The expected influence of biomass in the British Columbia energy sector to 2010 AD

Pacific and Yukon Region — Information Report BC-X-325

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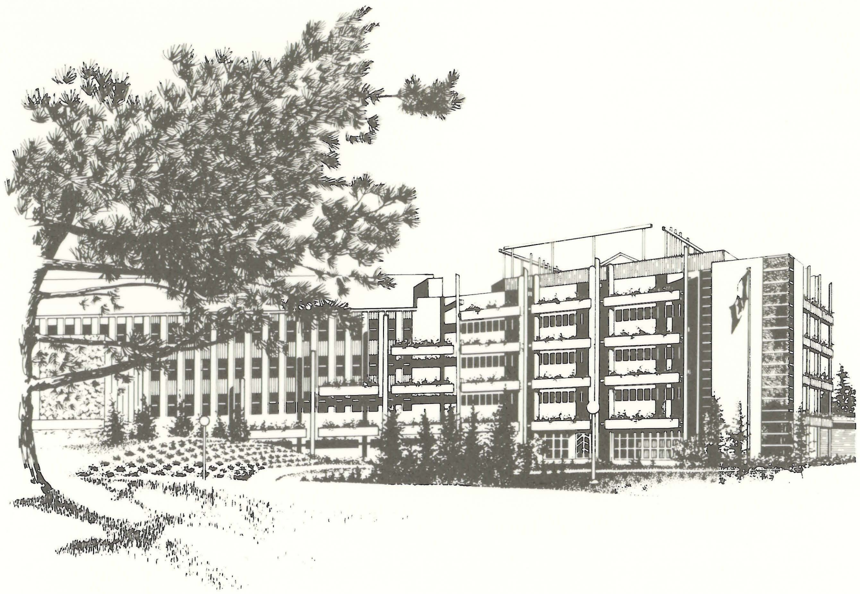

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The Pacific Forestry Centre undertakes research in response to the needs of the various managers of the forest resource. The results of this research are distributed in the form of scientific and technical reports and other publications.

The expected influence of biomass in the British Columbia energy sector to 2010 AD

Based on a report prepared under contract by

Nawitka Resource Consultants
Victoria, British Columbia

and

Strategic Services Division
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Vancouver, British Columbia

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Foreword

ENFOR (Energy from the Forest) is a contract research and development (R & D) program managed by Forestry Canada. It is aimed at generating sufficient knowledge and technology to realize a marked increase in the contribution of forest biomass to Canada's energy supply. The program was initiated in 1978 as part of a federal interdepartmental initiative to develop renewable energy sources.

The ENFOR program deals with biomass supply matters such as inventory, growth, harvesting, processing, transportation, environmental impacts, and socioeconomic impacts and constraints. A technical committee oversees the program, developing priorities, assessing proposals, and making recommendations. Approved projects are generally carried out under contract.

General information on the operation of the ENFOR program, including the preparation and submission of R & D proposals, is available upon request from:

The ENFOR Secretatiat
Forestry Canada
Ottawa, Ontario
K1A 1G5

This report is based on ENFOR projects P-364 and 365, which were carried out under contract by Nawitka Resource Consultants, Ltd., Victoria, British Columbia (DSS File No. 01k51-8-0038/01-SB). The Departmental Representative was Glenn H. Manning, Pacific Forestry Centre, 506 West Burnside Road, Victoria, British Columbia V8Z 1M5.

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Abstract

This report examines future supply and demand for wood fibre, including traditional forest products and energy feedstock. Policy and economic variables influencing supply and allocation of fibre are reviewed. Several alternative utilization scenarios are examined, and policy initiatives are suggested for increasing use of forest residuals for bioenergy.

Résumé

Ce compte-rendu porte sur les prévisions de l'offre et de la demande en matière de produits à base de fibres ligneuses, notamment les produits forestiers traditionnels et les produits de combustion. Les auteurs examinent les variables politiques et économiques pouvant influer sur la production et l'utilisation des fibres ligneuses. Ils examinent enfin plusieurs possibilités d'utilisation de la fibre ligneuse et proposent un programme d'actions axé sur le développement de nouveaux créneaux bioénergétiques pour les résidus des forêts.

1. Background

Following a prolonged bout of energy uncertainty, and a severe recession in the early 1980s, a clear picture of the current British Columbia bioenergy situation is presently emerging. During this same period, many sweeping changes have occurred within the broader provincial, national and world energy scene. The petroleum scarcity crisis became the petroleum glut crisis and the situation is currently (1988) reapproaching long-term trend lines somewhere in between. The National Energy Policy of Canada has come and gone. Nonetheless, several partly subsidized energy mega-projects are underway from the Atlantic seaboard to British Columbia. Patterns of energy consumption have shifted rather rapidly to adapt to the apparent scarcity of petroleum products, and have been shifting again in the late 1980's. New energy technologies have been developed continuously through the decade.

Throughout this period the British Columbia forest industry, from logging to processing and marketing, was undergoing significant dynamic changes. Total levels of harvest fell during the 1981/82 recession and rose continuously to new record levels in 1987/88.

Following this decade of massive change in the forest industry and the bioenergy problem, this review has been prepared to:

- examine present and future demands on the British Columbia forest resource (including residual biomass) for traditional products, and forecast the availability of biomass (at mills and in the forest) that would be available for new energy production;
- examine present and future energy requirements in British Columbia with particular emphasis on industrial energy requirements and likely sources of supply;
- review the economic and policy variables influencing the allocation and use of forest resources and forest residuals;
- analyze the impact of social values on use of biomass in British Columbia;
- assess the economic and institutional constraints to increased use of bioenergy in British Columbia;
- develop and examine several scenarios for the future of increased biomass utilization for energy in British Columbia;
- examine the policy implications of each scenario and provide suggestions for policy initiatives which might favor increased economic use of biomass for energy production in British Columbia.

2. Forestry sector of British Columbia

The future of biomass utilization for energy in British Columbia is dependent on the future of the forestry sector. The forest industry is the largest total energy user in the province; it produces virtually all of the readily available biomass fuels, and is almost the sole user.

In order to analyze future use of biomass energy in British Columbia, the present status and likely trends of the forestry sector must be analyzed. The most complete data set is for 1987 but many industry plans are in place which can be used to project capacity and likely utilization patterns to about 1990.

This data can be summarized under current demand for forest products, existing industry production, and total forest harvest. Biomass production and use and the potential for the future can be summarized according to residues at mill sites, and residues in the woods.

2.1 Demand for forest products

The sustained level of housing starts in the United States since the recovery of North America from the recession of 1981/82 (1.6 to 1.8 million starts every year) has led to steady increases in British Columbia lumber production to current record levels. Shipments to the European Economic Community and Japan have also increased. In spite of trade disputes with the United States over softwood lumber exports from Canada, this trade remains the single most important element in the forestry sector of British Columbia. Recent increases in the value of the Canadian dollar with respect to the United States' dollar, combined with a softening of North American lumber prices, reduced activity in this sector. However, the strong upward cycle in pulp and paper markets (e.g. 115% price rise by the end of 1988 in

Table 2-1. Production of forest products in British Columbia in 1987

	Coast	Interior	Total
Wood products			
		(000 cubic metres)	
Lumber	8930	18 800	27 730
Plywood	770	1220	1990
Particleboard/MDF[1]	130	150	280
Waferboard/OSB[1]	0	50	50
Other[2]	1200	1300	2500
Total wood products	11 030	21 520	32 550
Dried and transferred pulp			
		(000 metric tonnes)	
BKP1	1880	2270	4150
UKP1	75	10	85
Other chemical	120	0	120
Mechanical/chem.-mech.	0	330	330
Total	2075	2610	4685
Paper and paperboard			
		(000 tonnes)	
Newsprint	1526	0	1526
Printing/writing	385	0	385
Linerboard	333	0	333
Corrugating medium	38	0	38
Kraft paper	100	95	195
Cartonboard	45	0	45
Other	162	0	162
Total	2589	95	2684
Total pulp and paper	4664	2705	7369

1. MDF - medium density fibreboard, OSB - oriented strand board, BKP - bleached kraft pulp, UKP - unbleached kraft pulp

2. shakes and shingles, fuelwood, miscellaneous, remanufactured products, etc.

market pulp prices over the recent low in 1985) has kept economic activity generally high in the British Columbia forest industry (Hay-Roe's Papertree Letter 1989).

The current cycle in forest industry production and profits has peaked, and some retrenchment is occurring in 1989. However, the industry in general has had one of its best five-year periods.

Current concerns with increasing inflation will create an interest rate trap for housing. Current demand for lumber is down and may get worse. However, the long-term projections of demand for wood products are favorable.

Pulp and paper demand remains strong at present (1989), although some problems are appearing in the demand for newsprint. In spite of this, the integrated forest products industry has been enjoying one of the benefits of multi-product output - a balancing counter-cyclical trend in various subsectors. Often in the past the lumber and pulp cycles have been out of phase, providing a measure of stabilization to the sector as a whole. Lumber reacts very quickly in a downturn through housing while pulp and paper reactions are lagged significantly, falling and rising slowly with gross national product.

In general the prospects for demand for British Columbia forest products in North America, on the Pacific Rim, and in Europe appear to be excellent. There is no apparent constraint to the industry on the demand side. However, there are potent new suppliers of softwood fibre on the Pacific Rim (e.g. Chile and New Zealand). The total market is expected to grow rapidly enough to absorb British Columbia's supplies as well as those from these suppliers.

2.2 Forest industry production

A recent review of the British Columbia forest industry (Price Waterhouse 1989) estimates, based on preliminary data, that in 1988 the British Columbia industry produced roughly two million tonnes of newsprint, 4.7 million tonnes of market pulp, 2.7 billion sq. ft. (3/8" basis) of plywood and veneer, and 16 billion board feet of lumber.

A more complete statistical summary of industry output in 1987 is provided in Table 2-1. The production of each subsector and the roundwood inputs necessary are analyzed in the following sections.

2.2.1 Wood products

The British Columbia lumber industry has been subdivided into several regions for analysis of timber supply. (In general, logs cannot be moved economically more than 100 miles over land.) A clear distinction can be maintained between the coastal region (west of the Cascade or Coast Range) and the interior region of British Columbia (east of the Coast Range).

In 1987, British Columbia's coastal mills produced 8.9 million m^3 lumber (99% softwood). In the same year, mills in the interior of British Columbia produced 18.8 million m^3 of lumber (all softwood). Thus, in lumber, the ratio of roughly 2:1 for interior:coast production of lumber represents a comeback for the coastal industry from the severe problems of the early 1980s. The British Columbia interior accounts for over 40% of total Canadian lumber production.

In other wood products (mainly plywood/veneer and shingle/shakes) the two regions are closer to equal; the coast produces about 2.1 million m^3 of these products and the interior about 2.7 million m^3 of panelboard and other products in 1987.

The complex of wood product mills in both regions produces the bulk of fibre inputs to the British Columbia pulp industry (chips made from sawmill and plywood mill residues). The bulk of biomass materials currently burned for energy or disposed of by other methods is also generated by the wood products industries (sawdust, shavings, bark, and miscellaneous waste materials).

In 1987, British Columbia's coastal wood product mills produced a total of over 10 million m^3 of final products (lumber, plywood, shingle, shakes, other panels) and about 8.5 million m^3 of chips which were utilized in the pulping process or exported. A total hog fuel* volume of about 10 million m^3 was also generated. It can be seen that most of this biomass material is produced by sawmills. Coastal British Columbia also exported 3.4 million m^3 of roundwood in 1987.

* Hog fuel is defined here as combustible wood residue in mechanically shredded form, including bark. It is comprised of divergent aggregates of sawdust, shavings, chip fines, bark, sander dust, veneer trim. In some cases it also includes waste wood from mill or log yards, such as trim ends, slabs, and edgings, which have not been used for the production of pulp chips (see Sec. 2.3).
The coastal lumber industry has always produced special grades and sizes for off-shore markets. Most of these grades are "full size" and shipped rough, therefore a lower proportion of the total log goes into sawdust and shavings.

Interior British Columbia mills produced over 19 million m^3 of wood products of which about 87% was softwood lumber. Interior wood product mills also generated 19 million m^3 of chips and over 17 million m^3 of hog fuel materials. Roundwood exports from the interior of British Columbia amounted to 100 000 m^3.

Lumber

The wood product industries in coastal and interior British Columbia are significantly different. On the coast, most production is by mills that manufacture over 200 000 m^3 of lumber annually. Many coastal sawmills are complementary to adjacent pulp and paper facilities, and traditionally produce commodity grades of lumber and a high proportion of chips.

Many coastal mills have been undergoing major redesign programs in the 1980s. The trend in this region is away from commodity grades of lumber towards more valuable lumber grades. There are a number of smaller sawmills on the coast with a wide variety of special approaches to log breakdown.

The remanufacturing segment of the coastal lumber industry is expanding rapidly (production of planed and shaped fancy grades of lumber and siding). The proportion of wood going into sawdust and shavings increases in remanufactured lumber. The lumber industry of interior British Columbia is typified by spruce-pine-fir (SPF) dimension lumber production to North American standards.

The manufacturing costs at British Columbia sawmills in both regions are among the lowest in the world. The high throughput and low production costs are achieved at the expense of value extraction from the input raw logs. The proportion of log converted to lumber is comparatively low by European or Japanese standards, and the range of construction grades produced has traditionally been rather limited.

Panels

Softwood plywood is the principal panel product of the British Columbia coast. Most mills produce sanded and specialty plywoods and minimize the production of regular construction sheathing except in peak markets. Particleboard and high-density fibreboard (hardboard) are also produced on the coast.

Softwood plywood is also the major panel product in the interior of the province. However, most production is in sheathing grades, although one small mill produces specialty products. A large waferboard plant has recently been constructed in the interior, with a capacity 240 000 m^3/annum. Particleboard is manufactured at two mills in the interior. These mills utilize residues from nearby sawmills.

2.2.2 Pulp, paper and paperboard

In 1987, total British Columbia production of paper, paperboard, and market pulp was 7.4 million tonnes. Market pulp comprised approximately 64% of this total. Bleached kraft pulp (BKP) forms the largest share of market pulps from British Columbia, while newsprint is the predominant paper product.

Coast market pulp production was 2.1 million tonnes, and paper production was 2.6 million tonnes. Pulpmills in the British Columbia interior produced 2.6 million tonnes of pulp and a small amount of paper (100 000 tonnes).

Some details of this production will be necessary in assessing regional consumption of wood fibre.

Newsprint

The newsprint industry of British Columbia is relatively modern and competitive in North American markets. All present production is at coastal locations (Table 2-2).

Total present capacity is 1.5 million tonnes. Table 2-2 also shows current firmly established plans for expanded capacity of 720 000 tonnes/annum of newsprint production. One new mill is proposed for the MacKenzie area, northeast of Prince George.

The pulp furnish for newsprint in British Columbia is 60% thermomechanical pulps (TMP), 25% stone groundwood, and 15% kraft pulp.

Market pulp

Of the 13 producers of pulp on the British Columbia coast, six produce market pulp in significant quantities (Table 2-3). It should be noted that Table 2-3 excludes pulp used in integrated or affiliated paper and paperboard production.

Most of these mills were built between 1960 and 1975. A few date back to the period between the two world wars. There has been significant capital improvement to each mill since its initial construction, and some of the mills have been basically rebuilt. There have been large investments since 1986 to increase productivity and to reduce the environmental impact of mill emissions to both air and water.

Table 2-2. British Columbia newsprint mills, existing and new capacity

	Current capacity	New capacity	When
		(000 tonnes/annum)	
Fletcher Challenge, Crofton	450	65	1988/89
Fletcher Challenge, Mackenzie		220	1988/89
CIP, Gold River		170	1989
Crown Forest Industries, Campbell River	460	45	1989
Howe Sound Pulp		220	199?
MacMillan Bloedel, Powell River	400		
MacMillan Bloedel, Port Alberni	190		
Total	1500	720	

Table 2-3. Dried and transferred chemical pulp production on the British Columbia coast, existing and new capacity

	Current capacity	New capacity	When
		(000 tonnes/annum)	
Fletcher Challenge, Crofton	250		
Fletcher Challenge, Elk Falls	170		
Canfor, Howe Sound	220	125	1989
CIP, Gold River	250		
MacMillan Bloedel, Harmac	360		
Skeena Cellulose, PrinceRupert	420	45	1989
Western Pulp, Woodfibre	220		
Western Pulp, Port Alice	150		
Total	2040		

Fibre supply comes primarily from coastal sawmill chips which consist mainly of western hemlock, Douglas-fir, western red cedar, and balsam (*Abies* spp.). A significant volume of SPF chips is also imported from southern and west-central interior sawmills for use in coastal pulp mills.

There are nine pulp producers currently established or under construction in the interior of British Columbia. Existing mills were built in the 1960s and 1970s, but have had major capital improvements since. The principal product is market pulp (Table 2-4).

New chemi-thermomechanical capacity (CTMP) will be brought on stream this year (1989) at Taylor and Quesnel. The new mechanical pulp capacity at Finlay Forest Products will be integrated into newsprint production within Fletcher Challenge Limited.

The interior pulp industry is relatively modern, although some of the bleached kraft pulp (BKP) mills are somewhat small by current world standards. One interior BKP mill has recently doubled in size.

Fibre supply for interior pulpmills comes almost entirely in the form of sawmill chip residues. Two species, white spruce and lodgepole pine, dominate this pulp furnish supply and provide a high standard of uniformity to interior pulps. Chip sales are an integral economic component of the interior British Columbia lumber industry. These sales provide critical revenue to a wide range of independent sawmills, as well as mills integrated within pulp companies.

2.3 Current fibre balance

In order to arrive at reasonable estimates of current fibre production and use by region, estimates of current demand at existing facilities were made. The following approach was used:

1. Typical conversion factors were derived for each process (i.e. fibre equivalents per unit of output).
2. An analysis was made of existing (including new) capacity and probable operating rates under normal market conditions.
3. The fibre equivalent for lumber and plywood was assessed for the actual volume of fibre contained in the product.
4. The fibre equivalent for reconstituted panels (fibreboard, flakeboard) was assessed for each process to develop the inputs for the recorded volume of production.
5. Loss due to shrinkage in lumber and plywood drying kilns was assessed.

Table 2-4. Dried and transferred pulp production in the British Columbia interior, existing and new capacity

	Current capacity	New capacity	When
		(000 tonnes/annum)	
Fletcher Challenge, Mackenzie	340	55	1989
Canfor (IC), Prince George	240		
Canfor (PGPP), Prince George	175		
Cariboo Pulp, Quesnel	270	50	1989
Celgar, Castlegar	200		
Crestbrook, Skookumchuck	190		
Fibreco, Taylor		180	1988
Northwood, Prince George	540		
Quesnel River, Quesnel	200	120	1988
Weyerhaeuser, Kamloops	410		

Total	2565		

6. Chip and sawdust production was assessed mill by mill with a cross check according to recorded consumption by the pulp and paper industry (Some reconstituted boards also take sawdust and shavings).

The remainder of log byproducts and bark becomes hog fuel or unutilized residue. Table 2-5 summarizes fibre production and consumption in the British Columbia forest industry in 1987. Production of primary products and byproducts is shown for each industry group for the coast and the interior regions and the total province.

2.3.1 British Columbia coast

About 32 million m^3 of roundwood was processed by the coast forest industries in 1987 (after deducting log exports). Of this total, about 26 million m^3 passed through a wood products mill, while about 6 million m^3 passed directly through a fibre-oriented mill (groundwood or chipper).

In total, the larger coast fibre industries used over 19 million m^3 of fibre; this was made up of about 45% chips from wood product mills, 30% fibre roundwood inputs, about 25% chip imports from the interior, and sawdust. Sawdust represented only 4-5% of the total fibre input, but its use has been growing rapidly in recent years. Sawdust exports were approximately 87 000 m^3 in 1987.

Almost 300 000 m^3 of sawdust and shavings was used as inputs to reconstituted panels on the coast. Sawdust and shavings were also used in the production of minor products, such as fire logs and soil conditioners. This amounted to over 300 000 m^3 in 1987.

About 5 million m^3 of hog fuel went into steam and power generation in coast forest product mills in 1987. Thus, in total, the coast utilized about 6.5 million m^3 of hog fuel or wood waste in 1987 (sawdust for pulp, export, panels, minor products and energy).

2.3.2 British Columbia interior

The larger interior wood products industries produced over 19.5 million m^3 of pulpable chips in 1987. Of this production, approximately 13 million was utilized by interior pulpmills and about 6.5 million exported to the coast and offshore.

Over 750 000 m^3 of interior sawdust was utilized for pulp. Approximately 175 000 m^3 of sawdust and shavings were utilized in the production of reconstituted boards. Net sawdust exports from the interior amounted to 268 000 m^3.

Approximately 4.4 million m^3 of hog fuel went into the generation of steam and power in the forest industries of the British Columbia interior. Something less than 100 000 m^3 of hog fuel went into miscellaneous uses such as soil conditioners and animal bedding. Thus, in total, the interior utilized about 5.7 million m^3 of hog fuel or wood waste in 1987. The residual biomass from this general utilization pattern is analyzed in section 2.4.

2.4 Biomass residuals at millsites

The traditional term hog fuel, as used in the British Columbia forestry sector, means any form of waste wood or bark broken into shreds and small particles for burning. The hammer-mill (originally steam driven) used to break up the mill wastes was known as "the hog". The material traditionally burned also included sawdust, shavings, and bark.

In 1987 hog fuel was used for energy and other end uses. The other uses generally create higher values than the use in burning, under current petroleum prices. In rough descending order of value, they include sawdust for pulp furnish, panel board production, fire logs, bark mulch, and others. However, energy still accounts for the largest proportion of hog fuel usage on both the coast and in the interior (about 75% of total hog fuel utilization in 1987).

Section 2.3 summarizes end product and byproduct volumes which were produced from total log production (under bark), plus bark volume for the coast and interior regions. In order to calculate the available surplus of residual biomass for the coast and interior, the total utilization of fibre by British Columbia industry and exports must be subtracted from the production figures. Table 2-6 provides a summary of this calculation. Section I of this table resummarizes production of forest products, section II shows the utilization of chips and other residuals, section III shows the surplus of residuals by region.

Chips are generally produced from clean wood (white wood is preferred). Utilization of chips (including exports) was virtually 100% in 1987. The coast region is absorbing about 4 million m^3 of interior chips, and the pulping of sawdust and shavings has already commenced in both regions. This trend is expected to continue. However, there is still about 12 million m^3 of sawdust and shavings that is either burned or otherwise disposed of.

