the level of competition and efficiency in production and allocation.

The method of analysis in this section is first to briefly review current industry structure and then to trace out the probable effects of conversion to biomass energy upon that structure. Emphasis is placed upon conversion costs, organization of inputs, and tenure issues.

80 **Vancouver *Sun,* "Interior Mills Get New Policy on** Wood **Chips", March 7, 1980, p. C-1.**

TABLE IV-I
CONCENTRATION OF HARVESTING RIGHTS
WITHIN REGULATED FOREST UNITS, BRITISH COLUMBIA
1975

	Committed Allowable Cut[a]	
Number of Firms	('000m^3)	(% provincial total)
Largest 4 enterprises	21,725	35.4
Largest 8 enterprises	32,458	52.9
Largest 10 enterprises	35,952	58.7

Source: Pearse (1976)

a As of July, 1959

2.2 The Extant Industry Structure

The forest industry is actually a composite of a number of component industries that have a common feedstock (wood fibre) but produce commodities that are intermediate, imperfect substitutes or not substitutes at all. We will limit our discussion to four industries–namely, logging, lumber, plywood and pulp.

a) Logging

Narrowly defined, the logging industry involves the actual harvesting of trees and its product is the raw material–that is, logs. Superficially, logging in British Columbia appears highly fragmented, with Statistics Canada enumerating 549 establishments on the Coast and 868 in the Interior for 1975 (Statistics Canada, 1977). The control of logging, however, is tied to harvesting rights, whether emanating from outright ownership of forest lands or from rights granted by tenure. Control over these rights is not fragmented; indeed, it is concentrated and, according to the Royal Commission on Forest Resources, is becoming more so (Pearse, 1976).

Table IV-1 shows that the four largest holders of rights within regulated units–principally Tree Farm Licenses and Public Sustained Yield Units-accounted for 35 per cent of the provincial total, while the ten largest held 59 per cent. Concentration of holdings within the unregulated units–primarily Crown grants and Old Temporary Tenures–was even higher, with four enterprises controlling 49 per cent, and ten holding 70 per cent, of the acreage in these units, as shown in Table IV-2.

TABLE IV-2
CONCENTRATION OF HARVESTING RIGHTS
OUTSIDE REGULATED UNITS, BRITISH COLUMBIA
1975

	Hectares	Share of Provincial Total
Number of Firms	('000s)	(%)
Largest 4 firms	548	49
Largest 8 firms	724	65
Largest 10 firms	777	70

Source: Pearse (1976)

The large number of establishments noted above is explained by the site-specific nature of logging. There are few economies of scale in logging and, thus, minimal cost penalties are associated with small operations. Also a fair number of these establishments are owned by independent operators who subcontract to the enterprises who actually hold the cutting rights. Subcontracting occurs because different types of tenures require the holders to allocate a proportion of the logging to small independent operators, although the fibre remains the property of the tenure holder. Owing to restrictions on exports, most timber harvested is at least processed to some degree within the province.

b) Sawmilling

The sawmilling industry also supports numerous establishments–Statistics Canada (1977) shows 92 operating on the Coast and 228 in the Interior in 1975.[81]

As shown in Table IV-3, control of sawmilling capacity is somewhat less concentrated than harvesting rights. The largest four enterprises hold 22 per cent and the top ten account for 38 per cent of provincial capacity. Actually, concentration is considerably higher on the Coast than in the Interior. In 1975, one firm, MacMillan Bloedel, held 18 per cent, and the six largest firms accounted for 48 per cent of coast sawmilling capacity (Schwindt, 1977).

The Coast and Interior are distinct in terms of species cut and geographic markets served. From Table IV-4, it is seen that, on the Coast, hemlock is the principal species used, while in the Interior, spruce is of paramount importance. The Interior ships mainly via road and rail to the central United States and to Canadian markets, while coastal shippers emphasize water-borne shipments to U.S. Atlantic ports, Great Britain, and other overseas markets. Also, Interior lumber is nearly all kiln dried, while as much as 85 per cent of coastal production is shipped "green". There are multiple reasons for this pattern, including traditional consumer preferences, insensitivity of water-borne carriage to weight differentials, and the propensity of certain species (especially spruce) to stain and discolor when shipped in a green state.

c) Plywood

Plywood production capacity is highly concentrated within the province, as it is throughout the country. In 1974, five enterprises held 74 per cent of provincial capacity and, at the time, operated 14 separate plants.

Plywood is, of course, kiln dried. There is, however, considerable intra-company transportation of green veneer. The reason for this movement is that certain core material (for example, spruce) commands a higher price when combined with fir faces. Hence, not all veneer mills have the need for kilns.

Number of Firms	Capacity/Shift ('000 m^3)	Share of Provincial Total (%)
Largest 4 firms	15.3	21.5
Largest 8 firms	23.3	33.6
Largest 10 firms	26.9	37.7

Source: Pearse (1976)

81 Note that Statistics Canada reports only larger mills.

TABLE IV-4
SOFTWOOD LUMBER PRODUCTION BY SPECIES AND REGION
BRITISH COLUMBIA
1978

	Coast		Interior	
Species	('000 m^3)	(%)	('000 m^3)	(%)
Douglas-fir	1,833.7	16	1,780.4	10
Hemlock	6,654.5	59	810.6	5
Red Cedar	1,959.3	17	596.8	3
Spruce	379.9	3	12,125.7	66
Other	507.4	5	2,954.9	16
Total	11,334.6	100	18,268.5	100

Source: Calculated from Council of Forest Industries (1978)

TABLE IV-5
DISTRIBUTION OF CAPACITY
AMONGST MAJOR INTEGRATED FIRMS
BRITISH COLUMBIA
1975

	(% Provincial Total)				
Firm	Harvest	Lumber	Plywood	Market Pulp	Newsprint
MacMillan Bloedel	14.3	7.2	17.6	13.1	62.2
Crown Zellerbach	5.7	3.4	13.0	4.2	15.2
Canadian Forest Products	7.4	3.6	13.5	14.0	---
B.C. Forest Products	7.2	6.4	9.0	12.8	16.3
Weldwood	3.8	3.4	20.9	6.4	---
Cancel	7.1	3.1	---	11.9	---
Northwood	4.1	4.3	---	5.9	---
Weyerhaeuser	1.9	2.2	---	10.6	---
Rayonier	3.8	1.8	---	8.9	---
Tahsis	2.6	1.3	---	6.4	---

Source: Schwindt (1977); Pearse (1976) and various submissions to the 1976 Royal Commission on Forest Resources.

British Columbia plywood producers ship the bulk of their production to the Canadian market. In 1978, for example, 79 per cent was shipped to domestic markets, 20 per cent went to the EEC, and the remainder went to a number of other importing countries. At present, little plywood is exported to the United States, although industry sources claim that the product is on the verge of becoming cost competitive in that market. Energy cost advantages might, at the margin, make plywood exportable to the United States.

d) Chemical Pulp

Chemical pulp is produced for the most part by the sulphate or kraft process, which has displaced sulphite over the years. A proportion of sulphate pulp is used in the production of liner board and wrapping paper, and newsprint uses roughly 15 per cent sulphate and 85 per cent groundwood. However, over 80 per cent of chemical pulp production in the province is termed "market pulp", which is bleached, dried kraft pulp, a large proportion of which is exported. Concentration in the production of market pulp is very high in the province, with four enterprises containing 52 per cent and eight holding 84 per cent of provincial capacity in 1975 (Schwindt, 1977).

e) Vertical Integration

Logging, lumber, plywood, and pulp, while separate industries, are not populated by different sets of specialized enterprises. Vertical integration is pervasive, as the major companies are active from logging through pulp and paper production. As Table IV-5 shows, ten integrated enterprises all operated in logging, sawmilling, and pulp manufacturing and had varying importance in each. Five dominated the plywood industry and three effectively constituted the province's newsprint industry.

The industrial structure of the forest sector of British Columbia is concentrated, characterized by large vertically integrated enterprises. Policy makers have become sensitive to the impacts of exogenous forces, particularly their own policy moves, upon this structure. Moreover, the Ministry of Forests has publicly held that further concentration should be avoided insofar as possible. A move to biomass energy utilization will affect this structure, and as will be discussed later in this section, the industrial organization of the sector will impact upon the rapidity and extent of conversion to wood fuel.

2.3 Impacts of Biomass Energy Use

a) Logging

Logging, owing to its site specific nature and low energy use, holds little potential for conversion to wood biomass energy. However, conversion by downstream processing units will have notable effects upon logging operations.

As the value of forest and mill residuals rises, it will become profitable to remove greater amounts of fibre from a given stand. More intensive harvesting of a fixed area results in increasing costs per unit of volume removed. Evidently, the removal of lower-quality timber is more costly than higher-quality. This implies that, as conversion to biomass fuel evolves, more resources will be committed to the logging industry and that, with respect to variable inputs, additions will be greater than proportional to the amount of fibre removed–in other words, to extract an additional unit of fibre will require more variable inputs than were necessary to extract the previous unit.

Therefore, one would expect the movement of economic resources–capital and labor–into logging. There would also be strong incentive to develop technology more appropriate to the removal of residuals in order to dampen the current cost penalties associated with this type of harvest.

One could also expect the value of energy residuals to enter into the decision of what constituted a "harvestable stand". A significant proportion of the total costs of a logging operation are of a fixed nature. Administrative costs (for example, surveys, cutting plans, environmental studies), transportation costs (for example, roads, bridges, marshalling yards), and outlays for labor amenities (for example, camps in remote locations) are basically fixed, regardless of the volume of timber harvested. The spreading of these fixed costs over a wider range of products should make feasible the harvesting of hitherto uneconomic stands.

While the conversion to biomass fuel should induce resources into the logging industry, it is unlikely that the structure of the industry will change to any marked degree. The control over logging is tied to control over harvesting rights, and there is little reason to expect reallocation of these rights. To the extent that tenures require the licensee to subcontract a given proportion of the actual harvesting to independent loggers, the demand for the services of these operators would increase and potentially new operators would enter the industry.

The extraction of lower-quality fibre will also impact upon enterprises involved in post-harvest stand management. Site preparation and replanting would ostensibly be less costly as a result of reduced logging wastes. Again, subcontractors carry out a proportion of reforestation, and this group would be expected to gain from residual removal.

b) Lumber

Both its own conversion and the conversion by downstream processors to biomass energy will impact upon the provincial lumber industry. On the one hand, conversion will entail capital costs and eventual fuel savings for sawmills; on the other hand, conversion by pulp and paper convertors will increase the demand for sawmill residuals.

Scale **of** Mill Operations

In its report, the Royal Commission on Forest Resources noted with some alarm the rapid attrition of smaller sawmills within the province. This trend is shown in Table IV-6 and, apparently, characterized the national, as well as the provincial, industry. "The downward trend (that) has been noticeable in the number of establishments (almost unbroken since 1961) is apparent again this year [I975] ·· (Statistics Canada, 1977).

In large measure, this attrition is explainable in terms of technological imperatives. Estimates made in 1975 placed minimum efficient scale–the smallest plant size compatible with exploitation of all significant scale economies–between 190 and 285 cubic metres per 8-hour shift (Schwindt, 1977). In 1975, 627 mills, accounting for 83.5 per cent of provincial capacity, were below this minimum (Pearse, 1976). Moreover, in a study prepared for the provincial government in 1973, the consultants limited their analysis to mills ranging in size from 175 cubic metres per shift to 670 cubic metres per shift and concluded that construction of larger mills should be encouraged. Indeed, their study showed the largest mill enjoying manufacturing costs 18 per cent lower than the smallest (Philips et al., 1973).

Given that there will continue to be pressure on the smaller mills, a relevant question is whether the move to biomass energy will exacerbate the trend toward larger capacity units.

It is in lumber drying that the greatest potential for wood fuel use lies in the sawmill sector. Moreover, it is most likely that future conversion to wood fuel will be more common in the Interior than on the Coast. This pattern is likely for two reasons. First, a significant proportion of Coast production is not kiln dried because of species cut, transporation factors, and market preferences. Second, many of the Coast mills have already converted to hog fuel, either independently or because they are contiguous to a pulp mill and share the hog-fueled steam system.

TABLE IV-6
NUMBER OF SAWMILLS AND AVERAGE CAPACITY
BRITISH COLUMBIA
1950-1974

Year	Number of Mills	Average Capacity Per Shift ('000 m^3)
1950	1,826	24.7
1955	2,489	26.6
1960	1,938	35.8
1965	1,191	54.7
1970	881	63.4
1974	787	79.7

Source: Pearse (1976)

These observations are clarified by referring to Table II-11 of Chapter II. It is seen that, of the kilns with an identified fuel source on the Coast, **45** per cent were hog fuel-fired, while the figure for the Interior was only 12 per cent. Two-thirds of Interior mills depend upon natural gas.

The Interior sawmills are generally smaller than their coastal counterparts. Owing to the density of timber stands and the availability of water transport to carry logs to mills, coastal operations have tended toward concentrated capacity at tide-water locations. Interior mills, however, "went to the timber", which resulted in a more fragmented industry structure. One could expect that rationalization of Interior milling, as evidenced in a trend to larger units, will continue with or without conversion to biomass energy.

Retrofit

In the short term, if fossil fuel prices rapidly rise, the capital cost of installing wood fuel systems will constitute a financial burden for the mills with kilns. In some instances, small, marginally economic mills will fail. However, it should be noted that the truly small operations do not kiln dry. Many, especially portable operations, cut rough lumber and supply it to agricultural users, mining operations, and larger mills with planer and drying facilities. For example, in the Interior Forest District of Nelson, the British Columbia Forest Service listed **188** sawmills as of December **1975.** Of these, **131 (70** per cent) were portable mills **(33** per cent of which were farmer-operated), **40** (21 per cent) were stationary but without kilns, and only **17 (9** per cent) were equipped with lumber-drying kilns (B.C. Forest Service, **1976b).**

From Table **IV-7, it** is seen that, of these **17** kiln-equipped mills in the Nelson Forest District, eight had capacities below **190** cubic metres per shift, five had capacities between **190** and **470** cubic metres per shift, and four were above **470** cubic metres per shift. Information identifying energy source is available for ten of these mills (Ministry of Industry, Tourism and Small Business Development, **1980).** Three of the ten fell in the smallest size class and were using diesel, heavy oil, and propane, respectively. In the 190 to **470** cubic metres per shift class, information was available for three mills–two of which employed propane and one used diesel. Fuel source information for all four of the largest mills was available and showed that three used natural gas and the fourth combined natural gas and hog fuel.

The prices of propane, diesel, and heavy oil have escalated much more rapidly than the price of natural gas, and therefore the mills using these fuels would be the most likely candidates for conversion.[82] These, however, are the smaller mills–some not even of efficient scale–for which the capital cost of conversion would be burdensome, if not overwhelming. If the Nelson Forest District is representative, we can conclude that it is the smaller

TABLE **IV-7**
SIZE DISTRIBUTION OF SAWMILLS WITH KILNS
NELSON FOREST DISTRICT
1975

Size Class (m^3/shift)	Number of Mills	% of Capacity
0-190	**8**	**17**
190-470	**5**	**37**
470+	**4**	**45**

Source: Calculated from unpublished mill survey data, Nelson Forest District

82 **Considering only private cost, while ignoring assumptions of Chapter II regarding the social cost of fuels.**

kiln-equipped mills who will face the greatest pressure from escalating conventional fuel prices and will be least able to bear the capital cost of conversion to biomass energy; some attrition among such mills could be expected.

New installation

In addition to its effect on existing industry structure, conversion to biomass energy sources could affect the structural evolution of sawmilling. If the construction of wood-fueled kilns imposed an inordinate capital expense on potential entrants, this would tend to dissuade all but the largest enterprises from entering the industry. In the parlance of the industrial organization economist, this would constitute an absolute cost barrier to entry. However, the evidence indicates that no such barrier will exist.

Wood-fueled systems appropriate for lumber drying apparently are available in an extensive range of sizes. For example, the popular Konus-Kessel system is available in a size as low as **1.7** million kj per hour. This heat output could dry the production of a sawmill cutting **14,100** to **16,500** cubic metres per annum or, assuming **480** shifts per annum, between **30** and **35** cubic metres per shift. This is, of course, well below minimum efficient scale for a sawmill and, therefore, would not raise the lower boundary of the optimally sized plant.

At a highly efficient capacity, say 320 cubic metres per shift, a compatible kiln could be heated by a Konus-Kessel system producing **17** million kj per hour. That heat system is estimated to cost about **$1** million installed in **1980 (QM** Engineering Ltd., pers. comm.). An output of **320** cubic metres per shift corresponds roughly to a double line (with headrig and carriage) Interior dimension mill, which, in **1980** dollars, would entail a capital investment of about **$12.5** million. Relative to the total capital requirement for mill construction, the cost of a wood energy system would not seem to be of a magnitude to dissuade a potential entrant.

Sale of Mill Residuals

Perhaps far more important to the structure of the sawmilling industry than conversion costs will be the markets created for mill residuals. As prices for wood wastes increase, an additional source of revenue could be created for all mills–large and small, portable and stationary, with and without kilns. Such an increase in demand for mill residuals would benefit all lumber manufacturers able to collect and transport mill wastes, Obviously, those more closely located to transportation systems or residuals markets would be advantaged. Moreover, the sale of residuals might well act to dampen the cyclical nature of demand for sawmill products. By selling wood fuel, sawmills would essentially be diversifying into the energy field, thereby reducing their singular dependence upon lumber markets.

Conclusion

It is predicted that the move to biomass energy will not disrupt the structure of the sawmilling industry. Some smaller kiln-equipped mills, currently relying on high-cost fossil fuels, may meet with financial difficulties in converting to wood fuel. For new kiln-equipped mills, the cost of a wood-fueled system will not be so great, relative to the total cost of the mill, as to create an additional barrier to entry. Finally, the sale of wood wastes should benefit all mills, regardless of size.

c) Plywood

As noted earlier, plywood manufacture is concentrated in British Columbia. Opportunity for entry into the industry is very restricted, especially on the Coast, mainly because of the lack of "peelable" logs. Existing mills often have raw material supply problems, especially with respect to Douglas-fir–the mainstay of the Coast industry. Estimates put minimum efficient scale at the equivalent of **7.4** million square metres of one cm material per annum (Schwindt, **1977).** At present, more than **90** per cent of industry capacity is found in mills at or above this scale.

Retrofit

As shown previously in Chapter II, regional energy sources for plywood manufacture are similar to sawmilling. Coastal mills rely much more heavily on hog fuel than do their Interior counterparts, although **23** per cent of coastal capacity does rely on natural gas. Clearly, the greatest potential for conversion lies with the Interior mills.

From Table **IV-8, it** is seen that hog fuel use is apparently more common by larger mills than small but that, in each size class, more than half of capacity depends upon hog fuel. Biomass energy use is obviously well established in the plywood industry.

TABLE IV-8
SIZE DISTRIBUTION OF PLYWOOD MILLS BY PRIMARY ENERGY SOURCE AND SIZE CLASS
1979

Size Class (million sq. metres/annum)	Number of Mills	% Total Capacity	% of Capacity of Class Using Wood Fuel
Less than 7.4	4	9	58
7.4 to 14	13	61	66
14+	4	30	76

Source: Calculated from: Ministry of Industry, Tourism and Small Business (1980); Forest Industries (1979) and pers. comm.

If the price of natural gas rises high enough to mandate the use of hog fuel, the capital cost of retrofitting will fall on the largest–as well as the smallest–mills, and in the population of plywood manufacturers, few would qualify as small in absolute terms. For example, of the likely candidates for conversion, the smallest is owned by Evans Products, a multinational enterprise with sales over $40 million, owning multiple sawmilling and two plywood operations in the province. In short, retrofitting of wood energy use is not expected to alter the structure of the industry.

New Installations

The critical datum in any decision to construct a new plywood mill is the availability of "peelers", not the capital cost of biomass-fueled (as opposed to fossil-fueled) veneer dryers. The capital cost of wood-fueled dryers would, therefore, not constitute a barrier to entry to plywood milling.

Biomass Fuel Costs

A sector-wide move to biomass energy would have a limited impact on the plywood industry. Levelton (1978) estimates that a mill with a 14 million square metres per annum (1 cm) capacity could supply roughly three-quarters of its energy requirements from its own wood wastes. The remainder would have to be purchased externally. Depending upon proximity to sawmills or other sources of wood fuel, this dependency could prove burdensome.

Of considerable current interest is the cost competitiveness of British Columbia plywood mills relative to American producers. While the Coast producers (because of mill age, technology, and the dwindling supply of peelable Douglas-fir) can only, with difficulty, match the prices of fir plywood produced in the U.S. Pacific Northwest, the situation of the Interior mills is very different. These plants mainly produce spruce sheathing, which competes with sheathing from the U.S. Northwest and Southern Pine Regions. In late 1977, a report prepared for the British Columbia Ministry of Economic Development showed that Interior sheathing actually had a cost advantage over US. production (Price Waterhouse, 1977). As shown in Table IV-9 (with Canadian dollars at par with the U.S. dollar), Interior plywood production costs were 5 per cent less than Southern Pine and nearly 10 per cent less than for US. fir sheathing. At that time, a 20 per cent tariff deterred Canadian exports to the US.

Two aspects of this comparison are noteworthy. First, the Interior had the lowest energy costs of the three regions. Second, the comparisons were made in national currencies so that today the Interior's cost advantage would be more marked.

As a result of GATT negotiations, tariffs on plywood are in the process of being lowered between the US. and Canada. If Interior plywood is to expand its market into the US., as many have predicted, the cost advantage will have to be maintained and this includes the energy components of that advantage. As the Canadian prices of fossil fuels, especially natural gas, move toward world levels and as conversion to wood waste energy accelerates in the

TABLE **IV-9**
PLYWOOD MANUFACTURING COSTS FOR
BRITISH COLUMBIA INTERIOR, US. NORTHWEST,
AND SOUTHERN PINE REGIONS
($ **1977** per **'000** square metres, **1** cm equivalent)

Cost Factor	British Columbia[a] Interior	U.S.[b] Northwest	U.S.[b] Southern Pine
Direct Labour	$ **29.99**	$ **25.57**	$ **15.56**
Wood	**30.56**	**57.73**	**44.11**
Glue	**8.57**	**5.56**	**8.59**
Power and Fuel	**3.55**	**3.70**	**8.34**
Other Overhead	**28.46**	**19.38**	**30.31**
Total	**$101.13**	**$111.94**	**$106.91**

Source: Price Waterhouse **(1977)**

a **Canadian dollars**

b **U.S. dollars**

U.S., British Columbia plywood manufacturers will have to move apace. If not, they could lose their energy cost advantage and thereby jeopardize not only a potential share of the U.S. market but also their position in the Canadian market.

d) Pulp

Chemical pulp mills are the greatest users of energy within the forest products industries. Chapter **II** shows they consumed over **60** per cent of the total energy used by the forest sector in **1978.** They also have the' greatest potential for conversion to biomass energy.

Retrofit

Fortunately, several studies of the economic feasibility of converting existing pulp mills to hog fuel boiler systems have been produced, including analysis for this report. These are reported on in detail in Chapter **II.**

Retrofitting those mills, which now rely on residual oil and natural gas, will unquestionably entail considerable capital expenditures. Data, cited in Appendix **A,** show that to convert the province's **19** major mills would cost roughly **$275** million **(1980** dollars). Individual mill conversion costs range from a low of **$8** to a high of **$35** million and obviously are related to mill capacity and extant hogfueled capacity. While these conversion costs are obviously not inconsequential, our calculations (summarized in Table **II-12),** as well as Cox and Helliwell's **(1978),** indicate that, with some exceptions, conversion would constitute a profitable investment, based on world oil prices of late **1979.** If the prices of fossil fuels escalate more rapidly than the price of biomass fuel, these conversions will be even more attractive in the future.

New Investment

These economic feasibility studies included the assumption that mills had efficient conventionally fueled power boilers in place. However, Cox and Helliwell **(1978)** also ran their model, assuming the mills must add to their process heat capability and, thus, must choose between a fossil fuel and a hog fuel boiler system. Under this assumption, the cost of a fossil fuel burner is deducted from the (generally higher) cost of the hog fuel project, which, of course, makes conversion even more desirable. In a sense, if retrofitting can be shown to be profitable, investment in hog fuel systems to meet process heat requirements for new mill capacity can be shown to be even more profitable.

In short, capital costs for retrofitting and new investment in biomass energy systems to support chemical pulp operations will be substantial. However, pulp making is extremely capital intensive, regardless of energy system employed and is open only to enterprises of large absolute size. Evidently, most, if not all, enterprises in the industry (presently or in the future) will find it profitable to convert to wood fuel. It is unlikely that any mill would fail as a result of conversion.

e) Vertical Integration

Vertical integration already characterizes the forest products sector. At issue here is whether the move to biomass energy will affect the general trend toward integration and, corollary to this, whether the integrated firms are more advantaged in the efficient use of wood fuel.

Economies In Integration

Economists speak of four broad sets of economies of vertical integration. First, economies exist because of technological complimentarity, as in the case of pulp and paper manufacture. There are obvious cost economies in having a continuous process from pulping through to finished paper in that the pulp need not be dried, baled, transported to the paper mill, and then put back into solution.

Another class of economies is associated with the coordination of the output at different stages of production. By synchronizing the output of one process that constitutes the input of another, the firm can minimize inventorying cost and smooth out the total production flow.

A third source of economies of integration is based upon the avoidance of transaction costs. By dealing through internal transfers, the firm avoids the costs of market transactions.