When the current use for energy is deducted, there is still a surplus of about 4 million m^3 on the coast and about 13.6 million m^3 in the interior of mill-generated byproducts that could be used as burnables in 1987. This material is already delivered to a log yard or

Table 2-5. Forestry industry fibre consumption in 1987 (million m^3)

	Total province		Coast region		Interior region	
	1987 coeff*	Solid volume	1987 coeff	Solid volume	1987 coeff	Solid volume
Sawmill products						
Sawnwood	0.39	28.4	0.41	8.9	0.39	19.5
Chips	0.37	26.8	0.36	7.8	0.38	19.0
Sawdust	0.12	9.0	0.14	3.1	0.12	5.9
Planer/reman	0.07	5.0	0.05	1.2	0.07	3.8
Misc hog material	0.03	1.9	0.03	0.7	0.02	1.2
Kiln loss	0.02	1.5	0.01	0.3	0.02	1.2
Inside bark total	1.00	72.6	1.00	22.0	1.00	50.6
Bark	0.11	8.1	0.14	3.0	0.10	5.0
Total sawmills		80.7		25.0		55.6
Veneer/plymills						
Veneer/plywood	0.56	2.0	0.54	0.8	0.57	1.2
Chips	0.27	1.0	0.25	0.4	0.29	0.6
Misc hog material	0.11	0.4	0.14	0.2	0.09	0.2
Kiln loss	0.06	0.2	0.07	0.1	0.05	0.1
Inside bark total	1.00	3.6	1.00	1.5	1.00	2.1
Bark	0.14	0.5	0.17	0.3	0.14	0.3
Total plymills		4.1		1.8		2.4
Cedar roofing products						
Shingles	0.15	0.3	0.16	0.2	0.12	0.1
Shakes	0.32	0.7	0.32	0.5	0.31	0.2
Chips	0.21	0.4	0.21	0.3	0.21	0.1
Sawdust	0.16	0.3	0.16	0.2	0.20	0.1
Misc hog material	0.16	0.3	0.15	0.2	0.16	0.1
Inside bark total	1.00	2.0	1.00	1.4	1.00	0.6
Bark	0.13	0.3	0.14	0.2	0.12	0.1
Total sha/shingle mills		2.3		1.6		0.7
Misc wood products						
Poles/piling	0.26	1.4	0.15	0.6	0.57	0.8
Log exports	0.63	3.4	0.82	3.3	0.07	0.1
Misc other	0.11	0.6	0.03	0.1	0.36	0.5
Inside bark total	1.00	5.4	1.00	4.0	1.00	1.4
Bark	0.11	0.6	0.11	0.4	0.11	0.2
Total misc wood prod use		6.0		4.4		1.6
Total logs into wood products		83.6		28.9		54.7
Total bark wp logs		9.5		3.9		5.6

Table 2-5. (cont'd)

	Total province		Coast region		Interior region	
	1987 coeff*	Solid volume	1987 coeff	Solid volume	1987 coeff	Solid volume
Groundwood mills						
Ground fibre	0.74	1.6	0.74	1.6	0.71	0.0
Chips	0.19	0.4	0.19	0.4	0.22	0.0
Sawdust	0.07	0.2	0.07	0.2	0.07	0.0
Inside bark total	1.00	2.2	1.00	2.2	1.00	0.0
Bark	0.11	0.2	0.11	0.2	0.11	0.0
Total groundwood mills		2.4		2.4		0.0
Roundwood chippers						
Chips	0.93	4.4	0.92	3.4	0.95	1.0
Misc hog material	0.07	0.4	0.08	0.3	0.05	0.1
Inside bark total	1.00	4.8	1.00	3.7	1.00	1.1
Bark	0.11	0.5	0.11	0.4	0.13	0.1
Total chippers		5.3		4.1		1.2
Total logs into fibre mills		7.0		5.9		1.1
Total bark fibre logs		0.7		0.6		0.1
Total wood harvest inside bark		90.6		34.8		55.8
Total bark all logs		10.2		4.5		5.7

*******Summary*******	Province	Coast	Interior
Total wood products	31.4	10.4	21.0
Misc roundwood wood products	2.0	0.7	1.3
Total chips wood products	28.2	8.5	19.7
Chips roundwood	4.8	3.8	1.0
Groundwood fibre	1.6	1.6	0.0
Total sawdust/shavings	14.5	4.7	9.8
Misc hog material	3.0	1.4	1.6
Total bark BC	9.8	4.1	5.7
Kiln losses	1.7	0.4	1.3
Log exports	3.4	3.3	0.1
Bark (export)	0.4	0.4	0.0
Total BC production	100.8	39.3	61.5

* Coefficient: the proportion of one m^3 of debarked wood recovered in product or byproduct; bark is in addition

Table 2-6. Summary of 1987 production and utilization of byproducts (million m^3)

	Coast			Interior			B.C. total		
	SW	HW	Total	SW	HW	Total	SW	HW	Total
I. Production									
Chips, Wood Prod. Industry	8.50	0.09	8.59	19.70	-	19.70	28.20	0.09	28.29
Pulp roundwood	5.40	-	5.40	1.00	-	1.00	6.40	-	6.40
Sawdust/shavings	4.70	-	4.70	9.80	-	9.80	14.50	-	14.50
Misc. hog material	1.40	0.10	1.50	1.60	0.10	1.70	3.00	0.20	3.20
Bark	4.10	0.02	4.12	5.70	-	5.70	9.80	0.02	9.82
Total byproducts	24.10	0.21	24.31	37.80	0.10	37.90	61.90	0.31	62.21
II. Utilization of byproducts									
Chips/groundwood									
Pulp industry	18.21	0.09	18.30	12.91	-	12.91	31.12	0.09	31.21
Chip exports	-	-	-	6.50	-	6.50	6.50	-	6.50
			18.30			19.41			37.71
Sawdust/shavings									
Pulp industry	0.59	-	0.59	0.75	-	0.75	1.34	-	1.34
Panels	0.28	-	0.28	0.17	-	0.17	0.45	-	0.45
Miscellaneous	0.33	-	0.33	-	-	0.00	0.33	-	0.33
Exports	0.08	-	0.08	-	-	0.00	0.08	-	0.08
			1.28			0.92			2.20
Residual hog fuel burned									
Energy use	4.87	0.20	5.07	4.41	-	4.41	9.28	0.20	9.48
Exports	0.25	-	0.25	0.27	-	0.27	0.52	-	0.52
			5.32			4.68			10.00

III. Surplus of byproducts

	Coast total	Interior total	Total province
Chips	0.28*	2.04	2.32
Sawdust/shavings not used	3.42	8.88	12.30
Unburned resid. hog**	0.30	2.72	3.02
byproducts surplus	4.00	13.64	17.64

* After 4.0 million m^3 shown in interior chip exports received. The remaining 2.5 million m^3 from the Interior were exported.

** Misc. hog and bark less 1987 energy use (burned) and exported.

residual pile at the mill site. The expected continuing availability of this surplus in future and its likely uses are analyzed in sections 3 to 7.

It should be noted that there are significant differences between various estimates of hog fuel production in British Columbia. For example, estimates based on studies by Reid Collins (Appleby 1988 and 1989) show a surplus of about 1 million m^3 on the coast and about 9 million m^3 in the interior for a total surplus 10 million m^3 of hog fuel in that period. The volume of harvest was up significantly in 1987, and some industry estimates show a higher proportion of miscellaneous hog fuel materials, sawdust, and bark than do the Reid Collins estimates. In general the estimates shown here are believed to be a fair representation of the production and consumption of hog biomass byproducts within the forest industry under the high harvest levels of 1987.

The (delivered) surplus of burnable biomass materials is widely dispersed over the roughly 650 000 km^2 of British Columbia. Real opportunities for biomass utilization occur only in local pockets of surplus. Costs limit the transportation of this bulky, low-value material.

2.5 Total harvest and biomass potential of British Columbia forests

The forests of British Columbia have been managed for wood and fibre products since 1912. The concept of sustained yield was introduced in 1945. There have been many definitions of what timber is considered merchantable and included in the allowable harvest since that time. Changes in species utilization, extraction and milling technology, product markets, and silviculture have all contributed to the shaping of continuously moving targets in forest management.

A distinction should be maintained between the physical potential and the economic feasibility of harvesting timber in British Columbia. On the physical side, several parameters are of interest: the volume standing on each hectare of harvestable forest, the area harvested, the location of this harvest, and finally the volume left on the ground after harvest as "waste." Each of these will be dealt with in this section.

2.5.1 Timber harvest in British Columbia

Table 2-7 shows the timber harvest in British Columbia for the last decade for the six forest regions of the province. The harvest is shown by major tenure or ownership. These are Crown licences that are mainly volume-based and Crown licences that are area-based (i.e. Crown land in Tree Farm Licences) and private land. The latter also includes a small percentage of land under federal jurisdiction.

In the Cariboo Region, the harvest has increased from some 7 million m^3 to over 9 million m^3. Most of this increase was in recent years and has involved the harvest of beetle-damaged timber. The Kamloops and Nelson Regions have shown little change over the decade. In the Prince George Region the harvest has increased from about 14 million m^3 to some 17 million m^3. Most of this increase has come from Crown lands outside tree farm licences (TFLs).

In the Prince Rupert Region, a slight increase in the harvest on Crown licences has occurred, while a slight decrease has occurred in the harvest on Crown lands within TFLs and on private land. The total harvest showed little change.

In the Vancouver Forest Region, the harvest has increased some 4.3 million m^3 over the decade on Crown licences (including timber licences) and 0.6 million m^3 on Crown lands within TFLs. The harvest on private lands decreased about 1.8 million m^3, leaving a total increase in the region of about 3.0 million m^3.

The province as a whole has shown a net increase in harvest of about 10 million m^3 since the late 1970s. This consisted of an increase of about 14 million m^3 on Crown licences and a decrease of 0.7 million m^3 on Crown land within TFLs and 1.7 million m^3 on private land. The total provincial cut in 1986/87 was about 79.9 million m^3 and preliminary figures indicate the 1987/88 cut was about 90.3 million m^3.

2.5.2 Biomass residuals in the forest

Table 2-8 provides an estimate of the utilization of stem volumes in British Columbia from standing timber. The data were compiled on a regional basis and can be used to estimate logging waste generated when the large remaining area of mature merchantable forest is harvested over the next several decades.

Note that the figures were compiled on specified merchantable inventory available as of 1985, but the cut conversion relations are for 1986. They will predict with greater accuracy for large numbers of hectares than they will for a small number and their predicting accuracy will decrease with time and changes in technology.

Table 2-7. Timber harvest (000 m^3) by region and major types of tenure, 1977 to 1987[1]

Region and year	Crown[2] licenses	Tree farm[3] Crown	Private[4] lands	Total
Cariboo				
1986-87	9204	152	519	9875
1985-86	7899	123	474	8496
1984-85	7026	156	528	7710
1883-84	6731	156	679	7566
1982-83	6801	143	339	7283
1981-82	6066	94	357	6517
1980-81	6798	111	438	7347
1980	6478	106	532	7116
1979	6138	152	583	6873
1978	6731	105	634	7470
1977	6315	86	343	6744
Kamloops				
1986-87	7546	537	647	8730
1985-86	8545	670	450	9665
1984-85	7057	794	359	8210
1883-84	7680	864	587	9131
1982-83	6268	793	220	7281
1981-82	8319	719	554	9592
1980-81	7268	733	435	8436
1980	7474	815	497	8786
1979	7318	791	628	8737
1978	7383	786	739	8908
1977	7479	789	680	8948
Nelson				
1986-87	4244	1347	1004	6595
1985-86	4494	1339	878	6711
1984-85	4581	1154	894	6629
1883-84	5150	1075	768	6993
1982-83	4265	897	487	5649
1981-82	3986	941	537	5464
1980-81	4139	1469	742	6350
1980	4386	1601	840	6827
1979	4413	1454	1001	6868
1978	4894	1169	1191	7254
1977	4314	1345	1137	6796
Prince George				
1986-87	15 736	471	852	17 059
1985-86	15 989	496	535	17 020
1984-85	16 378	468	415	17 261
1883-84	16 440	689	540	17 669
1982-83	13 443	378	303	14 124
1981-82	11 860	429	319	12 608
1980-81	12 005	542	584	13 131
1980	13 384	498	714	14 596
1979	14 561	595	746	15 902
1978	12 644	439	843	13 926
1977	12 470	458	562	13 490

Table 2-7. (cont'd)

Region and year	Crown[2] licenses	Tree farm[3] Crown	Private[4] lands	Total
Prince Rupert				
1986-87	8634	1296	276	10 206
1985-86	7946	1202	158	9305
1984-85	9043	2357	215	11 615
1883-84	8866	2051	354	11 271
1982-83	6313	1402	263	7978
1981-82	7942	2076	334	10 352
1980-81	8751	2757	644	12 152
1980	9304	3147	722	13 173
1979	8532	2446	634	11 612
1978	6454	2424	546	9424
1977	6782	2391	468	9641
Vancouver				
1986-87	16 739	7130	3574	27 443
1985-86	15 297	8346	4041	27 684
1984-85	12 259	7370	3417	23 046
1883-84	13 619	8008	3451	25 078
1982-83	10 308	5788	2530	18 626
1981-82	9826	5324	2941	18 091
1980-81	13 768	7076	4323	25 167
1980	14 176	7201	4965	26 342
1979	14 441	6879	4920	26 240
1978	14 760	7842	5589	28 191
1977	12 431	6554	5372	24 357
Province				
1986-87	62 103	10 933	6872	79 908
1985-86	60 169	12 176	6536	78 881
1984-85	56 344	12 299	5828	74 417
1883-84	58 486	12 843	6379	77 708
1982-83	47 398	9401	4142	60 942
1981-82	48 000	9582	5043	62 625
1980-81	52 729	12 687	7168	72 584
1980	55 201	13 368	8271	76 840
1979	55 402	12 317	8513	76 232
1978	52 866	12 765	9542	75 173
1977	49 791	11 623	8563	69 977

1. British Columbia Ministry of Forests, Annual Reports, statistical tables that show volume of all products billed annually.

2. All Crown licences, including timber licences, but not including Crown lands in TFLs.

3. Tree farm licences; includes only harvest from schedule B (Crown) lands.

4. Includes the small harvest from federal and indian lands as well as the small harvest from private lands in TFLs.

Based on the figures in Table 2-8 and harvest data, general estimates can be made concerning the potential burnables that might be available in British Columbia from increased forest utilization. Such estimates reflect the physical potential, not economic potential. Estimates of economically available burnables would have to take into account the value of products removed, and the cost of their extraction, delivery and processing.

At the time of felling, decayed, defective, or small wood is attached to sound, commercial-sized wood on most tree boles.

It is bucking and yarding practice (to a variable commercial standard) which creates "logging waste." Varying markets for wood products and pulp fibre create changes in extraction practices.

Based on the figures in Table 2-8 and estimates of area harvested, general estimates can be made concerning the potential burnables that might be available through salvage logging in British Columbia in 1987. These estimates are shown in Table 2-9.

These estimates compare favorably with other estimates considered in this study. Reid Collins reports very similar estimates of primary products and mill wastes. Similarly, the Ministry of Forests reports a total billed volume of 79.9 million m^3 for all products in the same period. This compares favorably to the estimated removable volume in the table of 82.8 million m^3 considering losses in transit, different scaling methods and minor variations in utilization standards.

Thus there is at present a very large physical potential for increased use of forest biomass in British Columbia. In 1987 the total unused biomass material at millsites and logging sites was about 40 million m^3 (15 million m^3 at millsites; 25 million m^3 at logging sites).

Table 2-8. Industrial utilization (m^3/ha) of British Columbia stem forest biomass in 1985/86

Region	Standing[1] timber (Gross inventory less decay)	Logging waste (Waste and breakage)	Merchantable volume (Removable wood)
Nelson	429	111	318
Cariboo	369	87	282
Kamloops	430	94	336
Prince George	413	94	319
Prince Rupert Interior	426	124	302
Prince Rupert Coast	752	197	555
Vancouver Coast	825	176	649

1. Based on good, medium and low sites for inventory age classes five through nine; subject to minimum stand volume (less decay) of 400 m^3/ha on the coast and 180 m^3/ha for the interior.

Table 2-9. Potential for forest industry biomass in British Columbia

Region	Area harvested[1] (ha)	Estimated removable volume	Estimated logging waste
		000 m^3	
Nelson	23 646	7519	2625
Cariboo	42 166	11 891	3668
Kamloops	26 221	8810	2465
Pr. George	60 681	19 357	5704
Pr. Rupert, Interior	29 276	8841	3630
Pr. Rupert, Coast	1985	1100	391
Vancouver	39 045	25 340	6872
Total Interior	181 990	56 416	18 092
Total Coast	41 030	26 442	7263
Total British Columbia	223 020	82 858	25 355

1. Based on clear-cutting; selective harvesting taken as 2 selective ha equal 1 clear-cut in wet regions (i.e. Nelson and Vancouver) and 3 selective ha equal 1 clear-cut in dry Regions (i.e. Kamloops and Cariboo).

Source: British Columbia Ministry of Forests. Annual Report 1986/87

3. Market and policy scenarios to 2010

3.1 Dynamics of the forestry sector

Since World War II, rapid increases in demand for commodity grades of forest products have encouraged British Columbia producers to focus on volume rather than value. However, supply limitations in some regions now appear to challenge the development potential of the industry in British Columbia. These factors, coupled with continued growth and demand for high-value-added products, point to a restructuring of the British Columbia forest industry in the decade ahead.

Given rising market demand for market pulps, paper and paperboards, the key factor expected to dominate shifts in the British Columbia pulp and paper industry will be the increasing scarcity of available fibre. Each segment of the industry will be seeking a combination of mills to optimize the usage of this resource in the face of markets accessible to them.

3.1.1 Demand for British Columbia forest products

This section provides a demand forecast to 2010 with the most important underlying forces and trends shown for each major product group. Further analysis can be found in a six-volume, 20-year analysis and forecast of Canada's forest industry (Woodbridge, Reed and Associates 1988).

Wood products

The dominant forest product in British Columbia historically has been softwood lumber. Figure 3-1 shows shipments from British Columbia mills from 1961 to 1987, with obvious cyclical variation, the trend line rises for almost three decades. Figure 3-2 shows the trend in the major driving force of lumber consumption in North America - housing starts. This trend line shows the cyclical variation but not the steady rise of British Columbia lumber.

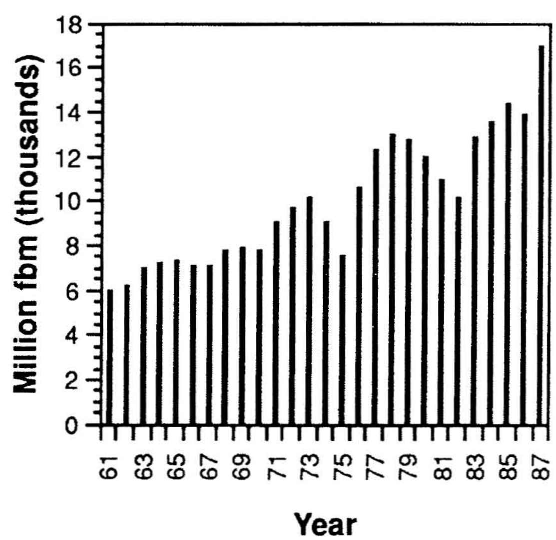

Figure 3-1. Lumber shipments from British Columbia, 1961 - 1987

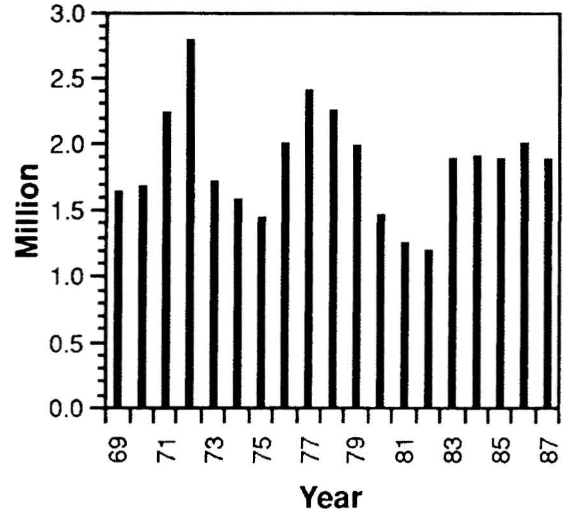

Figure 3-2. Housing starts in North America, 1969 - 1987

There are other factors in the total demand for lumber: for example, the size of house has been steadily rising over the past 15 years. Further, as the housing stock of North America ages, expenditures for renovations and repairs rises steadily. Significant quantities of wood products are used in these activities, and in normal home improvements and the do-it-yourself market.

The total demand for lumber has grown gradually in North America. More significantly, the British Columbia share of this market has expanded fairly rapidly in the past decade. The reasons for this relative expansion have been hotly debated during the recent Canada-United States lumber tariff dispute. The reasons advanced include the relative decline of the Canadian dollar, the high quality of British Columbia lumber species, and subsidy through low stumpage rates.

Demand for British Columbia lumber will at least be steady at 11 to 15 billion board feet over housing cycles for the next two decades. Of more interest is whether current high levels of production can be sustained for the long term, let alone rise significantly in the future under likely physical and economic scenarios.

Some significant shifts in the type of lumber sawn are likely. The Japanese and European markets have become increasingly important to the coast lumber industry, and even interior mills are now sawing for these markets. The type of lumber demanded is in a range of full sawn sizes, unplaned. In general this type of accurately sawn rough lumber produces less biomass residuals at the sawmill.

Further manufacture of lumber products, on the other hand, generates a higher proportion of shavings and sawdust. In general, it is expected that total British Columbia lumber shipments will have a higher average value due to an increase in quality. Further price increases are likely over the long term through a continued relative price increase for softwood sawn products made from fine-grain old-growth timber.

Demand for plywood moves through roughly the same patterns and is influenced by the same forces as the demand for lumber. One important difference is that wood-based panel consumption has shifted significantly in the direction of inexpensive composite boards (flakeboard, oriented strand board (OSB), and particleboard). The question of which panel and which market to pursue is basically one of corporate strategy. However, demand for British Columbia plywood will likely increase to 2010.

Other panel products are also manufactured on the British Columbia coast and in the interior and this production is already expanding (e.g. a new OSB plant is planned for the British Columbia interior, with a capacity of 240 000 m^3). In the long term, it is expected that the majority of these other panel shipments will be to nearby markets in Canada and the western United States.

Pulp and paper products

World demand for pulp and paper products of the type produced with British Columbia long-fibre wood resources rose steadily in the 1980s in spite of increased competition from short-fibered pulps (of which British Columbia also has a supply) and in spite of shifts in overall paper demand due to electronic communications and other social factors.

Demand in the Third World is expected to rise even more rapidly than in the developed world. However, the major moving forces in pulp and paper demand to 2010 will still be the developed market economies. Figures 3-3 and 3-4 show the latest forecast by the Food and Agriculture Organization of the United Nations (FAO) of demand in the developed market economies for the two types of pulp which make up the bulk of British Columbia production - mechanical wood pulps and chemical wood pulps. The forecast increase in consumption in North America alone by 2000 is twice the current total production in British Columbia; therefore, demand for pulp and paper will likely continue to increase.

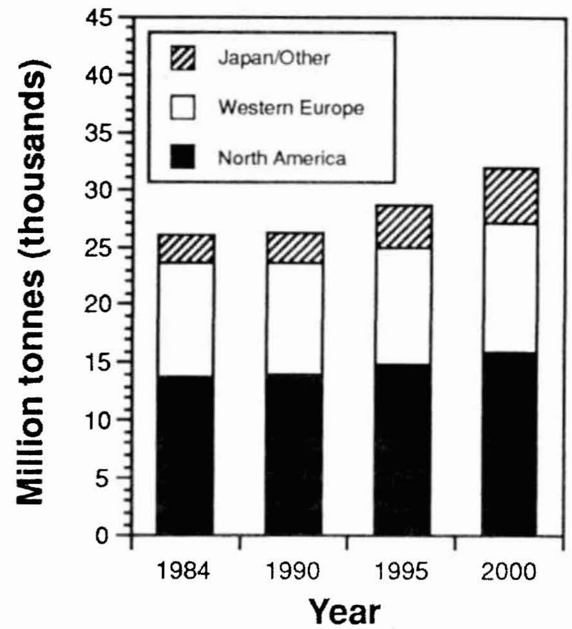

Figure 3-3. Mechanical woodpulp consumption in the developed market economies, 1984 - 2000

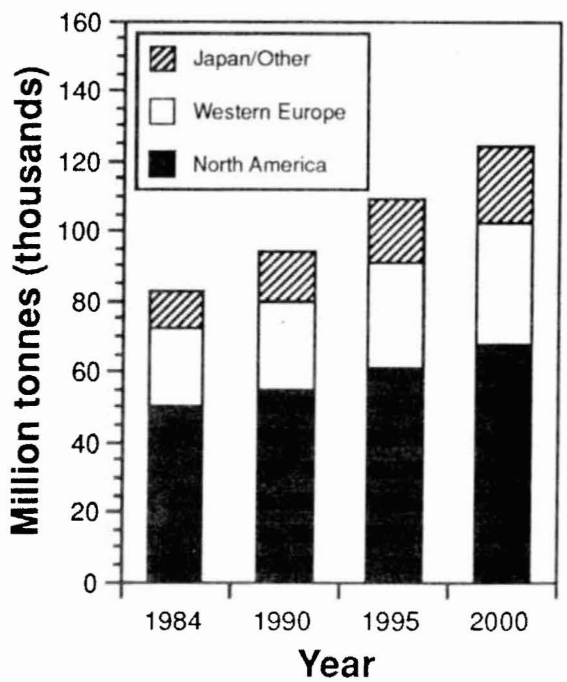

Figure 3-4. Chemical woodpulp consumption in the developed market economies, 1984 - 2000

Nonetheless, markets for British Columbia's fibre products are shifting and demand for several products will be dramatically different by the year 2010. Naturally, the dynamics of the market have implications for fibre utilization and ultimately for the available biomass in British Columbia. Some of these expected shifts will be dealt with in the following section on marketing of British Columbia fibre products, and they are made explicit in the forecast in Section 3.2.

3.1.2 Market strategy

British Columbia coast

Wood products

A major shift is already under way in the British Columbia coastal wood products industry. Rather than competing in the regular construction lumber and panel markets, which can generally be satisfied from sources of less expensive fibre, coastal sawmills are devoting more and more production to specifically manufactured products where quality of raw material and manufacturing are more important. This development aims to capitalize on the high-quality old-growth fibre still available in the coast region. In part, this development will overcome the increasing cost and decreasing availability of fibre. Both the sawmilling and the panel industry will focus on value rather than volume in the future. It seems unlikely that there will be large new mills other than replacements for existing operations.

A rising share of lumber production will be aimed at offshore markets in the European Economic Community and Japan. Sawing patterns will thus change to full size specifications used in those markets.

There has been a significant debate within the industry for two decades over the future of the coastal plywood industry. Its apparent demise has been announced (prematurely) several times. The general prospects for the industry will be changed significantly within the parameters of the free trade agreement with the United States. The British Columbia industry's response is not yet clear, but there are at least as many opportunities as risks in the new environment. Offshore markets for softwood plywood (European Economic Community and Japan) are expected to grow.

Market pulps

In the past most of the pulp and paper produced on the British Columbia coast was in commodity grades, with production being largely concentrated in integrated operations, where corporate group sawmills and company logging operations provided most of the raw material. All of the mills have deep-sea berths and are strategically positioned for offshore shipments, or shipments down the west coast of North America.

Most western United States mills are relatively well supplied with raw fibre, while freight costs for delivery of market pulp to the eastern and mid-western United States markets are high. As a result relatively small volumes of market pulp are shipped to North American paper mills.

Forward integration into more value-added manufacturing is expected to move the industry from market pulps towards paper products. The strategy for pulp producers on the coast is likely to be a combination of available options:

- integration of existing bleached kraft pulp (BKP) mills into paper product chains
- more affiliation of the current market BKP
- conversion from commodity BKP grades to more specialized grades
- closures of marginal chemical pulp mills
- expansion in chemical-thermomechanical pulp (CTMP) capacity.

Total BKP production on the coast is projected to decline as marginal producers convert operations to alternative higher-yield products. New BKP capacity is unlikely because of limited fibre supply and relatively high cost. Further affiliation of existing mills with paper producers is likely.

Conversion to wood-free printing and writing paper will be limited by a lack of the hardwood pulps needed for these grades on the coast. However, imports from the interior are a possibility if economics favor a paper mill on the coast.

This reduction of true market BKP shipments will have a regional bias. Shipments of BKP to Asia (notably Japan) will likely increase, but will be within affiliated channels as Asian paper companies strive for security of supply. Affiliations in western Europe will have somewhat the same effect. Shipments of market pulp to the rest of Canada and into the United States market will likely decline.

Affiliations are likely to go in both directions, that is, British Columbia coast producers can be expected to acquire paper mills in the United States and western European markets.

Newsprint

The British Columbia coastal newsprint industry is relatively modern and efficient. Consequently, a strategy of wholesale conversion to higher value added publication papers (based on mechanical pulp) is unlikely. British Columbia coastal producers are expected to continue the current course of upgrading existing capacity and generate only moderate growth in new capacity.

Longer-term projections indicate a marked increase in shipments to Asia (400 000 tonnes to Japan alone). Shipments to the western United States are expected to level off at a volume of about 1.4 million tonnes.

In the longer run, newsprint machine conversions to mechanical pulps which will produce higher-value printing papers will be greater than in the short term. Some existing newsprint machines will, by the end of the century, become obsolete in newsprint production but can be upgraded for production of other publication papers.

Marginal gains in newsprint capacity will be realized through further upgrades and in the form of two to three new newsprint machines.

Printing and writing papers

If coastal producers can capture only about 3% of the incremental demand for these high-value products in Asian markets, output could rise from about 400 000 tonnes to more than a million tonnes from this region.

Shipments to the United States market are also expected to rise significantly; a shift to more wood-free and less mechanical pulp is possible. The pressures to integrate pulpmills on the British Columbia coast to ensure their long-term viability is expected to generate some new wood-free capacity. Only minor amounts of British Columbia wood-free grades are expected to enter the Asian market, as Japan is a strong producer of wood-free product and this strength is expected to be maintained.

Thus, the British Columbia coast will develop its printing and writing industry through a balanced combination of BKP integration and newsprint conversion strategies. Fibre will likely become scarce in the region in the medium to long run, and this will place printing and writing papers in competition with newsprint for fibre. The coast area will import hardwood BKP from other regions (e.g. the British Columbia interior) as needed for some printing and writing wood-free grades.

Other paper and paperboard

Few major changes are expected in other grades of paper and paperboard. Limited promise is seen in the production of commodity grade unbleached sack kraft paper. It seems likely that a proportion of current British Columbia capacity will be upgraded to produce white top liner or multi-ply board which are expected to have good markets in the United States and Japan.

British Columbia interior

Wood products

The comparative advantage enjoyed by interior lumber mills due to relatively low logging costs and modern lumber mills will continue through the 1990s. However, there is unlikely to be any substantial increase in the availability of softwood sawlogs. Producers in this region will be compelled to improve yields and develop new grades and specifications that capitalize on the characteristics of the available log supply.

Most investment in large mills will likely be related to the more efficient production of commodity grades, or will go into specialty or remanufactured products. Some mills are expected to develop product lines that can be differentiated from normal commodity lumber to provide a buffer against low prices during the normal construction cycle.

Currently, 90% of plywood shipments from the interior of British Columbia go to the Canadian market. Under the pressures and opportunities of free trade, interior plywood mills are expected to further improve their operations. Expansion of the Canadian market is expected to be limited. But an export opportunity will exist for the interior as for the coast.

Substantial additional production of waferboard or OSB is expected to be installed in the interior of British Columbia over the next two decades, based on the hardwood (aspen) resource.

Fibre products

All of British Columbia interior pulp mills are dedicated to market grades, with some having major affiliations in North America and overseas paper companies. It is estimated that about 20% of annual shipments from the interior are directed to affiliated mills.

Interior pulp mills face a $30-35/tonne rail freight/terminal cost to transport their products to coastal ports for water-borne shipments. About 40% of shipments are directed to the North American market, where rail freight costs to the United States mid-west are comparable to offshore options.

In the interior region, fibre costs are more favorable for BKP production than on the British Columbia coast. However, transportation costs to the Pacific Rim are, in total, higher than for coastal mills. The region is also geographically distant from the in eastern Canada and the United States where market BKP is consumed.

The quantity of TMP and CTMP produced in the British Columbia interior is expected to grow significantly in the future. The availability of hardwood in the northeastern part of the region will allow a response to demands for CTMP and bleached hardwood kraft pulp (BHKP). Both these pulps will provide opportunities for increased dried and transferred shipments from this region as well as new possibilities for integration into paper production. Demand growth for printing and writing papers in the western United States will provide an opportunity for integration for some existing BKP producers.

Newsprint

The interior's first newsprint machine will come on line in 1989 as the market mechanical pulpmill at MacKenzie integrates forward into paper-making. The product will be directed to western United States and Pacific Rim markets. In the 1990s there is a good opportunity for a second interior newsprint machine to serve the same newsprint market area.

Towards the turn of the century fibre scarcity and rising fibre costs will move industry strategy towards the production of higher value-added printing papers from mechanical pulps as well as newsprint.

Printing and writing

Printing and writing capacity (zero at present) is expected to develop to about 400 000 tonnes in the interior over the next two decades. No wood-free pulp or paper capacity is expected to develop. Integration is expected into mixed fibre grades with significant CTMP pulps. Such fully integrated operations can produce wood-containing paper grades efficiently, which will offset high transportation costs from the region.

3.2 Fibre utilization for British Columbia - outlook for 2010

3.2.1 Scenario I: AAC expandable by 2010

This scenario envisages that British Columbia forest resources can meet (on a sustained basis) a likely total forest industry demand for fibre of over 90 million m^3 inside bark. It should be noted that this is not official Ministry of Forests policy. The current allowable harvest set by the Chief Forester for regulated forest lands (1988) is 72.2 million m^3/annum. The additional wood harvested in 1987 came from unregulated lands (12.6 million m^3) and allowances for short-run fluctuation in regulated lands (5.7 million m^3).

However, with changes in the level of investments in silviculture in British Columbia and utilization of timber species and timber lands not currently economically accessible, as defined in the regulated AAC, it may be feasible to sustain a harvest of 90 million m^3 or more in British Columbia.

Industry capacity clearly could exceed this level by 2010, unless there are major drop-outs from the current industry.

Wood products

British Columbia coast

There is effectively little potential for an increased log harvest on the coast. High quality sawlog material will slowly decline in the total coastal harvest with an increase in the proportion of lower-quality and second-growth timber, much of which is more suitable for pulp than lumber. The sawmilling focus, as already outlined, is expected to be on value rather than volume in the future.

It is unlikely that there will be major new wood products mills other than replacements for existing operations. It is expected that improved technology will provide better utilization of the input logs to produce a higher proportion of lumber and solid wood products from each log. This trend will be countered by a gradual decline in log size; thus, even a maintenance of current solid wood product per m^3 sawn will represent considerable improvement in technology.

British Columbia coastal plywood and panelboard production is expected to remain relatively static to 2010. The major uncertainty in this industry at present is the impact of the free trade agreement with the United States. In the short run it will create new problems for the coast plywood industry, but in the long run will provide new opportunities.

British Columbia interior

The demand for commodity grades of lumber in North America is expected to remain strong, in the long run, and represents the largest fraction of the interior production. It is expected that most investment in interior sawmills will be related to more efficient production of commodity grades. However, some investment is expected in the manufacture of specialty or remanufactured products. The industry will also be constrained by a gradual decline of the higher-quality logs and a concomitant increase of smaller and lower-quality logs.

Plywood shipments from the interior are expected to shift their current emphasis on the Canadian market to a broader North American perspective. Opportunities for offshore expansion may also emerge by 2010.

Substantial additional production of waferboard or OSB is expected in the interior of British Columbia by 2010. New mills are expected to focus on the hardwood (aspen) resources of the northeast interior.

Pulp and paper products

British Columbia coast

Total BKP production is projected to decline by 2010. A significant expansion is forecast for production of CTMP products.

A combination of strategies and market reactions is expected to induce additions to coastal newsprint production of almost 1 million tonnes by 2010. Some newsprint machines are expected to convert to production of other printing papers based on mechanical pulps.

Output of printing and writing papers on the British Columbia coast is expected to increase by over half a million tonnes by 2010. New opportunities in the Asian markets for printing and writing paper which will increase demand by over 20 million tonnes over the period are expected to be a major factor in this increase.

The British Columbia coast will develop its printing and writing industry base through a balanced combination of BKP integration and newsprint conversion. The region is expected to become constrained by fibre supply before 2010, and this will generate increasing competition for fibre between these higher-value papers and newsprint.

British Columbia interior

Production of bleached kraft pulps is expected to be held relatively flat in the British Columbia interior by intense competition for fibre with lumber mills. Demand growth for printing and writing papers in the western United States will provide an opportunity for integration for some existing interior market BKP producers.

The availability of a significant hardwood resource in the northern and eastern part of the region will provide a response to demand-led growth in CTMP and BHKP. Opportunities for expansion of shipments from this region will be provided as well as new possibilities for integration into paper manufacture. Total production of pulp should rise slowly in the region. The first newsprint mill in the interior will have its product directed to western United States and Pacific Rim markets in the 1990s. By 1995 there is expected to be a solid opportunity for a second interior newsprint machine to serve this same market area.

Beyond 1995, fibre scarcity and rising real fibre costs are expected to dictate a swing towards the production of higher value-added printing papers and newsprint based on mechanical pulps. Thus, a new capacity for about 400 000 tonnes of printing and writing papers is expected to develop in the British Columbia interior.

Forecast British Columbia fibre use in 2010 - Scenario 1

The basic parameters of this forecast are shown in Table 3-1. This table lists the major forces and events that are expected to shape the forest industry of British Columbia over the next 20 years.

The resolution of all forces is forecast through:

1. Predicted log inputs to each segment of the industry (reflecting expected ability to command these inputs through bidding for them in relatively open log markets).

2. Predicted coefficients of transformation in each industry segment, which yield specified amounts of solid products, chips, sawdust, miscellaneous hog material and bark.

The results of these explicit forecasts are shown for the coast and interior regions in Table 3-2. The resultant totals for the province of British Columbia are shown in Table 3-3.

It can be seen that both coast and interior lumber mills are still the largest single users of log inputs in their respective regions. In spite of dramatic changes in technology that are likely by 2010, no other material is expected to undermine the dominant position of lumber in small structures.

One fairly likely event is not quantified - that is the potential for radical changes in cutting technology. New forms of laser or particle cutting

Table 3-1. Basic parameters of forecast British Columbia forest industry fibre utilization, 2010

I. Wood products

Markets/demand

Sawnwood
- increased share to Japan and other Pacific Rim
- increased total volume of full-sawn sizes, interior & coast
- increased total volume of specialty and reman products

Wood-based panels
- increased competition in Canadian plywood market
- increased total volume of flakeboard and OSB
- concentration on Western North America markets for fibre panels
- North America, EEC and Pacific Rim markets for plywood
- improved designs into engineered structural products

Technology

Sawmills
- more accurate green sawing
- somewhat thinner saws
- improved small-log technologies
- new log breakdown technologies likely (e.g. laser or particle-based) but not explicit in forecast

Plymills
- improved automatic peeling, layup, finishing
- improved adhesives and fasteners
- improved utilization of veneer wastes in composites

Shingle/shake mills
- improved small-scale automated handling/splitting

II. Pulp/paper products

Markets/demand

Bleached kraft pulp
- strong world demand vs. increasing costs production/transport

Mechanical pulps
- increasing demand through high value publication papers

Newsprint
- strong world demand vs. increasing costs production/transport

Paper and paperboard
- increasing demand for top grades of liner and paperboard
- strong demand for printing and writing papers in North America and Japan

Technology

Chemical pulp mills
- new chemical/biochemical approaches likely (not explicit in forecast)
- improved emission technologies, higher costs

Mechanical pulps
- improved thermo- and chemi-thermomechanical pulping

Paper and paperboard
- refinements in blending (long fibre/short fibre/other)
- improved recycling technologies

III. Wood-based energy

Markets/demand

- increasing prices of fossil fuels
- increasing demands for improved urban waste disposal systems

Technology

- improved fuel production technologies (dried, pelletized)
- improved mass burning technologies including municipal waste
- improved methods of use in process heat (drying, recycling) in forest and other industries

Table 3-2. Scenario I: Forest industry fibre consumption in 2010 (million m^3), British Columbia coast and interior

	Coast region			Interior region		
	2010 coeff*	Solid volume	Log use forecast	2010 coeff	Solid volume	Log use forecast
Sawmill products						
Sawnwood	0.51	9.4	18.4	0.45	21.6	48.1
Chips	0.30	5.6		0.33	16.0	
Sawdust	0.12	2.2		0.09	4.0	
Planer/reman	0.04	0.7		0.09	4.5	
Misc hog material	0.02	0.3		0.03	1.5	
Kiln loss	0.01	0.2		0.01	0.5	
Inside bark total	1.00	18.4		1.00	48.1	
Bark	0.11	2.0		0.11	5.3	
Total sawmills		20.4			53.4	
Veneer/plymills						
Veneer/plywood	0.53	0.8	1.5	0.52	1.2	2.4
Chips	0.27	0.4		0.29	0.7	
Misc hog material	0.13	0.2		0.12	0.3	
Kiln loss	0.07	0.1		0.07	0.2	
Inside bark total	1.00	1.5		1.00	2.4	
Bark	0.13	0.2		0.13	0.3	
Total plymills		1.7			2.7	
Cedar roofing products						
Shingles	0.14	0.2	1.5	0.14	0.1	0.4
Shakes	0.35	0.5		0.35	0.1	
Chips	0.25	0.4		0.25	0.1	
Sawdust	0.15	0.2		0.15	0.1	
Misc hog material	0.11	0.2		0.11	0.0	
Inside bark total	1.00	1.5		1.00	0.4	
Bark	0.11	0.2		0.11	0.0	
Total sha/shingle mills		1.7			0.4	
Misc wood products						
Poles/piling	0.55	1.0	1.9	0.50	0.3	0.6
Log exports	0.34	0.7		0.20	0.1	
Misc other	0.11	0.2		0.30	0.2	
Inside bark total	1.00	1.9		1.00	0.6	
Bark	0.11	0.2		0.11	0.1	
Total misc wood prod use		2.1			0.7	
Total logs into wood prod		23.3			51.5	
Total bark wp logs		2.6			5.7	

Table 3-3. Scenario 1: Forest industry fibre consumption in 2010 (million m^3), total British Columbia

	Total province		
	2010 coeff	Solid volume	Log use forecast
Sawmill products			
Sawnwood	0.47	31.0	66.5
Chips	0.32	21.6	
Sawdust	0.09	6.2	
Planer/reman	0.08	5.2	
Misc hog material	0.03	1.8	
Kiln loss	0.01	0.7	
Inside bark total	1.00	66.5	
Bark	0.11	7.3	
Total sawmills		73.8	
Veneer/plymills			
Veneer/plywood	0.52	2.0	3.9
Chips	0.28	1.1	
Misc hog material	0.13	0.5	
Kiln loss	0.07	0.3	
Inside bark total	1.00	3.9	
Bark	0.13	0.5	
Total plymills		4.4	
Cedar roofing products			
Shingles	0.14	0.3	2.0
Shakes	0.35	0.7	
Chips	0.25	0.5	
Sawdust	0.15	0.3	
Misc hog material	0.11	0.2	
Inside bark total	1.00	2.0	
Bark	0.11	0.2	
Total sha/shingle mills		2.2	
Misc wood products			
Poles/piling	0.54	1.3	2.5
Log exports	0.31	0.8	
Misc other	0.15	0.4	
Inside bark total	1.00	2.5	
Bark	0.11	0.3	
Total misc wood prod use		2.8	
Total logs into wood prod		74.9	
Total bark wp logs		8.3	

Table 3-3 (cont'd)

	Total province		
	2010 coeff	Solid volume	Log use forecast
Groundwood mills			
Ground fibre	0.71	0.7	1.0
Chips	0.22	0.2	
Sawdust	0.07	0.1	
Inside bark total	1.00	1.0	
Bark	0.11	0.1	
Total groundwood mills		1.1	
Roundwood chippers			
Chips	0.95	19.2	20.2
Misc hog material	0.05	1.0	
Inside bark total	1.00	20.2	
Bark	0.11	2.2	
Total chippers		22.4	
Total logs into fibre mills		21.2	
Total bark fibre logs		2.3	
Total wood harvest inside bark		96.1	
Total bark all logs		10.6	

*******Summary*******	Total province	
	1987	2010
Total wood products	32.5	34.0
Misc roundwood WP	2.0	1.7
Total chips WP	28.2	23.2
Chips roundwood	4.8	19.4
Groundwood fibre	1.6	0.7
Total sawdust/SH	14.5	11.8
Misc hog material	3.0	3.5
Total bark BC	9.8	10.5
Kiln losses	1.7	1.0
Log exports	3.4	0.8
Bark (export)	0.4	0.1
Total production	100.8	106.7

Table 3-4. Production of pulp, paper and paperboard (000 m^3 of fibre) in 2010

	Coast			Interior			Total		
	SW	HW	Total	SW	HW	Total	SW	HW	Total
Paper and Paperboard									
Newsprint	7375	0	7375	2655	0	2655	10 030	0	10 030
Printing and writing	1869	200	2069	788	742	1530	2657	942	3599
Others	1800	0	1800	438	21	459	2238	21	2259
Total	11 044	200	11 244	3881	763	4644	14 925	963	15 888
Dried and Transferred Pulp									
Chemical	9280	0	9280	9308	1210	10 518	12 296	1210	13 508
Mech/Ch Mech	0	0	0	3938	1900	5838	3938	1900	5838
Total	9280	0	9280	13 246	3110	16 356	16 234	3110	19 344

seem likely to become economic towards the end of the next 20 years. However, as there are many problems and many higher-value applications yet to be served, the nature and impact of these technologies in wood products is still highly uncertain. Therefore it has not been included in the explicit forecast of sawmill coefficients.

Both sawmills and plymills obtain slightly more solid final product from slightly lower log inputs. This implies significant further refinements of mechanical peeling technologies (given that the average size of log will decline throughout the period).

Pulp mill usage expands as shown in Table 3-4. Raw fibre mills (groundwood and roundlog chippers) consume over 20 million m^3 of roundwood, a rise of over 200% over 1987 levels.

The forecast fibre balance in byproducts in 2010 under this scenario is shown in Table 3-5.

Chips are roughly in balance, with virtually no exportable surplus. Sawdust and shavings still show a surplus as pulping generally has continued to use expanded inputs of small roundwood (see scenario 2).

Coast millsite burnables are also nearly all used in process heat at wood product and fibre mill complexes. The interior region still shows a likely surplus of burnables of about 12 million m^3 in 2010.

3.2.2 Scenario 2: AAC held constant to 2010

This scenario envisages that the Ministry of Forests will not substantially raise the AAC from British Columbia regulated forests from the present levels before 2010, and that the total cut will approximate 75 million m^3. Pressures from environmentally concerned groups and citizens are the most likely dominant force in such restraint.

Questions regarding resources on the ground, soil conservation, growth and yield of managed forests, and of economic access are forecast to be answered in favor of a more conservative approach in this scenario, compared to scenario No. 1.

Table 3-5. Scenario I: Forecast of production and utilization of byproducts (million m^3) in 2010

	Coast			Interior			B.C. total		
	SW	HW	Total	SW	HW	Total	SW	HW	Total
I. Production									
Chips, Wood Prod. Industry	6.40	0.09	6.49	16.80	-	16.80	23.20	0.09	23.29
Pulp roundwood	10.40	0.19	10.59	5.13	3.87	9.00	15.53	4.06	19.59
Sawdust/shavings	3.20	-	3.20	8.60	-	8.60	11.80	-	11.80
Misc. hog material	1.20	0.10	1.30	2.20	0.10	2.30	3.40	0.20	3.60
Bark	3.80	0.02	3.82	6.70	-	6.70	10.50	0.02	10.52
Total byproducts	25.00	0.40	25.40	39.43	3.97	43.40	64.43	4.37	68.80
II. Utilization of byproducts									
Chips/groundwood									
Pulp industry	19.73	2.00	19.93	16.36	3.87	20.23	36.09	4.07	40.16
Chip exports	-	-	-	5.57	-	5.57	5.57	-	5.57
			19.93			25.80			45.73
Sawdust/shavings									
Pulp industry	0.59	-	0.59	0.77	-	0.77	1.34	-	1.36
Panels		0.28	-	0.28	0.17	-	0.17	0.45	- 0.45
Miscellaneous	0.33	-	0.33	0.25	-	0.25	0.58	-	0.58
Exports	0.10	-	0.10	-	-	0.00	0.10	-	0.10
			1.30			1.19			2.49
Residual hog fuel burned									
Energy use	5.50	0.20	5.70	5.00	-	5.00	10.50	0.20	10.70
Exports	0.25	-	0.25	0.27	-	0.27	0.52	-	0.52
			5.95			5.27			11.22

III. Surplus of byproducts

	Coast total	Interior total	Total province
Chips	0.59 *	0.77	1.36
Sawdust/shavings not used	1.90	7.41	9.31
Unburned resid. hog **	-0.83	3.73	2.90
byproducts surplus	1.66	11.91	13.57

* After 2.85 million m^3 shown in Interior chip exports received.
The remaining 2.72 million m^3 from the Interior expected to be exported.
The 0.59 million m^3 shown results from sawdust substitution.

** Misc. hog and bark less energy use (burning) and exported.
The shortfall would likely be made up by sawdust.

Basic industry forecast

The underlying forces outlined in Table 3-1 are expected to function in roughly the same manner, regardless of British Columbia's AAC policy. There will no doubt be some local variations due to increasing scarcity of fibre of all types.

Inter-industry adjustments within British Columbia will be the most significant likely changes from scenario 1. It is expected that the wood products industry will be slightly smaller in 2010 and slightly more efficient in terms of final product per m^3 of log input.

However, the impact of declining log size works against marked change in sawmill and plymill manufacturing coefficients. More small logs will enter wood product mills; therefore, a higher proportion of chips will be produced.

Roundwood inputs to chipper mills (from the official allowed harvest fraction) will be lower than in scenario 1. However, it is anticipated that salvage from allowed logging residues will increase significantly under the conditions of scenario 2. Table 3-6 shows the forecast industry inputs and outputs under scenario 2 with the 1987 base provided for comparison. Table 3-7 shows the combined British Columbia totals.

No attempt has been made to simulate the regional economic impacts of these different forest industry futures in various regions of British Columbia. Obviously this factor will weigh heavily in Ministry of Forests policy decisions, to the degree that they can affect industry investments and activities.

The total wood product solid output is forecast to decline by about 13% from the output levels of 1987. The total value-added in wood products manufacture is forecast to be significantly higher and the total employment (including remanufacturing) is also expected to be significantly higher.

Fibre balance

Table 3-8 provides a summary of the expected fibre balance and byproducts under scenario 2. The British Columbia coast pulp and paper industry as forecast would be 3 million m^3 short of raw wood inputs even after pulping 76% of coast-generated sawdust and shavings.

The British Columbia interior would be close to a balanced state in chip production and consumption but would have 1 million m^3 to ship to the coast. The interior sawdust and shavings surplus would be of great interest to both regional industries. An appropriate market balance would likely be struck which would see a fraction of this material pulped in the interior, together with shipment of some chips and perhaps some sawdust to the coast.

Residual biomass at millsites

The residual biomass at millsites suitable for burning will also be in much closer balance in 2010. Less bark is expected to be delivered to mill yards through a combination of factors including smaller trees and new logging technologies (e.g., mechanized delimbers which remove a significant fraction of tree bark in the landing).

The coast is expected to burn all suitable residues and at a slightly lower consumption level than in 1987. The British Columbia interior is forecast to have a substantial surplus in 2010 if sawdust is not being pulped in significant quantities; however, this seems unlikely. Most interior whitewood sawdust is expected to be pulped by 2010 under scenario 2, with a large proportion being transferred to the coast.

If, say, 50% of surplus sawdust and shavings as shown is suitable for pulping and in a feasible location, this would provide about 3 million m^3 of roundwood equivalent to fill the coast shortfall. This would leave a surplus of burnables of some 5.0 million m^3 in the British Columbia interior.

Accessible logging residues

Under scenario 2, if sufficient sawdust cannot be transferred to the coast from the interior to cover the chip deficit, additional material (outside the regulated AAC) can be obtained from logging residues left in the woods under 1987 standards.

It is forecast as part of scenario 2 that some 2.4 million m^3 of salvage material can be obtained from expected coast logging areas at that time at an economic cost. At least 1.5 million m^3 of this material would be suitable for pulping.

The initiation of large-scale salvage operations on the coast will also deliver a significant quantity of material not suitable for pulping along with the clean fibre. These non-pulp salvage materials will add to the burnable fraction available on the coast.