And finally, there are pecuniary economies. These are not true resource savings but, rather, are the capture by one firm of revenue that otherwise would have gone to another. For example, a firm may avoid paying noncompetitive prices to a monopolistic supplier if, through backward integration, it secures its own source of supply.

Integration Economies In Biomass Energy

There are clearly some economies in integrating the production of wood fuel and its consumption. Recognizing that logging and sawmilling operations are the principle producers of wood fuel and that the pulp and paper mills will be major consumers, this means advantages in integrating these operations. Which classes of integration economies can be expected?

One can see economies of technological complimentarity in biomass when sawmills are contiguous to pulp mills. Since sawmills produce residuals in excess of their fuel needs and pulp mills require supplemental fuels, there is a transportation saving when the two operations share a common site. A similar argument would hold for a common location for sawmills and plywood mills, as the latter are also unable to satisfy their total wood fuel needs. Obviously, these economies should not be overstated. While the cost of transporting residual to consumer is important, more important is the cost of transporting log to sawmill. In the Interior, where waterborne transportation is not available, sawmills will continue to locate near their log supply rather than near their residuals customer, regardless of whether that customer has a filial relationship.

There are probably also organizational economies available to the integrated company. At the point of harvest, the tenure holder might well gain some advantage from being able to direct its logging operation to collect a larger initial harvest in order to expand its supplies of low-quality material for energy use. More importantly, the integrated company might be able to create some synchronization between sawmill residual production and pulp mill fuel consumption. Pulp mills view synchronization as a severe problem that could, in the extreme, impede the adoption of biomass energy technology.

Avoidance of transactions costs obviously occurs on each occasion that the firm transacts internally rather than externally. These savings should not be overestimated. Avoiding market transactions is a mixed blessing in that the direction and discipline provided by market-determined prices are foregone and, thus, decision-makers escape market accountability. Under ideal conditions, competitive prices would insure that fibre was allocated to its highest value use. Without prices as a guide, management must make these decisions, which may or may not prove as efficient as market solutions.

In sum, there are some real resource savings available to the vertically integrated firm. While we have not attempted to quantify these savings, the investigation does not provide any obvious evidence of savings so significant that they would hasten the process of integration.

Outlook For
Further Integration

Pressure for further integration will come from another quarter. We suspect that pecuniary economies will be conducive to more upstream integration. In resource-based industries, enterprises are extremely sensitive to these economies and, according to Caves **(1971),** will be more sensitive:

- the fewer in number are both buyers and sellers;
- the more heavily dependent upon long-term prices is the profitability of investment of both buyer and seller;
- the larger are these investments in absolute terms: and
- the fewer are the substitutes for, and the alternative uses of, the resource.

In other words, the more dependent the capital intensive resource processor upon a particular input and the narrower the market for that input, the more likely the processor will move to secure an exclusive supply of the input.

The latter three of Caves' criteria will be met if the integrated companies convert their power plants to biomass fuel–they will make large investments in absolute terms, there will be few substitutes for the input, and the price of the input will determine the long-term profitability of the investment.

At present, the first of Caves' criteria is not met. While the buyers of biomass energy-predominantly the pulp, paper, and plywood mills–are few in number, there is still a significant number of independent sawmills, However, if timber and chips provide a lesson, it is that the major processors put extreme emphasis on total security of supply. In fact, the history of the structural evolution of the industry is explained by the drive for security of supply. In recent months, the issue of chip supply in the Interior has drawn considerable public attention. Several pulp and paper enterprises have contested the allocation of chips from a specific region. One of these firms has indicated that, if its protestations to government are unsuccessful, it will be forced to acquire independent sawmills to guarantee its supply of fibre.[83]

The scenario of further integration could, but need not, result from dependence upon biomass energy. If the uncommitted sources come to be encumbered through government fiat, contract, or absorption, this will trigger a drive by each pulp, paper, and plywood enterprise to secure a guaranteed source of supply. In the extreme, acquisition of wood waste producers would result, overall concentration in the sector would increase, and the allocative function of competition would be thwarted. These adverse effects could, however, be forestalled. If a broad market for wood fuel is maintained, security of supply would be guaranteed for every mill able to pay the competitive price, and the incentive for integration would be reduced.

3.0 ENVIRONMENTAL QUALITY IMPACTS

3.1 Introduction

Any significant change in the pattern of forest utilization, particularly one involving conversion of wastes to energy, would have pronounced effects upon aspects of British Columbia's natural environment. For purposes of discussion, we can separate these into effects from wood waste utilization, forest residue utilization, and energy conversion facilities. Such categories are somewhat artificial, since any example of biomass energy use would involve impacts relating to the supply source and conversion process. The divisions are nevertheless useful, since they allow us to deal with classes of impacts from similar activities, rather than effects from specific bioconversion operations.

83 **Vancouver *Province,* "Forestry-vested interests at stake as Victoria decides fate of chips", January 23, 1980, p. D-10.**

Assessments of environmental impacts invariably require a significant measure of subjectivity. This subjectivity often comes not in the degree of scientific rigor applied to the problem but rather in choosing what impacts should be considered, gauging how they should be predicted and measured, and judging whether they are positive or negative. Impact studies have come to rely on guidelines to indicate what factors should be analyzed and environmental standards to judge the magnitude and direction of impacts. These standards–or, in British Columbia, objectives–are assumed to be set at levels that do not impair health or seriously degrade environmental quality.

Most environmental impact assessments involve three key steps–inventory of the existing natural environment, prediction of the effects of the development in question upon that environment, and comparisons of these predicted effects with established standards or other measures–to determine the degree of impact on the environment. In this section, which broadly deals with changing forest use patterns and a number of conversion processes, we can do no more than touch on these steps, where relevant. The basic approach is to discuss how the changing use patterns would affect environmental quality (as indicated by provincial pollution control objectives or other measures) and to rely on examples to indicate general patterns.

Readers should note that this section is entirely dependent on secondary sources, in keeping with our emphasis on economic and institutional problems rather than technical ones.

3.2 Effects of Wood Waste Utilization

Certainly the most visible environmental impact of forest energy use would be reduced wood waste accumulations.[84] Chapter II indicated that roughly 11 million ODt of wood wastes are produced annually in British Columbia, with over half of that total output being unused for any purpose. Particularly, in the province's central Interior, surplus wood wastes present disposal problems of considerable magnitude, requiring incineration or landfill. In outlining the negative environmental effects stemming from current wood waste disposal methods, we can identify the potentially beneficial side effects to be derived from utilization of these wastes for energy.

a) Waste Disposal Regulations

Evans points out that, before **1971,** the forest industry employed such crude disposal methods- open burning, incineration in simple burners, or dumping in natural defiles–to eliminate its wood wastes (Evans, **1976).** As public awareness of environmental quality grew in the **1960s,** control of these activities became necessary, and in **1971,** the provincial Pollution Control Branch issued its "Pollution Control Objectives for the Forest Industry in British Columbia". This document sets forth guidelines regulating wood waste disposal, as well as other environmentally sensitive activities of the forest industry. Although somewhat revised in **1977,** these regulations are in effect today.

The Board's **1977** objectives for the forest industry are generally set at two levels:

- Level A objectives are the ***desirable*** goals for all discharges and generally apply to all ***new*** discharges; and

- Level B objectives are intended as ***acceptable*** interim objectives for all other discharges.

Established in the objectives are acceptable levels of discharge by the industry to air, water, and land resources. Objectives for land resources refer to wood waste landfills. Basically, waste disposal sites are required to operate as modern sanitary landfills with frequent soil cover and compaction, with the two objective levels differing in terms of frequency of cover, as shown in Table **IV-10.** The objectives note that landfills must "minimize fire nuisance and leachate pollution" but also acknowledge that satis-

[84] R.D. **Roop (1978) identifies four types of environmental impacts resulting from use of refuse (including wood wastes) for energy. These are: reduced problems from refuse disposal; reduced problems from other energy generation systems; improved recycling potential; and new impacts from the conversion process. The first of these impacts is discussed in this section; the second and third are not considered relevant in this context; and the last is discussed subsequently.**

TABLE IV-10
LANDFILL OPERATING OBJECTIVES FOR THE FOREST INDUSTRY
BRITISH COLUMBIA[a]

Daily Discharge Volume (m^3)	Operating Level	Frequency of Intermediate Cover[b]
Up to 230	B	Once every 29 days of operation and at least once per month
Over 230	A	Once per week

Source: British Columbia, Ministry of the Environment (1977)

[a] Level A operation shall be required if the probability of leachate pollution is significant. Normally, the potential for leachate pollution shall be considered significant, if excess moisture exceeds 85 millimetres per metre (1 inch per foot) of refuse depth; if the refuse is less than 1.25 metres (4 feet) above the normal highest groundwater level; or if the refuse is located near surface waters.

[b] Where soil material in sufficient quantities is incorporated with the waste, intermediate covering may not be required.

TABLE IV-11
SELECTED AIR EMISSION OBJECTIVES FOR THE FOREST INDUSTRY
BRITISH COLUMBIA

Air Emission Objectives	Parameter	Units	Level A	Level B
Power boiler (oil only)	Particulate matter	mg/mol	3.9	5.5
	Sulphur dioxide	mg/mol	19.2	64.0
	Opacity	per cent	10.0	-------
	Ringlemann number	number	0.5	-------
Power boiler (combination fuel, including wood)	Particulate matter	mg/mol	5.5	11.0
	Sulphur dioxide	mg/mol	-------	-------
	Opacity	per cent	20.0	-------
	Ringlemann number	number	1.0	-
Wood waste burners	Opacity	per cent	20.0	40.0
	Ringlemann number	number	1.0	2.0
	Minimum temperature	°C	-------	-------
Trench burners	Opacity	per cent	20.0	40.0
	Ringlemann number	number	1.0	2.0

Source: British Columbia, Ministry of the Environment (1977)

TABLE IV-12
SELECTED AIR QUALITY OBJECTIVES FOR THE FOREST INDUSTRY
BRITISH COLUMBIA

Ambient Air Quality Objectives	Period Over Which Analysis Is Averaged	Units	Level	
			A	B
Sulphur dioxide	1 hour	ug/m^3	450	900
	24 hours	ug/m^3	160	260
	1 year	ug/m^3	25	50
Total suspended particulate matter	1 hour	ug/m^3	150	200
	1 year (geometric mean)	ug/m^3	60	70
Total dustfall	2 weeks	mg/(dm^2.d)	-------	-------
Residential	-------	-------	1.75	1.75
Other	-------	-------	2.90	2.90

Source: British Columbia, Ministry of the Environment (1977)

factory technology is not available to control water leachates (B.C. Ministry of Environment, 1977).

The industry's air quality objectives specifically refer to wood waste burners and set parameters for their operation. Table IV-11 shows that levels are set only for opacity of emissions, with no objective for quantity of particulate or dust emissions.

In addition to air objectives for quantity of emissions, the Pollution Control Board has established ambient air quality objectives, which refer to measurable concentrations of air pollutants. The objectives note that "where the ambient air quality objectives are exceeded, the Director of Pollution Control may require more stringent emission levels" (B.C. Ministry of Environment, 1977). Ambient objectives thus serve as a check on the efficacy of emission control objectives; these are summarized in Table IV-12.

b) Environmental Effects

Despite the advent of emission controls and improved practices, wood waste disposal often poses significant environmental problems in the Interior-landfills of wood waste can impair water quality; incineration of wastes can impair air quality; and both landfills and incinerators can be unsightly, reducing aesthetic features of the landscape.

Landfill Leachates

The environmental problem of leachates from wood waste fills has been documented in research and in publications. Although conditions vary significantly, water that has leached through wood waste can: be highly acidic; carry salts, heavy metals, and trace elements; reduce dissolved oxygen; and be discolored. Perhaps the most well-documented statement regarding the potential hazards of leachate is contained in a brief to the Public Inquiry to Review Pollution Control Objectives for the Forest Products Industry, held in 1976. The brief, compiled by a faculty member of the Department of Civil Engineering at the University of British Columbia, summarizes the results of leachate monitoring and testing at three test sites, as shown in Table IV-13 (Cameron, 1976). Evidence in the table indicates that landfill disposal methods could lower water quality in the vicinity of landfills by increasing heavy metals, decreasing dissolved oxygen, and increasing acidity. These observations led the researcher to conclude that stronger controls on wood waste leachates were required, although it has been recognized that the problem cannot be eliminated.

TABLE IV-13
PEAK CONCENTRATIONS IN WOOD WASTE LEACHATES
(mg/1, except where noted)

Water Quality Parameter	Peak Concentrations
BOD	8,000
COD	10,000
TDS	8,000
Acidity[a]	1,650
pH	4.1 - 5.0
Tannin-like compounds	2,200
K	200
Na	500
Ca	200
C1	1,300
SO_4	150
Fe	100
Mn	25
Mg	100
Al	20
Zn	10
Color[b]	9,000

Source: Cameron (1976)

a mg/1 as $CaCO_3$

b APHA color units

Air Emission
From incinerators

Effects of incinerator emissions on air quality have been acknowledged but not well documented. The lack of documentation likely springs from the variety of air quality factors in the province. Some modern well-operated incinerators burning dry wastes produce only minimal particulate fallout because of efficient burning and bouyant smoke plumes. On the other hand, less efficient burners with wet fuels could produce heavy particulate deposits and dense smoke. Similarly, adverse weather conditions could create inversions and trap smoke to form a foggy haze in valleys, while in other weather conditions, smoke would dissipate rapidly.

Air quality problems from incinerator emissions have been recognized in briefs to the Pollution Control Board. The Council of Forest Industries' brief to the Board's 1976 hearings acknowledged that teepee burners create air pollutants, particularly when burning wet fuel but argued that the burners are essential to industry operation, since alternative disposal methods were not at hand. The brief emphasizes that, with good conditions, emissions can be maintained below provincial objectives (COFI, 1975). Other briefs from regional environmental groups to previous hearings emphasize the adverse effects of smoke emissions. For example, the Nelson Branch of the Kootenay Pollution Control Association provided data on rates of particulate deposition and frequency of haze from teepee burners in that area (Kootenay Pollution Control Association, 1978).

c) Environmental Costs of Waste Disposal

Current methods of wood waste disposal impose two kinds of costs. The first is the expense involved in landfill or incineration, borne by the forest industry and indirectly by the public.[85] The second is the perceived reduction in value of air and water resources on the part of the public resource owners as a result of pollution.

Costs of wood waste disposal vary significantly in the province, depending upon the distance from the mill to the disposal site and on the quality of disposal methods. Well-operated landfills that are compacted and covered frequently are more costly than simple dumping; similarly, new efficient burners have higher capital costs than old obsolete ones. Data from Reid, Collins and Associates Ltd. indicated the average cost of landfill disposal to be roughly $3.25 per ODt during 1978 in the South Coast Region. Information regarding the cost of incineration is not at hand.

The reduction in the value of environmental resources like air and water because of pollution cannot be neatly measured. Following the academic literature regarding evaluation of nonpriced public goods, these value changes could theoretically be measured by the decrease in the willingness of the public to pay for air and water resources after the resources become polluted.[86] No attempt has been made in British Columbia to evaluate in dollar terms the costs imposed by air and water pollution.

d) Environmental Benefits of Wood Waste Utilization

Simply enough, the environmental benefits of wood waste utilization stem from the reduction in refuse disposal. Use of wastes would reduce the need for landfill and incineration and, consequently, reduce the cost and severity of disposal impacts.

These potential benefits should not be considered trivial. In certain parts of the province, reduction of smoke and refuse piles would go far to alleviate public irritation with forest wastes. For example, the export of wood wastes by Slocan Forest Products has been termed a significant boon to local residents, since persistent smoke in the area would be reduced.[87] Such benefits could be particularly important, since environmental quality is a major attraction for some Interior residents.

3.3 Effects of Forest Residues Utilization

Environmental effects of forest residues management is an extremely complex subject, dealing with man's intervention in the delicate and varied linkages of forest ecology. Typically, residues of forest operations are managed through some form of controlled burning in order to reduce the hazard of uncontrolled forest fires. A number of different approaches to controlled burning are practiced in British Columbia, including area slash burning, piling and burning, and prescribed brush burning. Herbicides or chipping and scattering of residues are also sometimes used for residue control, particularly in the Northwest States.

Most of the available research conerning forest residues deals with the environmental effects of these management practices. It is fair to say that available information is far from conclusive regarding the advantages and disadvantages of residue management, in light of the variety of environmental questions that are at issue with different methods of treatment.

85 Costs of forest processing, including waste disposal, are incorporated into the Interior stumpage system. Under normal market conditions, increases in costs mean that payments to the Crown fall so that disposal costs indirectly reduce stumpage revenues. The public also pays for waste disposal costs through higher lumber prices.

86 Willingness-to-pay measures for public resources are appropriate if no property rights exist for the resources in question. Alternatively, assuming that implicit ownership or right of clean air and water is vested in the public, then the appropriate measure would be the compensation required by the public in exchange for use of air and water for waste disposal purposes. For a discussion of the difference between willingness-to-pay and required compensation measures, see Krutilla and Fisher (1975).

87 Vancouver *Province,* January 27, 1980, p. F4.

Utilization of larger residues for energy purposes through chipping would introduce a new variable into the complexity of residue management by reducing the quantity of slash occurring on logging sites and, consequently, would reduce the need for controlled burning.[88] Residue recovery would normally require collection of residues at a landing or roadside, chipping, and transport to an energy conversion plant. No new roads or logging activity would usually be required.

The following discussion presents in broad terms the possible effects of residue utilization, recognizing the dearth of conclusive information regarding residue management. It approaches the problem in three steps by discussing effects on the forest environment, effects on silviculture and forest protection, and effects on alternative forest uses.[89]

It should be recalled that utilization of residuals through second-pass recovery was considered in Chapter II to be a high-cost source of biomass that would be viable only in the long term. However, a fuller recovery in the initial harvest could be accomplished at a relatively low cost and would have roughly the same environmental effects. The discussion that follows applies to both these situations.

a) Effects on the Forest Environment

Soil

Forest residues, whether natural or the result of harvests, play an important role in soil formation and maintenance of forest soil productivity. Removal and utilization of large residues would affect these processes by: reducing the volume of organic material available for nutrient recycling; reducing the need for slash burning; and increasing soil compaction.

Studies have established that trees contain a significant proportion of the nutrients cycling within a forest ecosystem. Table IV-14 illustrates the distribution of organic material, nitrogen, calcium, and other elements in a typical second-growth Douglas-fir forest. Removal of residues would necessarily cause some loss of available nutrients and organic matter. However, Moore and Norris provide data showing that "nutrients in coarse residues represent a small fraction of the total nutrient capital", with the major portion contained in foliage and returned to the forest floor through litter fall. Table IV-15 provides a hypothetical distribution of nitrogen and biomass in an old-growth fir stand, indicating a low percentage of nitrogen in large residues. "Since the nitrogen in these residues would be released only very slowly if left on the harvesting unit, removal would not have a significant effect on reforestation , . . except on sites with low nitrogen." Moore and Norris (1974) note that foliage and small residues should remain in the forest to minimize nutrient loss.

A reduced requirement for slash burning could be beneficial to forest soil, since severe burning can: destroy organic matter in surface soil layers; impair soil physical properties such as "wettability", infiltration, and microbial activity; and cause some nitrogen loss. Long-term adverse effects from burns are, however, largely limited to intense forest fires, rather than slash burning.

Finally, operation of heavy equipment to handle residues when soils are wet could result in serious soil compaction. Compaction has adverse effects on soil porosity, aeration, and water passage and could reduce soil productivity for many years. Compaction effects would occur only on limited areas where machine activitv has occurred.

Water

Water quantity and quality could be moderately affected by residue utilization. If residue recovery disturbs forest litter and surface soil or leaves slopes exposed, surface erosion and sedimentation of surface water could occur. The effect on erosion would be related to the extent of soil disturbance. Soil compaction, as a result of machinery operation, could also encourage erosion. However, it is expected that residue recovery would not normally involve stumps so that tree root systems would remain

88 **One could also include fuller utilization of the forest at initial cutting as a factor that reduces slash and the need for burning. The environmental discussion that follows largely applies to both residue utilization and to fuller initial harvest.**

89 **Except where noted, the following discussion has been based upon Jamison and Lowden (1974).**

TABLE IV-14
DISTRIBUTION OF NUTRIENTS AND ORGANIC MATTER
IN A 35-YEAR-OLD SECOND-GROWTH DOUGLAS-FIR ECOSYSTEM
(kg/ha)

Component	N	P	K	Ca	Organic Matter
Trees	320	66	220	333	204,524
Forest Floor	175	27	31	137	22,772
Soil	2,809	3,878	234	741	111,550
Total Ecosystem	3,310	3,972	492	1,211	339,856

Source: Moore and Norris (1974)

TABLE IV-15
HYPOTHETICAL DISTRIBUTION OF BIOMASS AND
NITROGEN IN A 400-YEAR-OLD STAND OF DOUGLAS-FIR

Component	Biomass	Nitrogen	
	tons/acre	pounds/acre	% of total
Removed by harvest	328	321	4.4
Unmerchantable residue	142	139	1.9
Fire slash (4-inch pieces)	30	300	4.1
Forest floor	30	600	8.1
Soil (to 36-inch depth)	------	6,000	81.5
Total	------	7,360	-------
Total (kg/ha)	------	(8,249)	-------

Source: Moore and Norris (1974)

to minimize erosion. Residue handling near streams could also create sedimentation or cause biochemical oxygen demand to increase owing to increased organic waste in the water. Since recovery would reduce the need for burning, some of the adverse effects of slash burning upon water quality, such as increases in chemical ion release, could be avoided (Rothacher and Lopushinsky, 1974).

Air

A reduced need for slash burning due to residue recovery would likely improve air quality. Emissions resulting from slash burning vary widely, depending on fuel characteristics, dispersal of fuel, topography, weather conditions, and other factors (Cramer, 1974). Little scientific evidence is available regarding long-term adverse effects of slash burning on human health or well-being, although smoke from residue fires certainly reduces visibility and can be an irritation (Hall, 1972).

b) Effects on Silviculture and Forest Productivity

Stand Establishment

Residue removal could have both positive and negative effects on establishment of new forest stands. Positive effects would result from removal of slash material that would otherwise hinder seeding or planting. These benefits would be most noticeable in areas of heavy slash cover and where planting of closely-spaced, uniformly distributed stands is desired. Edgren and Stein point out that planting of nursery stock is more obstructed than seeding by current residue practices because residues cover surface area, hinder crew operation, and restrict planting of adjacent ground.

Negative effects of residue recovery upon new stands would result from reduced shade for seedlings, Evidence from many studies indicates that shade provided by residues, brush, or other cover is beneficial for planted and natural tree regeneration. "Shade is the single most important ameliorating factor on the seedling's site-determined environment, owing to reduction of insolation, temperature extremes, moisture loss, and wind movement."

The negative effects of a decrease in shade resulting from residue removal may be mitigated by the fact that brush and small cover regenerate more quickly on some sites when large residues are removed. Regeneration of this natural cover could provide some of the shade lost due to residue recovery (Edgren and Stein, 1974).

Stand Development

Conditions favorable to tree growth are unlikely to be adversely affected by removal of large residues. So long as foliage is left on site to decay and release nutrients, no great nutrient loss should result. In addition to providing nutrients, fine residues like foliage protect the soil, reduce evaporation, and filter moisture—all of which benefit tree growth. Removal of unmerchantable hardwood species or living "residues" would reduce competition for light, water, and space and thereby speed a second crop.

Fire Prevention

Large accumulations of dead residues in quantities that preclude effective fire prevention are a serious threat to forest management. Controlled burning has been found to be the most effective method of reducing fuel build-up in order to lessen the risk of conflagration. If larger residues were used for energy instead of being left in the woods, the result would be a significant boon to fire prevention. Residue management through controlled burning would often still be required to reduce the volume of small residues that are easily ignited. But the magnitude of fire prevention programs, as well as prevention costs, would be reduced (Martin and Brackenbush, 1974).

Insects

Forest residues attract many varieties of insects that hasten their decomposition. Few of these varieties are a hazard to the forest, although some serious epidemics of bark beetles have been generated in injured or residue trees. Removal of residues for energy use would lessen the chance of damaging infestations, since the amount of larger tree pieces would be reduced.

c) **Effects** on Alternative **Users of the** Forest

Pearse's report of the Royal Commission on Forest Resources presents extensive discussion on the need to consider alternative users of forest resources, such as wildlife, fisheries, water users, and recreationists. In that context, perhaps the most significant impact of residue utilization would be that it represents a further step in intensive forest use. Since recovery of forest residues for energy would also encourage recovery of material suitable for sawmills or pulp production, the amount of forest land–required to support a given level of industrial output–would be reduced. More intensive forest activity on some sites could make it easier to withdraw other sites–highly valued for purposes like recreation or wildlife habitat–from industrial harvest. Beyond this broad effect, residue utilization would have impacts upon specific alternative forest users, including fish and wildlife habitat, recreation, and aesthetics.

Fish Habitat

Removal of residues could increase the degree of erosion on certain sites and, consequently, increase siltation in streams. Handling or chipping of residues near streams could also increase the amount of fine organic waste (such as needles or leaves) in the water which would, in turn, reduce dissolved oxygen levels. Both these factors could have moderate to severe impacts on fish productions in streams, depending on species and many other variables, although prediction of effects on specific streams is not possible. Removal of residues directly in streams could adversely affect stream hydraulics, as well as bank stability, if done improperly. Shade provided by residues near streams may be important to maintaining desirable water temperatures and enhancing food supplies (Brown, 1974; Narver, 1970).