There are also other opportunities in the interior of the province to obtain further material from each hectare logged under conditions of fibre scarcity. These may contribute to the total provincial pulp fibre balance and could further add to the burnable surplus in the interior.

Table 3-6. Scenario 2: Forest industry fibre consumption in 2010 (million m^3), British Columbia coast and interior

	Coast region			Interior region		
	2010 coeff*	Solid volume	Log use forecast	2010 coeff	Solid volume	Log use forecast
Sawmill products						
Sawnwood	0.40	7.0	17.6	0.40	17.3	43.2
Chips	0.39	6.8		0.40	17.3	
Sawdust	0.12	2.1		0.11	4.8	
Planer/reman	0.06	1.1		0.06	2.6	
Misc hog material	0.02	0.4		0.02	0.6	
Kiln loss	0.01	0.2		0.01	0.6	
Inside bark total	1.00	17.6		1.00	43.2	
Bark	0.11	1.9		0.11	4.8	
Total sawmills		19.5			48.0	
Veneer/plymills						
Veneer/plywood	0.60	0.9	1.4	0.60	1.2	2.1
Chips	0.23	0.3		0.23	0.5	
Misc hog material	0.08	0.1		0.08	0.2	
Kiln loss	0.09	0.1		0.09	0.2	
Inside bark total	1.00	1.4		1.00	2.1	
Bark	0.13	0.2		0.13	0.3	
Total plymills		1.6			2.4	
Cedar roofing products						
Shingles	0.14	0.2	1.5	0.14	0.1	0.4
Shakes	0.35	0.5		0.35	0.1	
Chips	0.25	0.4		0.25	0.1	
Sawdust	0.15	0.2		0.15	0.1	
Misc hog material	0.11	0.2		0.11	0.0	
Inside bark total	1.00	1.5		1.00	0.4	
Bark	0.11	0.2		0.11	0.0	
Total sha/shingle mills		1.7			0.4	
Misc wood products						
Poles/piling	0.92	0.5	0.5	0.60	0.4	0.6
Log exports	0.00	0.0		0.00	0.0	
Misc other	0.08	0.0		0.40	0.2	
Inside bark total	1.00	0.5		1.00	0.6	
Bark	0.11	0.1		0.11	0.1	
Total misc wood prod use		0.6			0.7	
Total logs into wood prod		21.0			46.3	
Total bark WP logs		2.4			5.2	

Table 3-6. (cont'd)

	Coast region			Interior region		
	2010 coeff*	Solid volume	Log use forecast	2010 coeff	Solid volume	Log use forecast
Groundwood mills						
Ground fibre	0.71	0.7	1.0	0.71	0.0	0.0
Chips	0.22	0.2		0.22	0.0	
Sawdust	0.07	0.1		0.07	0.0	
Inside bark total	1.00	1.0		1.00	0.0	
Bark	0.11	0.1		0.11	0.0	
Total groundwood mills		1.1			0.0	
Roundwood chippers						
Chips	0.95	2.9	3.1	0.95	3.5	3.7
Misc hog material	0.05	0.2		0.05	0.2	
Inside bark total	1.00	3.1		1.00	3.7	
Bark	0.11	0.3		0.11	0.4	
Total chippers		3.4			4.1	
Total logs into fibre mills		4.1			3.7	
Total bark fibre logs		0.4			0.4	
Total wood harvest inside bark		25.1			50.0	
Total bark all logs		2.8			5.6	

*******Summary*******	Coast 1987	Coast 2010	Interior 1987	Interior 2010
Total wood products	10.4	8.6	21.0	18.7
Misc roundwood WP	0.7	0.5	1.3	0.6
Total chips WP	8.5	7.5	19.7	17.9
Chips roundwood	3.8	3.1	1.0	3.5
Groundwood fibre	1.6	0.7	0.0	0.0
Total sawdust/SH	4.7	3.5	9.8	7.5
Misc hog material	1.4	0.9	1.6	1.0
Total bark BC	4.1	2.8	5.7	5.6
Kiln losses	0.4	0.3	1.3	0.8
Log exports	3.3	0.0	0.1	0.0
Bark (export)	0.4	0.0	0.0	0.0
Total production	39.3	27.9	61.5	55.6

* Coefficient: the proportion of one m^3 of debarked wood recovered in product or by-product; bark is in addition.

Table 3-7. Scenario 2: Forest industry fibre consumption in 2010 (million m^3), total British Columbia

	Total province 2010 coeff	Total province Solid volume	Log use forecast
Sawmill products			
Sawnwood	0.38	24.3	60.8
Chips	0.35	24.1	
Sawdust	0.13	6.9	
Planer/reman	0.09	3.7	
Misc hog material	0.04	1.0	
Kiln loss	0.01	0.8	
Inside bark total	1.00	60.8	
Bark	0.11	6.7	
Total sawmills		67.5	
Veneer/plymills			
Veneer/plywood	0.60	2.1	3.5
Chips	0.23	0.8	
Misc hog material	0.08	0.3	
Kiln loss	0.09	0.3	
Inside bark total	1.00	3.5	
Bark	0.13	0.5	
Total plymills		4.0	
Cedar roofing products			
Shingles	0.14	0.3	1.9
Shakes	0.35	0.6	
Chips	0.25	0.5	
Sawdust	0.15	0.3	
Misc hog material	0.11	0.2	
Inside bark total	1.00	1.9	
Bark	0.11	0.2	
Total sha/shingle mills		2.1	
Misc wood products			
Poles/piling	0.75	0.9	1.1
Log exports	0.00	0.0	
Misc other	0.25	0.2	
Inside bark total	1.00	1.1	
Bark	0.11	0.2	
Total misc wood prod use		1.3	
Total logs into wood products		67.3	
Total bark WP logs		7.6	

Table 3-7. (cont'd)

	Total province		
	2010 coeff	Solid volume	Log use forecast
Groundwood mills			
Ground fibre	0.71	0.7	1.0
Chips	0.22	0.2	
Sawdust	0.07	0.1	
Inside bark total	1.00	1.0	
Bark	0.11	0.1	
Total groundwood mills		1.1	
Roundwood chippers			
Chips	0.95	6.4	6.8
Misc hog material	0.05	0.4	
Inside bark total	1.00	6.8	
Bark	0.11	0.7	
Total chippers		7.5	
Total logs into fibre mills		7.8	
Total bark fibre logs		0.8	
Total wood harvest inside bark		75.1	
Total bark all logs		8.4	

*******Summary*******	Total province	
	1987	2010
Total wood products	31.4	27.3
Misc roundwood wood products	2.0	1.1
Total chips wood products	28.2	25.4
Chips roundwood	4.8	6.6
Groundwood fibre	1.6	0.7
Total sawdust/shavings	14.5	11.0
Misc hog material	3.0	1.9
Total bark BC	9.8	8.4
Kiln losses	1.7	1.1
Log exports	3.4	0.0
Bark (export)	0.4	0.0
Total production	100.8	83.5

Table 3-8. Scenario 2: Forecast production and utilization of byproducts in 2010 (million m^3)

	Coast			Interior			B.C. total		
	SW	HW	Total	SW	HW	Total	SW	HW	Total
I. Production									
Chips, Wood Prod. Industry	7.41	0.09	7.50	17.90	-	17.90	25.31	0.09	25.40
Pulp roundwood	3.61	0.19	3.80	-	3.50	3.50	3.51	3.69	7.30
Sawdust/shavings	3.50	-	3.50	7.50	-	7.50	11.00	-	11.00
Misc. hog material	0.80	0.10	0.90	0.90	0.10	1.00	1.70	0.20	1.90
Bark	2.78	0.02	2.80	5.60	-	5.60	8.38	0.02	8.40
Total byproducts	18.10	0.40	18.50	31.90	3.60	35.50	49.90	4.00	54.00
II. Utilization of byproducts									
Chips/groundwood									
Pulp industry	17.66	0.20	17.86	16.73	3.50	20.23	34.39	3.70	38.09
Chip exports	-	-	-	1.17	-	1.17	1.17	-	1.17
			17.86			21.40			39.26
Sawdust/shavings									
Pulp industry	2.66	-	2.66	0.77	-	0.77	3.43	-	3.43
Panels	0.28	-	0.28	0.17	-	0.17	0.45	-	0.45
Miscellaneous	0.06	-	0.06	0.25	-	0.25	0.31	-	0.31
Exports	-	-	0.00	-	-	0.00	-	-	0.00
			3.00			1.19			4.19
Residual hog fuel burned									
Energy use	4.00	0.12	4.12	5.00	-	5.00	9.00	0.12	9.12
Exports	-	-	0.00	0.27	-	0.27	0.27	-	0.27
			4.12			5.27			9.39

III. Surplus of byproducts

	Coast total	Interior total	Total province
Chips	-2.73 *	0.77	-1.96
Sawdust/shavings not used	0.50	6.31	6.81
Unburned resid. hog	-0.42 **	1.33	0.91
Byproducts surplus	-2.65	8.41	5.76

* After 1.17 million m^3 shown in Interior chip exports transferred to the coast. The shortfall would have to be made up from foregoing wood products, by better utilization/extraction from logging, or very likely by importing more pulpable sawdust from the interior.

** Coast would likely be made up by sawdust/shavings and/or hog transfers from the interior.

4. Energy demand and current sources

4.1 Energy use patterns by sector

This section examines the types of energy used in each major sector of the British Columbia economy. Some important end uses and characteristics of these end uses that affect the potential use of biomass are also examined. Table 4-1 shows the quantities and types of energy that were used in each major sector of demand during 1986.

4.1.1 Industrial sector

The industrial sector accounted for about 400 PJ, about 45% of total energy use in the province during 1986. The forest industry used about 300 PJ, or 75% of total industrial energy use. About 80 PJ of this total was supplied by wood wastes, and 119 PJ was supplied by spent pulping liquor during 1986. Thus, the forest industry of British Columbia, by far the largest user, is already two-thirds self-sufficient in energy supply.

Biomass energy use is concentrated within the forest sector for a number of reasons:

- Wood wastes are generated as on-site byproducts that must be disposed of in any case.
- Forest products plants, particularly pulp and paper mills, are of a sufficiently large scale to permit more economic utilization of these residues than in many other smaller industries.
- Forest products manufacturing is typically located on large sites outside the urbanized core of communities. Such sites are much more suitable for wood waste storage and utilization than those of other industries which are smaller and located within urban areas.

For these reasons, the examination of opportunities for increased biomass use within the industrial sector is focused on forest industries: pulp and paper mills, sawmills, plywood and veneer mills, and composite board mills.

Substantial decreases in natural gas and refined petroleum product prices in recent years have reduced the economic incentive for increased use of wood wastes in the forest sector, resulting in a levelling off of wood waste utilization for energy purposes, even though there is a large surplus of mill residues in many parts of the province where forest industries continue to purchase fuels and electricity.

During 1986, the industrial sector used 73 PJ of natural gas, 53 PJ of refined petroleum products, and 88 PJ of electricity. The forest sector alone accounted for about 25 PJ of natural gas, 26 PJ of refined petroleum products, and 38 PJ of hydroelectricity use. Most of the refined petroleum products used in the industrial sector were in the form of either diesel fuel (24 PJ) or heavy fuel oil (23 PJ).

Heavy fuel oil in the industrial sector is concentrated in pulp and paper mills in the south coastal region of British Columbia where more than 20 PJ were used in 1986. While a substantial surplus of hog fuel (470 000 GPU) was shown to be available in the Reid Collins (Appleby 1988) study, much of this surplus is beyond economic reach of south coastal mills, given currently low heavy fuel oil prices of less than $2.25 per GJ. In any case, the present surplus could disappear completely in a low lumber production year (see Section 3).

Forest industries generated about 3 PJ of electricity from wood wastes, 4 PJ from spent pulping liquor, and 2 PJ from hydroelectric installations during 1986, while purchasing about 38 PJ. With the surplus of mill residues that exists throughout most of the interior, there is clearly long-term technical potential for the increased use of biomass as a fuel for thermal-electric generation.

To date, the development of the cogeneration potential in the forest industry has been hindered by a combination of low hydroelectricity rates and the inability to sell surplus power back to B.C. Hydro on favorable terms. However, the regulatory environment, as discussed in Section 6.2, is currently undergoing changes which should encourage the development of more of this cogeneration potential within the forest sector.

One continuing problem of power generation is the servicing of small remote communities. Although relatively small in total, it is costly in local terms. New systems of gasification of wood with internal combustion in special engines appears to offer promise of economic biomass use in future. Delivery cost of diesel fuels is very high to many of these communities.

4.1.2 Transportation sector

This sector includes all forms of transport: road, rail, ship, air, and pipeline. Thus, the fuel types vary widely and include the following:

Fuel type	1986 Use (PJ)
Gasoline	125
Diesel	51
Heavy fuel oil	5
Aviation fuel	20
Natural gas	1
Propane	3
Total	205

Table 4-1. Energy demand in British Columbia, 1986

Sector	Nat gas	RPP	ELC	Wood fuels	Pulp liq	Coal coke & oth	Still gas	Total
	Petajoules							
Residential	66	17	39	32				154
Commercial	35	12	35					82
Industrial	73	53	88	77	115	7		413
Transport	1	204						205
Non-energy						23		23
Pipe & trans. lines	9		15					24
Total secondary	184	286	177	109	115	30		901
Converted to elect.	3	3		3	4			13
Used in energy supply ind.		2				5	15	22
Less elec. gen. from fossil fuels			7					7
Primary demand	187	291	170	112	119	35	15	929
	Percent of total							
Residential	7.1	1.8	4.2	3.4				16.6
Commercial	3.8	1.3	3.8					8.8
Industrial	7.9	5.7	9.5	8.3	12.4	0.8		44.5
Transport	0.1	22.0						22.1
Non-energy						2.5		2.5
Pipe & trans. lines	1.0		1.6					2.6
Total secondary	19.8	30.8	19.1	11.7	12.4	3.2		97.0
Converted to elect.	0.3	0.3		0.3	0.4			1.4
Used in energy supply ind.		0.2		0.0	0.0	0.5	1.6	2.4
Less elec. gen. from fossil fuels			0.8					0.8
Primary demand	20.1	31.3	18.3	12.1	12.8	3.8	1.6	100.0

RPP = Refined petroleum products, including gasoline, diesel fuel, light and heavy fuel oils, aviation gasoline and turbo fuel, and liquified petroleum gases.

ELC = Thermal and hydro electricity.

Wood Fuels include roundwood used by the residential sector, as well as hog fuel (sawdust, shaving, bark, chip fines, etc.).

Sources: British Columbia Ministry of Energy, Mines, and Petroleum Resources. 1987; Statistics Canada. 1986.

Diesel fuel is also used in off-highway mobile equipment and in stationary engines in forestry, mining and construction. In total, 51 PJ of diesel were consumed in British Columbia during 1986. Thus, there is a large potential market for alcohol fuels from biomass in British Columbia, given an adequate price spread between the cost of producing these fuels and the price of gasoline and diesel fuel. The imposition of more stringent emission standards could have significant impact, as alcohol fuels have the potential for considerably reduced emissions.

4.1.3 Residential sector

The residential sector includes all types of private dwelling units, including apartments, row houses, and mobile homes, as well as single family dwellings. This sector accounted for about 17% of total energy use in the British Columbia during 1986.

Natural gas (66 PJ) is the major energy type used in this sector, primarily in space and water heating applications. Petroleum products (17 PJ) are used for these purposes where natural gas is not currently available, primarily on Vancouver Island. Electricity is used in a wide variety of applications including lighting, space heating, and appliances.

With the rapid escalation in fuel prices that occurred during the 1970s, wood heating became very popular in British Columbia, particularly in areas outside the lower mainland where wood fuel was readily available at little or no direct cost to the user. Energy Mines and Resources Canada (EMR) estimates that 26 PJ of wood was used as a primary heat source in the residential sector during 1982-83, while 6 PJ was used for "recreational" purposes. Given EMR's conversion factor of 18 GJ per oven-dried tonne (Odt), these figures translate into 1.44 and 0.33 million Odt, respectively.

As a cross-check on these estimates, a B.C. Hydro survey of residential energy use (B.C. Hydro 1988a) was analyzed. During 1988, 10% of all dwelling types within the B.C. Hydro service area relied on wood as their major heat source. Applying this proportion to the total number of dwellings in the province during 1986 (1 087 115), it is estimated that about 108 712 dwellings used wood as their primary heating source. Dividing the EMR fuel number (26 PJ) by the estimated number of dwellings, an average use of about 239 GJ per dwelling would be implied. This coefficient is more than twice the average natural gas use coefficient per dwelling. However, several factors need to be taken into account in making such a comparison:

1. In addition to the dwellings that use wood as their primary space heating source, another 19% of all dwellings (or almost twice as many) use wood as a supplemental space heating source.
2. Wood is often burned at high moisture contents, which results in much of the heat being used to evaporate the moisture, rather than providing useful heat to a dwelling. It also is frequently burned in inefficient appliances such as fireplaces. As a result, the overall efficiency of conversion from higher heating value to output heat may be very low compared to a natural gas furnace. Thus, it may require much more wood energy than natural gas energy to heat a dwelling, if measured in terms of the higher heating value of the input energy.

Therefore, the EMR estimate of residential wood consumption in British Columbia is considered to be reasonable.

With the stabilization of conventional residential fuel prices in recent years, the popularity of wood heating may have peaked. The percentage of dwellings reporting wood as their major space heating fuel decreased from 10.8% in 1984 to 10.1% in 1988, while the percentage of total dwellings using any wood decreased from 35 to 29% over the same time period. With much of the provincial population concentrated in Greater Vancouver and Victoria where wood is less available and more expensive, the residential sector is not considered to be a likely market for the greatly expanded use of wood fuels.

4.1.4 Commercial sector

Included in this sector are a wide range of building types, ranging from stores and office buildings, to schools, hospitals, and other institutional buildings. The commercial sector accounted for about 82 PJ of total energy use in 1986, only about 9% of the provincial total. Little, if any, biomass is used in this sector; this is due to the smaller scale of commercial users (relative to industrial users), combined with their location in urbanized areas that are not well-suited to biomass fuel use. Some wood-burning boilers were installed in commercial buildings in eastern Canada at the peak of oil prices and with the assistance of government grant programs, such as the FIRE program. With the move to deregulated natural gas prices, the commercial sector of British Columbia is not seen as a major target market for increased biomass use.

Local interest (Vancouver Island) seems to be growing in pelletized wood-fuel burners for small commercial and residential applications. A local supply of the fuel is currently being established near Victoria.

4.2 Types of energy used

4.2.1 Energy supply and demand overview

British Columbia possesses large energy resources in terms of coal, natural gas, and hydroelectric potential. It is a net exporter of each of these energy forms, but is a net importer of crude oil as the province has only limited oil reserves relative to its domestic requirements. Figure 4-1 provides an overview of energy supply and demand patterns in British Columbia during 1985.

Coal

Coal is the largest single energy form produced in British Columbia; however, more than 99% of the 670 PJ produced during 1986 was exported. The bulk of coal produced in British Columbia is metallurgical coal, rather than thermal. Only 2 PJ of coal was used domestically in final demand applications in 1986, primarily in coal drying and in the cement industry. Lower fuel, capital and operating costs associated with natural gas use have discouraged the use of coal in recent years.

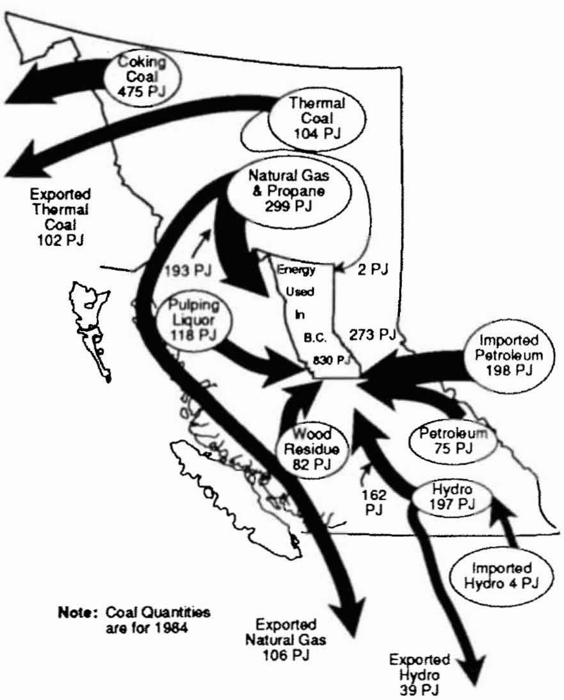

Figure 4-1. Analysis of the British Columbia energy balance, 1985

Natural gas

Of about 287 PJ of natural gas produced during 1986, 70 PJ or roughly one-quarter was exported. With strong increases in both export demand (105 PJ) and domestic demand (231 PJ) during 1987, production increased to 336 PJ. Currently established natural gas reserves will meet the domestic requirements of British Columbia well into the next century.

Refined petroleum products

Refined petroleum products, primarily gasoline, diesel fuel, and heavy fuel oil, accounted for 291 PJ, or 31.3% of total domestic provincial energy demand during 1986 - the largest single share of any energy type. Approximately 71% of the crude oil used to produced these products was imported, mainly from Alberta. This dependence on out-of-province crude oil is expected to continue over the long term.

Electricity

Electricity consumption in British Columbia during 1986 totalled 177 PJ, while net exports from the province were about 5 PJ. About 95% of total requirements were provided by hydroelectric generation. Thermal plants (coal, wood wastes, and natural gas) are expected to provide an increasing share of provincial electric production in future as B.C. Hydro's new policy of purchasing power from private generators is implemented. Hydroelectric generation, however, is expected to remain dominant well into the next century.

Wood and pulp liquor

Biomass fuels already make an important contribution to provincial energy supply, accounting for about 231 PJ or more than 25% in 1986. Firewood accounted for 32 PJ: about 26 PJ was used in residential use and about 6 PJ for recreational use. Pulping liquor use is estimated at about 119 PJ of this amount, while wood residue (sawdust, shavings, bark, chip fines, etc.) use is estimated at 112 PJ.

5. Economic constraints to biomass utilization

5.1 Relative energy costs/prices

In assessing the economic viability of substituting wood wastes for purchased fuel and electricity in selected applications, the future price spread between wood waste and the type of energy it replaces is a key variable. This section examines factors affecting energy prices in British Columbia and, based upon this analysis, forecasts the prices of these fuels for the time horizon considered in this study (1988 - 2010). The cost of acquiring and utilizing various types of biomass fuels is covered in Section 7.

The extreme instability of world crude oil prices in recent years clearly demonstrates the difficulty of predicting future energy prices over the short term, let alone the much longer forecast period considered here. Over the time horizon of this report, many unexpected political, technological and economic factors could influence the prices of all energy forms. To reflect this uncertainty, two scenarios have been developed for future energy prices - low and high price cases. Price forecasts are provided for natural gas, heavy fuel oil, and electricity to industrial users in the forest sector (pulpmills, sawmills, and panel mills).

5.1.1 Crude oil prices

A forecast of world crude oil prices is necessary as a benchmark from which to forecast not only refined petroleum product prices, but also natural gas prices, given the substitutability of natural gas and refined petroleum products in many end use applications.

World crude oil prices have been extremely volatile in recent years - plunging from about $28 U.S. per barrel (West Texas Intermediate crude oil at Chicago) in 1985 to $10 per barrel in mid-1986, and recovering to about $18 per barrel on average during during 1987. Oil prices again weakened to less than $13 per barrel during September 1988, before strengthening to about $25 per barrel in early 1989, with the November 1988 OPEC agreement on production quotas, and disruption of Alaskan oil transport in 1989.

Many oil industry observers, however, are skeptical about the ability of OPEC to adhere to these quotas for more than a few months, based upon the lack of discipline in the cartel during the past. The Alaskan oil spill of 1989 had temporary impacts, but long-run cost increases may result. Analysts expect prices to continue their recent fluctuations for at least a few years, or until such time as global oil demand begins to outstrip global production.

Such instability in crude oil prices makes forecasting very difficult. In preparing the price forecasts used, a considerable number of forecasts produced by specialist energy organizations were reviewed. The National Energy Board has recently released its forecast of "Canadian Energy Supply and Demand, 1987 - 2005" (September 1988). This forecast is based upon the following world oil price assumptions:

	Low Case	High Case
	(Constant 1987 US$ per barrel*)	
1990	15	22
1995	16	27
2000	18	30
2005	20	30

* West Texas Intermediate crude oil delivered to Chicago

The National Energy Board's price projections are based on the estimated incremental supply costs of non-OPEC oil over time. The high price scenario is predicated upon stronger economic growth which increases oil demand, resulting in more rapid movement into higher cost non-OPEC oil supply and a more rapid increase in OPEC's share of the oil market. This scenario levels out at $US 30 per barrel because the National Energy Board expects that, at this price, alternative oil and other energy supplies would emerge, while demand would shrink to prevent higher prices from being sustained.

On the other hand, the low price scenario has a minimum price of $15 per barrel, based upon three considerations:

- this price level represents the approximate floor for oil prices since the post-1986 price recovery;
- prices of less than $US 15 per barrel may not be sustainable because of their negative impact on non-OPEC supply and their tendency to increase demand;
- at oil prices of less than $US 15 per barrel, heavy fuel oil would already be cheaper than major competing fuels such as coal; thus, it would not benefit producers to put more oil on the market and let the price fall further.

5.1.2 Heavy fuel oil prices

Heavy fuel oil use in British Columbia is largely restricted to pulp and paper mills in the Vancouver Island and south coastal regions where natural gas service is not available. It now appears very likely that construction of the natural gas pipeline to Vancouver Island will begin in 1989, with service commencing in 1991.

Even with the availability of natural gas service it is expected that south coastal pulp and paper mills will continue to use about 1 million barrels of heavy fuel oil annually in boilers which are not economically convertible because they are not base-loaded, or in locations not expected to be served by natural gas (Gold River and Port Alice). In addition, it is expected that the price of natural gas will be closely linked to that of heavy fuel oil. Thus, the prices forecast for heavy fuel oil will continue to be valid when natural gas service is extended to Vancouver Island.

The National Energy Board's forecast of heavy fuel oil prices in British Columbia, with some minor adjustments as detailed in Table 5-1, has been adopted. In the low price case, only modest increases in heavy fuel oil prices occur over the forecast period, as the price increases to $3.41/GJ by the year 2005. In the high price case, however, the heavy fuel oil price is about 60% higher than in the low price case year, at $5.44/GJ.

5.1.3 Natural gas prices

In the past, natural gas prices in Canada were linked to a fixed percentage relationship with oil prices. With the recent move to a deregulated pricing environment, natural gas prices will now be determined by market forces. As a result, it is expected that there will be divergence of natural gas and oil prices.

The surplus of natural gas that has existed in North America in recent years has driven wellhead prices down to less than the long-term replacement cost in many cases. As the North American "gas bubble" shrinks over the next few years, substantial increases are expected in the gas price, even with relatively constant oil prices.

Natural gas prices to large industrial users in British Columbia are forecast in Table 5-1, based upon the recent National Energy Board forecast. These prices are representative of those paid by pulpmill-scale users. Sawmills and panel mills will probably pay up to $1 more per GJ than large-scale users.

In the National Energy Board's low case gas price scenario, the increase in gas prices over the forecast period is much less than in the high case for a number of reasons:

1. In the less buoyant economic conditions of the low case, gas producers accept a lower rate of return than they otherwise would.
2. With the poor economic environment for the oil and gas industries, input costs (particularly drilling) are lower than in the high price case, reducing the supply cost of gas.
3. Low heavy fuel oil prices limit the price increase of gas in the industrial sector.*

5.1.4 Electricity prices

B.C. Hydro's twenty-year resource plan (B.C. Hydro 1988b) for the period from 1988 to 2007 indicates that the utility expects to be able to meet base case forecast power demands until around the year 2000 without building any additional capacity. Instead, B.C. Hydro plans to rely on demand-side management programs, coordination of Columbia River projects with Bonneville Power Administration, purchase of power from Alcan, and return of Columbia River downstream benefits to avoid construction of further projects until the next century. After that time, Site C on the Peace River (2001), Keenleyside on the Columbia (2004), Murphy Creek (2004), and Hat Creek (2006) have been recommended as projects which could be built to meet anticipated electricity demand.

This plan also makes provision for the purchase of electricity from private power producers. Legislation in the United States requires utilities to pay private generators of electricity the full marginal cost that would have otherwise been incurred by the utility in order to supply an equivalent amount of capacity and energy. This method of pricing, however, is unlikely to be repeated in British Columbia where B.C. Hydro has recently released a draft policy concerning its proposed terms for purchasing electricity from industry. Three

* Any new emission controls which reduced the allowable sulfur could increase the relative value of natural gas on the British Columbia coast.

Table 5-1. Fuel price-forecasts, British Columbia industrial sector

Year	HFO	Nat. gas	Nat. gas/ HFO	HFO	Nat. gas
	($/output GJ)		%	($/input GJ)	
Low price case (1987 Canadian $)				Adjusted to $1 Can = $0.82 US	
1989	3.15	2.40	0.76	2.61	1.94
1990	3.17	2.53	0.80	2.62	2.05
1991	3.22	2.70	0.84	2.66	2.18
1992	3.26	2.87	0.88	2.70	2.32
1995	3.39	3.05	0.90	2.81	2.47
2000	3.71	3.33	0.90	3.07	2.69
2005	4.12	3.71	0.90	3.41	3.00
High price case (1987 Canadian $)				Adjusted to $1 Can = $0.82 US	
1989	4.43	2.50	0.56	3.67	2.02
1990	4.72	2.88	0.61	3.91	2.33
1991	4.99	3.36	0.67	4.13	2.72
1992	5.25	3.71	0.71	4.34	3.00
1995	5.95	4.32	0.73	4.92	3.49
2000	6.58	5.34	0.81	5.45	4.32
2005	6.57	6.55	1.00	5.44	5.30

Notes:

1. Source of output energy prices: National Energy Board 1988.

2. National Energy Board prices are converted to prices per input GJ (higher heating value basis using 87 and 85 percent conversion factors, respectively, for heavy fuel oil and natural gas.

categories of electric generation are considered in this policy: projects on the integrated grid of less than 5 MW versus those over 5 MW, and projects in remote areas where grid power is not available.

For projects on the grid generating less than 5 MW, the utility proposes to establish a fixed purchase price to minimize transaction costs. The purchase price will be fixed annually at a value somewhere between B.C. Hydro's short-term and long-term marginal costs (presently between 1.5 cents and 3.4 cents per kWh, respectively). For purchases beginning in 1989 and extending for a minimum period of 20 years, B.C. Hydro will pay 3 cents/kWh. This rate will be adjusted annually, based on changes in B.C. Hydro's marginal costs. This rate is considerably lower than those in both Alberta and Ontario, where small generators are paid about 5 cents/kWh.

For large generators of more than 5 MW on the integrated grid, the utility plans to solicit competitive bids from private industry to supply power on a long-term basis. The intent is to negotiate a price that provides an adequate return to the parallel generator, but which falls between B.C. Hydro's estimated short-term and long-term marginal costs of electricity, and reflects the values of firm and secondary energy. In this manner, the utility hopes to provide power to its consumers at less than the marginal cost of the next major project (Site C), estimated to be about 3 cents/kWh.

This price level coincides with the approximate cost of power to most pulp mills under B.C. Hydro's transmission service rate (5 MW and over). Sawmills and panel mills fall into the 35 kW and over general service category. Customers in this rate class currently (1988) pay trailing rates of $6.01/kW of peak demand each month, and 2.64 cents/kWh of energy. Taking into account load factor patterns, the combined energy and demand charge is estimated at 4 cents/kWh for sawmills and panel mills.

Thus, the rates currently paid by British Columbia forest industries are already at least as high as the ceiling price set by B.C. Hydro, raising the question as to whether the new policy position offers sufficient economic incentive for the forest industry to install increase generating capacity. In the past, however, mills did not always have the option to sell surplus power back to the utility during periods when they did not require it internally. In addition, B.C. Hydro indicates in its draft policy paper that it may offer other incentives, including front-loaded prices, low-interest loans, and grants in order to encourage parallel generation.

For the purposes of examining the feasibility of generating additional electricity from biomass, it is suggested that electricity generated from biomass be valued at 3.5 cents/kWh, as this figure approximates the long-run marginal cost to B.C. Hydro. For sensitivity purposes, this rate is varied plus and minus one-half cent/kWh - i.e., 3 and 4 cents/kWh. These rates are maintained in constant dollar terms over the forecast period.

5.2 Wood costs and prices

The most apparent economic constraints to biomass use in energy production, apart from the cost of alternate energy sources, are the value of wood in other uses and the cost of delivering waste wood products to a central site for burning.

5.2.1 Fibre use

Historically, pulp and paper use has been the dominant factor in the market for all wood left over after wood products manufacture. This has been true of whole stands as well as mill residues. Integrated manufacture of wood products and fibre products had become the dominant pattern of the whole North American forest industry by 1987. Some trees and logs go to a wood products manufacturing facility first, then the residuals go to pulpmills. The proportion going directly to a chipper or other roundlog pulp process is dependent on the quality of the original stand (size, species).

As total wood products and fibre balance in the world shifts, new balances will be struck in each region. High-value pulp and paper uses can at times reach up into the "sawlog" pool, and conversely in periods of high wood product demand sawmills and plymills will reach down into the "pulpwood" resource.

Clean mill residues of all kinds are being tested and used for pulp and paper production. Sawdust is probably the most suitable and, in general, the coarser the saw, the better. Shavings and dust from planing and remanufacturing operations are also generally suitable for pulping with appropriate technology. Their value in this use (even with the higher cost of pulp production) seems likely to be higher than in most energy applications under foreseeable alternate energy prices over the forecast period.

High-quality (whitewoods) clean pulpwood chips or roundwood are expected to carry a value of about $40/m^3$ in real terms during the forecast period. Cedar and hardwood species are expected to have slightly lower values.

With even 50% yield into appropriate pulps, the equivalent input value of sawdust and shavings fibre could be in the order of $\$20/m^3$ in the forecast period. Current hog value is around $\$5/m^3$, and electricity generation at 3.5 cents/kWh yields even less (see Section 7).

5.2.2 Wood delivery costs

The cost of moving bulky wood wastes to a central processing or burning point has often been prohibitive to their economic use in energy production. Their high moisture content and low density both contribute to a high cost per delivered unit of fuel.

Figure 5-1 shows the heating value of wood residues in relation to various price levels of Bunker C fuel oil. For example, wood waste at 60% moisture content which costs $25/tonne to extract and process is roughly equivalent to Bunker C fuel oil at $18/barrel at the boiler (dashed line on Figure 5-1).

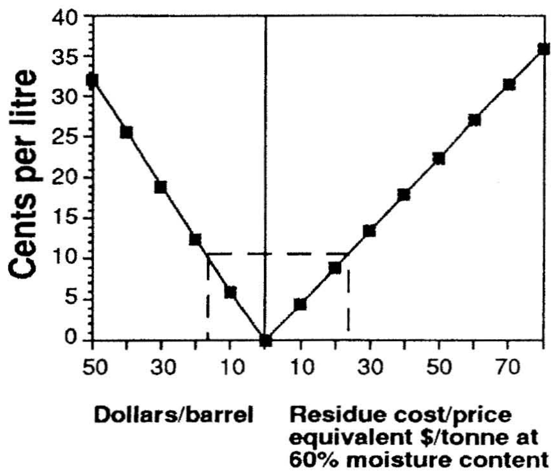

Figure 5-1 Comparison of the value of wood residues in terms of oil prices

Only on the British Columbia coast, where relatively cheap transport of mass volumes of wood waste by barge is feasible, can long haul distances (say over 70 km) be expected to be economic.

This materials movement problem is especially relevant to the fraction of the current waste which is left in the woods in British Columbia. Scattered over more than 200 000 ha each year in relatively small and misshapen pieces, this material will generally have higher extraction costs than conventional log materials.

However, since it is generally not considered in the economics of present operations, several elements of total cost can be considered as not relevant to this "salvage" fraction. These include felling and bucking costs, roading costs, protection costs, and others.

Only the true incremental costs of salvage operations need to be considered. These range from the cost of loading and hauling only (material already delivered to roadside or landing) to the cost of short yarding, loading and hauling (material within say 100 m of the existing road network).

The average piece size removed will also have a significant impact on the expected delivered cost per cubic metre of the total salvage volume.

Table 5-2 provides current estimates of extraction costs for forest residuals within several types of operation currently in use in various regions of British Columbia. These cover the relevant range of conditions likely in the forecast period, and are therefore used in the simulation of case studies in Section 8.

5.2.3 Wood-based energy technologies

Wood-fired boilers are expensive to build, complex to run, and variable in output. High and variable moisture content, variable density and variable particle size create tremendous variations in daily operating characteristics.

The capital cost of these facilities is relatively high. The recent Williams Lake study (Sandwell Swan Wooster 1989) cited a number of power plants built in North America over the past decade. The construction costs of each expressed in 1988 Canadian dollars per megawatt are shown in Table 5-3. When wood delivery costs are added, together with materials handling costs at the site, the end result historically has been a relatively high cost of delivered energy. Some further details of the Williams Lake case are used in the simulation of case studies in section 8.

The efficiency of transporting and burning wood wastes can be improved (at some cost) through drying and densifying the mix of woody materials. Various forms are used at present (e.g. pressed logs, briquettes, or pellets).

In British Columbia, pressed logs have been produced for the household fuelwood market for many years. More recent technologies used elsewhere in western North America include various means of pelletization for creation of consistent industrial fuels from wood and other biomass wastes. The densified product typically weighs about 1 g/cm^3.

The advantages of the dried/densified material include ease of bulk handling and feeding and good burning characteristics compared to raw wood wastes.

These densified wood fuels have only been commercially produced within the past decade. One British Columbia operation has been opened and shut down; another is currently beginning production in small quantities. The export of such a prepared fuel is conceivable under the right conditions. A review of these materials and their production costs was conducted under the FIRE program in 1982 (Canadian Resourcecon 1983). A detailed updating of this technology to 1989 was not feasible within the resources of this study; however, the potential is considered in the case studies discussed in section 8.

Table 5-2. Estimated biomass extraction costs

		$\$/m^3$
Coast		
A.	landing clean-up; integrated with logging	
	piece size 0.25 m^3 to 0.45 m^3	
	haul distance one-way - 35 km	9.50
	- 70 km	13.15
B.	landing and road clean-up; 2nd pass, skidder assisted	
	piece size 0.25 m^3 to 0.55 m^3	
	haul distance one-way - 35 km	15.50
	- 70 km	19.15
C.	integrated with logging (yarding crane)	
	piece size 0.30 m^3 to 0.50 m^3	
	average yarding distance 100 m	
	haul distance one-way - 35 km	21.00
	- 70 km	24.65
D.	small conifer/alder (skidder logged)	
	average stand diameter 25-30 cm d.b.h.	
	haul distance one-way - 35 km	19.50
	- 70 km	22.95
Interior		
E.	wet belt, decadent, lst pass (tower)	
	piece size 0.25 m^3 to 0.453	
	average yarding distance 100 m	
	haul distance one-way - 50 km	23.15
	- 100 km	25.65
F.	wet belt, decadent, 2nd pass (R-T skidder)	
	piece size 0.25 m^3 to 0.45 m^3	
	haul distance one-way - 50 km	16.00
	- 100 km	18.25
G.	pine and spruce (skidder logged)	
	piece size 0.10 m^3 to 0.30 m^3	
	haul distance one-way - 50 km	18.50
	- 100 km	21.00

Source: Based on Nawitka file data and data and relationships in Sinclair 1983, MacDonald 1987, Oakley and Manning 1984, Nagle 1980 and Nawitka Resource Consultants 1987.

Table 5-3. Estimated power plant construction costs

Startup date	Million $/MW construction cost*		MWatt size	1988 million$/MWatt CDN $	Project name
1983	US $	2.02	46	2.67	Kettle Falls WA, WWP
1984	US $	1.30	50	1.63	Burlington VT, McNeil
1987	CDN$	1.82	7	1.84	Chapleau ON
1987	US $	2.18	49	2.59	Anderson CA, Wheelabrator
1989	CDN$	1.69	60	1.69	Williams Lake BC Proposed

* Currency at 1 US$ = 1.1765 CDN; 1 CDN$ = $0.85 US

6. Institutional constraints to biomass utilization

6.1 Forestry sector

The forestry sector has been the major source of economic growth in British Columbia since before the Crown colony joined confederation in 1871. Public policy has always played a major role in timber supply, as the Province owns about 94% of the productive forest land. The forest resource is administered by the provincial government through the Ministry of Forests. The Forest Act sets out the guiding principles of forest management. The Ministry of Forests is responsible for ensuring the resource is used to its fullest potential within the framework of integrated use. The Crown is to receive a full return for the harvest of the resource.

The forestry sector of British Columbia has been undergoing continuous change during the past decade. The industry has been buffeted by high interest rates and a slowing housing cycle, fluctuating Canadian and American currencies, trade conflicts, technological change, and emerging new players in international markets.

At the same time, pressures to improve forestry practices and set aside new forest wilderness areas have intensified. The owners of British Columbia forests – the people of the province – are expecting higher quality forest environments as well as higher economic performance from the sector.

The forest policy environment in the late 1980s is one of change and is currently somewhat uncertain. Responsibility clearly rests with the British Columbia Ministry of Forests. Recent policy initiatives include a revised system of timber pricing, support of forest renewal being shifted significantly from the Province to industry, and initiatives to promote competition, diversification and increased utilization.

Since many forest policies have significant impact on biomass energy prospects in British Columbia, this report attempts to clarify these implications and likely future directions. Significant policies can be classified as those affecting the tenure of land and harvest rights, the level of allowable harvest, the utilization of the harvest, the measurement and pricing of the harvest, and the control or distribution of environmental and social effects.

6.1.1 Forest tenure

Private timber lands in British Columbia amount to only about 5% of the total productive forest land base. A significant fraction of these lands (about 750 000 ha) is in old railroad land grants on the eastern side of Vancouver Island and a lesser fraction (about 200 000 ha) is in the Kootenay region. The bulk of these lands is still owned by the forest industry. Another one million ha is in about 21 000 small private woodlots or farms throughout the province. Harvest on these lands is basically uncontrolled, although a few municipal constraints have emerged in developed areas and log export controls are currently in force for all British Columbia forest lands. Much of the industrial private forest land is under intensive forest management.

Considerable fuelwood and minor forest products are produced on the smaller forest tenures each year. The 1985-1990 Canada-British Columbia Forest Resource Development Agreement (FRDA) injected new management practices into a significant fraction of these lands. Forest land on Indian Reserves has been similarly subject to new management through FRDA. However, the bulk of British Columbia forest sector production has and will be produced from provincial forest land.

Public timber has been allocated in British Columbia according to a dynamic strategy of encouraging forest industry development. As long as unallocated timber rights remained and while the Ministry of Forests perceived gaps or weaknesses in the balance of regional forest industries, timber allocation was used to encourage various forms of sub-sector growth and change (e.g. increased pulp and paper production, improved sawmill efficiency, utilization of small trees).

At present the public timber of the province is divided into two main types of management unit:

- timber supply area (TSA) - a sustained yield unit managed by the Ministry of Forests
- tree farm licence (TFL) - a sustained management unit under management by a private licensee who must be a forest industry owner (see Table 6-1).

In TSAs the right to harvest timber is allocated to a number of individuals or companies through a system of volume-based tenures.

The defined land base and timber harvest rights within TFLs are allocated to a single company to support a defined large forest enterprise (except in the cases of the one municipal TFL and the one Indian Band TFL). A portion of the timber on a TFL may now be allocated to small operators through the small business forest enterprise program.

Table 6-1. Current status of tree farm licences[1]

TFL No.	Licensee name	AAC (000 m^3)	Area (000 ha)	Operable area (000 ha)
1	Skeena Cellulose	720	596.9	133.5
3	Slocan Forest Products	108	78.8	38.0
5	Weldwood Canada	110	34.3	33.2
6	Western Forest Products	1300	170.0	143.8
8	Pope & Talbot	275	77.0	72.1
10	Weldwood Canada	219	231.1	61.8
13	Galloway Lumber	27	37.1	22.1
14	Crestbrook Forest Ind.	123	139.5	47.5
15	Weyerhaeuser Canada	72	48.2	37.9
18	Slocan Forest Products	210	74.2	67.5
19	CIP, Inc	978	192.4	113.7
23	Westar	997	563.5	287.9
24	Western Forest Products	115	112.5	77.6
25	Western Forest Products	653	146.7	100.8
26	District of Mission	37	8.9	6.9
30	Northwood Pulp & Paper	428	180.8	158.9
33	Federated Co-op	28	8.5	7.7
35	Weyerhaeuser	88	79.5	36.9
37	Canadian Forest Products	1085	186.3	134.6
38	Weldwood Canada	263	218.0	62.8
39	MacMillan Bloedel	3821	721.0	468.0
41	Enso/West Fraser	430	1019.7	49.7
42	Tanizul Timber	120	49.6	46.3
43	Scott Paper	27	9.1	4.8
44	MacMillan Bloedel	2838	453.1	376.0
45	Fletcher Challenge	305	287.4	60.1
46	Fletcher Challenge	1178	181.5	164.1
47	Fletcher Challenge	1090	226.9	202.5
49	Fletcher Challenge	380	144.9	134.7
51	Westar Timber	220	77.5	40.8
	TOTAL	18 244	6355.0	3192.4

1. AACs accurate to Jan 1/89; ha accurate to Oct/86.

Source: Ministry of Forests

Small business forest enterprise program

The small business program was implemented in the 1978 Forest Act, following the 1976 Royal Commission recommendations. Since then it has grown steadily in importance. In 1987, the Ministry of Forests announced changes to the program (British Columbia Ministry of Forests 1988b, Press Release: Small business forest enterprise program expanded, July 2, 1988, British Columbia Ministry of Forests; Press Release: Major changes to small business forest enterprise program, Nov. 3, 1988, British Columbia Ministry of Forests) to encourage more secondary and tertiary manufacturing. The share of Crown harvest awarded through this program is expected to increase from 7 to 15% over time.

Increased timber supplies are awarded through bid proposals to firms who engage in further manufacturing. These proposals are evaluated by how well they:

- create or maintain employment opportunities
- provide for management and use of timber
- further the development objectives of the province
- meet provincial objectives for environmental management
- contribute to provincial revenues.

The importance of each of these criteria varies and the proposals are primarily evaluated on the amount of value-added that is proposed and the bonus bid. Each bidder gets a score based on the formula:

Score = Value-added ($\$/m^3$) + Bonus Bid ($\$/m^3$)

These scores determined by both the regional manager and the district manager. In cases where the scores are within 4% of the high score, the regional and district managers use other more subjective criteria to evaluate the proposal.

Recent allocation policy changes

The Timber Harvesting Branch of the Ministry of Forests allocates the right to harvest the AAC to various tenure holders. In doing so, they take into account Ministry of Forests' policies, the wood supply required by the company, and the company's past performance. In September 1987 (British Columbia Ministry of Forests 1987a), the Ministry of Forests announced a number of changes to the allocation process by:

- doubling the amount of wood available through competitive sales, with additional volumes becoming available through
  - selling more of the unallocated AAC (the provincial reserve)
  - transferring 5% of the AAC on replaceable licences, including TFLs
  - allocating 5% of the AAC upon the sale, transfer or assignment of a licence
  - recovering up to 10% of the AAC upon converting an existing tenure to a TFL
- retaining the increased AAC that has not been earned rather than including it as an automatic supplement to existing cutting rights
- reselling, through competitive sales, annual undercuts of more than 50%
- regaining five-year undercuts of more than 5%.

These changes were introduced to encourage companies to use their wood supply as fully as possible and to permit access to timber by companies without long-term replaceable tenures that have an annual cut of 10 000 m^3. In addition, the Ministry of Forests stated its desire to increase the proportion of the cut coming from the TFL tenure. At present the Ministry of Forests is receiving applications which would boost the TFL tenure from 29% to about 67% of the provincial Crown forest land base. Currently, this policy is under review.

Constraints and opportunities for biomass utilization

The historic allocation of public forest lands and harvest rights in British Columbia has at least a potential to inhibit biomass utilization in several ways.

On tenures with a defined land area (principally TFLs) the licensee has full responsibility for fire protection and full liability for accidents. Therefore licensees tend to discourage salvage operations which return only small revenues for any extra volume removed, but may carry significant risks to high-value timber through fire, or may pose significant extra risk of accidents on logging roads.

This latter issue is also important in permitted public use of TFL roads, lands and recreation areas. These uses may include hiking, hunting, or merely road touring.

It seems likely that a rational sharing of risks and costs could be arrived at between the private licensee and the public forest owner (including a potential need for additional biomass for energy). A fully economic salvage logging operation for fibre and energy residuals would no doubt provide a lot of the incentive to reach a feasible and equitable access solution for all interested parties. This issue will become more important in the future if the proposed increase in TFL tenures takes place.

On volume-based tenures (which have no defined area in the long term) the problems of responsibility and risk are different than in a TFL, but elements of the same problem remain. While an operator is actively logging within a certain area, he and any subcontractors are similarly responsible for fire prevention and control. Once he has moved out of a defined area, responsibility shifts back to the Crown.

However, this transition period can be problematical. A salvage operation works best in conjunction with or immediately following first-pass harvest operations. Once the operator notifies the Ministry of Forests that he is ready to quit an area, a further 90 days must be allowed for necessary inspections of cutting boundaries, road closures, and forest utilization (the amount of wood left on the ground). This period can often erode the "salvage window" due to weather or deterioration of the salvageable wood on the ground.

The new small business programs within the tenure system should provide additional scope for innovative forms of salvage harvesting from all public forest lands in the province. However, one of the constraints imposed on parts of this program, that all timber allocated to small business enterprises must be of equal quality to the timber logged by TSA or TFL tenure holders in the area (British Columbia Ministry of Forests 1988b), may somewhat restrict its application to salvage logging. In order to use a small operator for salvage purposes (through the program) it seems that the Ministry of Forests or the tenure holder would have to offer him a harvest profile comparable to the average for the area.

This provision was put in place to inhibit the "dumping" of the toughest logging areas on the small operators. However, it might also constrain the application of their particular skills to certain specialized problems, such as salvage logging. One further potential problem of forest tenure in British Columbia is native rights of tenure or use. Should new policies be developed and new allocations ensue, the effects could be significant for all forms of forest use in the future.