The best methods to mitigate these potentially adverse effects are to preserve buffer strips on stream banks in order to avoid debris falling in the water, minimize siltation, and avoid reduced oxygen levels. Residue recovery should be planned to minimize erosion or water disturbance.[90]

Wildlife Habitat

Because they occupy ground space, large volumes of forest residues limit the extent of forage growth on cut areas. For example, Garrison and Rummel reported that a 33 per cent reduction in cover of shrub and herbaceous vegetation compared to brush cover before logging, owing to the combined effects of slash and soil disturbance (Garrison and Rummel, 1951). Larger slash pieces can, according to Young (1967), also be serious obstacles to movement of grazing animals. Thus, the chief effects of residue recovery would be to encourage shrub and forage growth and to allow better passage of animals. Both these factors would enhance cut areas as habitat, particularly for ungulates.

On the other hand, living and nonliving residues provide favorable cover for many species of small mammals and birds. Complete removal of all residues would impair the quality of their habitat. Stumps, small branches, and living brush residues could remain on logging sites for habitat maintenance (Dimock, 1974).

A factor to consider is that, by improving habitat and thus increasing animal populations, residues recovery could indirectly encourage animal damage to young trees. Animal damage to regenerating forests has been amply documented. Dimock states that the correlation between animal population and animal damage would appear to be close for certain animal species. The presence of small debris could mitigate damage by providing physical protection from animals. Lightly-piled small slash has been used to protect Ponderosa pine and Douglas-fir seedlings from browsing of big game animals in U.S. national forests, according to Dimock.

Recreation and Aesthetics

In keeping with the strengthened concern for environmental quality, public interest in outdoor recreation and forest aesthetics has grown markedly in recent years. Forest residue management practices can have an important influence upon the public's perception of forest amenities and commercial harvests. Wagar emphasizes that logging debris is by far the most prevalent residue problem affecting forest amenities.[91]

90 **Environmentallysound logging techniques are already encouraged in provincial forest operations to minimize adverse effects on fish. Conflicts have, however, occurred between logging practices and fish habitat, most notably on the Queen Charlotte Islands.**

91 **The term "amenity" refers in this context to both outdoor recreation and forest aesthetics. Growing interest in forest aesthetics can be seen in the rapid development of professional literature on the subject. Wagar (1974) cites some 20 references on landscape and aesthetics in forestry, none of which were written before 1966.**

Many studies have demonstrated a widespread preference for perceived "naturalness" in forest landscapes. Logging residues violate this preference by providing ample evidence of man-made environmental change. As a result, residues are a literal "misfit" in the public's expectation of a natural context.

Variations of this principle have been substantiated in many studies. For example, Rabinowitz and Coughlin (1971) found that dislike "of landscapes . . . seems to focus on individual elements, primarily man-made ones". They defined "misfit" as "any man-made object not significant or obviously attractive".

Several kinds of indexes or rating systems have been developed to assess landscape quality. These usually fall into three catagories: physical descriptions, judgements of quality, and analyses of the psychological dimensions involved in landscape preferences. Wagar has distilled from these catagories a number of criteria for judging the effects of residues upon forest amenities. Those that most directly relate to recovery of residues for energy include:

- *passability* or degree of obstruction, which is particularly important for landscapes used for active recreation;
- *horizontal order,* which, as defined by Gould, is: "the dominant pattern set by trees and dead material on the forest floor". Horizontal order "misfit" occurs if material is disorderly, over two feet deep, and covers more than 50 per cent of the forest floor (Gould, 1974);
- *plant form* can be an aesthetic misfit "when scraggly, damaged, or dead trees are left standing following fire, epidemic, flooding, or logging"; and
- *waste* can be perceived in large quantities of slash by the casual observer unfamiliar with the cost of extracting small material. This perceived inefficient use of resources is an example of psychological misfit in forest aesthetics.

Recovery of residuals for energy purposes would go some distance toward alleviating these aesthetic "misfits" that result from harvest and residue management. Wagar has, in fact, recommended fuller utilization as a means to avoid the appearance of waste. He also recommends opening of slash areas to firewood harvest, in order to reduce the perceived "waste" and improve the natural appearance.

There are two sources of negative aesthetic impacts connected with utilization of residues for energy. First, the incentive for larger harvests would slightly expand the margin of economically recoverable forest. One could, therefore, expect the borders of clear-cut areas to extend farther up hillsides, becoming more visible. Second, the process of recovering residues in a second pass (including collection, chipping, and transportation) would entail some adverse impact on aesthetics, primarily from local noise. However, the aesthetic benefits involved in greater utilization should at least partially offset any of these negative effects.

d) Environmental Costs and Benefits of Forest Residue Utilization

The foregoing qualitative discussion has indicated there would be both positive (nonpriced benefits) and negative (nonpriced costs) environmental externalities associated with forest residue utilization. There are no direct methods with which to quantify these externalities in dollar terms, which would involve extensive economic research into forest ecology and silviculture. The only approach is to qualitatively present these environmental effects in concise form and point out whether the impacts are expected to be positive or negative. Such a summary is found at the end of this chapter.

3.4 Effects of Biomass Energy Conversion Facilities

Environmental effects of biomass energy conversion could be divided into three sequential categories.

The first to occur would be impacts stemming from transportation of biomass material to the conversion site. These impacts would primarily be of a socio-economic nature and are discussed elsewhere in this chapter.

The second to occur would be impacts associated with the actual conversion processes. Reference to Chapter II shows that direct combustion, gasification, and gas conversion could derive energy from wood in British Columbia, with direct combustion in steam boilers being the prevalent choice. To the degree permitted by available data, impacts from these processes are discussed in this section.

The third to occur would be impacts associated with substitution of biomass energy for other sources. For example, adoption of wood fuel in coastal pulp mills would reduce the consumption of imported oil in Canada. Cogeneration by pulp mills or construction of a wood-fueled power plant would postpone the need for new hydroelectric generation capacity in the province. Impacts in this third catagory are not considered further because they stray beyond our terms of reference,

a) Direct Combustion

Potential Pollutants

Sulphur and ash are traditionally considered the principal impurities in combustion fuels. When burned, the sulphur forms SO_2, which, itself, is a worrisome pollutant; in the atmosphere, SO_2 can also combine with rain to form a dilute sulfurous acid or other deleterious compounds. Ash in fuel produces particulates that are carried in the smokestack gases and may be deposited on surrounding areas. Both these emissions can be reduced by control devices; SO_2 emissions are lessened by stack gas scrubbers, while particulates are controlled by electrostatic precipitators and baghouse installations (Tillman, 1978).

The ultimate analyses of selected solid fuels in Table IV-16 show wood to be low in sulphur and ash. Of the four species presented, the average sulphur and ash contents are less than 0.1 per cent and 1.2 per cent, respectively. These data show wood to be relatively free of pollution problems posed by other fuels, although control of particulates is required for industrial wood combustion,

Analyses of other solid fuels in Table IV-16 show them to be less desirable than wood, from the viewpoint of potential pollutants. The coals have sulphur content ranging from 1.0 to 3.1 per cent, while other bituminous coal in western Canada has sulphur content over 4.0 per cent. Ash content of coal reaches 13.8 per cent in Table IV-16, while lignite coal at British Columbia's Hat Creek deposit contains nearly 28 per cent ash (Dolmage, Campbell Ltd., 1976). Municipal waste is also shown to have a

TABLE IV-16
ULTIMATE ANALYSES OF SELECTED SOLID FUELS[a]
(Percentages)

Element	Softwoods		Hardwoods		Coals		Others
Analysis	Douglas-fir	Hemlock	Maple	Poplar	Wyoming	Pennsylvania[b]	MSW[c]
Carbon	52.3	50.4	50.6	51.6	70.0	75.5	33.9
Hydrogen	6.3	5.8	6.0	6.3	4.3	5.0	4.6
Oxygen	40.5	41.4	41.7	41.5	20.2	4.9	22.4
Nitrogen	.1	.1	.3	.0	.7	1.2	.7
Sulphur	.0	.1	.0	.0	1.0	3.1	.4
Ash	.8	2.2	1.4	.7	13.8	10.3	38.0
Btu/lb	9,050	8,620	8,580	8,920	14,410	13,650	5,645

Source: Tillman (1978)

[a] Dry weight basis, higher heating value basis

[b] Pittsburgh coal number 1

[c] Municipal Solid Waste

very high ash content.

From the viewpoint of controlling formation of SO_2 and minimizing particulate emissions, wood biomass is preferable over all other solid fuels. The advantage of biomass is, however, less pronounced when compared to the chief nonsolid fuels–oil and gas. Wood has considerably less sulphur than residual oil, which is a compelling attraction at a time when concerns over acid rain are increasing. On the other hand, wood has a higher ash content than oil. Pipeline grade natural gas is a much cleaner fuel than residual oil or wood biomass.

Air Quality Objectives and Impacts

British Columbia has devised pollution control objectives for forest industry boilers fired by wood in combination with another fuel (previously shown in Table IV-11). No objectives have been set for wood fuel burners outside the forest industry, but the forest sector objectives can be assumed to apply.

Table IV-11 indicates that Level A objectives for wood fuels allow about 40 per cent more particulate emissions than the Level A objectives for oil. Conversely, the objectives for oil allow 19 mg/mol emissions of SO_2, while no objective is given for SO_2 from wood fuels. The variation in objectives reflects the difference in ash and sulphur content of the fuels, as well as the Board's philosophy of setting limits on the basis of practicable technology. According to Board representatives, the wood fuel particulate objectives were set on the assumption that "double-bank multi-clone" systems would be employed to reduce particulates.[92] The oil burner particulate objectives were set to require efficient burning conditions, but do not necessitate special control systems. Level A objectives for SO_2 presuppose burning low sulphur oil.

Pulp mills that operate in the Interior have generally been able to comply with the particulate objectives for hog fuel boilers, according to the Waste Disposal Branch. Other sources indicate that some Interior mills marginally fail to comply with the objectives when employing the multi-clone control technology. Coastal pulp mills have encountered considerably more difficulties in compliance owing to the presence of salt in their wood fuel.

Most of the wood supply for coastal mills is transported and stored in floating log booms. While in the water, the logs absorb salt into their outer layer. The affected wood and bark finds its way into waste piles and, when the wastes are combusted in power boilers, the salt forms chloride particulates, which enter the atmosphere.

A two-year environmental impact study of chloride emissions from MacMillan Bloedel's Harmac pulp mill has documented this problem. The study monitored various parameters of air quality in the vicinity; it showed peak ambient chloride concentrations of 24.6 ug/m^3 and peak chloride dustfall of 1,498 mg/m^2/month near the mill. According to the environmental consultants, these levels did not pose severe environmental impacts (Envirocon, 1975).

The Waste Control Branch maintains that the Level A objectives for particulate emissions from hog fuel boilers should be met by Coastal pulp mills with new installations. Current installations clearly do not meet the objectives and receive "allowances" on their air emission permits to accommodate salt particulates. The Branch expects that improvements in the control technologies employed by coastal mills will be necessary.

Some coastal mills are considering electrostatic precipitators to reduce their particulate emissions, according to the provincial authorities. Discussions with engineering consultants indicate that new hog fuel boiler systems on the Coast and in the Interior are being designed with the multi-clone system or with the more efficient, and considerably more expensive, precipitator system. Whether the multi-clone system is sufficient to meet the objectives depends on fuel characteristics, burner design, and other factors (H.A. Simons (International) Ltd., pers. comm.).

Other Impacts

Beyond effects associated with air emissions, direct combustion could produce other environmental impacts. Handling and disposal of wood

92 **These are control systems involving bundles of long cylinders that create "cyclone" effects, thus, eliminating large particulates from stack gases.**

ash from burners could impair the quality of surrounding water. Various studies have provided analyses of ash from wood fuels; they show that wood ash can contain relatively high proportions of minerals and trace levels of some heavy metals (Hall et al., 1975). If ash is disposed of improperly, water could leach through and increase mineral or metal concentrations in receiving groundwater. A mitigative measure would be to utilize the wood ash for soil fertilizer or other purposes, rather than to store it in ash piles.

b) Gasification

Only general information is available regarding the environmental impacts of gasification processes based on wood. The best source appears to be a study for the US. Industrial Environmental Research Laboratory, which provides a preliminary environmental assessment of biomass conversion to synthetic fuels. It considers pyrolysis and gasification, along with various other conversion processes. The study's comments on environmental impacts of pyrolysis and gasification are abstracted here.

> The direct [air] emissions from pyrolysis production processes should be small. The product gases from each process will be contained and can be scrubbed to remove acid gases and particulates. The entire gas output of the Torrax and Union Carbide processes will be so treated . . . [in general] the lower quantity of air required for pyrolysis [including gasification] as compared to incineration should result in less entrapment of particulates in the off-gases from the reactor.
>
> Ash loads from several of these [pyrolysis] processes will approximate those from direct incineration. Those with fluidized-bed reactors will produce about 50 per cent more than incineration. Thus, the landfill requirement is larger and leachate loads may be slightly higher than from the other processes.
>
> During the pyrolysis step, water and organic compounds are formed and distilled from the biomass material. While the resulting mix is somewhat variable, depending on the nature of the feedstock, the water fraction has been shown to contain a variety of aldehydes, ketones, alcohols, phenol acids, etc. Treatment of this water is not expected to be a problem if a secondary sewage treatment plant is incorporated into the design or is available nearby (Battelle Columbus Laboratories, 1978).

The report summarized the potential environmental effects of a 5,000 mt per day pyrolysis or gasification plant, as shown in Table IV-17. This table suggests that control technologies would be required for air emissions, water effluents, and ash residue.

c) Gas Conversion

Conversion of low-energy wood gas to methanol or other chemicals would involve virtually the same environmental impacts as methanol plants based on natural gas. The only difference between plants based on wood rather than gas feedstocks would be those associated with the wood gasifier process, which have already been discussed. Thus, gas conversion processes are not considered in detail here.

d) Environmental Costs of Conversion Facilities

Environmental impacts from conversion of biomass to energy impose two kinds of costs: the dollar costs of environmental control technologies required for the conversion facilities, and unpriced cost of reduced air and water quality. On the assumption that the provincial pollution control objectives are set to minimize adverse effects on the environment, we can expect that reductions in the public value of air and water should be slight, if companies comply with pollution control objectives. Thus, the important costs are the expenditures required for environmental control systems.

Previous sections have indicated that control of particulate emissions from hog fuel boilers is the chief environmental control problem posed by bioconversion in British Columbia. A leading engineering consulting firm has provided information on alternative particulate control technologies and their costs, as shown in Table IV-18.

According to the engineering consultants, the multi-clone system is preferable because of its low costs but, in situations where that approach would not comply with provincial objectives, the electrostatic precipitators would be preferable. The sub-

TABLE IV-17
SUMMARY OF ENVIRONMENTAL IMPACTS
FROM A HYPOTHETICAL 5,00O/MTD WOOD PYROLYSIS PLANT

Pollutants	Quantity
Air Emissions	
- Particulates	0.6 to 1.2 kg/MT of wood wastes (3,000 to 6,000 kgIday for 5,000 MT plant).
- Hydrocarbons, SO, NO_x	Small due to nature of source and conversion process.
- Noise	May be locally severe, e.g., near shredders, but most activity will occur in remote areas.
- Organics	Should be negligible.
Water Effluents	
- BOD/COD	Estimated to be 500 to 3,000 mg/1 and plant to treat 2,600 MT/day (0.7 MGD) of wastewater. This results in a needed treatment capacity of 1,300 to 7,800 kgIday or that required for a population of 7,500 to 40,000.
- Metal Content	Unknown, but should be very low.
Solid Residue	
- BOD/COD	May be high in leachate. The quantity estimated to be landfilled will occupy a volume of 3,300 to 6,600 ft^3/day based on a bulk density of the ash between 50 and 100 lb/ft^3.

Source: Battelle Columbus Laboratories (1978)

TABLE IV-18
ALTERNATIVE EMISSION CONTROL TECHNOLOGIES
FOR A HOG FUEL BOILER[a]

System	Estimated Capital Costs (1980 $)	Comments
Multi-clone	1 stage $600,000 2 stage $1.2 million	Widely used on existing hog-fuel boilers; poor efficiency for small particles; may not comply with Level A objectives.
Baghouse	$3 to $5 million	Recommended by U.S. EPA; high maintenance requirements; some fire hazard.
Wet Scrubber	$1.8 to $3.5 million	High operating costs; requires large quantities of water and energy; produces visible plume.
Electrostatic Precipitator	$3 to $5 million	Very high efficiency; low energy requirements; low operating costs; becoming more popular in North America.

Source: H.A. Simons (International) Ltd., pers. comm.

[a] Size of boiler assumed to be 112,000 to 180,000 kg of steam per hour

stantial cost of a precipitator system is a concern to the forest industry, since, at $5 million, the cost for pollution control approaches the cost of the hog fuel boiler.

4.0 SOCIO-ECONOMIC IMPACTS

4.1 Introduction

Since its beginning in 1846, British Columbia's forest industry has played a dominant role in the province's economic development. During 1978, some 92,500 people (or 8.5 per cent of the provincial labor force) were directly employed by the industry (B.C. Ministry of Industry, Tourism and Small Business Development, 1980). Estimates indicate that, during the same year, indirect employment, in industries supplying goods and services to support forest industry operations, provided an additional 46,000 jobs. And beyond that, consumer services for those directly and indirectly employed would have occupied roughly another 139,000 workers (F.L.C. Reed & Associates, 1975).

There are five basic sectoral divisions within the forest industry. Sawmill operations comprise 40 per cent of total direct forest industry employment, with facilities primarily concentrated in the Lower Mainland, southern Vancouver Island, and the Prince George area. Logging, which produced 75.2 million cubic metres of timber in 1978, is the second most important employer, providing jobs for 26.3 per cent of the industry's direct labor force. Some 23 per cent of industry workers are employed in pulp, paper, and allied operations located in the South Coast Region and the Interior. The manufacture of plywood and shingles and shakes provides jobs for 9 per cent and 1.5 per cent, respectively, of the industry labor force.

These figures illustrate the significance of the forest industry in the provincial socio-economic structure. Viewed at the regional and local scales, forestry activity is even more predominant as an economic mainstay. Many small communities throughout the province depend on logging or a sawmill to provide virtually all jobs, apart from those in the service sectors.[93] Similarly, nearly all the towns that contain pulp mills are highly dependent upon the pulp sector for their base employment.[94]

Utilization of forest biomass energy would affect three aspects of the forest industry's present socio-economic significance. First, employment would increase, owing to fuller harvests and to utilization of wood energy in the industry's boilers and elsewhere. Second, the potential for regional economic development could possibly be enhanced. Third, changes in social conditions and the public's perception of the forest industry may occur. These three kinds of socio-economic impacts are the topics addressed in this section.

Since utilization of wood energy is just in its nascent stages in British Columbia, it is difficult to project its specific economic and social effects. Quantitative prediction of impacts is particularly uncertain, as is stressed in the following sections. It is, nevertheless, clear that wood energy would provide employment benefits and that these benefits would accrue primarily to individuals within the existing forest industry labor force. Although it would be preferable to provide estimates of increased direct and indirect employment on regional bases, such detailed assessments would be too speculative to be useful at this point. Instead, we provide crude estimates of employment increases on a province-wide basis. It can be stated that both economic and social effects of forest energy use would occur, in the short term, in existing forest industry employment centres around the province. In the longer term, forest energy use may provide an impetus for regional growth in less developed areas, as a result of electricity or methanol plants.

4.2 Employment Effects

a) Introduction

The probable employment effects of forest biomass utilization are addressed in this section, considering the four most promising applications assessed in Chapter II. Near-term potential applications in the forest industry include pulp industry boilers and

93 **For examples, see Ministry of Economic Development (1978).**

94 **The situation of Powell River, a town dependent upon MacMillan Bloedel's pulp and newsprint mill, is documented in Schwindt (1977).**

wood products boilers and dryers; longer term applications include thermal electric generation and methanol production.

First, employment effects of the marginally larger forest harvests that would result from bioconversion are discussed in general terms. Then, effects associated with the four potential applications are considered, including employment in fuel transport and plant operation. The approach is to attempt to quantify direct employment effects and then, at the end of this section, address the possible indirect employment effects, as well as effects on stability of employment. The focus is on effects from various kinds of biomass energy developments, rather than from specific projects.

The reader should note that no attempt is made to estimate the economic impacts associated with construction of bioconversion facilities or with fabrication of special components, such as pressure vessels. These impacts would be similar to those of construction of facilities for other fuels and would be of short duration.

b) Harvesting Sector

It was argued in Chapter III that the value of wood wastes for energy would provide an incentive for marginally larger harvests from given areas of forest land. The nature of the incentive was illustrated in Figure III-1. Fuller harvests at the time of initial logging would require more resources–both capital and labor–than current harvests levels, all else being equal. One could thus expect a marginal increase in logging employment, or better utilization of current employees, as a result of biomass energy utilization.[95] The scale of the potential increase in logging employment cannot be predicted with any certainty. Although in Chapter III there was discussion of the amount of added revenue that might be expected from energy use of wood wastes, there is no way to estimate the added recovery of low-quality material that is made feasible by this extra revenue. That is, we cannot estimate the elasticity of supply of wood harvest with respect to price.

Even if that calculation were possible, there appears to be no expedient way of estimating the extra labor involved in an incremental increase in supply. The amount of labor (relative to capital) needed for marginal increases in harvests may be less than that needed for average harvests. In other words, marginal harvests could be relatively capital intensive. This was suggested in one study of biomass supply (Intergroup, 1978) and seems reasonable, given that there would be no need for extra effort by fallers.

In view of these uncertainties, the only possible approach is to pose an increased level of harvest and employment for illustrative purposes. Suppose that the value of wastes for energy expands initial harvests of timber by 2 per cent. Suppose further that this marginal expansion involves an increase of labor resources in logging of only 1 per cent, on the assumption that each unit of marginal harvest requires only half the labor of a unit of average harvest.

Provincial employment in the logging sector averaged approximately 21,000 during the period 1972-77 (Statistics Canada, 1972-77). On the basis of a 1 per cent labor increase, provincial direct employment in the logging sector would grow by roughly 200 jobs as a result of fuller harvests induced by forest energy. It should be stressed that this is an illustrative calculation and not a predicted employment effect of forest energy utilization.

c) Pulp Industry Boiler Applications

Power boilers exhibit the greatest potential for the expansion of wood energy use within the pulp sector. Table II-12 and Appendix I of this report indicate that virtually all major pulp mills in the province have an economic incentive to invest in new hog fuel boilers. It is estimated that conversion of boilers would increase hog fuel consumption by some 3.6 million ODt annually.

All but three of the 19 chemical pulp mills in British Columbia currently operate hog fuel boilers. An increase in total wood waste consumption would involve replacement of existing gas- or oil-fired

[95] This discussion is concerned with larger first-pass harvests, which seem to be a more likely development than relogging of areas to utilize forest residuals for energy. That special case is discussed later, along with methanol development, which appears to be the only potential application that could bear the high cost of recovering residuals from the forest.

boilers. Two types of employment would result from this conversion: transport of residuals from sawmills to pulp mills and operation of the boilers.[96]

Transportation Employment

Requirements for the movement of wood wastes vary significantly between Coastal and Interior mills. In the Interior, an abundance of wood wastes relative to pulp mill requirements means that each mill would normally need only short hauls from nearby sawmills to supply its needs. On the Coast, the concentration of pulp mills is relatively higher, resulting in greater hog fuel demands than in other forest regions (see Table II-1). These relatively high wood waste demands suggest that the hauling distance from the mill of origin to the pulp mill is generally greater on the Coast; in addition, barges are often used to transport fuel. These factors make it difficult to estimate transport manpower requirements for any one mill; however, a recent study by the Ministry of Economic Development has calculated such estimates for six coastal mills in aggregate (B.C. Ministry of Economic Development, 1979).

Both the calculations of this report (see Appendix I) and those produced in the Ministry of Economic Development report place the predicted increase in hog fuel use of these six coastal mills at roughly 1,505,000 ODt. According to the provincial report, some 70 per cent of this total would be delivered to the mills by truck and 30 per cent by barge. Assuming an average round trip of 2 hours and an average truck load of 15 ODt of hog fuel, roughly 80 driving positions would be required to deliver 70 per cent of the fuel needs. Data was not available to indicate the increase in jobs in the marine transport sector, according to the Ministry report.

This calculation may be used as a basis for estimating transport jobs resulting from the movement of residuals to the 19 major pulp and paper mills identified in this report as likely candidates to convert to hog fuel boilers. The predicted increase in total annual hog fuel consumption for these mills is about 3.6 million ODt.

Coastal mills are estimated to consume 2.4 million ODt, or 67 per cent of the total. On the assumption that 70 per cent of coastal mill hog fuel demand would be met by truck delivery, approximately 125 driving positions would be created.[97] A lack of data prevents estimation of the number of jobs that would be created for barge operators.

Interior pulp mills converting or adding new boilers would require delivery of an incremental 1,190,000 ODt of hog fuel each year. Changing the total round trip time in the Ministry of Economic Development formula to 1 hour to reflect the fact that hauling distances are typically shorter in the Interior, we calculate that approximately 44 driving positions would be created.

Therefore, assuming that all 19 major pulp and paper mills in the province made full use of hog fuel for energy in their boilers, a total of about 170 jobs in the trucking sector (and an unspecified number in the marine sector) would result from residuals transport.