6.1.2 Defining the harvestable forest

In all regions, the Ministry of Forests adjusts its management to meet local conditions. One of the important parameters of adjustment is a definition of which forest areas will be included in the calculation of timber harvest, and which will be left out in each management unit.

Significant implications for both the allowable harvest and for potential energy use are apparent in the exclusion of over mature, decadent stands of softwood (generally hemlock/cedar types) and in the hardwood types (alder, aspen, and other species). Large areas of decadent softwoods have been excluded from AAC calculations in the north and central coast and the upper Columbia basin. These stands are significant in total area, the growing stock is currently depleting through natural attrition, and the merchantable timber growing potential of these areas is fairly high (4 to 10 m^3/ha).

The economic status of hardwood types of British Columbia, particularly the large aspen *(Populus tremuloides)* types in the north and east of the province, has been radically altered in the last five years. New pulp mills are using this resource to make TMP and CTMP pulps, and new silvicultural systems are being developed to sustain the harvest of this species, once considered a weed. Therefore the volume and increment of these stands is or will be entering the AAC calculations for the relevant TSAs.

In the past, these stands have often been considered a potential source of biomass energy, at least during a conversion operation to more valuable softwoods. This prospect appears to have vanished with technological change.

However, the inclusion of hardwood areas and volumes and those portions of each tree and stand not used for pulpwood will become an important addition to logging residuals.

Alder *(Alnus rubra)* exists in significant quantities on excellent sites throughout the coast region. In accessible locations it already provides a significant proportion of the household firewood consumption. These stands are common on the small private holdings on Vancouver Island, the Fraser Valley, and the Sunshine Coast. On the TSA and TFL tenures the area they cover is excluded from AAC calculations. In general, red alder has not yet enjoyed successful large-scale utilization for pulp in British Columbia. A detailed case study including a technological forecast, while beyond the resources of this study, would be appropriate.

Constraints and opportunities for biomass utilization

The process of elimination of stands from the calculation of allowable harvest could have implications for the amount of biomass available for use as energy. Some stands which are uneconomic for timber harvest may be usable within an integrated biomass and silviculture operation.

Important examples include over-mature, partially broken down forest types, such as those found in the wet belt of the upper Columbia River basin and in several areas of the mid and north coast. Hardwood stands (e.g. alder on the coast and aspen in the interior) were also excluded from harvest calculations. Recent developments in utilization of aspen for pulp are rapidly bringing these stands into the harvest calculations of the province. The status and prospects for red alder on the coast will need further clarification.

6.1.3 The planning process

For each management unit, an AAC is established to ensure an orderly harvesting of the timber on that unit. To arrive at the decision, the Ministry of Forests goes through a number of steps:

1. Issue identification

   The planners determine the problems that need to be addressed and develop procedures for addressing them. They produce terms of reference that state the procedures they will follow.

2. Information assembly

   Planners decide what information is required to resolve the problems that have been identified. This includes inventory data, environmental data, economic data, research findings, and any other relevant information. The planners will produce a number of options for analysis.

3. Analysis

   The planners use a number of computer models to predict timber supplies for each option. The planners also analyze other resources such as range and recreation.

4. Evaluation of options

   The planners develop a matrix of the implications of the various options on other resources and budgets. These are submitted to the chief forester for consideration.

5. Selection of an option

   The chief forester selects an option and determines an AAC for the management unit.

6. Allocation of the AAC

   Once the chief forester has set the AAC, the Timber Harvesting Branch of the Ministry of Forests allocates the cut to the various tenure holders in a TSA.

Constraints on biomass utilization

The planning process may constrain biomass use through the omission of biomass energy as a concern at each level of the process. Explicit consideration of biomass energy during issue identification, information assembly, analysis and evaluation could help to define significant bioenergy prospects in an operational way.

The degree and type of cross subsidy (with better portions of the stand carrying less economic portions) can be affected significantly by regulations governing allowable logging residuals.

Several ENFOR and other projects have attempted to clarify the total volume, species and piece size of these materials (McDaniels 1982; Manning and Massie 1986; Tunner and Standish 1986; McDaniels and Manning 1987). Further studies have analyzed the cost of extraction and processing (Nagle 1980; Sinclair 1983; Oakley and Manning 1984; MacDonald 1987; McDaniels and Manning 1987; Nagle *et al.* 1987).

Significant problems and opportunities for forest use in total are generated through the inputs of other Departments and the public to the planning process. Single-minded maximum fibre and fuel production is no longer a feasible option for forest managers, public or private.

This study has attempted to assess some of the important concerns of society regarding increased use of forest materials for energy purposes (see section 6.1.7).

6.1.4 The utilization of harvest

Many recent policy changes were introduced to encourage companies to use their wood supply as fully as possible. Standards for the amount and type of wood which may be left on each hectare after logging have been defined for many years. The Ministry of Forests is currently implementing a new utilization policy to get more of the total fibre of each stand out of the woods. The utilization standards in effect are:

Coast	Old growth	Second growth
Diameter, stump height		
Lodgepole pine	20.0 cm	15.0 cm
Other coniferous species	25.0 cm*	20.0 cm
Maximum stump height	30.0 cm	30.0 cm
Top diameter, inside bark	15.0 cm	10.0 cm
Log length	2.5 m	2.5 m

* If more than 15% of the stems have a diameter of 20.0 cm, the minimum cutting diameter will be 20.0 cm.
Note: All logs except grades Y and Z must be used.

Interior

Diameter, stump height	
Lodgepole pine	15.0 cm
Other coniferous species	20.0 cm
Maximum stump height	30.0 cm
Top diameter, inside bark	10.0 cm
Log length	2.5 cm

For both the coast and interior, cutting specifications for deciduous species and selective logging will be set by the district manager. Clearly, the pricing of raw materials from the forest will also have a significant impact on residuals.

6.1.5 Measurement and pricing of the harvest

Waste measurement

Further to the utilization standards, the Brtish Columbia Ministry of Forests policy requires the waste to be assessed according to the Ministry's new waste measurement manual (1989b) and submitted under the seal of a registered professional forester within 60 days of the completion of logging. All waste volumes will be added to the scale volume for cut control and all avoidable waste will be billed. If an operator wishes to operate on standards that use more of the wood, he can apply to have these standards used to increase his AAC. The waste will be assessed according to the standards that are specified in the licence document. If a licence holder practices a poorer standard of utilization than specified for two years, his AAC may be reduced by the volume of waste in the second year.

In an attempt to get increased utilization of the forest, the Ministry of Forests offers lower grade* logs at a reduced price – $0.25/m^3. These logs are not considered as part of the cut for cut control purposes and are not included in the AAC determination.

It is important to note that the AAC that is allocated to an operator is based upon these utilization standards. The operator's cut is equal to the scale volume plus the "total waste volume". The distinction must be made between avoidable and unavoidable waste. All "waste" is merchantable material that should be removed from a logged site. Unavoidable waste is that portion which cannot be reasonably removed because of physical impediments. The remainder is avoidable waste and the company is charged for failure to use this material.

Constraints to biomass utilization

Both the policy definitions and the systems of measurement and assessment have implications for the potential biomass energy material which may be removed. Some of the recent controversy has involved definitions, exceptions to rules granted under poor lumber market conditions, and systems of measurement.

Since this is one of the most significant measures of the forest harvest (the amount left on the ground) it seems highly likely that new and improved systems will be defined and used in the next few years (for example, see British Columbia Ministry of Forests 1989b).

Stumpage policy

The Ministry of Forests implemented its comparative value pricing system in September 1987 (British Columbia Ministry of Forests 1987b) as a means of determining the charges to Crown timber. The system was to replace the 15% federal softwood lumber export tax and to increase provincial revenues from the forest resource.

The system calculates an appraised rate for the stand as a whole. The value is based on the selling price of the products and the relative value of the stand to the Province. The value index is the difference between the selling price and cost of production. It takes the costs of production and the quality of the timber into account. The value index for the stand will be compared with the average value index for the coast or the interior.

A base rate is established for the average value index and this base rate will change according to movement in Statistics Canada's industrial product price for British Columbia softwood lumber. The base rate is assessed on the amount that the province feels it needs from the forest resource.

The province has established a minimum stumpage rate of $0.25/m^3 for "salvage" wood. Further, it has established nominal rates for a variety of miscellaneous forest products and deciduous species (Appendix).

Constraints on biomass utilization

Obviously a stumpage which exceeds the conversion return (value in use minus cost of extraction) will

* Grade Y (a grade between firmwood rejects and utility grade logs) and Z (firmwood rejects — more than 50% defective) logs on the coast and lumber reject logs in the interior.

inhibit or completely deter biomass use for energy. During the period of rapid adjustment of British Columbia stumpage rates in 1987, a problem quickly emerged with the new prices when applied to salvage wood as they exceeded the conversion return.

The current minimum stumpage rate of $\$0.25/m^3$ for grades and types of material not normally utilized by the industry should provide no serious deterrent to biomass use, given that other economic parameters are favorable.

Silviculture costs

The price which each forest industry can pay for its harvest of public wood is affected by the level of its responsibilities in protecting and restoring the forest resource within tenures under its control.

Recently, the Province has shifted more responsibility to the forest industry for the costs of basic silviculture. The costs of many silviculture projects and timber roads and bridges were credited to stumpage under Section 88 of the Forest Act. In September 1987 (British Columbia Ministry of Forests 1987c), this policy was amended so that no further costs would be allowed under this section. Industry had to assume the full costs. The Forest Act was amended to make pre-harvest silviculture prescriptions mandatory.

For the small business forest enterprise program, the Province will undertake silviculture activities but the stumpage charged to the operator must be high enough to recover all costs of planning and silviculture.

Constraints to biomass utilization

Both constraints and opportunities for biomass utilization can be created through silviculture. Harvest and silviculture costs can be inter-related in important ways (e.g., the cleaner the hectare after logging, the lower the planting cost). The achievement of a joint minimum cost or of joint maximum net benefits is not often explicitly considered at present.

It would be highly useful to analyze explicit cases for important typical conditions within each region of British Columbia.

6.1.6 The level of allowable harvest in British Columbia

During the last decade the harvest in British Columbia has increased significantly on Crown volume-based licences (and Timber Licences in the Vancouver Region) where the harvest has increased some 10 million m^3. Table 6-2 indicates the harvest on Crown provincial forest land relative to the commitments the Crown has made for timber and the most recent crown AAC decisions. The net effect of institutional and policy constraints in British Columbia forestry is the allowable harvest.

During the last five years minor variations have occurred but a reasonable balance can be seen between the harvest, the commitment, and the allowable cut in British Columbia. In the Vancouver Forest Region the harvest appears to exceed both the commitment and the AAC if the harvest from Old Temporary Tenures (Timber Licences) is included (British Columbia Ministry of Forests 1989a). A reasonable balance could be said to exist as Timber Licences are not included in calculating the AAC.

Commitments over the past five years are very close to the allowable cut and the harvest is about the same order of magnitude, with a few exceptions. This indicates that under current conditions physical supplies of timber in the province have reached a point where only policy changes can permit new supply (open-up new areas of Provincial Crown forest, intensify management, or change utilization policies or standards, etc.) or where additional commitments must be curtailed.

A harvest from Crown regulated lands of 67 million m^3 appears readily feasible provided the Crown forest land base is maintained. A harvest of 73 million m^3 would require rationalization of the unregulated Timber Licence situation. In addition, a harvest of 6.9 million m^3 from private lands may or may not be sustainable, depending on the degree to which intensive forest management is being practiced.

Tree Farm Licences (a combination of mostly Crown with some private land) appear to have a harvest level which is well under the AAC. The latest TFL data are presented in Table 6-1. The current AAC is some 18.2 million m^3. During the last three years the annual harvest has averaged 12.4 million m^3 and currently is at 11.4 million m^3.

As TFL's (mostly Crown land) have an excess of some 6 million m^3 of AAC over the current harvest, and total Crown lands have an AAC of only 1 million m^3 in excess of the current harvest, one can assume that Crown volume tenures are exceeding their share of the AAC, and TFLs are not cutting up to their full potential of AAC at present.

The future level of AAC will be determined by the chief forester in consultation with other ministries and various publics. As already discussed, one of the key variables in simulations and decisions is the

Table 6-2. Allowable annual cut, commitment and harvest on provincial Crown land[1] (000 m^3)

Region and year	Crown AAC	Commitment Within AAC	Commitment Outside[2] AAC	Crown harvest
Cariboo				
1986-87	8559	8559	906	9356
1985-86	8559	6769	2293	8022
1984-85	8559	6168	32	7182
1983-84	6159	6168	32	6887
1982-83	6159	6046	0	6944
Kamloops				
1986-87	8130	8011	65	8083
1985-86	7780	7770	0	9215
1984-85	7768	7770	0	7851
1983-84	7768	7770	0	8544
1982-83	7768	7620	0	7061
Nelson				
1986-87	6098	6846	0	5591
1985-86	6098	5995	620	5833
1984-85	6998	6155	0	5735
1983-84	6998	6168	0	6225
1982-83	6998	5974	0	5162
Prince George				
1986-87	16 806	15 512	321	16 207
1985-86	14 851	15 687	0	16 485
1984-85	14 851	15 726	0	16 846
1983-84	14 851	15 725	0	17 129
1982-83	14 851	15 341	0	13 821
Prince Rupert				
1986-87	7992	7827	1298	9930
1985-86	6367	7606	1245	9147
1984-85	6817	12 091	0	11 400
1983-84	6817	12 268	0	10 917
1982-83	6817	11 888	0	7715
Vancouver				
1986-87	20 849	20 734	126	23 869 (17 541)[3]
1985-86	20 333	20 766	126	23 643 (17 315)

Table 6-2. (cont'd)

Region and year	Crown AAC	Commitment: Within AAC	Commitment: Outside[2] AAC	Crown harvest
Vancouver (cont'd)				
1984-85	18 357	16 420	10	19 629 (14 346)
1983-84	18 357	16 972	0	21 627 (15 932)
1982-83	18 357	16 641	0	16 096 (14 733)
Province				
1986-87	68 434	67 489	2716	73 036 (66 708)
1985-86	63 988	64 593	4284	72 345 (66 017)
1984-85	63 350	64 330	42	68 643 (63 360)
1983-84	60 950	65 071	32	71 329 (65 634)
1982-83	60 950	63 510	0	56 799 (55 436)

1. All provincial Crown forest land including Crown land within TFL's

2. Licences (and volumes) not included in the AAC calculation, i.e. beetle and fire damaged timber; salvage sales; deciduous trees and minor special sales.

3. Not including the harvest from Timber Licences which are not included in calculating the AAC.

productive forest area which is expected to contribute (fully or partially) to the harvest.

Significant changes to the contributing forest estate have been defined in the past decade. Table 6-3 presents an analysis of recent changes to the Crown forest land base, which affect the definition of AAC. The analysis estimates the land base (area) upon which the AAC is calculated. Caution is urged in interpretation as the absense of an entry in a particular category does not mean that previous deductions were not made or that future deductions cannot be made.

During the past decade, significant reductions have been defined in the contributing land base. Caution must be used in interpreting this table as the forestry deductions shown include allocations that can be reversed under changing economic and policy conditions.

The forestry deductions include lands that are currently deemed not operable because of current cost or price situations, but could be operable under conditions of increased demand. Similarly, large areas in the Cassiar and Fort Nelson TSAs could support timber production, but are currently not accessible. Intensified management on accessible lands that have not regenerated satisfactorily (backlog reforestation) could also increase the production base.

Thus, many forestry-related deductions can be reversed and are not necessarily permanent constraints. However, any reversal process will require a change in economic circumstances or provincial policy or both.

Deductions for other uses are smaller, but also are significant. Timber production from some lands has been curtailed in favor of environmental protection or the protection of other resources (e.g., water or wildlife).

Increased timber production from these lands will require both improved multiple use policies and improved technology. This will involve increased extraction and management costs (British Columbia Ministry of Forests 1988a).

Many of these "other" lands are stocked with merchantable timber (e.g., the Queen Charlotte Islands' new national park proposal). Loss of this production impacts the harvest immediately rather than at some future date in the planning process. Timber supplies in the Nelson Region and particularly in the Vancouver Region (where the harvest has exceeded the AAC in recent years) could be expected to decrease if further forest land is excluded from harvest.

The balance between the harvest and the productive forest land base can be broadly assessed in terms of the number of hectares producing the harvest (or the mean annual increment). Broad definition is possible of the annual biological production of forests over large areas.

Table 6-4 notes the current harvest per hectare of net productive Crown forest land and the potential growth over large areas of forest land, given the timber types in the region and a basic level of forest management. This growth potential can be compared broadly with current harvest, and the current level of management.

The interior of British Columbia appears to be in rough balance. The Cariboo and Kamloops regions have a mean annual harvest slightly within the range expected for growth. Given basic levels of management, it would be expected the harvest level could be maintained. The Nelson Region is within the expected growth range. The harvest should be maintainable with a moderate level of forest management.

In the Prince George Region the harvest level is still below the expected growth. However, in this region significant age balance problems (gaps in merchantable forest availability based on tree size or age) have occurred in some TSAs. Poor regeneration and brush problems have also occurred. These factors will delay capture of the full growth potential of this region's forest in the short run.

In the Prince Rupert Region, the harvest is just at the range expected for growth and an annual harvest of the current magnitude can be maintained with basic forest management.

The British Columbia coast seems to have a tighter potential supply demand situation in forestry. In the Prince Rupert Coast Region additional attention is expected to be paid to replacing deteriorating old-growth forests with a more vigorous new forest.

In the Vancouver Forest Region an imbalance may be developing between the annual harvest and the annual growth on Crown forest lands. While the five-year average harvest has been 8.8 m^3/ha per year, the rate has been 9.6 m^3 during the last two years.

In this region, intensive analysis of all deductions from productive forest land will be necessary in future. Similarly, opportunities for more intensive forestry should be explored. Continued harvesting on Crown forest land in this region without additions to the land base or increased forest management, at levels of over 17 million m^3 annually will lead to age class balance problems, inequities in allocation (wider variation in extraction costs), and eventually a sharp fall-down in available timber.

Table 6-3. Provincial Crown forest land base analysis, 1988 (000 ha)

Region and TSA	Productive Crown forest	Recent deductions[1] Forestry related	Other uses	Net operable Land base for timber production
Vancouver				
Arrowsmith	115	28	6	81
Queen Char.	464	154	217	94
Mid. Coast	745	517	-	228
Kingcome	576	169	78	329
Fraser	520	144	12	364
Soo	193	-	22	170
Strathcona	350	78	20	251
Sunshine Coast	444	48	102	293
Total	3405	1138	456	1811
Percent	100	33	13	54
Prince Rupert				
Bulkley	403	-	32	371
Cassiar	4104	3715	179	210
Kallum	551	319	137	95
Kispiox	1011	460	168	383
Lakes	617	3	35	579
Morice	79	14	61	694
North Coast	1377	1220	54	103
Total	8832	5731	666	2435
Percent	100	64	8	28
Prince George				
Dawson Creek	1034	352	39	643
Fort St. John	1360	434	40	886
Mackenzie	1889	632	9	1248
Prince George	5431	1869	326	3236
Robson Valley	384	60	93	231
Fort Nelson	4307	3391	150	766
Total	14 405	6738	657	7010
Percent	100	46	5	49
Cariboo				
100 Mile House	954	169	27	758
Quesnel	1209	48	49	1112
Williams Lake	1869	155	78	1636
Total	4032	372	154	3506
Percent	100	9	4	87

Table 6-3. (cont'd)

Region and TSA	Productive Crown forest	Recent deductions[1] Forestry related	Other uses	Net operable Land base for timber production
Kamloops				
Kamloops	1641	474	131	1036
Lillooet	482	138	6	338
Merritt	818	100	59	659
Okanagan	1249	17	109	1123
Total	4190	729	305	3156
Percent	100	17	7	76
Nelson				
Arrow	399	45	89	265
Boundary	424	83	23	318
Cranbrook	471	-	-	471
Golden	232	35	27	170
Invermere	488	199	10	279
Kootenay Lake	939	446	230	263
Revelstoke	84	21	29	34
Total	3037	829	408	1800
Percent	100	27	13	60
Coast	4782	2357	511	1914
Interior	33 119	13 179	2136	17 804
Province	37 901	15 536	2647	19 718
Percent	100	41	7	52

1. In general reflects the net down or deductions that have occurred since 1981. Forestry related include NSR/DSD, NC, non-merchantable/ inoperable, problem areas, etc. Other uses include allocation to another resource use, environmentally sensitive areas, road development, etc.

Source: British Columbia 1988c.

As previously noted, TFLs in the Vancouver Region are not harvesting up to their AAC. As they comprise some of the best forest land in the province, a ratio of annual harvest to operable hectares would be expected to be higher than the regional Crown average of 8.8 m^3/ha shown above. Harvest in the last three years averaged 6.3 m^3/ha. This implies the cut is well under the potential of 7 to 10 m^3/ha shown in Table 6-4. Conversely the Crown volume-based tenures may be harvesting in excess of their growth potential.

Harvest in the Vancouver forest region

Data are available from the annual reports of the Ministry of Forests to indicate volumes and areas harvested by type of ownership. The data shown in Table 6-5 are for 1983-87.

Starting in 1985/86 the harvest increased about 4.5 million m^3 and the area harvested about 10 000 ha. Crown lands provided about 3.0 million m^3 of cut from 8000 ha, while private lands contributed about 1.5 million m^3 from 2000 ha. Crown lands had lower volumes per ha than private lands. It would appear that Timber Licences (harvest over 6 million m^3) are contributing a high volume per hectare cut.

The harvest in the Vancouver Forest Region is now about 27 million m^3. Nearly 10 million m^3 of this harvest is coming from private lands and timber licences which are not regulated by the Crown and are not included in the AAC.

If these high volume lands are largely old growth or the second growth on better sites, and have not been managed on a sustained yield basis in their own right, then a significant decrease in the regional harvest could occur if additional harvest is not available from the regulated Crown lands. Currently, the AAC on these lands is set at approximately 21 million m^3.

6.1.7 Environmental and social issues

The management and control of environmental effects of forest harvesting and other forest industry activities affect the jurisdiction and mandate of a number of other provincial and federal departments, such as Environment Canada, the Department of Fisheries and Oceans, and the British Columbia Ministry of Environment including the Recreational Fisheries Branch and the Wildlife Branch.

In this section, the basic responsibilities of the Ministry of Forests can be classified as those affecting wilderness and those affecting other forest uses.

Wilderness

After the Wilderness Advisory Commission (1986), the Forest Act was amended to include wilderness as

Table 6-4. Balance between expected mean annual growth and mean annual harvest per hectare, by region

Region	Mean annual[1] Harvest (m^3/ha)	Expected mean[2] Annual growth (m^3/ha)
Cariboo	2.2	2 - 5
Kamloops	2.6	2 - 5
Nelson	3.2	2 - 5
Prince George	2.3	3 - 6
Prince Rupert	4.0	4 - 7
Vancouver	8.8	7 - 10

1. Based on the average 5-year harvest from the net operable Crown forest land base from 1982-83 to 1986-87. Timber Licences not included.

2. Based on the second-growth forest in terms of anticipated scale volume 1988 utilization standards; low end of the range basic management only; upper end of the range moderately intensive forestry; average site index coast breast height site index = 25 to 30, Interior breast height site index = 15 to 20.

Table 6-5. Volumes and areas harvested by type of tenure, Vancouver Forest Region, 1983/84 to 1986/87

	1983/84	1984/85	1985/86	1986/87
Crown TFL "B"				
Vol. (mil m^3)	8.01	7.37	8.35	7.13
Area (000 ha)	10.3	12.0	15.2	16.5
m^3/ha	778	614	549	432
Other Prov. Crown				
Vol. (mil m^3)	7.55*	6.62*	8.68*	16.44**
Area (000 ha)	12.7	12.6	18.0	20.18
m^3/ha	594	525	482	815
Private Lands				
Vol. (mil m^3)	9.10**	8.65**	10.34**	3.53
Area (000 ha)	10.8	10.6	12.4	3.32
m^3/ha	843	816	834	1063
All Above Tenures				
Vol. (mil m^3)	24.66	22.64	27.37	27.1
Area (000 ha)	33.8	35.2	45.6	40.0
m^3/ha	730	643	600	678

* Not including woodlots and federal lands; largely "quota" type licences

** Includes timber licences and Old Temporary Tenures. Note that in 1986/87 these were considered Crown lands.

Source: British Columbia Ministry of Forests (various years) Annual Reports

a legitimate use of forest land. The Ministry of Forests was given the responsibility of designating and managing forest wilderness areas. Since then, three wilderness areas (the Height of the Rockies and two in the Stein Valley) have been created.

This provision withdraws some forest land from commercial timber harvesting. The policies and procedures for wilderness management are currently being developed.

Other forest uses

The forests are managed in the context of integrated resource uses. In establishing the AAC, the Ministry of Forests makes allowances for other resources through Environmentally Sensitive Areas and discussions with other resource agencies. Timber harvesting will be restricted in some areas to meet the objectives of other resource managers.

Public opinions and attitudes have become an important variable in formulating government resource use policies. The Ministry of Forests has developed a system of planned points for public inputs in the course of policy formulation.

The Forest Land Use Liaison Committee comprises interest groups as well as forest industry and government representatives who meet to discuss forest management problems and solutions. Representatives from public interest groups tend to be well informed about forestry and environment issues and are influential in molding public opinion.

Some studies of public perceptions of the forestry sector have indicated a general lack of knowledge of the workings of the industry and the public policies regarding resource management. Specific issues, such as biomass utilization, are generally even less well understood.

Potential constraints to biomass utilization

The review of social issues within this project focused on relatively well informed segments of the public with special interests in the forestry sector. They included:

- opinion leaders, who represent some special interest group and are in a position to influence others through their groups or the mass media
- opinion recipients, who by virtue of their position frequently receive opinions regarding forestry sector issues from the public.

A total of 38 people were interviewed. They were generally selected geographically to provide representation from all parts of the province. The study examined public values associated with both mill and logging residues. Respondents were asked for their impressions, the position of their particular group, or the public position in general. Interviews were informal and open-ended to provide maximum freedom for expression of respondent opinions.

Although the opinions expressed reflected the divergent points of view and regional focus of the different respondents, some convergence of important concerns and areas of interest were evident. For example, there is a common divergence between urban and rural residents regarding several issues; the former tend to be more concerned with "waste" or "destruction" of forest resources.

There is a fairly universal desire to see:

- increased recreational use of forest lands
- increased utilization of fibre from each hectare logged
- increased value-added from manufacture for each hectare logged
- improved silvicultural practices to sustain the harvest and protect soil and water resources.

There is quite universal concern with:

- the sustainability of current harvest levels
- the monitoring of forest industry practices in the woods
- the safety of current emissions of the forest industry into air and water
- uneconomic public subsidy of major projects - energy or forestry sector
- economic concentration (monopoly) in forest industries

Within this general framework of opinions the study also compiled opinions on the use of forest biomass. These responses can be summarized under two major headings:

- residues from forest industry mills
- residues left in the woods after logging

Milling residues

The use of mill residues emerged as a major concern in the Williams Lake region. Air quality in the town is a major problem that became a political issue in the 1987 municipal elections. The Williams Lake City Council is currently assuming that remedial measures must be taken to alleviate the smoke and fly ash problem resulting from the burning of sawmill wastes in beehive burners. Local concerns include negative impacts on health, costs of damage and clean-up to residences and business, and general quality of life in the community.

There is obviously some conflict between the importance of the industry to the economic base of the city and the desire for improved local air quality.

In other regions, mill residues were not identified as a major problem. The widespread use of hog fuel in boilers at pulpmills was generally supported, subject to air quality standards.

Specific concerns were expressed in several regions regarding alternative means of disposal if wood wastes were not burned. Problems have been encountered with wood wastes in landfills and in water bodies in several parts of the province.

Logging residues

The use of logging residues in general seems to rank below other forest management issues in public opinion. Reforestation of all logged lands appears to dominate the public concern once logging is completed.

In parts of the coast region, logging residues have become a political issue. Specific tenures on the Queen Charlotte Islands and other coastal areas have been audited for excessive logging residues.

In the complex of issues surrounding the level of coast logging residues (economics of harvesting, necessity for slash burning, recycling of nutrients, esthetics and regulation) it seems clear that better public information and understanding is essential. Both industry and government experts perceive an important need to improve the information and communication process.

6.2 Energy sector regulatory environment

Over the past few years there has been a profound shift in Canadian energy policy away from a highly regulated energy pricing system. This switch to market-based pricing has been particularly important in the industrial sector which offers the most potential for increased biomass use. The impact of deregulation provides both opportunities for and constraints to biomass use, depending upon which forms of energy are being considered.

From the mid-1970s to the early 1980s, Canadian crude oil prices were regulated by the federal government at levels far below world prices. Canadian crude oil prices are now based upon world oil prices, adjusted for transportation and crude oil quality differentials. The fall in world oil prices during the winter of 1985 - 1986, however, has more than offset the impact of deregulation which moved the Canadian oil price to parity with the world oil price. In recent years, therefore, low crude oil prices have acted as a disincentive to the substitution of refined petroleum products by biomass fuels.

While Canadian crude oil prices have been deregulated, both the federal and provincial governments do continue to exercise a major influence over the prices of refined petroleum products through various taxes (e.g., federal sales and excise taxes, and provincial road and sales taxes).

Natural gas pricing has also been deregulated in Canada, with the benefits most apparent in the industrial sector. Large natural gas consumers are now able to negotiate the wellhead price directly with gas producers, and contract with transmission and distribution utilities to process and deliver the gas. This has resulted in substantial savings to forest industries in the Inland Natural Gas and Pacific Northern Gas service areas.

Deregulation also permits natural gas utilities to selectively reduce the price of natural gas to individual customers in order to compete with alternate fuels, rather than being locked into a fixed rate schedule for each class of customer. With the advent of deregulation, natural gas utilities in British Columbia have substantially reduced the price of gas to pulpmills and sawmills in their service areas in order to keep them from converting to wood waste fuels.

In the short term, then, deregulation of natural gas pricing has worked to discourage the further use of wood wastes in the province. Over the long term, however, it could provide opportunities for increased biomass use. With the price of gas for use in domestic markets no longer regulated at a price which is substantially lower than that of gas exported to the United States, the anticipated shrinkage of the United States' gas "bubble" over the next few years will result in higher gas prices to users in British Columbia, as well as in the United States. Most industry observers expect substantial increases in the current percentage relationship between the price of natural gas and crude oil as the United States' natural gas supply-demand balance adjusts. A rebound in the world crude oil price would have a compounding effect on increasing natural gas prices.

Deregulation of electricity generation and transmission in British Columbia, while not as far advanced as that of oil and natural gas, is also underway. B.C. Hydro has recently announced that it will be more actively seeking to purchase electricity from the private sector, from both large-scale and small-scale users. In addition, it is expected that industrial generators, such as pulp mills, will be able to sell power to third parties, using B.C. Hydro transmission facilities. Both these developments will provide incentives to increase generation of electricity from biomass.

In summary, then, deregulation of fossil fuel prices has not encouraged increased use of biomass for process heat applications, given currently low world oil price levels. Any future increase in world oil prices and United States gas prices, however, will be fully passed on to consumers in British Columbia, providing an increased incentive for substitution of biomass for these fuels.

Deregulation of electricity generation and transmission, on the other hand, is expected to have a more immediate impact on the biomass demand for electricity generation by private industry, given the new policy direction of B.C. Hydro.

7. Opportunities for biomass energy use

The preceding sections have identified a number of forest sector applications in which there may be technical and economic potential for increased bioenergy use in British Columbia. This section examines technical and economic factors affecting the viability of biomass use in each of these applications, and provides estimates of the total technical potential for increased biomass utilization in each.

7.1 Pulp and paper mills

Pulp and paper mills in British Columbia are already quite self-sufficient in energy use, with hog fuel, pulping liquors, and self-generated electricity contributing more than 70% of total annual energy requirements of about 250 PJ. Reid Collins (Appleby 1988, 1989) indicates that south coastal pulp mills used 1 863 600 GPUs of hog fuel for steam and power during 1985, while interior and north coastal mills consumed 1 162 000 BDUs. This equates to about 3 million oven-dried tonnes (Odt) in total.

The major types of energy purchased by pulp and paper mills during 1986 consisted of natural gas, heavy fuel oil (south coast and Vancouver Island), and electricity, as detailed below (Table 7-1).

While large quantities of natural gas and heavy fuel oil are still used in the pulp and paper industry of British Columbia, the potential for further substitution of biomass use is constrained by a number of technical and economic factors (Robinson and Wetton 1986):

1. Biomass supply: The supply of hog fuel in the south coastal region is expected to be approximately in balance with demand during a year of low lumber production. Thus, in order for mills in this region to use more biomass, much more expensive sources such as forest residuals would have to be utilized.

2. End use constraints: Much of the remaining fossil fuel use in British Columbia kraft mills is in lime kilns. To date, direct firing of lime kilns with wood wastes has only been undertaken on a limited experimental basis, at least in North America. Contamination of the lime with residual ash and derating of kiln capacity are major concerns. Resolution of these concerns or the firing of kilns with gasified wood wastes would permit technical substitution of wood wastes in kraft mill lime kilns. Fossil fuel use in lime kilns varies considerably from mill to mill, with newer mills in the interior considerably more efficient than older south coastal kraft mills. On average, lime kiln fossil fuel use is estimated at about 3 GJ/tonne of kraft pulp output.

In addition, kraft mills require less heavy fuel oil or natural gas as start-up and supplemental fuel in recovery boilers.

It is generally accepted that direct combustion of biomass fuels is not technically or economically viable in this application, while the use of gasified wood wastes would probably

Table 7-1. Energy purchased - British Columbia pulp and paper mills, 1986

Energy type	PJ	% Total
Natural gas	23.6	9.6
Heavy fuel oil	22.6	9.2
Purch. electricity	23.1	9.4
Self-gen. electricity	1.9	0.8
Black liquor	120.0	48.7
Hog fuel	53.1	21.6
Pet. coke	1.2	0.5
Other	0.8	0.3
Total	246.3	100.0

not be economically viable. Again, there is substantial variation in the coefficient of recovery boiler fossil fuel use, with 0.5 GJ/tonne of kraft considered to be a representative figure.

In total, then, about 3.5 GJ of present kraft mill fossil fuel energy use per tonne of output is considered to be non-substitutable by biomass fuels. Given a total provincial kraft pulp output of about 5.3 million tonnes at present, more than 18.5 PJ of present fossil fuel use is non-substitutable by biomass fuels, unless wood gasification proves to be economic during the forecast horizon.

3. Load factor considerations: Power boilers, which account for the remainder of fossil fuel use in pulp and paper mills, have a very seasonal load factor pattern. Many mills generate most of their power boiler steam from hog fuel during the summer months, using oil or natural gas primarily in the winter when higher steam requirements and wetter hog fuel necessitate the firing of supplemental fossil fuels. Thus, while it is technically possible to burn more hog fuel in such mills, either through the use of hog fuel drying or the construction of additional hog fuel boiler capacity, these alternatives may not be economic, given the poor load factor of fossil fuel use in this application. With declining oil and gas prices, investment in incremental hog fuel burning capacity in British Columbia mills has decreased in recent years.

Aside from these considerations, the potential for increased biomass use in the British Columbia pulp and paper industry over the long term depends upon the degree to which increases in energy demand due to expansion of product output are offset by energy conservation measures in existing mills.

The basic forecast (prepared by Woodbridge, Reed and Associates) done for this study shows interior and north coastal kraft pulp production declining slightly from 3.125 million tonnes during 1987, to 2.895 million tonnes by 2010, a reduction of 230 000 tonnes. South coastal chemical pulp production is projected to decrease by 515 000 tonnes per annum from the 1987 level of 2.220 million tonnes. This is attributable to the projected closure of older chemical pulping capacity on the south coast, and replacement with higher value-added products.

Mechanical and chemi-thermomechanical pulp production, on the other hand, is expected to show strong growth over the forecast period, increasing by 1.2 million tonnes on the south coast by the year 2003 and remaining constant until 2008. Interior and north coastal mechanical pulp production is projected to increase by about 1.9 million tonnes over the same period.

While new mechanical pulp mills use a lot of electricity, they require relatively small quantities of purchased fuels, given the opportunity to recover most of their steam

requirements from waste heat produced during the mechanical pulping process. As a result of this factor, combined with their relatively small scale, it is generally considered uneconomic to install hog fuel boilers at stand-alone mechanical pulp mills.

Most new mechanical mills producing market pulp are expected to use natural gas for flash drying, at the rate of about 2.5 GJ per tonne of output. Biomass could only be substituted in this application if wood gasification proves to be economically viable. Market pulp, however, represents only 550 000 tonnes of the total incremental mechanical capacity forecast by Woodbridge Reed, so just 1.4 PJ of fossil fuel use would fall into this category.

The remaining 2.55 million tonnes of mechanical pulp output will be used as input to higher value-added products, primarily in newsprint and printing and writing papers. While the steam requirements of these products may vary considerably, it is unlikely that more than 2 GJ of supplemental fuel would be required on average per tonne of output, given the opportunities for heat recovery noted earlier. This would require an additional 5.1 PJ of fossil fuels. Unless the mill were part of a larger complex, it is unlikely that such a small supplemental requirement could be economically provided by biomass combustion.

In total, then, incremental pulp and paper output is estimated to increase fossil fuel requirements by 6.5 PJ over the forecast period, of which only a limited proportion is likely to be supplied by the direct combustion of forest biomass.

The closure of 500 000 tonnes of south coastal chemical pulp capacity would likely reduce fossil fuel use by at least 3.0 PJ, while a net reduction of 230 000 tonnes of interior and north coast kraft capacity would probably reduce fuel use by almost 1.5 PJ, partially offsetting the projected increase in mechanical pulp mill fuel requirements. In addition, continuing upgrading of existing pulp and paper mills will further reduce the need for purchased fuels. On balance, it is expected that the purchased fuel requirements of the British Columbia pulp and paper industry will remain relatively constant or even decline somewhat over the forecast period.

With total current heavy fuel oil and natural gas use by British Columbia pulp and paper mills in the order of 45 PJ, and 18.5 PJ considered to be non-substitutable by direct combustion of biomass, the maximum quantity of fossil fuel use that is substitutable by biomass in the short term is estimated to be about 26.5 PJ. Making allowances for peaking oil or gas use, it is considered unlikely that the maximum substitution target would exceed 20 PJ. This figure will probably shrink during the forecast as further energy conservation measures are implemented.

Aside from process steam and heat requirements, pulp and paper mills in British Columbia are very large consumers of purchased electricity. During 1985, pulp and paper mills in the province purchased 5611.2 GWh of electricity. Kraft mills tend to cogenerate most of their power requirements, given the good balance that exists between process steam and electricity use in this pulping process. On the other hand, cogeneration is seldom practiced in mechanical pulp mills which are much more electricity-intensive, but which use much less process steam per tonne of output than kraft mills.

To date, a total of 470 MW of wood waste-fired cogeneration capacity has been developed in the British Columbia pulp and paper industry. A study by Acres-Shawinigan Ltd. (1979) indicated that the unexploited technical potential for cogeneration in British Columbia's pulp and paper industry may approach 500 MW (3500 GWh at 7000 hours per year). Another study by Intercontinental Engineering Ltd. (1980) identified a practical technical potential for additional cogeneration of 225 MW in the British Columbia pulp and paper industry, based on the use of currently installed steam plant equipment. The potential identified in the latter study is based upon the use of wood wastes as cogeneration fuel, rather than fossil fuels.

7.2 Sawmills and planing mills

Sawmills already recover much of their energy from wood wastes. Reid Collins (Appleby 1988, 1989) indicates that, in 1985, south coastal sawmills used 397 200 GPUs of hog fuel for steam and power, while in 1986 interior and north coastal mills consumed 629 700 BDUs for this purpose. Assuming an equivalency factor of one oven-dried tonne per GPU or BDU, total hog fuel use by sawmills amounted to 1 026 900 Odt during the 1985/1986 time period. This amount of fuel would be sufficient to displace about 15.4 PJ of fossil fuels, given that 1 Odt of hog fuel is equal to 15 GJ of oil or natural gas.

Kiln drying of lumber accounts for most of purchased fuel use by sawmills. During 1985, sawmills in British Columbia used a total of 8.6 PJ of purchased non-motive fuels - 8 PJ of natural gas, 0.5 PJ of liquefied petroleum gases, and 0.1 PJ of fuel oils. Virtually all of this fuel use could technically be substituted with biomass fuels, although large capital investments would be required to convert existing kilns from fossil fuel to wood waste firing. The basic industry forecast projects that British Columbia coastal lumber output will increase only slightly by 2010 (see section 3). Until recently, only 10 to 15% of coastal lumber output was kiln-dried. For a variety of reasons, it now appears that there is a growing trend to increased kiln- drying of coastal lumber output. Some industry sources suggest that as much as 50% of coastal lumber output could be kiln-dried in the future. If this scenario materializes, as much as an additional 2.0 billion board feet of lumber could be kiln-dried by the end of the forecast period. Given the typical moisture content of coastal lumber, about 2 GJ per thousand board feet would be required for kiln drying, or up to 4 PJ in total.

In the interior, nearly all lumber output is already kiln-dried. The forecast suggests that lumber output in this region could increase from 11.2 billion board feet in 1987, to 12.9 billion board feet by the year 2010, an increase of 1.7 billion board feet. Given an average coefficient of 1.6 GJ per thousand board feet for kiln drying of interior lumber, up to 2.7 PJ of biomass fuels could potentially be used in this market.

In total, then, increased kiln drying of both incremental and existing lumber output could add up to 6.7 PJ of potential market for biomass fuels in British Columbia. This estimate is in addition to the 8.6 PJ of fossil fuels which are currently used in this application.

Purchased electricity requirements of British Columbia sawmills and planing mills during 1985 amounted to 1753.2 GWh. The projected increase of 2 billion board feet of lumber output over the forecast period is expected to increase purchased sawmill electricity use by about 320 GWh. Only limited cogeneration capacity is currently installed at British Columbia sawmills, given their smaller scale and lower load factor relative to kraft pulp mills. Electric rates are actually projected to decrease slightly in constant dollar terms over the next decade, but B.C. Hydro's recent decision to purchase power from industry could conceivably make cogeneration economically attractive at some mills.

7.3 Panel product mills

Included in this industry group are plywood and veneer mills, fibreboard, waferboard, and OSB plants. These plants require heat in a diversity of applications, including hot ponds, driers, presses, and building heat. According to Reid Collins surveys (Appleby 1988, 1989), south coastal veneer and plywood plants used 184 600 GPUs of hog fuel for steam and power in 1986, while interior and north coastal plants consumed 126 800 BDUs. This equates to about 311 400 Odts, or 4.7 PJ of fossil fuels.

Unfortunately, only limited data are available concerning purchased energy use by this industry group. Plywood and veneer mills, the major component of this sector in British Columbia, consumed 1.6 PJ of natural gas, 0.1 PJ of refined petroleum products, and about 260 GWh of electricity during 1984. Virtually all of the fuel presently used in this industry could be substituted by biomass converted to either steam or hot oil. Again, however, the cost of retrofitting existing plants to biomass may not be economic within the time horizon considered in this study.

Output of plywood in the province is expected to remain relatively static to 2010. Future growth of the panel products industry, instead, will be concentrated in OSB and waferboard production. Output of these products is projected to increase from about 50 000 m^3 in 1987, to 750 000 m^3 by the year 2010 (see Section 3).

Fuel and electricity requirements of waferboard and OSB plants may vary widely per unit of output, depending upon the species and moisture content of wood used, whether residuals or roundwood are used as fibre input, the climate in which the plant is located, and the type of product produced.

A reasonable rule of thumb is that each cubic metre of output in this product group will require about 5 GJ of fuel and 150 kWh of electricity. Thus, the incremental output over the forecast period would require about 3.5 PJ of fuel and 105 GWh of electricity.

The quantities of wastes produced by these mills are sufficient to make them self-sufficient in fuel requirements, but not in electrical needs. In practice, most mills of this type have only elected to recover heat from their dry wastes, disposing of bark and other wet wastes by alternate means.

7.4 Electrical generation

Aside from on-site cogeneration associated with forest industries, stand-alone generating plants selling steam and electricity to third parties are another potential future use of wood wastes in British Columbia. A number of such plants have been built in the United States given the incentive of the relatively high prices utilities have been required to pay for cogenerated power in that country.

The feasibility of building and operating a wood-fuelled 50 MW plant in Quesnel has been studied in the past (H.A. Simons Ltd. 1978), but no plant was built. Interest in such a facility, however, has recently been revived as a result of two factors:

1. Present disposal methods (beehive burners and landfilling) do not comply with provincial government emission standards.
2. With the advent of recent policy changes in the province, the opportunity for private generators of electricity to sell to B.C. Hydro or to third parties at reasonable prices appears to have improved significantly.

The British Columbia government has recently initiated a study of the feasibility of a cogeneration plant in the Williams Lake area (see Section 8.2). Wood-fuelled cogeneration plants could also be considered in other areas of the province where major surpluses of wood wastes represent a disposal problem. In its current 20-year resource plan (B.C. Hydro 1988b), B.C. Hydro assumes that up to 2500 GWh per annum could be purchased from private producers, including coal-fired and small hydro plants as well as wood waste-fuelled cogeneration. This quantity of output equates to about 350 MW, assuming an availability factor of 7000 hours per year.

A 50-MW wood-fired thermal electric generation plant would consume about 350 000 Odt of wood wastes annually, limiting the number of sites that could support a plant of this scale.

7.5 Alcohol fuels

Alcohol fuels are most likely to replace gasoline and diesel fuel, the two major transportation fuels in the province. The British Columbia Ministry of Energy, Mines and Petroleum Resources most recent (British Columbia Ministry of Energy, Mines and Petroleum Resources 1987) forecast of future transportation fuel requirements shows the following growth patterns for gasoline and diesel fuel:

Year	Diesel (PJ)	Gasoline (PJ)
1986	92.7	141.6
1990	99.2	131.6
1995	116.6	136.8
2000	138.4	143.7
2005	156.0	151.9

The minimal growth in projected gasoline demand over the forecast period is attributable to several factors, including continuing improvements in automobile efficiency and the increased substitution of propane and natural gas. On the other hand, diesel fuel demand is shown to increase by more than 68% during this time horizon, reflecting an expectation of continuing growth in truck, marine and rail transport, as well as in mining activity.

Alternative fuel utilization in the British Columbia transportation sector has been largely restricted to the use of propane and natural gas to replace gasoline in cars, and light and medium trucks. In addition, Mohawk Oil has marketed gasoline blends consisting of gasoline, methanol, and ethanol. To date, the methanol for such blends has been produced from natural gas feedstock, while the ethanol has been made from grain.

It is expected that short-term future use of alcohol fuels in British Columbia will continue to be as blends, since this approach permits the use of stock vehicles without any of the expensive modifications associated with the dedicated fuelling systems, as with propane and natural gas vehicles. In the longer term, however, factory-built methanol vehicles may become available, permitting the use of neat methanol.

While diesel fuel, of course, does not lend itself to direct replacement by combustion of wood wastes, it could be replaced by alcohol fuels from wood wastes over the longer term. The use of neat alcohol fuels in current diesel applications would require the development of suitable heavy duty spark-ignition or glow-plug engines to replace conventional diesels. An alternative approach would be to blend alcohol fuels with diesel and use cetane booster additives to permit the use of these blends in stock diesel engines.

With oil prices expected to continue at low levels for a number of years, most interest in alcohol fuels in the short term is being driven by the potential of methanol to reduce emissions (particularly in California) and by the use of ethanol as an octane enhancer, rather than by their potential for fuel cost savings. For these reasons, it is difficult to judge the future demand for methanol and ethanol in British Columbia strictly on the basis of their expected costs relative to gasoline.

While methanol has the potential to produce less carbon monoxide than gasoline, levels of aldehyde emissions from methanol may pose a problem. Formaldehyde emissions from methanol are photochemically reactive, and the Environmental Protection Agency has listed formaldehyde as a probable human carcinogen. Methanol fuelling on a large scale will require a massive investment in methanol production, transportation and storage infrastructure. Even if methanol does become popular as a means of reducing emissions, it will probably be more economic to produce it from natural gas rather than biomass feedstock, given current expectations of natural gas prices in the foreseeable future.

The British Columbia Ministry of Energy's current forecast of transportation energy requirements makes no specific provision for the use of ethanol or methanol as transportation fuels. The large-scale substitution of methanol for refined petroleum products in California combined with much higher natural gas prices than at present, however, could result in the eventual establishment of biomass-based methanol plants to serve the export market.

7.6 Summary of potential bioenergy use

Based upon the foregoing discussion, Table 7-2 summarizes the the potential for increased bioenergy use in British Columbia forest industries. The indicated potential represents an increase of 90% over present levels of biomass utilization. Such an increase, however, is contingent upon two conditions:

1. The price of oil or gas being sufficiently high to justify the incremental capital and operating costs associated with the increased forest biomass use.
2. The commercialization of suitable wood gasification or combustion technology to permit the reliable utilization of wood wastes in kraft mill lime kilns.

Table 7-2. Potential biomass energy use by British Columbia forest industries

	Pulp and Paper Mills	Sawmills	Panel Mills	Total
		(Petajoules, fossil fuel equivalent basis)		
Present bioenergy use	45.4	15.4	4.7	65.5
Purch. fuel use, 1986	48.2	8.6	1.7	58.5
Substitutable by:				
- direct combustion	20.0	8.6	1.7	30.3
- gasification	18.5			18.5
Future increase in bioenergy use due to increased output		6.7	3.5	10.2
Total potential bioenergy use	83.9	30.7	9.9	124.5
		(Thousand oven-dried tonnes/annum)		
Present bioenergy use	3026	1027	311	4364
Purch. fuel use, 1986	3213	573	113	3900
Substitutable by:				
- direct combustion	1333	573	113	2020
- gasification	1233			1233
Future increase in bioenergy use due to increased output		447	233	680
Total potential bioenergy use	5592	2047	658	8297

NOTES:

1. One oven-dried tonne is assumed to be equivalent to 15 GJ of heavy fuel oil or natural gas, based on a higher heating value of 20 GJ per Odt of wood wastes and a conversion efficiency of 60 % versus 80 % for oil or gas.