Operation Employment

Jobs created by hog fuel boiler operation would depend upon such factors as plant size, operating hours, and available manpower skills. According to industry sources, the installation of a hog fuel boiler in a pulp mill that had previously relied exclusively on oil or gas would create approximately two new positions in each of four workshifts, assuming full-time mill operations. One bulldozer operator would be required in each shift to maintain the fuel storage pile, and one person in each shift would be required to remove and dispose of ash (H.A. Simons (International) Ltd., pers. comm.). Only three of the 19 major pulp mills in the province do not presently have a hog fuel boiler; therefore, the installation of these boilers would generate roughly 24 jobs.

96 **Employment effects from hog fuel dryers, which were identified as a possible means of expanding the potential use of wood wastes in pulp mills, are not considered here, since they would likely be minimal. Operation of the dryers could involve virtually no incremental employment, and the expanded consumption, which they might make possible in pulp boilers, could be accommodated with the same operating labor force and a slightly larger transportation labor component.**

97 **Based on the Ministry of Economic Development calculation (2,431,600 ODt/year) x .7/(.5 trips/hr) (15 ODt +/trip) (7 hours/man-day) (260 days/man-year) = 125.03 man-years.**

There is no clear way to assess the incremental employment created by the addition of hog fuel boilers in the remaining 16 mills. Since these mills already utilize hog fuel to some degree, they have labor contingents to tend to fuel piles and disposal of ash. It is reasonable to assume that each mill would require one to two more persons for fuel handling and ash disposal.

In sum, the number of operator's jobs, which would be created by conversion of the existing major mills to hog fuel boilers, would be in the range of 40 to 55. These figures are summarized in Table IV-19, along with the potential for increases due to long-term expansion in the pulp sector, as predicted in Chapter II.

d) Wood Products Application

Among the diverse processes involved in the production of wood products in British Columbia, lumber drying in kilns holds the greatest potential for replacing fossil fuels with wood wastes. At present, hog fuel is the primary heat source for 17 out of 113 kilns in the province. In Chapter II, it is suggested that, in the near term, some 30 kiln-equipped mills may find it economically viable to convert to wood wastes for kiln fuel. Interior mills are the most likely candidates, since only a relatively small proportion of coastal lumber production is dried. The employment effects associated with conversion of fossil-fueled lumber-drying kilns to hog fuel can be estimated only in general terms. Since sawmills produce more residuals than they require to meet their energy needs, no jobs would be created in the transport sector. In fact, there could be a net reduction of manpower for those mills that transport wood wastes to disposal sites, though a quantification of this cannot be attempted here.[98]

Manpower requirements for the operation of the steam boiler are similar to those for the operation of the pulp mill power boiler; that is, one person for fuel handling and one for ash disposal would be required on each operating shift. In addition, there would be a need for an operating engineer licenced to tend the steam boiler, if the previous kiln-heating system did not employ steam.[99] Assuming that sawmills operate on two shifts per week, the extra employment would total six jobs per mill.[100] The proposed 30 lumber kiln conversions could, therefore, create roughly 180 jobs.

According to industry sources, the requirement for a licenced boiler operator, which significantly raises operating costs, has constrained the adoption of steam systems burning wood wastes for lumber-drying processes. To reduce costs, many mills are considering the Konus-Kessel system (as mentioned in Section 2.0 of this chapter), which utilizes heated oil instead of steam to convey heat, thereby eliminating the need for a boiler tender (QM Engineering Ltd., pers. comm.). Complete adoption of the Konus-Kessel system, by sawmills converting to wood fuel, would decrease the total number of jobs created by *60.* Judging from industry behavior, at least some mills believe the Konus Kessel system to be the most attractive in terms of total costs.

e) Electrical Generation Employment

The technology for the operation of hog fuel-fired thermal electric power plants is well developed; however, as indicated in Chapter II, there are several limitations that constrain the use of wood wastes for electricity. First, the size and bulk of wood fuel restricts the ultimate size of the power plant. Second, the plant must be located near its fuel supply, usually a forest industry conversion centre, where there may be opportunities to use its waste heat in various thermal applications. The assessment in Chapter II indicates that a low-cost wood supply and the presence of cogeneration opportunities are prerequisites to an economical wood-fired electric power plant.

98 Such a reduction is expected to be small, since most sawmills that dispose of wastes use incinerators as a more economical method of disposal.

99 No requirement of extra steam-licenced operating engineers was identified in the discussion of pulp mills, since they already employ these people to tend their recovery boiler systems or fossil fuel-powered boiler systems.

100 In poor lumber markets, layoffs occur and mills often operate only one shift per week; conversely, high lumber prices could mean three shifts per week.

Clearly, these limitations have implications with regard to future employment possibilities. To date, only one site suitable for a wood waste-fired electric and steam plant has been identified in British Columbia. A study by H.A. Simons (International) Ltd. **(1978)** assesses the cost and feasibility of construction of a **50** Mw cogenerating power plant at Quesnel. In their report, the consultants suggest that a total of **18** to **21** persons would be required to run the plant: 9 to **12** operators, 3 maintenance persons, and 6 clerical and administrative staff. It has been suggested that this number of operators represents an absolute minimum (H.A. Simons, pers. comm.); a more detailed study of the proposed plant, which is in progress, may include higher estimates of labor requirements.

Transporting hog fuel from the six sawmills in the area to the power plant site would create employment for truck drivers, but the number of these would be small, since the hauling distance is short.

Potential employment effects of utilizing wood wastes to produce electricity may be further identified by considering a currently operational plant in Oregon. The City of Eugene operates a **25** Mw hog-fueled electric plant, which also contributes steam to the district heating system. Fuel is obtained from sawmills within a 50-mile radius of the city. When the plant runs at capacity, it employs about 30 people: **5** fuel operators, 10 boiler operators, **4** turbine operators, 6 maintenance persons, and **5** administrative staff (Eugene Waterworks and Electricity, pers. comm.).

Judging from this plant's experience and the Simons study, the operation of a small-scale wood waste electric plant would provide employment for approximately 20 to **30** persons.

f) Methanol Production

Largely on the basis of a study by Intergroup Consulting Economists Ltd. **(1978),** Chapter II indicates that there is good potential for methanol production in British Columbia employing the methane-hybrid process, which uses wood biomass and natural gas as joint feedstocks. For the purposes of this report, it is assumed that three 414 million LPY methanol plants (or one **1.24** billion LPY plant) could be operating in British Columbia by 1995. The likely location of these plants would be in the Interior of the province near forestry products centres such as Prince George, where wood fuel supplies are available.

Residue Recovery Employment

Each **414** million LPY methanol plant would require roughly 138,000 ODt of wood biomass per year as feedstock. This requirement could be filled from conventional wood wastes supplied by sawmills or from collection and recovery *of* forest residuals. Chapter II points out that methanol production is likely the only wood energy conversion path that could afford to pay the costs of yarding, loading, chipping, and transporting residues from logging sites. For illustrative purposes, the employment implications of residue recovery are briefly discussed. In its study for the ENFOR program, Paul H. Jones and Associates (1979) provided estimates of the costs of residue recovery for a number of systems. On the basis of discussions with Jones and Associates, these cost estimates were converted to approximate employment figures. It *is* estimated that yarding and loading of residues obtained on the second pass, sufficient to produce **75** ODt of biomass daily, would require roughly seven employees, although this figure could be subject to tremendous variation. Chipping of this volume would require perhaps one operator, while transport for **35** miles would require two trucks of **12.5** ODt capacity each making three trips daily.[101] In total, roughly 10 person-days of employment would be required to recover **75** ODt of chipped biomass residues from logging sites and transport them to a nearby conversion centre.

This ratio implies an average productivity of **7.5** ODt per worker per day of residue recovery. Based on a **138,000** ODt yearly biomass requirement, complete reliance on forest residues would mean that a 1,000 TPD methanol plant would provide 18,400 person-days of harvesting employment or roughly **75** full-time jobs. Three plants of this scale would require roughly **225** workers to obtain all their biomass needs. The speculative nature of these calculations

[101] Employment figures interpolated from Paul H. Jones and Associates (1979). in consultation with P. Jones. Trucks of smaller capacity than those discussed earlier for wood waste transport to pulp mills are assumed in this instance because off-road travel would be required for forest residue recovery.

must be emphasized, along with the fact that methanol plants could well obtain much of their biomass supplies from mill residues, which would drastically reduce the number of workers needed to harvest forest residues.

Operation Employment

Estimates of the number of operator jobs that would be created in methanol plants are subject to many uncertainties. Expected workforce requirements vary considerably, depending on the process used, plant size, and allocation of personnel. The Intergroup **(1978)** study suggests that a **414** million LPY methane-hybrid plant would employ from **45** to **90** persons. On that basis, total operating employment in three plants could range from **135** to **270** jobs.

g) Direct and Indirect Employment Summary

Table **IV-19** summarizes the direct employment that might be created by adoption of wood biomass energy use in British Columbia through **1995.** These estimates–which are based upon assumptions regarding the scale and feasibility of biomass applications discussed in Chapter II, and upon assumptions regarding employment requirements, as outlined in this section–are clearly subject to wide uncertainty. The projected increase of from **735** to **1,180** direct jobs is slight, in comparison to a projected total directly employed forest industry labor force of over **100,000** by 1995.[102] New jobs would be distributed in existing forest industry centres around the province and would primarily involve union-affiliated workers, as indicated in the table.

TABLE **IV-19**
POSSIBLE DIRECT EMPLOYMENT
RESULTING FROM BIOMASS ENERGY UTILIZATION BY **1995**

Application	Activity	Potential Job Creation	Job Affiliation
Harvest Sector	Logging	**200**[a]	IWA
Pulp Mill Boilers	Transportation Operation	**170** **40 - 50**	IWA, Operating Engineers, Pulp and Paper Workers
Pulp Mill Expansion[b]	Transportation	**50 - 55**	IWA, Operating Engineers, Pulp and Paper Workers
Wood Products Kilns	Operation	**120 - 180**	IWA, Operating Engineers
Electrical Generation	Operation	**20 - 30**	Various
Methanol	Residue Recovery Operation	**0 - 225** **135 - 270**	IWA Various
Total Potential Jobs		**735 - 1,180**	

Source: McDaniels Research Limited

a **An illustrative estimate only.**

b **Based on the assumption that pulp capacity expands by 25 per cent by 1995 and that forest energy employment grows accordingly.**

102 **In 1978, forest industry labor force was estimated at 92,500, based on information supplied by D. Roussel, an economist with the Manpower and Immigration Ministry.**

Beyond this increase in direct employment, one could expect an increase in indirect employment. Firms involved in harvest, transport, and utilization of forest biomass would require added supplies and machinery, thus creating employment in those sectors. The new directly employed workers and their families would stimulate expansion of the service sectors in their communities by spending their earnings.

Such indirect employment effects are typically calculated on the basis of some type of employment multiplier, often derived from the ratio of basic employment to total employment in a community, region, or province. Calculation of such a multiplier for biomass energy employment is beyond the scope of this study. We can, however, rely on an employment multiplier developed for the provincial forest industry in aggregate.

In its study for the provincial Forest Service, F.L.C. Reed and Associates estimated that each direct job in the forest industry indirectly created, at minimum, two jobs in other sectors.[103] On that basis, the projected direct increase in employment of between **735** and **1,180** jobs could generate a further **1,470** to **2,370** jobs in related sectors and service sectors.

h) Employment Stability

The forest industry in British Columbia is highly dependent upon exports to the United States. As a result, changes in **U.S.** economic conditions and Canadian currency exchange rates have drastic effects upon forest industry activity and employment. For example, employment in the British Columbia logging and wood products sectors fell by over **16,000** workers between **1973** and **1975,** owing to changes in lumber demands and other factors (Statistics Canada, **1973-75).**

The volatility of forest employment would be marginally reduced by development of forest energy. Because the output of biomass production would be almost completely utilized within the province, it would not be subject, to the same fluctuations as wood products. **As** mentioned in Chapter **III,** the energy value of residuals would provide a marginal incentive to maintain higher lumber production in low-market periods. Such effects would, however, be almost imperceptible, considering the scale of forest energy-induced employment relative to total forest industry employment.

4.3 Regional Considerations

a) Regional Patterns **of** Biomass Energy Employment

On the basis of information contained in Chapters II and III of this report, it is possible to make some general observations about the regional employment effects of wood waste utilization.

The province's largest users of hog fuel, at present, are coastal pulp mills that burn wood wastes along with residual oil in power boilers. **1977** data indicates that only **26** per cent of mill residuals on the South Coast were left as surplus—planned expansion of wood waste use by coastal pulp mills will eliminate any regional surpluses.

One effect of coastal mill boiler conversion would be the creation of trucking jobs for residents of the areas around pulp mills and sawmills that supplied them boiler fuel. With surpluses eliminated on the Coast, depending upon future hog fuel prices and transport costs, it may become economically feasible to obtain wastes from nearby parts of the Interior, where supplies exceed demand. This could significantly increase jobs in the coastal transport sector.

However, socio-economic benefits in the form of employment would generally accrue to Interior locations. The Interior forest industry has two advantages regarding hog fuel use: available supplies of mill and forest residuals and relatively low transport costs due to proximity of supply. Although increased use of wood wastes in the Interior will primarily be a function of the price of natural gas, environmental problems associated with the disposal of wastes may provide an added incentive for their alternative use.

At this point, it is not possible to identify precisely those areas where long-term developments such as methanol plants or electric power plants

[103] **F.L.C. Reed and Associates (1975). The** two **job ratio incorporates Reed's categories** of **indirect and induced employment, a distinction that is not of concern here.**

fueled by wood wastes may occur. However, surpluses of wood wastes in the Prince George, Cariboo, and Kamloops Forest Districts make these general locations most attractive.

b) Forest Biomass Energy Utilization as a Factor in Regional Development

Forest Industry

Use of wood wastes as an energy resource by the provincial forest industry may offer a modest incentive for greater economic development in isolated areas. Reliance upon hog fuel rather than conventional fuels may diversify potential locations suitable for the establishment of new forestry products conversion centres.

A recent article by R. Hayter (1978) examined the decision-making behavior of seven major firms interested in developing pulp and paper mills in British Columbia. Results of this study indicated that, on a regional scale, industry evaluations focussed mainly on supply conditions, including timber accessibility, quality, species mix, and tenure conditions. **A** list of principal locational factors included: economic access to wood supply and markets; adequate cheap power; availability of housing or the provision of a new town; adequate fresh water supply; waterways available for effluent disposal; and minimal air pollution effects on nearby residential areas. Power supply was not considered to take priority over any of the other factors.

None of the firms evaluated by Hayter decided on "remote" locations. In fact, post-construction evaluations indicated that two of the firms would have preferred to have located within commuting distance of established communities, owing to problems of labor turnover and housing in newer towns.

At first thought, these findings suggest that reliance on biomass energy would have little effect on location of future pulp mills. But they do emphasize the predominant importance of economical fibre supply. In the long term, as fibre supplies in the southern Interior become fully utilized, new pulp mills will be forced to locate in more remote northerly areas, despite the preferences of their workforces, in order to obtain fibre without incurring huge transport costs. In such cases, the presence of wood wastes for energy would mean that the cost of infrastructures, such as gas pipelines or power lines, could be reduced, although not eliminated entirely. All else being equal, reduced infrastructure costs would make development of forest conversion facilities in remote locations slightly more attractive.

Methanol Production

The true potential of biomass energy utilization for regional economic growth in British Columbia may be associated with the longer term development of methanol conversion plants or, possibly, electrical plants. No potential sites have been identified for alcohol bioconversion plants in British Columbia. For purposes of this report, we will consider Smithers as a case example to illustrate the regional impacts of such a production facility. At Smithers, supplies of wood feedstock are potentially available from surrounding timber supply units and from established wood-milling operations. Within the Babine, Smithers, and Morice public sustained yield units, supplies of forest residues could be obtained from second-pass recovery operations, as well as from harvest of decadent or diseased timber stands. Sawmilling operations in the Smithers-Houston area could also provide considerable supplies of wood waste. As shown in Table 11-1, there are sufficient mill wastes (over 308,000 ODt yearly in the Babine Region) to supply the requirements of a 414 million **LPY** methane-hybrid methanol plant.

Development of a methanol plant would create direct employment in the harvesting and transport of wood waste and in operation of the methanol plant. To supply a methanol plant only from forest residues, a crew of roughly 75 harvesters would be required. However, supplies of mill residues could also be utilized, which would significantly reduce the employment requirements, Depending on biomass sources, employment to supply feedstock could, therefore, range from 0 to 75 jobs; we will use 50 jobs as an illustrative figure.[104] Employment of truck drivers to transport the wood waste could provide 10 to 15 jobs.[105] Operational employment

104 **See Section** 4.2. **This figure refers to employment primarily in the recovery of forest residues and may overstate actual employment where substantial volumes of mill residues are used.**

105 **Based upon the annual biomass requirement of 138,000 ODt for the plant, a truck capacity of** 12.5 **ODt and 3 to** 4 **trips per day over a 250-day working year.**

for a methanol plant is estimated at between 45 and 90 workers. Total direct employment in harvesting, transport, and plant operation could therefore range between 105 and 155 jobs.

In addition to this direct employment, substantial indirect employment could be generated. Earlier discussion indicated that, for every job in the British Columbia forest industry, indirect employment accounted for roughly two additional jobs (Reed and Associates, 1975). This factor would imply overall employment creation of up to 465 jobs as a result of methanol plant development. However, such figures are based on provincial employment averages and are certain to overstate the multiplier effects when applied to specific regions. It is, therefore, necessary to scale down these figures; we will use 300 jobs as a rough estimate of total regional employment created by a 414 million LPY methanol plant.

Labor force statistics for the Smithers-Houston area during 1971 show that, of the 4,180 experienced labor force: 20 per cent were employed in resource sectors (including forestry, mining, and agriculture); 30 per cent were employed in construction and transportation activities; and the remaining 50 per cent were employed in business, trade, and other service activities (Ministry of Economic Development, 1978). Thus, the development of a methanol plant would increase total regional employment by roughly 7 per cent, compared to the 1971 figures. The plant would also provide diversification and, consequently, greater stability in the region. Because incomes within the resource sectors, particularly within the forest industry, are on average higher than in other sectors of the British Columbia economy, development of a methanol plant would likely increase the average income within the region (Copithorne, 1979). Overall, the expansion and diversification of primary employment attributable to a methanol plant would have positive impacts on the region's economic development. Moreover, there would be relatively little of the negative social impacts that often occur when larger projects are imposed upon a small stable community.

It was pointed out in Chapter II that there is great uncertainty about the rate at which methanol production might develop in British Columbia. If the industry expands at a more rapid rate than that outlined earlier in this section, it could provide significant employment potential in a number of regions. Moreover, the scale at which methanol plants operate could be relatively small, thus creating less impact at each location and spreading employment to different areas.

4.4 Social Effects

At this early stage of biomass energy utilization in British Columbia, it is difficult to conjecture about probable social effects. It is clear that there will be benefits to a certain number of people in the form of employment. And, with the exception of hog fuel-fired wood drying in sawmills, this employment may be relatively stable in comparison to logging and wood products manufacturing, which demonstrates significant seasonal and cyclical fluctuation.

Wood waste utilization may, in some cases, increase the range of employment and lifestyles available in relatively remote settings. Forest industry conversion centres, with power supplied by hog fuel-fired methanol or electricity plants, could become viable operations apart from existing centres. This may be especially true for coastal settings, since water transportation of wastes and of finished products is cheap in comparison to truck transport.

Other potential social effects of wood waste utilization may be changes in public perceptions and attitudes. It is probably reasonable to state that the general public has little, if any, knowledge of the technologies and impacts of hog fuel utilization. However, broad observation concerning public awareness of energy resource issues and of management of the forest resource suggests that there may be widespread potential public support for wood waste utilization.

Finally, there may be social effects that stem from changes in the environmental impacts of forest operations. Specifically, it was discussed elsewhere in this chapter that forest energy utilization could reduce the negative environmental effects of current wood waste disposal practices and improve the public's perception of forest aesthetics in cutover areas. Because the forest industry plays such a dominant and visible role as a user of resources and because environmental quality is likely an important consideration for many provincial residents, these improvements could provide considerable social benefits in the form of reduced dissatisfaction with the industry.

5.0 CONCLUSIONS

The focus of this chapter has been upon the probable impacts of forest energy utilization in British Columbia. Three perspectives were considered: forest industry activity, environmental quality, and socio-economic conditions. In the main, impacts are expected to be positive, although some probable negative effects have been identified.

Impacts upon the forest industry were analyzed largely in terms of possible changes in economic structure. Existing industrial structures within the major component industries (logging, lumber, plywood, and pulp) were discussed, along with an assessment of the present degree of vertical integration throughout the forest industry. Economic concentration in the four component industries was documented, with pulp production shown to be the most highly concentrated and sawmilling the least. Impacts of biomass energy use were assessed for the component industries on the basis of biomass supply considerations and costs of utilizing wood energy. These impacts are summarized in Table IV-20.

The potential for increased vertical integration in the forest industry was analyzed in terms of different types of integration economics. Biomass energy utilization holds the potential for pecuniary economies through backward integration. That is, major fuel users could be advantaged by acquiring secure sources of wood fuel supply. Such an effect would increase vertical integration in the industry and create greater economic concentration, worsening the industry's structure.[106] The impetus for further integration could be blunted by maintaining as large a competitive market for biomass supplies as possible.

Impacts on environmental conditions were analyzed in three sections: effects of wood waste utilization, effects of forest residues utilization, and effects of conversion facilities. The impacts of wood waste utilization are decidedly positive, since the adverse effects of current waste disposal methods would be avoided. Impacts of forest residues use are complex, but these, too, are expected to be largely positive. Potential negative impacts of forest residues use generally could be mitigated by leaving certain kinds of residues in the forest and by following careful operating practices. Finally, the environmental impacts of wood biomass conversion are expected to be less damaging than those from use of other solid fuels, although, in certain respects, worse than those of oil or gas. Control of particulates from coastal pulp mill boilers was identified as the biggest problem in wood energy conversion. Environmental control systems are necessary to keep emissions from bioconversion facilities within provincial pollution control objectives. In some instances, these control systems could be relatively costly, although different systems (of varying efficiency) are available. Environmental impacts of biomass energy utilization are summarized in Table IV-21.

Finally, the socio-economic impacts of biomass energy use were assessed by considering employment, regional development, and social factors. Direct employment benefits of between **735** to 1,180 jobs by **1995** were roughly estimated. This direct increase could result in another **1,470** to 2,370 (indirect) jobs in forestry-related and service sectors by that time. A moderate potential for improved regional development was identified, primarily as a result of long-term methanol development. Possible effects on social conditions were also addressed, including greater employment, the potential for more residents in remote areas, and better enjoyment of the outdoor environment on account of reduced negative impacts from the forest industry.

From the three viewpoints considered, the overall conclusion is that increased biomass energy utilization could result in primarily positive impacts in British Columbia. Potential negative impacts could, for the most part, be reduced or eliminated through various mitigation measures.

106 Increased concentration is equated here with reduced competition, implying a worsening of industry structure.

TABLE IV-20
SUMMARY OF IMPACTS UPON THE FOREST INDUSTRY
RESULTING FROM BIOMASS ENERGY UTILIZATION

Sector or Activity	impacts	Nature of Impact	Comments	Possible Mitigation Measures
Logging	Larger harvests	Positive	Expanded labor and subcontractors	---
Lumber	Retrofit of lumber kilns	Uncertain	Reduction in smaller mills	---
	Sales of mill residues	Positive	Added revenue sources	---
Plywood	Fuel costs	Uncertain	Depends on rate of biomass adoption	---
Pulp	Retrofit of boilers	Positive	Cost savings	---
	New investments in boilers	Positive	Cost savings	---
Vertical Integration	Potential for further integration	Negative	Result of attempts to secure supplies	Maintain active biomass fuel market

Source: McDaniels Research Ltd.

TABLE IV-21
SUMMARY OF ENVIRONMENTAL IMPACTS
RESULTING FROM BIOMASS ENERGY UTILIZATION

Environmental Aspect or Activity	Impact	Nature of Impact	Comment	Possible Mitigation Measures
1. Wood Waste Utilization	Reduced disposal	Positive	Reduced leachate and emissions	------
2. Forest Residues Utilization				
Soil	Reduced nutrients	Negative	Expected to be slight	Leave foliage in forests
Water	Reduced quality	Negative	Result of erosion	Leave root systems, employ proper recovery practices
Air	Improved quality	Positive	Reduced burning	
Stand Establishment	Improved planting	Positive	Reduced slash	------
	Reduced shade	Negative	Reduced shade	Regeneration of brush
Stand Development	Reduced competition	Positive	Reduced non-commercial species	------
Fire Prevention	Reduced fire hazard	Positive	Reduced residues	
Insects	Reduced infestation hazard	Positive	Reduced large pieces	Proper logging and recovery practices
Fish Habitat	Reduced water quality	Negative	Increased erosion	------
Wildlife Habitat	Improved forage	Positive	Reduced large residues	
	Reduced cover	Negative	Reduced large residues	Leave small residues
Recreation and Aesthetics	Improved aesthetics	Positive	Reduced "misfit"	
	Expanded clearcuts	Negative	Extended margin of harvest	------
3. Biomass Conversion Facilities				
Direct Combustion	Change in air emissions	Uncertain	Less pollutants than other solid fuels, possibly more than conventional fuels	Emission control systems
	Increased leachate	Negative	Result of ash handling and storage	Utilization of ash
Gasification	Increased emissions	Negative	Could be minimized	Control systems

Source: McDaniels Research Limited

TABLE IV-22
SUMMARY OF SOCIO-ECONOMIC IMPACTS
RESULTING FROM BIOMASS ENERGY UTILIZATION

Socio-economic Aspect or Activity	Impact	Nature of Impact	Comment	Possible Mitigation Measures
Direct Provincial Employment	Job creation	Positive	735 to 1,185 jobs	------
Indirect Provincial Employment	Job creation	Positive	1,470 to 2,370 jobs	------
Regional Development	Alcohol fuel plants	Positive	300 jobs in one community	------
Social Conditions	Higher employment	Positive	------	------
	More remote employment	Positive	------	------
	Improved attitudes toward forest industry	Positive	------	------

Source: McDaniels Research Limited

CHAPTER V

CONSTRAINTS TO FOREST BIOMASS ENERGY USE

1.0 INTRODUCTION

1.1 Objectives

In Chapter II, it was demonstrated that forest biomass could be an economically viable fuel for a number of specific applications in British Columbia. Yet the actual adoption of wood energy in the province has largely been limited to coastal pulp mills as a substitute for residual oil in boilers. Interior pulp mills using natural gas have not, with few exceptions, converted to hog fuel, and relatively few sawmills have adopted biomass energy for lumber drying. Outside the forest industry, biomass applications for electrical generation or conversion to liquid fuel remain untried. These apparent shortfalls indicate that constraints, on the part of key institutions, may be slowing the pace of biomass energy reliance.

How might biomass energy be hindered by so-called "constraints"? One clear and significant example can be inferred from Chapter II. There it was argued that the viability of wood energy should be calculated on the basis of prices that reflect the marginal costs of alternative energy sources. Yet, at present, conventional energy resources, particularly oil and natural gas, are priced to consumers at rates below their marginal costs. The result is a disincentive to switch from conventional to renewable fuels, such as biomass. Thus, "constraints" refers to financial, legal, regulatory, policy, or administrative factors that are the result of institutional behavior and have an effect on the viability of forest biomass energy. The institutions of note in this discussion are the forest industry, energy industry, governmental energy agencies, Ministry of Forests, and other groups.

The objectives of the chapter are to identify constraints that originate with these institutions and to weigh the relative importance of these constraints. In the final chapter, this information is used to recommend incentives and administrative measures that would remove constraints to forest biomass energy use.

1.2 Methodology and Organization

Although we have demonstrated that biomass energy use would provide adequate benefits to British Columbians as a whole, it is not surprising that these benefits would accrue to some interest groups more than others. In simplest terms, the groups that stand to gain from wood energy can be expected to encourage its use, while the interest groups that would suffer (or perceive themselves to suffer) would seek to impede its adoption. It is from this friction that institutional constraints would arise.

If the institutions of importance all pursued profit maximization as their single goal, analysis of the barriers to biomass energy would be a straight-forward task. The impact of wood fuel reliance upon profit, growth, and revenues for each of the institutions could be determined. For those groups that would suffer losses, appropriate re-distributional measures could be fashioned and wood energy use would grow at its maximum rate.

Unfortunately, such clear, concise objectives cannot be discerned as the sole motives for institutional behavior. Aside from a professed goal of profit maximization, managers in the private or public sectors might pursue more nebulous ends. Diverse factors (such as tranquility, autonomy, stability, or political popularity) play important roles in the policy decisions of many institutions.

To deal with these institutional factors, the following methodology is adopted. Each of the major institutions or interest groups involved in biomass energy will be identified and its objectives briefly described. Next, the direct effects on that particular institution of greater biomass energy use are assessed. Then, specific behavior of this institution that hinders forest energy use will be assessed. In the last section of this chapter, a summary analysis of identified constraints is presented.

2.0 THE FOREST INDUSTRY

As both the supplier and principal user of forest biomass, the forest industry holds great sway over wood energy development. We have established that this industry is increasingly dominated by large vertically-integrated firms that pursue the goal of profit maximization, as well as other goals related to corporate strategy. These objectives have indirectly established constraints to the further use of biomass energy.

2.1 The Profit Objective

In order to satisfy their investors, forest industry firms generally attempt to maximize their profits. This objective requires, among other things, that the costs of inputs are minimized and returns from investments are maximized.

a) Cost Minimization

When the industry's companies choose between alternative energy sources, they select the fuel that provides the needed energy at lowest total cost. Even at the current level of domestic prices, hog fuel appears less costly than fuel oil for coastal pulp mill power boilers, since most coastal mills have moved to increase wood energy use. Domestic gas prices are, however, low enough that Interior mills generally do not have an incentive to switch to wood fuel.

The Interior pulp mills and sawmills clearly recognize that gas prices that are high enough to make wood energy feasible would also raise their total energy costs. It is, therefore, not surprising that the forest industry has argued against substantial increases in wholesale natural gas prices.

Submissions by the Council of Forest Industries to the British Columbia 1980 Gas Price Hearings argue that gas prices should be set on the basis of supply costs, rather than in relation to oil prices (COFI, 1980). They maintain that, if it is necessary to raise well-head gas prices in the province, these increases should not be passed to the domestic customers. Instead, export markets should bear the cost of well-head price increases, and the current domestic price structure should be maintained, according to their briefs. While the Council also indicates support for greater use of biomass energy within the forest industry, the gas price structure it recommends would likely be insufficient to prompt conversion by most interior mills. Section 4.2 of this chapter analyzes the effects of different gas prices on the viability of boiler replacement.

While the pricing issue is much more complicated, the same cost-minimizing approach could be expected toward cogenerated electricity. Most pulp mills do not now self-generate their electricity because they find it less costly to purchase energy from B.C. Hydro. As discussed later in this section, B.C. Hydro is moving toward a marginal cost-based rate structure, but does not now charge users the full marginal cost of added energy production.

The positions of industry members toward price increases in electricity are not so well defined as for natural gas. One could expect general support for purchase prices that allow firms to sell any surplus cogenerated power to B.C. Hydro at the utility's marginal cost of supplying that power from other sources. On the other hand, most firms would oppose any change in the absolute level of prices paid by industrial users, since that would mean an increase in their electricity costs.

In sum, the forest industry is naturally concerned with the private cost of its energy inputs and seeks to minimize these costs. From a private perspective, viable wood energy depends on increases in gas and electric costs over present levels; it, therefore, would be a disadvantage for firms purchasing gas and electricity. When the industry makes its position known to regulatory agencies, in order to minimize potential cost increases in energy inputs, it indirectly provides a barrier to greater biomass use.

b) investment Criteria

Private firms naturally try to allocate their capital to the most productive or profitable investment opportunities they have available. Interviews have indicated that capital allocation criteria have, in some cases, slowed the rate of wood energy adoption by the forest industry. Some firms have postponed conversion to hog fuel despite the likelihood that the investment would provide positive returns. Simply enough, the firms may prefer to allocate their capital to more profitable alternatives in other components of their operations.

When choosing between alternative investments, a firm normally adopts a minimum rate of financial return or "hurdle" level for its prospective projects. Projects expected to yield returns below this "hurdle" level are excluded from detailed consideration. It is important to note that the return on an investment is directly related to the financial life or number of years over which the company amortizes the investment. **A** longer financial life will mean a higher rate of return, all else being equal.

According to industry representatives, forestry firms typically evaluate investments in areas such as biomass energy use on the basis of a 5- to 10-year financial life. An investment must yield sufficient returns when operated and amortized over only that period, even though the operating life of the investment would be much longer.

Alternatively, one could evaluate such investments by amortizing them over their full productive life, say 25 years. Still another alternative would be a social benefit/cost approach that, in one form, considers the net present value of an investment, comparing only the revenues to the costs and ignoring taxes. The latter two criteria are in keeping with an analysis from the public perspective, rather than a private perspective.

The effects of different investment criteria upon the viability of biomass conversion can be observed in Tables 11-12 and 11-13; they analyze investment in hog fuel boilers and turbogenerators, respectively, for provincial pulp mills. Results are shown for a 5-year financial life, a 25-year period, and net present values. One sees in Table II-13 that all cogeneration projects yield returns below 10 per cent, and seven have negative returns, when the 5-year financial life is used; conversely, all but two projects yield returns over 10 per cent when a 25-year financial life is employed. All but two show positive net present values.

In seeking to maximize returns on its capital investments, the forest industry could bypass cogeneration or other biomass opportunities in favor of more profitable projects with faster payoffs.[107] Yet based on social investment criteria, the projects of Tables 11-12 and 11-13 are economically viable ways to substitute biomass fuels for conventional energy sources.

2.2 Other Objectives

Aside from profit maximization, which is a primary objective for all private enterprises, the forest industry has been shown to pursue secondary goals that reflect its managerial strategies. These strategies, which include an avoidance of diversification and a drive for security of input supply, are related to the increasingly concentrated structure of the provincial forest industry. Both these strategies have implications regarding the outlook for greater biomass energy reliance in British Columbia.

a) Diversification Strategy

In his study of structure and performance in American industry, Rumelt (1974) provides an illuminating analysis of corporate diversification strategies. He classes the major forest products firms within his sample in the Dominant-Vertical group; these are companies that obtain the preponderance of their revenues from a single type of business (in other words, they are not diversified) and, also, are highly vertically integrated. Examples of other industries in this category include steel, oil, primary metals, and meat packing (Rumelt, 1974).

Rumelt's (1974) task was to explain the relatively low financial performance of such firms by exploring the reasons for their lack of diversification. His findings are of interest here because applications of biomass energy by the forest industry are a step in vertical integration and, in some cases, diversification. Some of the obstacles to diversification that Rumelt identified also constrain adoption of biomass energy.

Rumelt observed that, while vertical integration is a rational response to certain technologies and market conditions, those very conditions have become associated with mature and low-profit industries. The Dominant-Vertical firms are often suppliers of basic materials to other manufacturers and are tied to complex capital-intensive processes.

Since many are in slow-growing industries, the oligopsonistic struggle to be a low-cost producer with geographically dispersed capacity encourages overcapacity (on average) and poor profits. Diversification is limited because the firm's technology and skills in one industry are often not readily transferable to other sectors. Also, the management of such firms

107 These conclusions are similar to ones reached in a recent engineering study of cogeneration potential in British Columbia. Based on current rather than marginal cost-based electric rates, the study estimated returns ranging from **7** to **16** per cent for investment in a turbogenerating system, when replacing a conventional system with a hog fuel boiler, depending on the financial life. Yet the study concluded that little cogeneration potential would actually be developed because of the industry's stringent investment criteria (Intercontinental Engineering Ltd., 1980).

tends to be process-oriented and organization is departmentalized, with few generalists available to perceive and act on broad issues. Finally, the relatively low profits and low price/earnings ratios of these companies make substantial investment in new business difficult (Rumelt, 1974).

On the whole, Rumelt describes the province's major forest industry companies with remarkable accuracy. From his description, we can draw three inferences regarding the adoption of biomass energy by these firms.

Lack of
Diversification

Even though the forest industry controls substantial biomass supply, we would not expect it to seek diversification into biomass energy commodities marketable outside the industry, such as liquid fuels. The industry's process skills are not directly extendable into this type of bioconversion; its management is not broadly enough based to seek out and develop such opportunities and its capital is limited. While cogeneration does fit well with the pulp industry's technology, some firms may view electrical production as the role of a utility and, therefore, avoid it as being outside their scope. On the other hand, combustion of biomass for steam is intrinsic to the pulp process and would, therefore, not be limited on technical grounds. The other two restraining factors, however, may limit internal applications of biomass.

Lack of Managers
Knowledgeable in Energy

During the early **1970s,** energy inputs amounted to roughly 5 per cent of the provincial forest industry's total costs; by **1979,** the energy costs had grown to roughly 10 per cent of the total. Energy inputs are still a small proportion of the forest industry's costs, in relative terms, and have, therefore, not attracted substantial attention from senior managers. Of far more importance to the industry are issues, such as adequacy of wood supply and stability of markets, that have greater bearing on profits (Council of Forest Industries, pers. comm.).

This is not to suggest that energy issues have been ignored by the forest industry. Both the pulp and paper and sawmill sectors actively participate in the federal Energy Conservation Task Force initiatives to reduce overall energy consumption in those industries. But, as the Council of Forest Industries has acknowledged, the number of individuals from the management level of forest firms, who are experienced in energy issues, is very limited. Consequently, the industry would be relatively slower to take up biomass conversion opportunities, unless the payoffs are obviously high.

Lack of
Available Capital

For years, the British Columbia forest industry has experienced relatively low average returns.[108] This level of performance can be partly attributed to the industry's strategy and structure, as well as to other reasons such as relatively high-cost wood supplies. Whatever the reasons, low financial performance means companies have relatively smaller amounts of money available for investment. As was argued previously, capital is rationed to the most profitable investment opportunities available with the firm's operations; firms are understandably hesitant to invest in projects that involve any type of uncertainty.

Other than power boilers, biomass energy projects could involve many different uncertainties. Lime kilns depend on an unproven technology; cogeneration entails uncertain returns for electrical sales; gasifiers are not, at present, commercially available; and all bioconversion projects could be affected by uncertain biomass supply. The relative lack of available capital means these uncertainties take on greater importance and likely slow the rate of biomass energy use.

b) Desire for
Security of Supply

A characteristic feature of many vertically integrated firms is their control of key input supplies. Motivation for this type of backward integration is to eliminate uncertainty regarding input prices and to inhibit entry by other firms. Nowhere is this tendency more evident than in the British Columbia forest industry (Schwindt, **1977).**

[108] **Numerous submissions to the 1975 Royal Commission on Forest Resources discuss the pattern of low returns in the forest industry (see, for example, Dominion Securities Corporation 119751, and Pearse 119761 also discusses this phenomena in his report).**

In terms of biomass energy, this tendency means that firms will shy away from bioconversion unless they have assured supplies of wood biomass. One can, of course, understand a hesitancy to commit millions of dollars to wood energy conversion if the price and availability of fuel is uncertain. Firms without the sufficient captive biomass supplies will attempt to contract with sawmills or other firms to arrange a dependable fuel supply. But the experience of the Interior chip market is that independent producers may try to avoid long-term commitments to supply residues at a fixed price, in hopes of obtaining higher prices from marketed sales (Council of Forest Industries, pers. comm.). This friction- between buyers eager for fixed commitments and sellers maintaining independence–could slow wood conversion projects by companies without sufficient internal supplies.

3.0 THE ENERGY INDUSTRY

Forest biomass could be viewed by the conventional energy industry sectors as a potential competitor in the marketplace or, in some cases, as a potential source of hydrocarbons for bioconversion projects. Such a range of potential responses ensures that the conventional industry's activities could hold major significance for the rate of biomass energy adoption. The energy sectors of note here are gas and oil producers, gas utilities, and the province's chief electric utility–B.C. Hydro.

3.1 Gas and Oil Producers

Canada's oil production is dominated by large, integrated, multi-national firms and shows a high degree of economic concentration. Gas production is less concentrated, since a relatively larger share is provided by smaller, independent producers (Dept. of Consumer and Corporate Affairs, 1971). Neither group has shown a significant interest in wood biomass, which has positive and negative effects on the potential for bioenergy development.

a) Gas Producers

Based on the analysis of Chapter II, forest biomass could displace as much as 20 billion cubic feet of natural gas now consumed annually in provincial pulp mills. Such a drop in industrial demand would mean a perceptible reduction in domestic sales of British Columbia gas producers; one might, therefore, expect that gas producers would encourage the provincial government to keep domestic prices relatively low, in order to forestall conversion to biomass.

That strategy has not been in evidence. Gas producers are apparently unconcerned over the potential loss of pulp mill customers, since, in recent hearings, they have generally advocated significant increases in well-head and wholesale gas prices. For example, a brief for the Canadian Petroleum Association to the British Columbia Utilities Commission argues that domestic gas prices should increase and be set at near parity with oil prices (Foster Research Ltd., 1980). Gas priced at that level would provide greater incentives for conversion to biomass. Other submissions by gas producers include similar recommendations (Texaco, 1980). According to one brief, gas producers expect that petrochemical developments and export markets will take up any short-term drop in domestic demand (Gulf Canada Resources Inc., 1980). Thus, no obstacles to biomass energy are foreseen from this quarter.

b) Oil Producers

The biomass energy application of most consequence to oil producers would be bioconversion to alcohol for liquid fuel. As outlined in Chapter II, methanol from wood wastes could supplement or replace refined petroleum products for many fuel demands. It would, therefore, seem a natural direction for Canadian oil industry development, as is occurring in the United States, where a number of major companies produce and distribute alcohol in a "gasohol" blend.[109]

At present, there is only limited Canadian oil interest in ethanol production and, apparently, no interest in methanol. Mohawk Oil Canada Ltd., a smaller, partially-integrated firm, has purchased a distillery and intends to produce ethanol from grain. The company will then distribute gasohol in Manitoba. Two main factors led to Mohawk's involvement in ethanol. The first was the Manitoba government's recent decision to drop the 26 cents per gallon road tax on gasohol, which makes the product more

[109] *New York Times,* **"Major Oil Companies Testing Gasohol", August 28, 1979.**

economically feasible; the second was Mohawk's lack of a refinery and its desire to control some of its own product supply.[110] A survey of oil industry publications and organizations could not identify any research or interest regarding alcohol from wood biomass.

One industry spokesman stated his belief that the Alberta oil sands are a more understood and possibly more economically attractive synthetic fuel source than alcohol from wood. The technology of oil sands extraction and conversion is also better defined. Consequently, the oil industry has not pursued the biomass alternative (Canadian Petroleum Association, pers. comm.). Another observer noted that the industry is prone to allocate its research and development funds to problems within the oil industry, such as better well recovery or improved offshore technology, rather than to questions outside the oil sector. He also noted that there is often a lack of sufficient personnel at the head office level to evaluate all energy project alternatives. Finally, coal liquefaction was mentioned as a more attractive synthetic fuel alternative because the resource can be measured and controlled.

It is interesting to note that two of the factors mentioned above–that is, a focus upon the technology within the industry and a lack of personnel at the management level to consider other alternatives–are characteristics that, according to Rumelt (1974), limit diversification in Dominant-Vertical companies. Oil companies, in Rumelt's sample, fell into the Dominant-Vertical group. With the tremendous growth in oil industry revenues in recent years, there has been a growing degree of diversification within this industry, and some oil firms would no longer be classed as dominated by one product. Nevertheless, the tendency to refrain from diversification may be a key factor in the oil sector's lack of interest in alcohol from wood biomass.

Drawing further on earlier arguments, one could expect the oil industry's profit maximization criteria to inhibit against development of alcohol from wood. From the investor's viewpoint, oil sands projects or, possibly, coal conversion may be more attractive because he believes there is less uncertainty regarding conversion technology and input supply than with bioconversion. The oil sands are, of course, fraught with uncertainties of other types, such as government policy regarding oil prices, but methanol would likely face some of the same problems. Consequently, research funds are allocated to oil sands or coal projects that have a higher potential for profits, even though bioconversion may well be economically viable from a social viewpoint.

Finally, it is notable that the federally owned oil company, PetroCanada, has shown no active interest in alcohol fuels production. PetroCanada's research efforts are largely directed toward problems within the conventional industry, rather than alternative sources.[111] Moreover, the company's managers are completely involved in developing new projects within the conventional industry and, therefore, have little time to pursue other areas (Petro-Canada Ltd., pers. comm.). As a result, it has taken no initiative toward innovation in alcohol fuels or any other form of renewable energy.

3.2 Natural Gas Distributors

Nearly all the province's natural gas-burning pulp and paper mills and sawmills are on the Pacific Northern Gas or Inland Natural Gas distribution systems. These distribution companies are investor-owned private utilities serving the province's Interior and are regulated by the British Columbia Utilities Commission. Because their forest industry customers make up a major proportion of their total loads, the two utilities could face substantial losses of revenues if the mills converted to wood wastes in their boilers or lumber kilns. They could, consequently, be a major source of institutional resistance to greater biomass use.

a) Inland Natural Gas Co. Ltd.

Inland Natural Gas Co. Ltd. is the largest gas distributor in the British Columbia Interior. The forest industry is, in turn, Inland's largest single group of customers; in 1979, pulp mill consumption accounted for 32 per cent, while sawmills and plywood mills accounted for 13 per cent, of its total sales (Inland, 1980). The utility clearly stands to lose

110 ***Canadian Renewable Energy News,*** **"Mohawk First",** Vol. **3, (1980), p. 12.**

111 **Toronto *Globe and Mail,* "PetroCan has commitment to Energy Research", December 7, 1979.**

a considerable share of its revenues if the forest industry converts to wood wastes as its primary fuel.

Inland recognizes this potential and has incorporated a move to greater hog fuel use into its latest requirements forecast. It predicts that, by 1995, the proportion of total steam requirements, generated by hog fuel in the power boilers of its pulp mills customers, will increase by 10 per cent. This increase is expected to result from greater hog fuel consumption in existing boilers, rather than because of major boiler replacements. In plywood and sawmills, natural gas requirements are expected to peak in 1982 and decline steadily thereafter, owing to substitution of wood residue burners for natural gas. The substitution rate predicted by Inland is equivalent to one major sawmill converting to wood wastes each year, commencing in 1981.

These substitutions do not necessarily mean a decline in total natural gas use by the forest industry; the utility's forecasts predict a 1995 gas consumption by the forest sector of 20.87 pj, almost identical to the actual 1979 consumption. The steady rate is predicted because of current or planned expansions in the pulp and sawmill sectors, which would make up for lower average use.

These forecasts were based on the assumption that wholesale gas prices would be set in relation to the cost of supply and not in relation to crude oil prices. The utility recognizes that substantially higher prices for natural gas could encourage far greater wood waste substitution. Its submissions predict that higher prices could cause a number of hog fuel boiler replacements by its pulp mill customers. It also points out that wood wastes systems "would be attractive for all larger sawmills, if gas prices rise . . . significantly above general inflation" (Inland, 1980).

We calculate that, if the maximum possible conversion to wood wastes occurs, it would cause Inland's forest industry demand to fall to roughly 14 **pj** or about 7 pj below Inland's forecast. The calculation assumes that all pulp mills install new hog fuel boilers (with fossil fuels providing only 15 per cent of energy needs) and also that half the plywood and sawmill gas requirements are replaced by wood. Maximum hog fuel use could thus cause an approximate 10 per cent drop below Inland's predicted total gas requirements in 1995. However, even with this loss of forest industry demand, the total 1995 requirements would still entail a growth of roughly 7 pj over the 1979 consumption. The growth would occur because Inland foresees expanded requirements in all other customer classes.

The utility's submissions to the British Columbia Energy Commission suggest that, if it loses forest industry customers due to higher gas prices, it may experience underutilization of its capacity. In that case, it could be forced to raise its tariffs to residential and commercial customers. In order to retain its forest industry customers, the utility has encouraged the Commission to hold domestic wholesale gas prices at a lower level (Inland, 1980). This position obviously poses barriers to greater biomass energy use in Interior mills.

b) Pacific Northern Gas Ltd.

Pacific Northern Gas (PNG) is a much smaller utility than Inland, serving an area west of Prince George to Prince Rupert. The utility has two pulp mills, as well as a smaller number of sawmills among its industrial customers.

One of Pacific Northern's pulp mill customers, Canadian Cellulose at Prince Rupert, is in the process of installing a new hog fuel boiler and its predicted gas requirements have fallen accordingly. At present, the other pulp mill customer expects to maintain steady gas requirements. No explicit mention of sawmill requirements are made in Pacific Northern's recent forecasts (PNG, 1980).

In many respects, PNG is less vulnerable than Inland to a loss of industrial customers owing to wood waste conversion. The loss of part of the Canadian Cellulose mill's requirements will mean a drop in consumption by 16 per cent of its 1979 sales. PNG has acknowledged this reduction and is planning accordingly. Moreover, PNG expects that two natural gas-based methanol plants will be constructed in its market area by 1983. The proposed plants would more than triple PNG's natural gas requirements and entail significant increases in the system's capacity. If these plants go forward, they would more than compensate for any reduction in forest industry demand owing to wood energy use.

On the other hand, PNG's relatively small size means that it could be disadvantaged if its other pulp mill customer opts for greater wood waste use and, at the same time, the methanol proposals do not go forward. This scenario would entail a 1985 sales volume that is only about 85 per cent of the company's 1979 volume.

PNG has recognized this possibility and argued to the British Columbia Energy Commission against wholesale natural gas increases (PNG, 1980):

> The industrial market is normally the most sensitive to increases in natural gas prices and Pacific Northern is highly dependent upon large industrial sales to maintain a high system load factor and reduce per unit costs of delivery. Any loss in revenue from the conversion of industrial customers to oil or hog fuel from natural gas would result in a multiplying effect in which the remaining customers' retail rates would have to be further increased to cover such a loss.

It is not difficult to discern the motivation for positions held by PNG and Inland regarding natural gas prices. As profit-maximizing firms, it is in their interest to minimize the cost of their product and maximize their sales revenues. It is true that the utilities could suffer a period of contracting sales if wood energy conversion proceeds at its maximum rate. However, British Columbia is attempting to foster a movement from oil to natural gas in virtually all other sectors, and there is a strong likelihood that a petrochemical industry, based on natural gas, will develop in the province. Thus, one could expect that growing demands by all other customers would soon eliminate any drop in revenues the utilities experience in the short term.

c) The Proposed Vancouver Island Gas Pipeline

Vancouver Island is the only major market area in Western Canada not served by natural gas; at least three competing organizations have recently proposed to construct a pipeline to fill this need. Of interest here is how the proposed pipeline would affect the potential for biomass energy utilization on the Island.