2. Present bioenergy use figures are based on Reid Collins surveys of mills during 1985 on the South Coast and during 1986 for the remainder of the province. It is assumed that the units in these surveys (gravity-packed units on the coast, and bone-dry units in the interior), are roughly equal to one oven-dried tonne.

8. Specific biomass energy supply opportunities

It seems most likely that the large biomass surplus of the late 1980s will shrink significantly through pulp use of sawdust and shavings over the next 20 years. However, there are still likely to be new opportunities for use of biomass in energy by that time.

As already noted, a large total biomass surplus, if spread over the whole province, does not necessarily mean a significant economic opportunity for biomass utilization for energy. Only in local pockets of surplus or on the coast (where water access is widely available) might sufficient quantities be delivered to a central point for economic use.

Three case studies are used to illustrate the most likely of these opportunities. One deals with the harvest and processing of a significantly increased quantity of logging wastes on the British Columbia coast. The second deals with a recognized opportunity/disposal problem in the Williams Lake area. The third deals with a long-standing problem/opportunity in the decadent stands of the "wet belt" of the British Columbia interior.

8.1 Salvage logging on the British Columbia coast

The inland waterways of the British Columbia coast have enabled an historic integration of forest industry activity which is greater than in any other forest region of the world.

Raw materials of all kinds can be transported hundreds of kilometres for a fraction of the cost of road or rail transport. Most of this activity (mill and woods) takes place within the bounds of the Vancouver Forest Region. The mid-coast and north coast regions provide similar opportunities at a higher cost. The cost of camps and supply lines for logging crews are the most significant element in extra cost.

For the purpose of this case study, the Vancouver Forest Region is assumed to be a unified potential supply district for forest residuals after normal logging. Three known extraction systems are postulated for use in salvage of forest residuals:

- loading residual materials already delivered to the landing within existing yarding operations into special bin or truck units and hauling to a processing yard
- re-logging relatively accessible portions of each setting with a skidder/tractor, loading and trucking to a processing yard
- re-logging portions of steeper settings and small wood settings with a small yarding crane, loading and trucking to a processing yard.

The total volume harvested in the Vancouver Forest Region under Scenario 2 is estimated to be 23 million m^3 (2 million m^3 from other coast regions). The forecast volume available per hectare in the Vancouver Forest Region is estimated at 630 m^3/ha; down 19 m^3/ha from the 1985/86 base. The area logged would be 36 508 ha. The residual volumes assumed available on each ha logged is forecast at 173 m^3/ha, down 3 m^3/ha from the 1985/86 base year.

A simulation analysis of the harvest of the economically accessible logging residues under the forecast conditions was performed under various assumptions of logging area allocated to each major initial-pass logging system, and harvesting and processing costs. As well, an analysis of the likely economics of the potential salvage operations was performed. It is forecast that under the assumed conditions, a small industry of about 100 firms could economically be created to provide the residual logging service. Such firms could supply residuals from logging sites in the Vancouver Forest Region roughly as pictured in Figure 8-1 (annual volume supplied) in response to various prices of fibre and fuel products. The expected average revenue per cubic metre ($27.35) resulting from sale of residuals at mill processing yards is also shown.

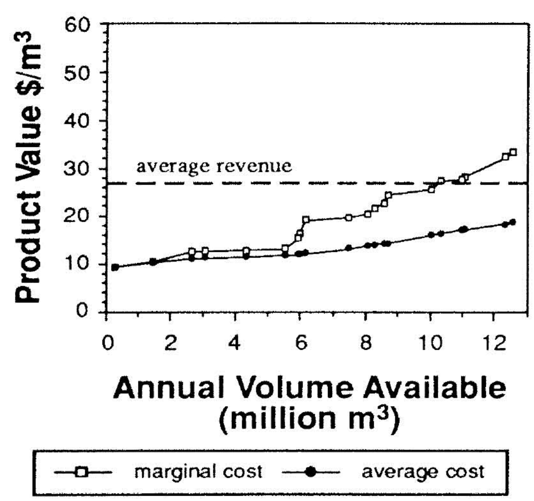

Figure 8-1. Estimated supply of fuel and fibre, Vancouver region logging residuals scenario

This new activity could supply the forecast fibre shortfall in coast pulpmills, plus provide a significant volume of additional biomass material to a central point. The pulp material should be competitive in cost and quality to whitewood sawdust imports from the British Columbia interior.

About 60% of the delivered salvage material is expected to be suitable for processing into pulp fibre. The forecast price per m^3 of clean pulpwood delivered to mill yard under scenario 2 is as follows:

Fir chips	$37.00
Whitewood chips	40.00
Cedar chips	25.00
Hardwood chips	25.00

The balance of the material, in miscellaneous hog and bark, is valued at $14/$m^3$ - its expected energy equivalent value by 2010.

8.2 Williams Lake area

A large concentration of wood waste and bark is currently being burned within or near the municipality of Williams Lake in sawmill waste-burners. The community is concerned with the emission of smoke, gases and fly-ash from these burners. A study was initiated in 1988 by the provincial government to determine the feasibility of using wood waste as a fuel for thermal power generation and cogeneration applications.

8.2.1 The supply of bark and wood waste

A detailed analysis of the fuel supply from the six sawmill-plymill complexes located in the Williams Lake area showed that the annual total of currently unused burnable wood waste generated is 356 000 dry tonnes. The expected annual unused burnable wood waste supply was estimated to be 320 000 dry tonnes in the medium term.

One major complex reported only bark, and did not report the wood components of their residue generation. They currently use much of the wood residue to generate steam.

The wood waste generated by the five mills reporting all of their wood waste ranged from 0.089 to 0.124 metric dry tonnes per cubic metre of logs used. These recovery factors included bark and log yard debris.

The sources of the current waste materials are shown in Table 8-1. This supply has an average moisture content of 38% and a higher heating value of 9500 BTU per dry pound.

8.2.2 Cost of waste materials

The total delivered cost of the Williams Lake bark and wood waste into a thermal generating facility depends upon the processing which must be performed on the material to make it suitable fuel and the transport cost from the wood products mill to the thermal plant.

Within current operations about 10% of the bark and wood waste produced is used for steam generation for forest industry purposes. An additional 2 to 4% is log yard debris which is disposed of by alternative systems, mainly landfills. The remaining 86 to 88% of the bark and wood waste is incinerated in uncontrolled wigwam burners.

The cost of operating these wigwam burners is relatively low, ranging from $20 000 to $110 000 per year per site. The resultant cost of disposal ranges from $2.00 to $4.00 per BDU. The cost of preparing the bark and wood waste for this burning disposal has been essentially zero.

Table 8-1. Source of current waste materials

Fuel source	BDU (000)*	Percent
Log yard debris & lily pads	19	5.8
Cedar chips	10	3.1
Sawdust & chip fines	103	31.5
Shavings	48	14.7
Bark	181	55.3
Mill usage	-34	-10.4
	----	------
Total net residue	327	100.0

* A Bone Dry Unit is equivalent to 2.18 tonnes of dry wood.

Table 8-2. Estimated cost of fibre transportation

Vehicle	Capacity (tonnes)	Hourly charge
"B" train	36	$70-75
Semi trailer	22	$55-60
Tandem truck	15	$45-50

If the supplying mills install hogs or other processors to reduce the large material to a uniform particle size, the cost will be higher.

The cost of transportation will be a function of distance and load density. The anticipated cost of hauling the relevant fraction of the bark and wood waste by truck will range from $2.00 to $4.00 per green tonne. If the thermal facility is located close to a large mill complex, the cost of transfer by belt conveyer will be about $1.30 per metric green tonne (assuming a 30-year conveyer life). The cost of fibre transportation was derived as shown in Table 8-2. The cost for each unit of waste wood is dependent on the distance hauled, load and unload time, and fuel cost.

The cost elements are 30 minutes each for loading and unloading, a travel speed of 65 km/h, and a March 1989 operating cost and capacity.

The equation for calculating the cost per metric tonne for a one way haul would be:

$$\frac{\text{one way kilometres} \times (2) \times \text{hourly charge}}{\text{average speed in km/h} \times \text{tonnes per truck load}}$$

plus

$$\frac{\text{hourly charge} \times (\text{load time plus unload time})}{\text{tonnes per truck load}}$$

The resulting answer is expressed in dollars per tonne for the haul with no backhaul. The backhaul should have the effect of reducing the cost. The cost calculation should be the same, except the distance should be just one way, not multiplied by two.

8.2.3 Economics of power generation

If the proposed thermal generating facility has construction costs as shown in Table 5-3 ($1.69 million/MW) and normal staffing and operating costs for such a facility, the price of power would have to be 5.6 to 6.0 cents per kWh to provide a real return on investment of 10% (assuming a debt:equity ratio of 2:1). The current B.C. Hydro offer for cogeneration power is 3.8 cents per kWh.

By using debt guarantees at a debt:equity ratio of 4:1, the power could be sold for 4.9 to 5.2 cents per kWh, with the same 10% return on investment in real terms.

On another basis, assuming alternate disposal to wigwam burners, a disposal fee of $16.50 to $21.00 per dry tonne paid to the generation facility would provide the 10% target rate of real return on capital employed. This cost is well above that of alternate disposal methods (land fill).

In the above analysis it was assumed that all of the wood waste materials would be available free at the mill source in the Williams Lake area. The forecast rise in value of whitewood sawdust and shaving materials as pulp furnish would have further detrimental impact on the economics of the proposed thermal power facility.

8.3 Salvage stands in the southern British Columbia interior

8.3.1 Defining the physical resource

In the areas of high rainfall in the southern interior of British Columbia (mostly within the Upper Columbia and Kootenay River basins) is a large area of decadent climax forest, predominated by hemlock, cedar and other shade-tolerant, moisture-demanding species. The lack of fire in the area (which has moist conditions year round) has led to maintenance of mature stand structure long after increment has ceased.

Trees in these stands are characterized by a high proportion of rot or stain, hollow cores, broken tops, and other degrading effects of old age in trees (from the point of view of utilization). The oldest and most deteriorated stands are uncommercial under normal forest industry conditions, and have remained so for over 50 years.

However, the prospect of a chip shortage in British Columbia and an improved value for biomass as fuel could bring some of these stands within the bounds of economic utilization. Once the over-mature stand is removed from each individual hectare these rather productive sites can be returned to commercial forest production through reforestation with appropriate valuable species.

One problem with this resource is that of definition - many of the defects in individual trees are not visible on the exterior. This can only be determined accurately by felling the tree. The defect or degrade is also highly variable within each locality.

The Ministry of Forests has conducted sample surveys of the volume and decay in these stands, and has defined merchantable and unmerchantable material for each important type. This information, combined with species of each strata, which is also defined in the British Columbia forest inventory, can be used to define at least the bulk of these wetbelt salvage types within the southern interior forest regions.

Table 8-3 shows the volumes in types which are in the oldest age classes and predominately cedar-hemlock or hemlock-cedar in composition. Large areas and volumes are found in portions of the Nelson and Kamloops forest regions within TSAs as shown. The table also provides the status of these types within current AAC definitions. In total, they are about 83% non-contributing at present.

8.3.2 Cost of salvage logging

Logging in these stands is only slightly more costly than in similar (sound) forests in the region if a high fraction of the total stand can be economically removed. Falling costs will be slightly higher due to some high risk from rotten trees which take extra time and care.

Table 8-4 provides an estimate of average extraction costs of about 80% of stand material to a processing yard 80 km from the forest site. The costs of in-yard processing are also estimated.

Table 8-5 shows the impact of varying haul distances on delivery cost. A crude map analysis indicates that a radius of 160 km would cover most of these salvage stands from a central point along the Enderby-Revelstoke axis. A generalized supply function for materials salvage from these stands can then be drawn roughly as in Figure 8-2.

8.3.3 Value of salvaged materials

The principal deterrent to use of these stands in the past has been the low average value of cedar products and the low quality pulp fibre in the area. With only about 25% of the stand usable, logging cost becomes prohibitive per unit of extracted volume.

However, the situation is forecast to be quite different by 2010. Table 8-6 estimates the recoverable products from each major type (decadent cedar-hemlock and hemlock-cedar) and shows the implied average value for each type and the weighted

Table 8-3. Summary of wet belt salvage stands

Region/TSA	Dominant species	Total volume (000 m^3)	AAC status assumptions	Total salvage vol. (000 m^3)
Nelson				
Golden-Revelstoke	Cedar	4100	no merch in stand	4100
	Hemlock	5400	50% merchantable	2700
Arrow-Kootenay	Cedar	1400	no merch in stand	1400
	Hemlock	3500	50% merchantable	1750
Nelson Subtotal		14 400	avg 69% outside current AAC	9950
Kamloops				
Okanagan-Kamloops	Cedar	12 100	no merch in stand	12 100
Total wet belt salvage in next 20 yrs.		26 500	avg 83% outside current AAC	22 050

average for an integrated operation producing fibre, cedar products and fuel.

The analysis assumes that the 50% of hemlock stands expected to be commercial in the British Columbia inventory estimates will in fact be recoverable to the 60% level with a small component of cedar products in addition. In the cedar-dominated types, about 20% cedar and about 15% hemlock chips are expected, together with 20% cedar products (percent of total volume). The balance of salvage materials extracted, up to 80% of total stand volume in the inventory, would be suitable for production of biomass fuel in a centralized yard (including roughly 11% bark on all salvaged materials).

The assumed prices are shown in the table and include a value of $12/m^3$ for biomass fuels delivered and processed in a central yard.

This production should result in an average value of nearly $28/m^3$ in cedar types and over $32/m^3$ in hemlock-dominated types with a weighted average of about $29.30/m^3$ for an integrated operation.

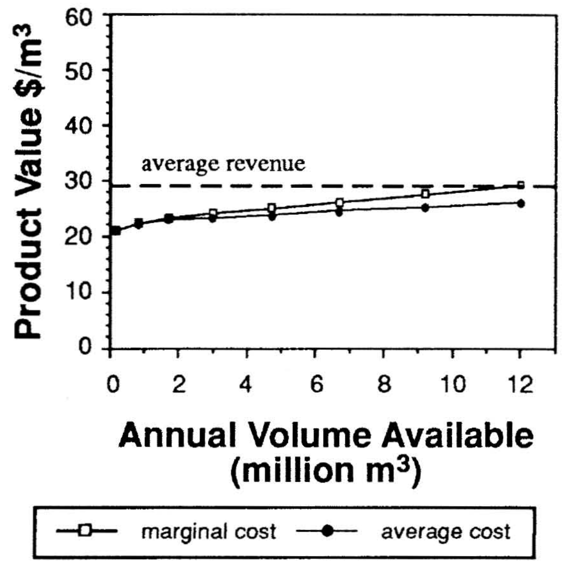

Figure 8-2. Estimated supply of fuel and fibre, wet belt salvage stand logging scenario

Table 8-4. Extraction costs (dollars) - interior wet belt

Activity	Cost per m^3	Cost per tonne
Felling/bucking	4.00	8.28
Skidding	7.60	15.73
Loading	1.25	2.59
Hauling (80 km)	6.10	12.63
Unload/shear in yard	3.62	7.49
Hog in yard	2.35	4.86
	-------	-------
	24.92	51.58

Table 8-5. Delivery costs (dollars) at various haul distances

Kilometres (one way)	Hauling cost		Total delivered cost (dollars)
	cost/tonne-km	cost/m^3	
20	0.165	1.59	20.40
40	0.161	3.11	21.92
60	0.157	4.55	23.36
80	0.158	6.11	24.92
100	0.158	7.63	26.44
120	0.160	9.28	28.09

Table 8-6. Expected utilization of total wet belt stands

Region-TSA	Dominant species in type	Total vol (000 m^3)	Pulp chips	Shakes/ shingles	Biomass fuel	Total	Prices \$/M^3 Chips	Prices \$/M^3 shi/sha	Prices \$/M^3 Fuel	Total revenue 000\$ Chips	Total revenue 000\$ Shi/sha	Total revenue 000\$ Fuel	Average per m^3	weight
Nelson														
Golden-Revelstoke	cedar	4100	35%	20%	36%	91%	\$34.30	\$45.00	\$12.00	49 221	36 900	17 712	27.83	0.15
	hemlock	5400	60%	5%	26%	91%	\$40.00	\$45.00	\$12.00	129 600	12 150	16 848	32.27	0.20
Arrow-Kootenay	cedar	1400	35%	20%	36%	91%	\$34.30	\$45.00	\$12.00	16 807	12 600	6048	27.83	0.05
	hemlock	3500	60%	5%	26%	91%	\$40.00	\$45.00	\$12.00	84 000	7875	10 920	32.27	0.13
Nelson subtotal		14 400												
Kamloops														
Okanagan-Kamloops	cedar	12 100	35%	20%	36%	91%	\$34.30	\$45.00	\$12.00	145 261	108 900	52 272	27.83	0.46
Total wet belt salvage in next 20 yr horizon		26 500	43%	15%	33%	91%	36.21	45.00	12.00	424 888	178 425	103 800	29.32	1.00

9. Conclusions

The utilization of biomass in British Columbia in the next two decades will be governed by its general availability and cost, by social values, by wood-burning technologies, and by the cost of alternate fuels and energy systems.

9.1 Biomass availability in British Columbia in the future

The principal conclusion of the analysis is that utilization of biomass for energy in British Columbia in future will continue to be driven by both supply of and demand for these materials within the forest industry.

The marketing prospects for principal British Columbia forest products appear to be excellent to 2010. There will be a large surplus of materials suitable for burning available at forest industry millsites in British Columbia through the 1990s. A gradual increase in utilization of sawdust and shavings for pulping will occur, however, and by 2010 the surplus will be significantly reduced. Increase in "waste" at millsites resulting from the utilization of smaller and lower quality logs will be offset not only by the increased use of appropriate residues for pulping but also by the increased use of hog fuel for process heat in the further manufacture of forest products. This will include kiln drying, veneer and board manufacture, and remanufacture.

Social values and environmental policies will limit expansion of the AAC between now and 2010 on regulated lands. Tighter wood supply, particularly in the Vancouver Forest Region, will effect closer and higher value utilization by the forest industries. A larger volume of "logging residues" will be removed from the woods; part will be suitable for and directed to pulping, but significant delivered volumes for burning will be available.

The economics of salvaging an increasing volume of logging residuals is expected to improve greatly by 2010. Areas that have good road systems connecting to a pulpmill or an easily accessible transfer point for barging to pulpmills or that have a high proportion of white wood species (spruce, balsam, hemlock and pine) will receive first priority. The real impetus behind this increased level of utilization will be rising fibre prices under increasing scarcity in the British Columbia pulp industry.

9.2 Wood-burning technologies

One of the most sophisticated biomass energy technologies of the forest industry is embodied in the recovery boilers of chemical pulpmills. Lignin, in the form of black liquor containing lignin and residue chemicals, which have been dissolved from wood to provide clean cellulose, is burned. Valuable chemicals are recovered from the ash for re-use in the pulping process.

Fuel oil is used to fire the black liquor in the recovery boiler. Developments in wood-based fuels which would generate perfectly consistent fuel (gaseous or dry dust form) could permit reliable use of waste wood in kraft mill recovery systems and hence entail significant new biomass use in energy.

However, the prospects of natural gas delivery to the coast (a consistent gaseous fuel) would provide a ready substitute for the fuel oil currently being used and hence will make this unlikely by 2010. Further, total chemical pulp capacity in British Columbia is expected to decline and capacity for mechanical pulps, which do not use this technology, is expected to increase. Therefore, less energy will be generated or used in this way.

The burning of hog fuel for process heat is expected to increase over the next two decades. The economics of burning massive quantities of wet, variable particle size, woody material are complex, and generally not attractive at current fossil fuel prices except as part of a waste disposal and process heat strategy at forest products complexes.

This form of use is expected to increase in the future as it becomes economically more attractive to direct a fraction of what is now logging waste into pulp chips and hog fuel. The further manufacture of wood and paper products within British Columbia will make this use even more attractive. Improved technologies will be very important in determining the rate of increase.

Refinement of wood waste into dry uniform fuels (e.g. pellets) appears to hold some economic promise for increased use of biomass fuels. This will be contingent upon provincial government policies supporting better utilization and continued public pressure for cleaner logging as well as increased demand for pulpchips. This will result in high levels of wood waste at manufacturing sites in a situation where alternate disposal such as open air burning or land fill disposal will be constrained by social and environmental considerations and hence disposal will involve a significant cost.

Markets for pellet or other dry uniform fuels would include industries, households, municipal disposal plants, and export markets in the United States Pacific coastal states. Improved technologies and local equipment manufacture will hold significant potential economic benefit for British Columbia in this field.

9.3 Competing fuels and energy sources

Further biomass use in energy in British Columbia to 2010 will be governed by the world market prices for fossil fuels over the period, and energy alternatives in British Columbia.

Even an oil price US$25 per barrel generates significant opportunities for biomass use if sustained for a few years. However, if the expectation is for a collapse back to $10-15 per barrel at least once per decade, the long-run investments required to enable biomass use would become difficult.

If the Middle East shows no indication of stabilization by the turn of the century, it seems most likely that national and provincial policies will be developed to encourage self-sufficiency. This tendency would significantly improve the prospects for biomass energy use in the forecast period.

B.C. Hydro costs in establishing new dams and generation facilities and their purchasing policy for cogeneration power are clearly a critical element in potential biomass utilization in British Columbia.

The proposed natural gas pipeline to serve the Sunshine Coast and Vancouver Island will generate both problems and opportunities for biomass utilization on the coast. It is proposed that the pipeline will supply natural gas to supplant imported fuel oils with high sulfur content currently purchased by forest products industries and usually burned in combination with mill wastes. It is not proposed that natural gas will supplant wood waste burning as practiced at present.

Various cogeneration plants have been discussed (e.g. Howe Sound) which would be supplied with natural gas. Such a plant could displace potential biomass use for the same purpose. However, there is not much surplus hog fuel on the coast (except logging residues which entail significant extra cost of delivery).

If such a thermal plant included provision for use of excess heat in drying solid wood wastes (for burning at the facility or for pelletization and shipment) a significant new opportunity could be created. Similar opportunities could be created on Vancouver Island, depending on the cost and price of the natural gas or surplus heat at the facility.

Investments in coal development in British Columbia and the current downturn in world coal prices could exert pressure for new approaches to coal use in British Columbia. The likely form is not clear at present. Discussions have been reported with Asian steel producers over potential sites for production in British Columbia. Potential impact on biomass use appears to be slight.

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Appendix

British Columbia Ministry of Forests minimum rates for special forest products and deciduous species

Minimum rates are listed in the table below. These rates may be superseded through a regional average appraisal, through an individual appraisal for the cutting authority, or in accordance with the British Columbia minimum stumpage regulation.

Species	*Product*	*Rate*
Forest Districts 11-19, 1A and 1B		
Cedar	Shake and Shingle bolts and blocks	$5.30/m^3$
Cedar	Shakes - handsplit	$6.00/m^3$
Cedar	Shakes - blanks	$7.20/m^3$
Cedar	Fence posts	$3.00/m^3$
Cedar	Fence rails	$3.00/m^3$
Cedar	Sticks and stakes	$2.00/m^3$
Cedar	Hop poles	$1.30/m^3$
All species	Firewood	$1.00/m^3$
All species	Building logs	Appraised
Deciduous species	All products	$1.00/m^3$
All species	Christmas trees	
	under 3m	$0.20 each
	3 - 5m	$1.00 each
	over 5m	$1.50 each
Forest District 28		
All species	Poles	$8.00/m^3$
Cedar	Shakes and shingles	$1.70/m^3$
All species	Mining timbers	$1.70/m^3$
All species	Building logs	Appraised
All species	Firewood	$0.50/m^3$
Cedar	Other log forms	$1.70/m^3$
Other species	Other log forms	$1.20/m^3$
Deciduous species	All products	$1.00/m^3$
All species	Christmas trees	
	under 3m	$0.20 each
	3 - 5m	$1.00 each
	over 5m	$1.50 each
Forest Districts 11 and 12		
All species	Grade X and grade y	$0.25/m^3$

Source: British Columbia, Ministry of Forests. 1988. Coast appraisal manual.

British Columbia Ministry of Forests minimum rates for special forest products and deciduous species

Special forest products, grades 04, x and y logs,
and deciduous species minimum rates

Species	*Product*	*Rate*
Cedar	Bolts and blocks	$5.30/m^3$
Cedar	Shakes	$6.00/m^3$
Cedar	Blanks	$7.20/m^3$
Cedar	Fence posts	$3.00/m^3$
Cedar	Mining timbers and fence rails	$3.00/m^3$
Cedar	Other log forms	Appraised
All species	Building logs	Appraised
All species	Firewood	$0.50/m^3$
All species	Poles	Appraised
All species	Christmas trees	
	under 3m	$0.30 each
	3 - 5m	$1.00 each
	over 5m	$1.50 each
All species	Grades 04, x and y logs	$0.25/m^3$
All deciduous	All products	$0.50/m^3$
Other species	Other log forms	$1.00/m^3$
Other species	Fence posts	$1.20/m^3$
All species	Orchard props, rails	$1.20/m^3$
	Mine cribbing	$1.20/m^3$
	Pickets and palings	$1.70/m^3$
	Stakes and sticks	$1.20/m^3$
	Rails (split), lagging (split)	$1.20/m^3$

Source: British Columbia, Ministry of Forests. 1988. Interior end-product appraisal manual