One of the competing organizations, B.C. Hydro, has produced a benefit/cost analysis of its proposal that demonstrates the project to be an economically viable undertaking (DPA Consulting Ltd., 1980). However, this pipeline proposal came under criticism in hearings of the House of Commons Committee on Oil Replacement and Alternative Energy. A submission argued that B.C. Hydro's evaluation of the line assumed natural gas could displace all fuels–including hog fuel–in pulp mills. If true, that would mean the line is of dubious benefit and presents barriers to biomass energy (Margolick, 1980). A review of the B.C. Hydro study shows that it assumed full utilization of hog fuel in pulp mill boilers, with natural gas filling only the remaining 15 per cent of thermal energy needs. Moreover, the study indicated the line to be economically viable, based only on commercial and residential sales and ignoring industrial sales (DPA, 1980). In that case, the line would not provide a direct barrier to wood energy in power boilers.

On the other hand, a pipeline may well remove the incentive to develop the technology that would permit greater utilization of wood fuel in pulp mills, such as in lime kilns. One mill on Vancouver Island is installing an experimental wood-fueled lime kiln, with the help of government funding, in an attempt to reduce its current oil consumption. If coastal mills have natural gas available for their lime kilns, they may find it more attractive than supporting the development of a technologically advanced wood fuel system. The crucial issue would, of course, be the price charged for natural gas, which, in the B.C. Hydro study, was assumed to be $3.11 per GJ in 1983. Thus, even though the proposed line may not have a major influence on wood energy in power boilers, it could constrain the viability of further wood energy substitution in pulp mills.

3.3 B.C. Hydro and Power Authority

B.C. Hydro and Power Authority, the province's chief electric utility, is a crown corporation. As such, it is expected to conduct its affairs in a manner similar to that of a private corporation but, also, to meet certain public objectives. This dual mandate is evident in a recent statement that sets the utility's goal as the supply of electricity at the minimum long-term cost to its customers (B.C. Hydro, 1981). It is probably fair to say that political considerations have a major influence on the activities of B.C. Hydro. Its Board of Directors is appointed by the government, and two provincial cabinet ministers are members. Thus, another objective of the utility would be to act in a manner that is politically acceptable to the government and to the public.

The two applications of biomass energy of relevance to B.C. Hydro are electrical cogeneration in pulp mills and a wood-fueled thermal electric plant at Quesnel. In certain respects, the utility has indirectly provided obstacles to these bioenergy uses.

a) Cogeneration

Previous studies have pointed to B.C. Hydro's rate structure as a major obstacle to greater cogeneration. This rate structure is being revised and the changes will lessen, but not eliminate, the barriers imposed by cogeneration by electric prices. Other kinds of constraints are, however, imposed by the utility's general approach to cogeneration.

Pricing Policy

There are four different dimensions to electric prices that affect the viability of cogeneration–absolute level of prices, uniform structure of prices, relative size of charges for energy and capacity, and size of standby charges.

i) Absolute Level of Prices

Until recently, B.C. Hydro based its rate structure on the average cost of providing power, allocated by customer class, on the basis of standard accounting procedures. As outlined in Chapter II, this approach removed much of the financial incentive for pulp mills to generate their own electricity. The mills found it more economical to purchase electricity, even though the cost of their self-generated power could, in many cases, be below the marginal cost of B.C. Hydro's future generation projects.

Apparently, the utility recognized this anomaly and, for this, as well as for other reasons, is changing its rate structure. B.C. Hydro representatives state that the firm is moving to a "marginal cost-based" pricing schedule; its announced rates for 1981 indicate that bulk customers would pay an average of 21 mills per kwh (including capacity and energy charges) or about 18 mills in 1980 dollars. This figure is somewhat below the 26 mills per kwh that was estimated in Chapter II to be the full marginal cost price in 1980. The utility is not adopting full marginal cost pricing because it would then generate substantial profits–a politically unacceptable result, according to one spokesman (B.C. Hydro, pers. comm.).

The price that the utility is willing to pay for surplus cogenerated power has recently been increased. B.C. Hydro has agreed to purchase power from one cogenerator at 14 mills per kwh, which is roughly equal to the energy charge under the 1981 rates but still far below marginal costs. Although the utility has eased the constraints imposed on cogeneration by the absolute level of prices, the full financial incentive to cogeneration is still not provided.

ii) Uniform Regional Prices

A more indirect price constraint arises from the utility's "postage stamp" rate structure, which charges uniform rates throughout the province, even though transmission costs are much higher for certain locations than others. This policy eliminates any extra incentive to cogenerate power in remote areas where a pulp mill might be able to supply its own electric demands at a lower cost than could B.C. Hydro. Good examples of this situation are found on Vancouver Island, to which B.C. Hydro is installing a controversial and expensive high voltage line.

Interestingly, the utility has indirectly given a boost to cogeneration on Vancouver Island by announcing that it cannot serve any added industrial loads until its new transmission line is completed in 1983. Two pulp mills planning capacity expansions have subsequently decided to install turbogenerators and self-generate power, since they could not purchase it. One would, however, expect that a differential pricing policy, based on transmission costs, would be a more efficient and rational method to encourage cogeneration in remote areas.

iii) Energy Capacity Charges

Critics have argued that B.C. Hydro's rate structure has discriminated against cogeneration in that the charges to bulk users for peak use were too large relative to the charges for average use (Cox and Helliwell, 1978). Cogenerators have high peak requirements but low average requirements. As the utility moves to its marginal cost-based pricing schedule in 1981, it will increase its average (energy) charge by roughly 70 per cent, while decreasing the peak (capacity) charge by 35 per cent. It also plans further increases in energy charges (B.C. Hydro, pers. comm.). Thus, the relative charges for energy and capacity will more closely match the relative costs to B.C. Hydro of providing these units of power from its hydroelectric-based system and this change should minimize constraints imposed by the relative prices for average and peak use.

iv) Standby Charges

Industrial cogenerators normally expect to be able to draw electricity from the utility if there is a shutdown or an equipment failure in their system. When this power demand occurs, B.C. Hydro would typically negotiate with the firm on an ad hoc basis regarding the price for that electricity. According to one source, this negotiation process could sometimes be lengthy, involving costly delays to the firm (Intercontinental Engineering Ltd., 1980). Moreover, B.C. Hydro representatives indicate that they tend to look upon the value that could be obtained in other markets or the opportunity cost as a measure of the price for that power. If the utility could otherwise export the electricity to the **US.** power grid, the opportunity price might reach as high as 40 mills per kwh. This ad hoc approach to setting standby charges introduces a further uncertainty into the costs and benefits of cogeneration by a pulp mill and, consequently, makes the prospect less attractive than would be the case with an established rate schedule.

Attitude Toward Cogeneration

Perhaps more important than constraints imposed by rate structures are those arising out of the utility's corporate approach to cogeneration. Although no specific policy has been spelled out by B.C. Hydro, interviews indicate that cogeneration is viewed within the organization as a relatively undependable and high-cost means of power generation. Those interviewed cite problems such as the relative insecurity of supply from cogeneration facilities because the power is a by-product of industrial processes and may, therefore, suffer interruptions due to strikes or shutdowns. They also mention safety issues that could arise if part of the utility's system has a failure while other parts, such as a cogeneration plant, are still producing power. Probably, most important is the viewpoint that cogeneration is a process associated with private industry and, therefore, not under the direct control of B.C. Hydro.

The result of these attitudes has been an apparent lack of progressiveness in providing encouragement or accommodation for cogeneration. The utility has not actively attempted to resolve the problems of reliability and safety that have been associated with this process. In some areas, other utilities have solved these problems with innovative solutions. For example, a cogeneration plant in Eugene, Oregon, is jointly operated by the local utility and a pulp mill. The utility owns the turbo-generating equipment, while leasing space and buying steam from the mill. The utility also has full control of the plant's electric output (U.S. Dept. of Energy, 1978). This approach has not been considered by B.C. Hydro. Utilities could also encourage cogeneration by allowing companies with multiple plants to generate power at one site and "wheel" it or use the utility's transmission system to move power to another plant for a transmission fee. B.C. Hydro does not allow "wheeling" of power from one plant to another; one spokesman cited safety concerns as the reason for this policy. The Bonneville Power Administration in the U.S. Pacific Northwest does, however, permit wheeling of power (Solar Energy Research Institute, 1980a).

In sum, it is fair to say that the utility does not approach cogeneration as a potential alternative that could reduce industrial loads or add to its generation capacity. It does not ask whether cogeneration could add power to the system at lower costs comparable to other alternatives. Instead, it views cogeneration as a complication in its system and one outside the utility's sphere of interest.

There are a number of possible explanations for this apparent position. Probably, most important is the fact that British Columbia still has a number of major undeveloped power alternatives that have low costs compared to those of other utilities. An abundance of conventional power sources means that little attention is devoted to nonconventional opportunities, particularly ones that would be outside the utility's integrated system.

A second point is that the increments in power production that could be achieved from cogeneration are relatively small, from B.C. Hydro's viewpoint, and associated with a number of installations, rather than one central plant. Thus, even though cogenerated power could potentially be brought on stream much faster than most of B.C. Hydro's future projects and could flexibly meet interim load growth, it is not easily included in the utility's system planning.

A third point is B.C. Hydro's recognition that cogeneration is only viable if a pulp mill has a hog fuel boiler in operation, since it would be prohibitively costly to burn oil or gas for the required energy. Cogeneration installations will, consequently, only be considered as part of a boiler replacement project or as part of an expansion in capacity. Thus, the same factors that inhibit the conversion of power boilers to hog fuel (specifically, the price of natural gas) also provide indirect barriers to further cogeneration.

A final explanation for B.C. Hydro's approach to cogeneration may be indirectly related to its structure. As a large crown corporation, rather than a smaller, investor-owned utility, B.C. Hydro does not have a direct profit-maximizing incentive. It, therefore, is not as motivated to seek out novel or innovative ways to meet its load requirements at the minimum cost. In contrast, some of the utilities that have shown high interest in cogeneration are smaller, investor-owned companies in the U.S. Pacific Northwest (U.S. Dept. of Energy, 1978).

b) Quesnel Thermal Electric Plant

In Chapter 11, it was established that, based on preliminary studies, the proposed Quesnel hog-fuel electric plant could be a otentially attractive alternative for B.C. Hydro.' - - At present, the plant is not under active consideration by the utility. This lack of interest can be attributed to three factors, all of which arise from B.C. Hydro's planning process. When conducting its initial evaluation of alternatives, the utility planners are primarily concerned with a project's dollar costs in terms of mills per kwh. For the Quesnel project, this unit cost figure is comparatively high. But, considered from a broader, social benefit/cost perspective, this high cost is partially offset by the savings in natural gas consumption that would arise from substitution of cogenerated steam for natural gas in the area's lumber-drying kilns. A further offsetting benefit would be provided by the reduction in waste disposal costs and lessening of environmental impacts now caused by wood waste disposal. These associated benefits are not fully considered by B.C. Hydro because there is no clear institutional mechanism that would compensate the utility for these associated benefits that would be provided by its project. At best, B.C. Hydro would be compensated by the local forest products companies for the natural gas consumption they are saved and for the waste disposal costs saved. But, any payments by those organizations for gas savings would be based only on the domestic gas price, rather than on the export price, which we have argued is the true measure of the marginal value of natural gas.

A second reason that the plant has not been given ongoing consideration is its size. The planned output of 60 Mw is very small relative to other B.C. Hydro alternatives. It, therefore, is not given as high a planning priority as other projects, such as the proposed Hat Creek thermal plant, which would likely entail even higher costs per kwh than the Quesnel plant. This inattention is unfortunate because the small size of the Quesnel plant would be an advantage in some respects. It would be brought on stream with a much shorter lead time than other projects and could be flexibly scheduled to begin generation as demands in the system warrant.

The final reason for a lack of interest in the Quesnel plant can be attributed to attitudes held by personnel within the utility. Surplus wood wastes at Quesnel are viewed as a problem that should be solved by the forest industry and not by B.C. Hydro. Because the fuel supply for the plant depends on industrial output and cannot be specifically delineated in advance, it is considered to be uncertain; therefore, the proposal is not treated as a potentially sound alternative. Instead, B.C. Hydro argues that a more efficient way to generate electricity with wood fuel at Quesnel would be through construction of a cogenerating kraft pulp mill.

4.0 GOVERNMENTAL ENERGY AGENCIES

Through their respective energy ministries, the federal and provincial governments share the responsibility for energy pricing and public energy policy in Canada. There has, of course, been continuing controversy over the precise division of responsibility between the two levels of government on energy matters. Such a controversy indicates the degree to which the objectives of energy agencies are affected by political considerations. In pursuing their objectives within their political context, federal and provincial energy agencies have posed indirect barriers to greater biomass energy use.

112 Interviews with B.C. Hydro representatives indicated that subsequent studies show that the plant will have somewhat higher construction costs on the order of 22 mills per kwh. Nevertheless, if the benefits from replacement of gas with cogenerated steam are valued at the export price of gas, as explained in Chapter II, then the effective cost of electric generation would be roughly 18 mills per kwh. Even at that level, the project would have costs that are roughly comparable to some of the utility's alternatives.

4.1 Federal Energy Issues

Energy, Mines and Resources Canada, the premier federal energy agency, recently released its 1980 *National Energy Program.* In this program, a number of substantial changes in federal energy policy are proposed; some would alter the barriers to biomass energy that have been implicit in previous policies. Two principal features of the 1980 program are planned increases in the domestic price of oil and planned moves to substitute consumption of other energy resources (including renewables) in place of oil.

a) Oil Prices and Industry incentives

Prices

The 1980 program calls for regular increases in the "blended" domestic price of conventional domestic and imported oil. By the end of 1983, the blended price of oil to refiners is planned to be $206.40 per cubic metre ($32.80 per barrel) in nominal terms. Allowing for the effects of inflation, this 1983 price would be roughly equal to $157.50 per cubic metre ($25.00 per barrel) in 1980 terms.[113] Thus, the plan calls for a real price increase of about 35 per cent over the August 1980 blended price of $116.40 per cubic metre ($18.50 per barrel). It is notable that, in real terms, the 1983 blended price would be roughly $88.00 per cubic metre–less than the 1980 *cost* of imported oil, which was about $245.00 per cubic metre in September of that year. While the National Energy Program does spell out increases in Canadian domestic well-head prices through 1990, it does not state the rate at which the cost of imports will be incorporated into the blended price after 1983. This latter figure is a crucial factor in future domestic-blended prices. Thus, no analysis can be made of potential increases after 1983.

The program does not specify planned increases in the overall level of natural gas prices because the price of gas produced and consumed within British Columbia is determined by the province. Nevertheless, the federal program calls for an increase in federal taxes on natural gas, which will amount to $0.27 per hm^3 ($0.75 per mcf) by 1983 in nominal terms (Energy, Mines and Resources [hereafter EMR], 1980a).

Incentives

Aside from prices, the other important issues in the program for oil and gas production are substantial proposed changes in the present system of incentives.

Like many countries, Canada has a number of different incentives designed to encourage exploration for, and development of, petroleum resources. The primary features of the present system are a series of deductions that reduce the income on which firms must pay taxes, notably:

- exploration costs can be written off at a 100 per cent rate–that is, written off completely in the year they occur;
- development expenditures can be written off at a 30 per cent rate; and
- land bonus payments can be written off at a 10 per cent rate.

Moreover, resource firms can deduct a further one third of exploration costs, most development costs, and certain capital equipment costs by virtue of the earned depletion allowance. This latter deduction can only be claimed against resource income. The effect of these allowances is to lessen the cost of investments to the company. **For** a firm able to make full use of the deductions, the after-tax cost of an exploration program is only 37 per cent of the investment undertaken (EMR, 1980a).

The 1980 program calls for major restructuring of this incentives system, with the most dramatic change in the "earned" depletion allowance. The earned allowance would be reduced considerably and, in its place, a "Petroleum Incentives Program" is proposed. A major change is that the size of payments would be related to the percentage of Canadian ownership in the companies. The net effect of these changes would be to change the distribution of

[113] The forecast of inflation rates used to calculate 1980 price equivalents is equal to that assumed by Energy, Mines and Resources in projecting the "oil sands reference price", in the *National Energy Program* (EMR, 1980a), p. 26.

TABLE V-1
EFFECTS OF ENERGY PRICE CHANGES ON THE VIABILITY
OF SELECTED PULP MILL BOILER REPLACEMENT PROJECTS[a]

Power Boiler Fuel	Fuel Price	Basis of Price	% Return On Investment In Hog Fuel Boiler
Residual Oil[b]	\$182/m^3 crude oil (\$29/barrel)	Marginal cost level	30.5
	\$157/m^3 crude oil (\$25/barrel)	National Energy Program	23.0
Natural Gas	\$1.57/hm^3 (\$4.45/mcf)	Marginal cost level	21.5
	\$1.06/hm^3 (\$3.00/mcf)	Possible 1981 price	2.3

Source: McDaniels Research Limited

[a] **Calculated as the percentage return of investment, over a 5-year financial life, averaged for a selected group of representative pulp mills. Results can be compared to Table 11-12. All figures in 1980 dollars. See Appendix I for details.**

[b] **Residual oil prices calculated as 85 per cent of the crude oil price, plus $1 delivery charge.**

incentives between firms but not greatly reduce the aggregate level of incentives offered to the industry.

Constraints

The program of planned increases in blended domestic oil prices would lessen, but not eliminate, barriers to alternative energy imposed by subsidized oil prices. By 1983, the domestic price would, in real terms, still be slightly below the 1980 marginal cost price level estimated in Chapter II; consequently, the barrier of subsidized oil prices would continue at least until then. The effect of this pricing policy on the viability of boiler replacement in pulp mills is shown in Table V-1. Returns from investment in a hog fuel boiler fall by roughly 7.5 per cent if oil is priced at \$157.30 per cubic metre (\$25 per barrel), instead of \$182.50 per cubic metre (\$29 per barrel), as estimated in Chapter II, and residual oil is priced accordingly. The change indicates that boiler replacement is very sensitive to oil prices and suggests that coastal oil-burning mills not yet fully converted to wood wastes would postpone their conversion longer than otherwise.

More important than pulp mill conversion is the effect of the pricing program on the viability of alcohol fuel production from wood biomass. Keeping the domestic oil price relatively low effectively reduces the value of synthetic fuels that could be substituted for petroleum products in transportation. Consequently, the planned domestic oil price reduces the potential viability of alcohol fuel production, compared to the case with marginal cost oil prices.

Equally important, but less obvious, are the economic barriers imposed by incentives to petroleum producers called for in the 1980 program. Incentives of this type effectively lower the private costs of delivering oil and gas to the marketplace by subsidizing the costs associated with exploration and development. While such subsidies may be desirable in order to expand petroleum reserves, they have an adverse effect on alternative energy sources because they lower the private costs of oil and gas consumption borne by consumers. By subsidizing one energy source, other alternatives are made less attractive in the consumers' eyes.

As discussed in the next chapter, the federal government has provided certain incentive programs to foster biomass energy use in Canada. Simple comparisons indicate that the federal incentives associated with biomass are far less (per unit of energy) than the subsidies implicit in the Petroleum Incentives Program and the present oil import compensation scheme.[114]

Subsidies associated with the petroleum industry have significance for biomass energy in British Columbia in the same ways as do oil prices. Since the full cost of oil or gas consumption is reduced, pulp mills have less of an incentive to convert to wood wastes for fuel. Similarly, subsidized oil supplies make the production of alcohol fuels less economically viable as replacements for petroleum products.

b) Biomass Energy Policy

A central theme of the 1980 program is to reduce oil consumption through conservation and reliance on other sources. Renewable sources are identified in the program as one of the chief alternatives with economic promise and, consequently, a much greater role for renewables is envisioned in Canada's future.

Programs

In the 1980 program, an increased financial commitment to biomass and other forms of renewable energy is outlined. Forest biomass energy would receive a specific boost through expansion of the FIRE program, as analyzed in Chapter VI. The 1980 program also establishes a new federal alternative energy corporation that will develop and commercialize renewable and conservation technologies. Other commitments include demonstration programs for solar hot water heating and renewable energy systems for remote locations.

In a sense, the chief commitment offered by the program is simply the government's stated willingness to pursue and support renewable energy options. Nevertheless, the program stops short of a full-scale commitment to set and achieve targets for increased renewable energy use.

Aside from these initiatives, the 1980 program stresses the importance of developing alternatives to gasoline for transportation fuel. The program notes that a high priority will be placed on research into nonoil fuels. It is in this area, as a potential source of fuel alcohol, that wood biomass could make a substantial contribution. However, the 1980 program does not allocate specific research funds nor state priorities for research into alcohol from biomass sources. Moreover, it does not clarify the important issue of federal taxes to be imposed on alternative liquid fuels (such as alcohol); nor are conversion incentives discussed (EMR, 1980a).

Constraints

With the incentives announced in the 1980 plan, a number of programs to foster biomass energy use would be in place. What is still lacking in federal policy is an aggressive commitment to reach specified targets for increased biomass use through programs designed to place biomass on an equal economic and institutional footing with other energy sources. Experience elsewhere indicates that, in order to foster adoption of a new energy technology, active programs must be undertaken to eliminate the economic and institutional barriers that are implicit in the energy status quo.[115] While the current

[114] **A detailed comparison of this type is beyond the scope of this study. Proposed changes in the petroleum incentives and the complexities of corporate tax situations make calculation of the total value of petroleum incentives very complex.**

[115] **For a discussion of the American situation, see Stobaugh and Yergin (1979).**

program does call for substantial federal involvement, it does not go so far as to commit federal initiatives to fully eliminate barriers that retard biomass energy below its economic potential.

A case in point is in the area of liquid fuels. The Intergroup study (1978) has indicated that early development of a forest biomass-based methanol industry would likely be contingent upon federal government policies and leadership in initial years. Some of the chief areas requiring federal leadership are:

- vehicle regulation and testing;
- fuel distribution regulation, pricing, and tax policies;
- federal-provincial resource and industrial development agreements and related tax incentives;
- regulation of interprovincial methanol movements; and

other factors. Of these, the questions of fuel pricing and tax policies are perhaps the chief uncertainty (Intergroup, 1978).

Apparently, the federal government is considering a number of options for new nonoil transport fuels and is, therefore, hesitant to proceed full scale on any one option like methanol (EMR, 1980b). One shortcoming of this cautious approach is that virtually all nonoil fuels will face some of the same problems. It would seem that interest in all nonoil transport fuel alternatives would be furthered by clarification of the federal role and policy in this area.

4.2 Provincial Energy Issues

The principal energy agencies of the British Columbia government are: the Ministry of Energy, Mines and Petroleum Resources, which is the leading agency and focal point of policy; and the recently established British Columbia Utilities Commission, which is responsible for regulation of and pricing by public utilities. Out of them come recommendations on energy issues that serve as input to key decisions made by the provincial cabinet. Policies of the provincial government regarding natural gas prices, electrical prices, and the role of bioenergy have constrained the adoption of wood energy reliance in British Columbia.

a) Natural Gas Prices

The province has responsibility for setting domestic natural gas prices. In recent years, it has chosen to subsidize domestic consumers of natural gas by keeping wholesale prices steady, despite increases in well-head prices. A recent provincial policy statement estimated the 1980 domestic subsidy to be \$0.24 per hm^3 or roughly \$100 million yearly, which is made up from gas export revenues (MEMPR, 1980c). The effects of such a subsidy are to:

- increase natural gas consumption levels;
- make natural gas a more attractive fuel, compared to alternatives; and, thus,
- forestall conversion to other fuels, such as wood wastes.

As detailed in Chapter II, Interior pulp mills and sawmills have shown relatively less interest in wood energy conversion than would occur with higher prices. Moreover, since the potential for cogeneration depends on switching to wood waste boilers, the low gas prices have indirectly provided barriers to that application.

As a result of hearings underway by the Utilities Commission, the domestic price of natural gas is likely to increase in 1981. We have discussed, elsewhere in this chapter, the viewpoints of groups–such as the Council of Forest Industries and the Natural Gas Carriers–regarding future prices. Briefly, these groups would prefer the domestic price to remain low in order to minimize the financial burdens that, they feel, would result from higher gas prices and the resultant conversions to wood fuel by mills. The Council of Forest Industries' (1980) submission clearly demonstrates the disincentive that low gas prices present for conversion to hog fuel in pulp mills.

Even if the current subsidy to domestic users is eliminated, the domestic price could stay well below the marginal cost level. The Council of Forest Industries (1980) suggests that, depending on many variables, future domestic industrial prices could range from about \$0.85 to \$1.27 per hm^3 (\$2.40 to \$3.60 per mcf) in July 1981. We will employ \$1.17 per hm^3 as a representative 1981 level, which converts to about \$1.06 (\$3.00 per mcf) in 1980 terms. The effects of this price on the viability of pulp mill boiler replacement are illustrated in Table V-1. The estimated average returns on investment fall dramatically to only about 2 per cent for the selected pulp mill projects. This result indicates that boiler conversion is highly affected by natural gas prices; at $1.06 per hm^3, conversion would likely be uneconomical for most mills.

The motivations for setting domestic gas prices below the marginal cost level are largely related to the government's political objectives. A provincial policy statement indicates the province's desire to adjust prices to reflect "long-term replacement costs and the value of the resource". However, the document notes that it, must balance the economically desirable effects of higher prices against the impacts on consumer costs (MEMPR, 1980b). In other words, a desire to avoid adverse reactions by consumers may be a compelling reason to keep prices low in the short term.

b) Electricity Prices **and** Utility Regulation

Under recent legislation, the Utilities Commission has responsibility for approving electrical rates, as well as other aspects of utility operation. Therefore, in the future, the Commission has the opportunity to fully eliminate constraints to cogeneration that result from electrical pricing. Whether the Commission pursues this objective will likely depend upon direction from the provincial government.

Aside from pricing, another barrier to cogeneration may be provided by utility regulation. Under the Utilities Commission Act, a corporation that supplies more than 15 per cent of its self-generated electric power to other consumers is subject to regulation as a utility. This rule greatly increases the regulatory problems and possibly the costs of a large cogenerating facility, while also reducing its flexibility. The Act does contain sections that would allow a cogeneration facility to apply for an exemption from the legislation. Nevertheless, the existence of this rule and the need to apply for exemption is an added uncertainty that makes cogeneration less attractive (MEMPR, 1980d).

c) Biomass Energy Policy

In its recent energy policy statements, the province has indicated support for wood waste energy conversion. It specifically mentions the potential of wood energy for steam and cogeneration in pulp mills, as well as for thermal electric generation and liquid fuels (MEMPR, 1980b). Unfortunately, the province has made no apparent attempt to coordinate its policy and eliminate constraints so that biomass energy can grow to its full economic potential. For example, the province has subsidized domestic natural gas prices while, at the same time, encouraging greater use of wood energy in the forest sector. The Council of Forest Industries has responded that these policies are in conflict, since the low gas prices inhibit conversion to wood fuel (COFI, 1980). A second example is the lack of clarification on tax regimes for synthetic transportation fuels. In contrast, the province of Manitoba has waived its road tax on gasohol blend fuels–a move that has spurred development of an ethanol plant and gasohol marketing in that province. Other examples are: a lack of clarification on stumpage charges for wood energy; a lack of priorities for regional wood waste uses; and a lack of analysis of the role of cogeneration in regional electric supply.[116] In sum, the province's lack of a coordinated role in fostering wood energy use means that existing constraints are perpetuated.

5.0 THE MINISTRY OF FORESTS

Commercial use of British Columbia's forests is administered through the Ministry of Forests' resource management system, as summarized in Chapter **III.** Briefly, the Ministry's objectives in forestry management are:[117]

- to obtain the full potential contribution of the forests to public well-being;
- to plan and integrate forest uses;
- to encourage a vigorous and efficient forest industry; and

[116] ***Canadian Renewable Energy News,*** **"Experts not enthused by B.C.'s renewable energy plans,"** Vol. **3,** No. **2, April 1980, p. 3.**

[117] **Adapted from Ministry of** Forests **Act, British Columbia (1978).**

to assert the financial interest of the Crown in its forest resources.

In administering forest uses to achieve these ends, the Ministry could have great influence on the supply of forest biomass available for energy applications and, consequently, could pose constraints. Discussed first are potential constraints inherent in current management practices and, then, constraints that could arise in future policy choices.

5.1 Current Administrative Practices

Overall, the current system of forest administration poses little obstacle to a dependable supply of wood wastes for energy purposes. Indeed, some aspects of the system actually provide incentives to greater wood waste supply. For example, the sustainable yield policy mandates relatively steady harvests, meaning that the flow of residuals available for energy use is more even than would be the case under some alternative cutting policies. Similarly, the close utilization policy mandates that material of a given minimum size must be removed from the forest, which increases the volume of mill wastes available. Nevertheless, certain aspects of the current system have been shown to remove the economic incentive to recover the full margin of timber, which makes recovery of low-quality material for energy more difficult.

The province employs a stumpage appraisal system (which includes timber scaling) to determine the volume harvested. First, an appraisal is conducted on the basis of a timber cruise to determine the average stumpage or price per cubic metre for a given stand of timber. Then, the actual harvest is scaled to determine the amount removed. In his Royal Commission report, Pearse (1976) argued that stumpage charges, based on a timber scale, eliminate the economic incentive to remove marginal-quality timber, since the forest industry operator is charged the average price for all logs harvested, including those that will yield a below-average return. Consequently, the operator would find it more profitable to take a smaller harvest and leave behind material of below-average quality. He will not voluntarily recover a log that is just worth the logging cost because to the latter must be added the average stumpage charge for the stand.

The measured volume of harvest is also used for cut-control purposes. Therein lies a second obstacle for removal of low-quality material. On the basis of an inventory, the Ministry allocates the rights to quantities of annual cut to operators within a given working area. The actual harvest of each operator is scaled and the amount recorded in the operator's "cut-control account" to ensure that the actual harvest is close to the allocated amount. Over a 5-year period, each operator must remove an amount of timber within **10** per cent of its accumulated 5-year cut allocation. The problem is that each log recovered is also scaled, including low-quality material that falls below the close utilization standards. The operator is, in a sense, penalized for recovering material below the prescribed standards because that material is recorded in the cut-control account and is counted toward the cut allocated to the operator. Recovery of a low-quality log could, therefore, preclude the recovery of a better-quality log later in the cutting period.

It should be recognized that neither of these effects has likely had a significant effect on the amount of wood recovered from the forest. The province's close utilization standards prescribe the minimum quality of wood to be recovered and counteract these implicit incentives to leave behind lower-quality material. Moreover, many observers believe that the prescribed standards generally result in too much harvest, rather than too little. The point is that the level of harvest is dictated by regulation, rather than by economic incentive. As a result, the flexibility to respond to changing market conditions (such as increasing value for wood energy) is eliminated.

The future could well see the need for greater flexibility, if rising energy values for residues expand the margin of harvest even beyond the prescribed utilization standards. In that event, the disincentive effects of scale-based stumpage and cut control would become undesirable barriers. Policy changes may, therefore, be necessary; the major alternatives are discussed in the following section.

5.2 Future Policy Issues

More important than current administrative practices are the future policy issues associated with biomass energy that may confront the Ministry. This emphasis on future issues reflects the fact that competition for biomass supplies and widespread utilization of bioenergy has not yet developed in the province. Attitudes, held within the Ministry regarding use of wood for energy, may have a major influence on these future policy decisions.

a) Scale-Based Stumpage

The Ministry has two choices to eliminate the apparent disincentive to extract the full margin of timber that is inherent in a scale-based stumpage system. One way would be to adopt a stumpage system based solely on the timber cruise. Under this approach, the value of the stand would be determined solely on the basis of cruise data and a company would pay a specified sum to log an area, no matter how much material is extracted.

This approach was given support in Pearse's Royal Commission report of 1976. The Commissioner advocated this method because:

> . . . under this system, the stumpage payable is independent of the volume actually harvested, so the licensee has a strong financial incentive to recover every piece that is worth as much as, or more than, the incremental cost of recovering it (Pearse, 1976).

According to the Commissioner, the U.S. Bureau of Land Management, which administers federal lands in the Northwest States, uses this method and finds it unnecessary to enforce utilization standards or regulate waste.

One would expect more flexible harvests and likely less waste with this system. An early U.S. study found that logging residues were more than two-thirds greater on lands where stumpage was charged on timber removed, than on lands where stumpage has been assessed on the standing timber (Howard, 1971). However, a more recent study indicates that other factors (such as stand age and topography) are at least as important as the form of the stumpage charges in determining the amount of logging residues left at a site (Hamilton et al., 1975).

According to interviews, there is some degree of interest within the Ministry in moving to a cruise-based stumpage system. In fact, the Ministry now permits this method to be used as an alternative to scale-based stumpage, if the forest operators desire. As yet, few companies have taken this option. Two likely obstacles to the cruise-based alternative are: the companies are more familiar with the scale-based system and so prefer its predictability; and the timing of required payments is uncertain under the new alternative (Ministry of Forests, pers. comm.).

A second possible way to eliminate disincentives in the scale-based system would be to make changes in scaling procedures. For this system to work effectively, judgement by technicians would be required to identify marginal material and exclude it from the scale.

Either of these changes to the present stumpage system would allow companies to respond to changing market conditions and adjust their margin of harvest.

b) Cut-Control Accounts

The same two alternatives are available to the Ministry if it wishes to eliminate the disincentives posed by current cut-control accounting procedures. Either cruise-based timber accounting or changes in the current scaling procedures to omit marginal and submarginal material could be employed. Again, the Ministry should recognize that, unless policy moves are made in this area, the future recovery of low-grade material will be constrained.

c) Stumpage Charges Incorporating Energy Values

Chapter III outlined the concepts behind and practices of the stumpage system and discussed how the values associated with energy uses could eventually be included in the system. It was indicated in the Royal Commissioner's view that no stumpage be levied on energy residues for a period of years to stimulate better utilization (Pearse, 1976). The Ministry should, however, consider that this policy implies a temporary subsidy at some point in the processing chain. For example, if sawmills pay nothing for the fuel value of their timber residues and yet charge freely determined prices for hog fuel, they receive an implicit subsidy. The Ministry should also recognize that a decision to incorporate the energy value of residuals into stumpage charges would directly affect the economic viability of wood energy conversion projects. Policy moves in this area should, consequently, be made carefully. Our recommendations on this subject are discussed in Chapter VI.

d) Regional Markets

In Chapter III, it was stressed that, where possible, regional markets for biomass supply should be developed. The Ministry would be the obvious organization to encourage these markets, particularly since the Minister of Forests has the option to "direct" residues from sawmills to a particular pulp mill if he chooses. Judging from recent changes in chip distribution, the Ministry is attempting to increase the reliance on market forces to price and allocate residues. For example, the province no longer sets minimum prices for chips; instead, it lets competition determine prices. Given this tendency in the Ministry's policy, it would likely favor the development of regional markets for energy biomass and, therefore, not pose constraints in this regard.

e) Attitudes Within the Ministry

A key factor in the Ministry's future policy toward biomass energy will be attitudes held by individuals within the organization. At one extreme, attitudes could be very positive, if managers recognize that there are potential benefits such as the incentive to fuller harvests and a reduction in adverse environmental impacts. Favorable attitudes would likely mean that barriers to biomass energy, implicit in the Ministry's policies, would be eliminated and that energy would be supported as an appropriate use of residues.

On the other hand, attitudes could be negative if energy use is viewed as a competitor of conventional forest products for fibre. Negative attitudes could mean that the Ministry would be slow to adjust its practices to encourage biomass energy, and would oppose bioenergy projects within provincial planning forums.

However, the real issue is whether use of wood for energy is seen to fit in with the management objectives of the Ministry. In that regard, the only question is whether use of wood for energy could somehow preclude a higher-valued application of the fibre in pulp or composite products. Earlier, in Chapters II and III, we attempted to show that this type of competition would not be harmful to the traditional forest industry and would, instead, have beneficial effects in terms of resource allocation. Following that reasoning, one would expect attitudes within the Ministry to be positive and, therefore, to encourage use of wood biomass for energy.

6.0 OTHER SOURCES **OF** CONSTRAINTS

In this final section, we briefly mention broader constraints associated with problems that are intrinsic to biomass energy. Although not necessarily the result of institutional behavior, these factors are of interest because they relate to alternative incentive schemes discussed in the following chapter.

6.1 Transport **of** Biomass and Fuel Taxes

Comparatively high transport costs for biomass fuels are one of the chief obstacles to greater utilization. The bulky nature of biomass material means that supply costs to mills are increased and the viability of inter-regional movement of fuels is reduced. For example, little, if any, hog fuel is moved from the Interior to Coastal British Columbia, even though shortages are expected on the Coast.

Truck, barge, and, occasionally, rail modes are used for hog fuel transport. Barge costs are lowest; therefore, barge is the preferred coastal mode. In the Interior, truck transport is prevalent. Based on the relative energy requirements, one U.S. study estimated the economic distances—that wood fuels could be transported—to be: 50 to 100 miles by truck; 100 to 200 miles by rail; and 300 to 400 miles by barge (Tillman, 1978).

In the British Columbia Interior, truck transport is prevalent. One of the components of trucking costs is the cost of fuel; in Chapter II, this proportion was estimated at 20 per cent of total costs. Fuel costs are, in turn, influenced by the cost of oil supplies, as well as by federal manufacturing taxes and provincial fuel taxes. It could be argued that, when governments collect revenues on the basis of fuel taxes, they place relatively higher barriers to transport of materials with high weight/value ratios (like biomass). In the United States, where road taxes are directly implemented on a weight-mile basis, the barriers are even greater (Doubleday, 1976).

6.2 Provincial Property Taxes

If a pulp mill installs a hog fuel boiler or a turbogenerator, the increase in value of its capital equipment would create an increase in property taxes. According to the Council of Forest Industries, this added tax cost could make up roughly 50 per cent of the incremental operating costs associated with a hog fuel boiler and, consequently, reduce the viability of conversion (COFI, 1980).

It is notable that, under some circumstances, a new hog fuel boiler may be partially exempt from municipal property taxes; that is because pollution control equipment is specifically exempt from property tax. The costs of technologies installed to reduce emissions (such as precipitators or fabric filters) would, therefore, not be subject to taxation. Moreover, the Ministry of Finance has, on occasion, granted a partial exemption on assessments to a firm for the value of the hog fuel boiler itself. This exemption has been granted when the returns from investment in the boiler are low, indicating that the project was undertaken for the purpose of waste disposal, as well as to save fossil fuel costs (Ministry of Finance, pers. comm.). Thus, the negative influence of property taxes on the viability of boiler conversion has been reduced for certain projects.

7.0 CONCLUSIONS

We conclude this lengthy and diverse chapter with three summary perspectives–a topical review of constraints, a comparative financial analysis of selected constraints, and a discussion of distributional effects.

7.1 Review of Chief Constraints

To recap the salient points of this chapter, key constraints to greater biomass energy use are noted below, by topic.

a) Constraints Affecting Biomass Supply

- High transport costs for biomass.
- Ministry of Forests' scale-based stumpage.
- Ministry of Forests' scale-based cut-control accounts.
- Desire for security of biomass supply by users.
- Lack of regional biomass markets.

b) Constraints Affecting Thermal Applications in the Forest Industry

- Subsidized oil and natural gas prices.
- Incentives that lower the private cost of oil and natural gas supplies.
- Lack of coordinated provincial policy regarding natural gas prices and wood energy use.
- Political actions by the forest industry and natural gas utilities to forestall large price increases in natural gas.
- Forest industry investment criteria.
- Avoidance of uncertainty by the forest industry.
- Relatively high capital costs of new installations.
- Effects of new installations on property taxes.
- Expansion of the natural gas distribution system to Vancouver Island.

c) Constraints Affecting Cogeneration by the Forest Industry

- B.C. Hydro's approach to cogeneration, relative to its other alternatives.
- B.C. Hydro's pricing structure.
- Forest industry investment criteria.
- Lack of diversification by the forest industry.
- Subsidized natural gas prices.

d) Constraints Affecting Thermal Electric Generation

- B.C. Hydro's planning process, relative to its other alternatives.
- Lack of institutional arrangement to compensate B.C. Hydro for the associated benefits of cogeneration.

e) Constraints Affecting Bioconversion to Alcohol Fuels

- Subsidized oil prices.
- Lack of diversification by the forest industry.
- Lack of diversification by the oil industry.
- Private industry investment criteria.
- Attention to other alternatives by the oil industry.
- Lack of lead role or articulated tax policy by the federal government.
- Lack of articulated tax or resource policy by the provincial government.

7.2 Comparative Analysis of Selected Constraints

A number of constraints have been identified as affecting the financial viability of wood energy

TABLE V-2
SENSITIVITY OF RETURNS ON INVESTMENT IN
HOG FUEL BOILERS TO CHANGES IN COST AND REVENUE PARAMETERS[a]

Parameter	Change	Average Effect on Rates of Return for Selected Projects
Oil and Gas Prices	20% increase	**+10.2%**
Capital Costs	20% decrease	+9.8%
Hog Fuel Costs	20% decrease	**+1.4%**

Source: McDaniels Research Limited

[a] **Figures show change in rates** of **return for a selected group of conversion projects, compared to the base case** of **Table V-1. See Appendix I for details.**

applications. In this section, we analyze the relative financial importance of three constraints (energy prices, capital costs, and fuel costs) that influence the returns from hog fuel boiler installations in pulp mills. The results for hog fuel boilers can be assumed to represent the situation for other thermal applications of wood energy in the forest industry.

The analysis starts from the situation shown earlier in Table V-1, using the assumed domestic natural gas price of $1.06 per hm^3 ($3.00 per mcf) and the assumed oil price of $157 per cubic metre ($25 per barrel) in 1980. We can demonstrate the relative importance of energy prices, capital costs, and hog fuel costs by charging each of these parameters a set percentage and then observing the effects on the returns from investment.

Results of these calculations are shown in Table V-2. It indicates that a **20** per cent increase in energy prices (above the levels in Table V-1) would increase returns on investment by an average 10.2 per cent over a 5-year financial life. In comparison, *reducing* the capital costs by 20 per cent increases the return on investment by roughly 9.8 per cent. A 20 per cent drop in fuel costs increases returns by less than 2 per cent. It can be seen that, in this range of prices, changes in fossil fuel prices and capital costs have roughly equivalent effects on returns from investment in boiler replacement. Changes in hog fuel costs have a very small effect on returns from investment.

7.3 **Distribution** Effects

When considering institutional behavior, it is useful to clarify which groups would gain and which would lose from greater use of forest energy in British Columbia. Such an analysis indicates the potential source of opposition to this change in energy patterns.

a) Gainers

First, we identify the potential winners. The only groups to unequivocally gain from greater biomass use would be the public at large and the sawmilling and logging sectors. Public gains would be achieved in three ways:

- reduced consumption of oil and gas;
- reduction in adverse environmental impacts from wood waste disposal; and
- positive regional economic effects.

Of these three, the savings in oil and gas consumption would be the most significant. The drain of public tax dollars to subsidize oil imports would be reduced, and the consumption of depletable natural gas for industrial thermal needs would lessen.

The sawmill sector would benefit from a new diversified output that augments revenues and from a savings in disposal costs now required for wood wastes. The logging sector would benefit from an expansion in the margin of economic harvest.

b) Losers

Organizations that would be disadvantaged by greater wood energy use are more cohesive and vocal than gainers. Potential losers include the gas-burning pulp mills that would face higher energy costs compared to current subsidized levels. The gas distribution companies would also be disadvantaged by greater biomass energy use, since they could face reduced sales and falling revenues, at least in the short term.

c) Mixed Effects

A large group of influential organizations would experience mixed effects from biomass energy–with gains from some perspectives and losses from others. The provincial government is a prime example. It would benefit from greater biomass energy use through reduced natural gas consumption and reduced conventional electric generation in the province; yet, to accomplish these benefits, the province would be required to raise natural gas prices substantially, which is a politically unpopular move. Thus, the associated long-term benefits of greater wood energy use may not compensate for the difficulties of substantial domestic price increases in the near term.

The federal government would also experience mixed results from greater biomass energy use. The oil price increases would make alcohol fuel production more attractive, minimize oil consumption by pulp mills, and be politically unpopular in large parts of the country.

B.C. Hydro, similarly, falls into the group experiencing mixed effects. Greater cogeneration and a wood-fueled thermal plant would ease some of the problems in meeting uncertain load growth in the coming decade and would postpone expensive new projects. Yet, from the utility's perspective, these projects are small, difficult to plan, and outside its control.

Finally, the Ministry of Forests falls into the group of institutions experiencing mixed results. Greater use of wood energy would increase utilization, increase forest industry employment, and reduce forest residues–all positive effects from the Ministry's perspective. Yet, the Ministry is concerned that use of wood wastes for energy could preclude manufacturing uses of fibre by the forest industry.

d) **Conclusion**

In sum, we observe that the chief group to benefit from wood energy, the public at large, is highly disaggregated and not directly involved in the economic decisions regarding biomass uses. The groups to be disadvantaged are well organized and vocal in their opposition to higher natural gas prices. The groups that perceive themselves to experience positive and negative results are, in some cases, subject to political factors and may find it more expedient to maintain stability than to undertake changes.

The clear implication is that an active program to reduce constraints will be required, with major initiatives by the federal and provincial governments. Recommendations for this program are the concern of the final chapter.

CHAPTER VI

INCENTIVES AND RECOMMENDATIONS

1.0 INTRODUCTION

This chapter presumes (without discussion) an objective to encourage forest biomass energy toward its full economically feasible potential. To that end, we recommend a range of incentives and other measures for dealing with various aspects of the wood energy question.

Our basic preference is to rely on the market system to make decisions regarding biomass energy. Under competitive conditions, market activity would be the most efficient means to determine the economic role for a new energy source. But, the preceding chapter indicates there are significant institutional barriers that restrict the smooth functioning of the energy marketplace. The most formidable barriers are associated with conventional energy prices. At present, the energy price structure is heavily distorted in favor of conventional resources such as oil and gas; their prices are too low, and their producers are heavily subsidized through the tax system.

If the market is to make proper energy choices, its distortions must be corrected so that biomass can compete with conventional sources on an equal footing. We provide nine recommendations to redress this distortion; the first three deal with pricing of conventional energy resources, while the next six suggest alternative incentives to encourage biomass energy development.

Aside from energy prices, the previous chapter outlined a variety of other causes of "market failure" that constrain the development of biomass energy below its economic potential. These barriers are, in large measure, due to the uneven distribution of benefits from biomass energy, lack of a public perspective in private energy decisions, and current administrative practices. Recommendations 10 through **18** deal with these issues.

2.0 ENERGY PRICE RECOMMENDATIONS

The most direct and economically efficient way to give biomass energy an equal economic opportunity in the marketplace is to raise the prices of conventional energy sources. In the parlance of the economist, this move would bring the private costs of energy alternatives more in line with social costs, thereby encouraging efficiency in fuel choice, consumption, and production. A readjustment of energy prices would foster a greater reliance on forest biomass, as well as other nonconventional sources, not because these resources are innately superior but because they make sound economic sense at the current margin of energy costs.

Recommending price increases for conventional energy sources is not a novel approach in Canadian energy policy debates. Many different organizations, including the Economic Council of Canada (1980), have made similar recommendations for different purposes. The focus in this report is on eliminating the obstacles to wood energy use in an efficient manner, rather than on the broader political and economic issues associated with energy price increases. However, it is recognized that there is a range of considerations, aside from economic efficiency, that influence energy pricing policies. For example, the distributional effects of price increases on socio-economic groups and effects on industrial development have a major influence on these decisions. It is also recognized that recommendations that provide a politically acceptable approach to energy pricing are more useful than an unworkable, yet economically optimum approach. Therefore, the next section provides possible incentives to wood energy development that could be considered in lieu of full price increases to marginal cost levels.

Recommendation **1:**

> **The** federal government should recognize the desirability of rapid increases in domestic oil prices to levels that reflect the marginal costs of new supplies.

In terms of biomass energy, the effects of this move would be to speed the conversion of the remaining oil-burning pulp mills to wood fuels and to encourage development of alcohol fuels from biomass. The rate at which prices are increased could follow that recommended by the Economic Council.

Recommendation **2:**

> The provincial government should recognize the desirability of increasing natural gas prices to levels that reflect the marginal opportunity costs of this resource.

The constraints associated with low gas prices have been amply demonstrated. If price increases are implemented, the effect on biomass energy would be to greatly speed conversion of Interior pulp mills and sawmills to wood fuels.

Recommendation **3:**

> The provincial government should recognize the desirability of B.C. Hydro charging its customers prices that reflect the full marginal costs of new generation projects. **It** should also consider the advantages **of** paying cogenerators for surplus power on the basis of the generation and transmission costs that are avoided. Finally, **it** should consider establishing consistent rates for standby power sales that reflect the marginal generation costs.

This recommendation has three parts; all are concerned with incentives to cogeneration in the electric energy rate structure. By charging marginal cost prices to its customers, the utility would foster a substantial increase in cogeneration by pulp mills. Another result of this policy would be to produce a major increase in the utility's profits, since marginal cost prices would considerably exceed average costs. One writer, discussing the beneficial effects of price increases for conservation, noted these profits could be used to decrease provincial taxes (Swain, 1980).

By also paying cogenerators a consistent price for surplus power on the basis of avoided cost, the full economic incentive for cogeneration would be provided. This approach to pricing cogenerated power would parallel that adopted by the U.S. Federal Energy Regulatory Commission. In 1980, the US. agency implemented regulations that require electric utilities to purchase electric energy and capacity made available by cogenerators and small producers "at a rate reflecting the cost that the purchasing utility can avoid as a result of obtaining energy and capacity from these sources" (U.S. Federal Register, 1980). There has apparently been some disagreement in the U.S. over what the term "avoided cost" entails, since that cost is influenced by the degree of reliability in the cogenerating source, as well as other factors. **It** is recommended that a broad interpretation be given to "avoided cost" *for* cogenerators in British Columbia so as to provide the full economic incentive for cogeneration.

Finally, it is also recommended that standby charges for temporary sale of power to cogenerators be made consistent and based on the conventional rate structure, rather than on the basis of opportunity costs of foregone power exports. Again, this recommendation agrees with the U.S. Federal Energy Regulatory Commission rules. The U.S. agency requires that electric utilities "must furnish electric energy to qualifying (cogeneration) facilities on a nondiscriminatory basis and at a rate that is just and reasonable and in the public interest" (U.S. Federal Register, 1980).

In Recommendation 11, another possible approach to pricing and operation of cogeneration facilities is discussed.

3.0 RECOMMENDATIONS FOR INCENTIVES

When should governments provide financial incentives to private industry? Broadly speaking, subsidies are rational when employed to encourage private activities that meet social objectives such as economic efficiency, regional development, or energy self-reliance. Subsidies are needed when the desired objectives would not be achieved if left solely to private initiative. In other words, incentives are warranted when used to induce activities that provide overall net social benefits. Normally, this is accomplished by making private benefits more closely agree with the social benefits of a particular undertaking.

Within this general context, there are three distinct conditions under which financial incentives to encourage forest biomass energy are justified.

(a) If the prices of conventional fuels remain below marginal cost levels:

Assuming that prices of conventional energy sources remain below marginal cost levels, financial incentives to encourage biomass energy would be in order. This conclusion is consistent with the so-called theory of the second-best, which holds that, when prices *of* some products are held below free-market levels, it may be economically efficient to hold the prices of competing products below their free-market levels.[118]

(b) If the costs of conventional energy sources are subsidized:

We have established that the oil and gas industry's costs of supply are heavily subsidized through the tax system; therefore, subsidies of equal magnitude are in order–for competing energy sources (such as biomass or solar energy) and for energy conservation.[119]

(c) If there are social benefits associated with biomass energy that are not reflected in the price of energy outputs:

These nonpriced benefits could include: the employment and regional development that would accompany biomass energy reliance; the security provided by domestic renewable energy sources; and the generally positive environmental impacts of waste use or other factors. Benefits of these types, which are not fully registered in market prices, are termed "positive externalities".

It seems certain that at least one, and possibly all, of these conditions will persist in coming years. Consequently, financial incentives for biomass energy are in order.

The following recommendations outline a number of incentives that could be used singly or in combination. Note that we do not recommend the absolute level of overall subsidy that is warranted for biomass energy. To make that calculation, we would need to specify, in dollar terms, three key factors:

(a) to what degree energy prices may remain below marginal cost levels;

(b) the level of subsidies received by the conventional energy industry; and

(c) the social values for the positive externalities provided by biomass energy.

These factors would be extremely difficult to quantify. For example, no research has been published in Canada regarding the overall level of subsidies provided to energy sectors. A study of this type has been produced in the United States and it has proven useful in energy incentive planning in that country (Battelle, 1978).

Based only on casual comparison with conventional energy sources, we believe that substantial subsidies are justified for biomass energy. This observation is based on the large incentive programs available for conventional energy industries and on the positive externalities associated with forest energy use. If conventional energy prices remain below marginal cost levels, even greater subsidies would be warranted.

Another issue not considered here is the distributional implications of the various subsidy proposals. For example, in one recommendation, it is suggested that municipal property tax exemptions could be considered to stimulate boiler conversion. That particular measure would see local municipalities foregoing tax revenues in order to benefit the public at large through natural gas savings.

Both the absolute level of incentives and the distributional issues associated with different measures should be analyzed in greater detail than is possible in this report.

Recommendation 4:

The federal government should consider expanding its existing financial incentives for biomass energy.

The federal government has two important financial incentives already in place–the Forest Industry Renewable Energy (FIRE) program and the tax advantage of rapid depreciation allowed on wood

118 See Rees (1968) and Baumol and Bradford (1970). This perspective and the citations were derived from Stolbaugh and Yergin (1979).

119 J.F. Helliwell (1980) has argued that, "Whatever accelerated depletion provisions are available for investment in exploration and development for oil and gas should be available for investment in any form of energy conservation."

TABLE VI-I
EFFECTS OF VARIOUS INCENTIVE MEASURES ON
RATES OF RETURN FOR INVESTMENT IN PULP MILL BOILER REPLACEMENT[a]

Incentive	Increase in Percentage Rate of Return For Selected Projects
(a) 20% capital cost grant–taxable	+ 3.4%
(b) 20% capital cost grant–nontaxable	+11.7%
(c) 40% capital cost grant–nontaxable	+30.3%
(d) 100% one-year depreciation on capital expenditure	+ 8.5%
(e) property tax exemption for wood energy equipment	+ 1.1%

Source: McDaniels Research Limited

[a] **Expressed as the increase in percentage returns on investment over a 5-year final life, averaged for a selected group of boiler replacement projects. The increases are relative to the base case considered in Table 11-12. See Appendix I for details,**

energy conversion systems. Both of these incentives are aimed at encouraging greater biomass energy use within the forest industry. There are also related incentives available through the Biomass Energy Loan Guarantee program (BELG) and the general 10 per cent investment tax credit.

At present, the FIRE program provides capital cost sharing for wood energy projects, up to 20 per cent of allowable costs, to encourage substitution of mill and forest residues for purchased energy in the forest industry. When applying, a firm considering a biomass energy conversion project provides financial information about its plans. The program committee evaluates this data and awards a grant, if rates of return for the project are neither too high nor too low and the project meets other criteria. The grant is taxable as income and also lowers the depreciable capital cost of the project (EMR, 1979).

Table VI-I summarizes the effects of the FIRE program on returns on investment for selected boiler replacement projects in British Columbia. Also shown are the effects of making the 20 per cent grant nontaxable and increasing a nontaxable grant to 40 per cent of capital costs. It can be seen that taxable grants of 20 per cent increase the return on investment to a modest degree (by roughly 3 per cent), while nontaxable grants of 20 or 40 per cent increase the return on investment dramatically.

The second major incentive in place is the favorable capital cost depreciation rate allowed under the federal Income Tax Act. Assets falling into Class 34–wood energy conversion systems–are depreciated at a rate of 50 per cent per year by the straight-line method. According to the Council of Forest Industries (1980), "This accelerated depreciation aids considerably in justifying a pulp mill boiler conversion."

This depreciation rate was employed in the calculations of Chapter II, dealing with returns from investment in hog fuel boilers and tubogenerators. Without the accelerated depreciation rate, the returns shown in Tables 11-12 and II-13 would be considerably reduced. The effects of increasing this incentive to a

100 per cent depreciation rate over 1 year are seen in Table VI-I; it increases rates of return by an average 8.5 per cent.

Two other types of incentive programs have been considered to encourage wood energy use in the United States forest industry (Mitre Corp, 1978). We shall briefly discuss their possible application in Canada.

One method is a special investment tax credit, based on a percentage of the capital costs of a conversion project. This credit would be similar to and in addition to the existing general investment tax credit. In terms of public costs, it would roughly equal the FIRE program (if those grants were non-taxable) for a given level of capital cost assistance. The disadvantage of an investment tax credit is that the company must have sufficient taxable income in that year to receive the benefit of the credit; the firm must also raise, on its own, all of the needed capital for the project.

A second incentive proposed in the United States is an early retirement tax credit. This credit is specifically designed to encourage early retirement of existing gas- or oil-fired facilities. Under this incentive, the remaining capital value of a boiler would be allowed as a tax credit in the year in which the boiler retired. "Remaining capital value" is, in this case, defined as the present value of the difference between continued use of the present facility and the next best alternative (Gsellman, 1974). While this credit would be a powerful incentive if fully implemented, it would involve problems. First, the "remaining capital value" would have to be calculated, which is far more complicated than simply calculating the capital costs of conversion. Second, the previously mentioned difficulties of tax credits would still apply. This method does have the advantage of theoretically being the most efficient means of encouraging conversion at a minimum level of subsidy.

Considering all factors, we believe the FIRE program to be more appropriate in Canada than either of the latter two alternatives—it applies to new facilities, as well as to replacement of existing ones; it is a capital grant rather than a tax credit; and it appears to be readily administered. We strongly suspect that further incentives for conversion to wood fuels in the forest industry are justified. In that case, making the FIRE grant non-taxable and increasing the level of cost sharing would be effective measures. It is also suggested that when evaluating applications for FIRE grants, the program committee should consider not only the private value of fossil fuel savings but also the social value. In other words, the marginal cost prices of oil and natural gas should be considered as one measure of the fuel saved. It could be that some projects are not accepted for FIRE grants because their returns are low when based on private fuel prices, even though the benefits of conversion would justify a grant, from the public's viewpoint.

The other existing incentives could also be increased. Increasing the depreciation on wood energy assets to 100 per cent over 1 year would have a positive effect.

Recommendation **5:**

> The provincial government should consider granting property tax exemptions for biomass energy conversion equipment.

By adjusting its assessment 'methods, the province could exempt wood energy conversion investments from property tax increases. The effects of such an exemption are indicated in Table VI-I; it shows that an exemption would cause an approximate 1 per cent increase in return on investment for a selected group of conversion projects.

This incentive is clearly much less effective than a change in the prices of conventional fuels or a capital cost grant. It would, nevertheless, be welcomed by the forest industry, particularly since a similar exemption is available for pollution control equipment in British Columbia. Exemptions or credits on property taxes for solar energy equipment are employed as an incentive in 27 American States (Solar Energy Research Institute, 1980b).

Recommendation ***6:***

> The provincial government should consider reducing taxes on fuel used in transporting wood wastes.

Provincial fuel taxes make up roughly 20 per cent of the wholesale price of diesel fuel. If these taxes were removed, the total cost of truck transport for wood wastes could be reduced by roughly **4** per cent.[120] While this is not a major incentive, it would extend the margin that wood fuels can be economically carried. At present, farmers in British Columbia receive a similar type of exemption on fuel used in their work activities.

Recommendation **7:**

> The federal and provincial governments should consider incentives to encourage alcohol fuel production from wood and other biomass materials. Incentives considered should include reduced taxes on synthetic fuels and capital cost grants.

The most direct incentive available to the provincial government would be to exempt gasohol blends from provincial fuel taxes. At present, this incentive would amount to 3.74 cents per litre. One province, Manitoba, has granted this exemption, and as a result, it is the site of Canada's first fuel alcohol plant.[121] Judging from industry publications, no other province has implemented this incentive. In the United States, some 23 states have granted tax exemptions to alcohol blends (Solar Energy Research Institute, 1980b).

The federal government could grant a range of incentives for alcohol fuels. For example, it could remove the federal manufacturing tax on alcohol blends, which would have an impact similar to provincial tax exemptions. Perhaps more important in terms of initial production, the federal government could supply capital cost grants and loan guarantees to alcohol fuel plants. It is possible that alcohol plants would fall under the Department of Regional Economic Expansion's (DREE) existing capital grant programs, depending on location and other factors. If that is the case, DREE could provide 25 to 30 per cent of capital costs. The participation of DREE would require clarification of the industrial sectors into which alcohol fuel plants are classified. At present, petroleum refining and the petrochemical industry are specifically exempt from DREE participation, while, on the other hand, wood processing plants are acceptable.

Capital cost grants and loan guarantees would be a major incentive for alcohol plants. The US. federal government is providing these types of incentive, as well as many others, to encourage alcohol production (U.S. Dept. of Energy, 1980). Recommendation 10 dicusses policy and administrative moves related to alcohol fuels.

Recommendation ***8:***

> The Ministry of Forests should consider foregoing stumpage charges on the energy value of residuals for a specific period—at least for **10** years. This policy should **be** clearly articulated as an incentive **to** forest energy use and should include definite statements as to how these values will eventually **be** included in stumpage charges.

By foregoing stumpage on energy values entirely, the Ministry is granting a subsidy to encourage wood energy applications for a specific period. In areas where significant competition for biomass supplies develops, this subsidy would largely be captured by sawmills, since they would not be charged stumpage on energy values and yet would sell their residues at competitive prices. Allowing a subsidy to sawmills would encourage marginally greater biomass supply in areas where competition is strong.

In areas with excess supplies of hog fuel and little competition, the subsidy would mean a marginal increase in the distance that residuals can be economically carried. Thus, in the latter instance, the subsidy would largely accrue to the wood energy user.

A lengthy period of time is required for the subsidy in order to allow wood energy users to become established and partially repay the capital costs of their plants. The subsidy should also have a specific end and a clear policy for implementation of eventual charges. This approach is required to avoid implicit property rights from being established and

120 In December 1980, the tax was 4.14 cents per litre for diesel fuel and 3.74 cents per litre for gasoline. Wholesale prices for these products vary. It is assumed that fuel costs amount to 20 per cent of total costs in truck transport.

121 ***Canadian Renewable Energy News,*** **"Mohawk First", Vol. 3, No. 9 (1980).**

to avoid objections from residue producers that result when charges are established. For example, strong protests are being registered by Interior sawmills over the Ministry of Forests' proposals to increase stumpage charges on chips.[122]

Recommendation 9:

The Ministry of Forests should consider attempting to compensate users of forest residuals for any associated silvicultural benefits of residue removal.

It is likely that removal of forest residues for energy (or chips) would lower the costs of silvicultural preparations needed before replanting a logged area. Once the removal of residues becomes established and these benefits can be quantified in dollar terms, the Ministry should compensate the residue users through the stumpage system or direct cash payments. Through this approach, the positive externalities of residue removal would be explicitly compensated and an incentive would be provided to achieve the appropriate level of residue removal.

4.0 ADMINISTRATIVE RECOMMENDATIONS

Recommendation 10:

The federal government should vigorously pursue a lead role in development of new liquid fuels, including alcohols from wood biomass. This lead role should include: a clearly articulated policy and set of priorities for the various options; an explicit policy on tax regimes, active research, development, and demonstration projects; and a program to remove regulatory barriers. Direct government involvement in production facilities should be considered.

As outlined in its *Discussion Paper on Liquid Fuel Options,* the federal government has a number of liquid fuel alternatives under consideration. The role of these various alternatives must be clarified and priorities established. There is already in place a joint federal-provincial agreement regarding research, development, and demonstration projects for energy use of wastes. It is expected that this agreement could play a major role in sponsoring research into alcohol fuel production.

Analysis in Chapter **V** indicates that neither the forest industry nor the oil industry can be expected to pursue alcohol fuel production on its own. Direct government involvement in initial production facilities may well be required to prove that existing barriers can be surmounted. The recently announced federal renewable energy corporation could play a major role in this regard.

Recommendation 11:

B.C. Hydro should consider direct involvement in cogeneration projects through joint ownership. It should also consider construction and licensing of wood-fueled electric generation for power exports.

Both parts of this recommendation deal with ways to eliminate administrative barriers to wood energy generation within B.C. Hydro. To minimize the perceived problems with cogeneration plants, the utility should consider joint ventures with pulp mills. The utility could lease space and purchase the steam from the mill; ownership and operation of the turbogenerators could rest with the utility and it could, therefore, control the entire electrical output of the plant. This approach has been employed with success in the United States.

A major obstacle cited for cogeneration and wood-fueled thermal plants is their relatively high costs, compared to the utility's other alternatives. However, the wood-fueled sources are very economical, compared with the costs of oil-burning thermal plants operated by California utilities. It would be possible for B.C. Hydro to contract with U.S. utilities to supply electricity from a plant at Quesnel (or from cogenerators) at prices that would easily justify the plant's construction. Since the high export revenues could repay the plant's cost in a period of years, the plant could then be available to produce electricity for domestic consumers.

122 Vancouver *Sun,* "New formula to cost mills $120 million", January 1981.

The provincial government has, in the past, opposed construction of electric plants for the primary purpose of export. But if a plant would create environmental benefits and produce power from waste materials, the province may find electrical exports acceptable for a period of time to repay the plant's costs. Similarly, the National Energy Board may be more favorably disposed to export of thermal power if it is from an environmentally beneficial source. The National Energy Board must approve exports'of electric power.

Recommendation 12:

> The provincial government should consider explicitly exempting cogeneration facilities from the Utilities Commission Act.

This move would eliminate the need to apply for exemption and reduce the regulatory difficulties faced by cogenerators.

Recommendation 13:

> The Ministry of Forests should consider implementing available resource management policies to ensure that it does not discourage the supply of low-quality material for energy purposes.

The difficulties posed for removal of low-quality material by the scale-based stumpage and cut control system were outlined in Chapter V. The Ministry has two alternatives to alleviate this problem–adopt a cruise-based system or adjust the present system to exclude marginal material, These approaches should be thoroughly considered by the Ministry.

Recommendation 14:

> Regional markets for wood wastes should be established wherever unencumbered supplies of residues exist. The province should also develop a regional wood waste planning model to set priorities for waste uses by region.

Both parts of this recommendation deal with allocation of wood residues on a regional basis. We have argued (at a number of points in this report) the importance of establishing regional wood waste markets in all locations where sufficient uncommitted supplies exist. Even though markets may be limited to only a few areas within the province because of extensive vertical integration, these regional markets may have an important influence on wood waste transactions in other areas.

While we emphasize the need for markets, there is also an important role for resource managers in setting priorities for wood waste uses on a regional basis. Therefore, a regional planning model–that incorporates supply data, alternative demands, transportation costs, and other factors–would be of great use in developing wood energy priorities in specific locations.

Recommendation 15:

> The Ministry of Forests should consider making available contracts to cut diseased or poor-quality stands for energy purposes. It should also make available contracts to remove forest residuals after initial harvest. No stumpage should be charged on these removals, and the contractor should have the option to not remove the material if it chooses.

The purpose of this recommendation is to lessen wood energy users' concerns over secure supplies of wood fuel. Both the harvest of poor stands and the removal of residues are expected to be very high cost sources of fuel supply. Consequently, they would only be called upon for marginal supplies or in situations where no mill residues were available. By obtaining a contract for this harvest at its discretion, the user has the security of knowing that these high cost supplies can be counted on if needed. Moreover, as discussed in Recommendation 9, the Ministry of Forests could compensate harvesters for any silvicultural benefits associated with these removals.

Recommendation 16:

> Educational programs and a government-industry task force should be established to disseminate information about the opportunities for use and the benefits of forest biomass as an energy resource.

These programs should be designed to reach individuals at the managerial level within the forest industry, oil industry, and provincial government. They should help overcome an apparent lack of knowledge regarding the benefits available from biomass energy.

Recommendation 17:

> If natural gas utilities are demonstrably disadvantaged by the loss of forest industry customers because of wood energy conversion, the provincial government should consider paying them compensation.

It was argued in Chapter V that expanded natural gas consumption in other sectors may ameliorate the loss of forest industry customers so that the two utilities may not be adversely affected by a switch to wood energy. If this growth in other demands does not occur and utilities are adversely affected by a change in forest industry energy patterns, compensation payments may be warranted. It would be more economically efficient to compensate the utilities for a period of years, thereby minimizing adverse effects on the utilities' other customers than to keep natural gas prices low in an attempt to protect the utilities' load factors.

From an economics perspective, adverse effects on the utilities and their customers, as a result of conversion to wood energy, are termed "pecuniary externalities". Side effects of this type need not be considered to arrive at economically efficient decisions regarding resource uses. Nevertheless, such effects could have adverse distributional consequences–in that one group within society would bear greater costs than others to achieve an economically desirable result. In that case, compensation could be warranted to improve the equity of the results of a change in resource uses. Decisions regarding compensation for equity purposes should rest with the provincial government. If the province judges that compensation is warranted, the size of the payments should reflect the amount needed to keep rates of the utilities' other customers at the level that would have occurred if the forest industry had not converted to wood energy.

Recommendation 18:

> If the natural gas distribution system is extended to Vancouver Island, the province should ensure that no potential uses of wood energy in the Island's forest industry are precluded.

Pulp mills on Vancouver Island have made the greatest moves of any segment within the provincial industry toward utilizing mill residues for energy purposes. One major reason for this progressive attitude is that natural gas is not available on the Island. If gas is made available at subsidized prices, further use of wood wastes may be forestalled. Natural gas should not be permitted to supercede any potential application of wood energy in the forest sector, including boiler replacement, fuel dryers, and lime kilns.

5.0 RECOMMENDATIONS FOR FURTHER RESEARCH

The following topics, related to economic and institutional issues of biomass energy, stand out as requiring further research:

(a) The total economic value of subsidies and incentives granted to conventional energy industries.

(b) The economic value of positive externalities associated with biomass energy, including silvicultural benefits, environmental benefits, and socio-economic benefits.

(c) The total value of incentives that are economically justified for forest biomass energy and the distributional effects of alternative incentive mechanisms. This analysis should consider (a), (b), and the level of conventional energy prices.

(d) Detailed regional analysis of supply, demand, and value of alternative uses for biomass materials to establish priorities in particular areas.

(e) The feasibility of, and procedures for, establishing regional markets for biomass materials.

(f) Priorities and policies relating to Canada's liquid fuel options and mechanisms for direct government participation.

(g) Improved methods of transporting and handling of biomass materials at low costs to enable biomass surpluses in some areas to remedy shortages in others and allow markets to work more smoothly.

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APPENDIX I

DATA SOURCES AND METHODOLOGY OF CONVERSION MODEL

This appendix discusses the methodology and data sources of Tables 11-12 and 11-13, as well as Tables V-1, V-2, and VI-I.

1. PULP MILL CONVERSION MODEL, TABLES 11-12 AND 11-13

a. Methodology

The returns from investment in boiler conversion and turbogenerator equipment were calculated on both a private (after-tax) and social (pre-tax) basis. For convenience, the private return on investment analyses was treated as if the financial flows were similar to an ordinary annuity. The general formula for an annuity is:

Present value of the annuity equals:

$$\text{Periodic Payment} \left(\frac{1-(1+\text{interest rate})^{-N}}{\text{interest rate}} \right)$$

(1) Present value of the annuity corresponds to the full capital cost of the hog boiler or turbogenerator project. The after-tax cost is found by multiplying the above capital cost by .594 (50 per cent depreciation and 15 per cent discount rate) to determine private cost.

(2) The periodic payment is the value of the annual savings expected with the implementation of the project. For an oil consuming mill, the general formula for the periodic payment is:

(barrels of oil consumed/years) (oil price)
– (hog fuel equivalent)

(hog fuel price) – (incremental operating and maintenance)

For the turbogenerator investment, the annual payment is the value of electricity displaced, minus the cost of the hog fuel, fossil fuel, and operating and maintenance costs necessary to produce the self-generated power. The above value is reduced by 50 per cent to yield the after-tax expenditure saving.

(3) N is the number of periods over which the investment returns are considered. These were set at 5 years and 25 years for the private returns calculations.

(4) Given the above values, the interest rate (or private internal rate of return) was solved for.

(5) To calculate *social* returns on investment, pre-tax earnings were used–the net present value of the periodic payments discounted at 10 per cent over 25 years and subtracting the capital costs.

(6) The maximum price of hog fuel is computed by dividing the annual present value of fuel savings by expected annual hog fuel consumption.

b. Data Sources and Assumptions

(1) Capital costs (of boiler replacement and turbogeneration equipment) were taken from the Ministry of Economic Development (1979) and updated to 1980 dollars, using an inflation factor of 1.3. This figure reflects information obtained from engineering consultants working on boiler replacement projects.

(2) Annual operating and maintenance costs were assumed to be 2 per cent of capital costs.

(3) Maximum potential hog fuel utilization of the various mills was assumed to equal 85 per cent of current purchased energy requirements.

(4) The following conversions were employed to calculate hog fuel requirements for each mill:

1 ODt = 16 million Btu
1 bbl = 6 million Btu
1 mcf = 1 million Btu

Burning Efficiencies:

oil = 82%
natural gas = 82%
hog fuel = 60%

(5) Fossil fuel prices were assumed to be $26/barrel for residual oil and $4.45/mcf for natural gas.

(6) Electricity prices were assumed to be 26 mills per kwh–for both buying and selling of energy.

(7) Hog fuel prices were assumed to be $7/ODt, delivered to the mill.

(8) To calculate after-tax returns, the following assumptions were used. A capital cost tax factor of 594 was used, reflecting a **50** per cent straight-line depreciation allowance and a 15 per cent discount rate. All expenses were assumed to affect taxes at a 50 per cent marginal tax rate. All capital expenses were assumed to occur in one year, with the operating costs and energy cost savings commencing in the second year. To simplify the calculations, a zero salvage value is assumed for the asset after the financial period.

2. SENSITIVITY ANALYSES FOR ENERGY PRICES, COST CHANGES, AND INCENTIVES–TABLES V-1, V-2, AND VI-2

To undertake these sensitivity analyses, a representative group of four (two oil-burning and two gas-burning) pulp mill conversion projects were analyzed.

a. Table V-1

In Table V-1, the "base case" is investment in a hog fuel boiler, with returns calculated on a private after-tax basis over a 5-year financial life. The returns were averaged over the four projects. These assumptions concur with those used for Table 11-12. The data basis and assumptions of Table 11-12 were also used. Two sets of fossil fuel prices were employed to test the sensitivity to this parameter, as shown in the table.

b. Table V-2

In this table, we consider the sensitivity of returns on investment in hog fuel boilers to changes in **key** parameters. The "base case" here is the returns on investment calculated in Table V-1, on the basis of likely 1981 fossil fuel prices. Marginal cost-based fuel prices were ***not*** employed. The table employed the same data base and assumptions as Table V-1.

c. Table VI-1

In this table, the percentage change–in returns **on** investment, due to various incentive programs–was calculated. Again, a sample of four conversion projects was used to determine the average change in returns. The "base case" for this table is that of Table 11-12, with marginal cost-based fossil fuel prices; returns are calculated on a private after-tax basis over a 5-year financial life.

APPENDIX II

TABLES OF EQUIVALENTS AND ABBREVIATIONS

1. METRIC EQUIVALENTS

Length

1 foot = .3048 metre (m)

Area

1 square foot = ,0929 square metre (m^2)
1 acre = .4046 hectare (ha)

Volume

1 cubic foot = 28.316 litres (L) or .02831 cubic metre (cm^3)
1 barrel = 158.9 litres or .1589 cubic metre
1 mcf = 28.26 cubic metres (API)
1 gallon (Imperial) = 4.246 litres

Energy

1 Btu (British thermal unit) = 1055.06 joules (J)

Forestry

1 cunit = 2.831 cubic metres
1000 board feet = .24 cubic metres

2. COMMON ABBREVIATIONS IN THIS REPORT

cm = centimetre
fbm = foot board measure
hm^3 = $hectometre^3$ ($100 m^3$)
kj = kilojoules (10^3 joules)
LPY = litres per year
mcf = thousand cubic feet
pj = petajoules (10^{15} joules)