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Cost structure of hog fuel transportation in Canada

Contents

1 Introduction
2 Objectives
2 Methods
2 Results
10 Discussion and implementation
12 Conclusions
13 Recommendations for further work
13 References
13 Acknowledgements

Abstract

The Forest Engineering Research Institute of Canada (FERIC) undertook a project for Natural Resources Canada (NRCan) to study the transportation of hog fuel from source to consumption site. In particular, FERIC gathered information from companies engaged in the supply, transportation, or use of hog fuel through direct visits or questionnaires. This report presents the types and costs of the various modes of transportation used—specifically truck, rail, and barge—and the advantages and disadvantages of each.

Keywords

Fibre recovery, Wood waste, Logging residues, Hogged fuel, Transportation, Productivity, Costs.

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Introduction

During the primary conversion process when whole logs are turned into lumber, flakes, veneer, and chips, residual products are generated that include broken stems, pulp chips, sawdust, trim ends from logs and lumber, planer shavings, sander dust, and bark. Wood waste is also generated at harvesting sites and consists of limbs, tops, foliage, and sections of stems that cannot be utilized. In the past, when markets were not available for the residual products, wood waste was either burned or stockpiled as landfill. However, the increase in fossil fuel prices and more stringent smoke abatement and landfilling regulations have made utilizing the wood waste more attractive.

Hog fuel is wood waste, primarily bark, that is torn up and shredded. It is used as a source of energy to fire boilers that generate steam for electricity, or it is used as a source of heat. A small portion of available wood waste can be utilized to reduce purchased energy costs at the originating site. However, facilities that can utilize large, continuous volumes of surplus wood waste are often remote from the primary conversion facilities. To maximize payload and allow storage and material flow, wood waste is usually processed into hog fuel prior to transportation.

Purchasers of hog fuel will not pay as much per thermal unit as for natural gas or oil. This is because, historically, hog fuel was considered waste and until recently, the supply has largely exceeded demand. In addition, capital costs are required for retrofitting boilers; heating energy from hog fuel is variable and depends on the species, type, and size of material and moisture content; and grit and sand mixed with the hog fuel increases boiler maintenance. Hog fuel boilers cost more to build and operate and are less thermally efficient than oil or gas fired boilers. Consequently, the cost of transporting hog fuel to the power plant can reduce the economic viability of operating the boiler on hog fuel rather than on gas, and therefore the transportation cost must be minimized.

Ledrew et al. (2004) compiled a literature review on the recovery, transportation, and processing of forest biomass into fuel, but little work has been done to examine the most efficient modes of transportation in Canada. This report describes the results of a study that FERIC undertook for NRCan to determine the types, costs, productivity, and limitations of transporting hog fuel from source to consumption site, and focuses on truck, rail, and barge (water-based) transportation.

Objectives

There were several objectives for this study:

- Determine the costs and productivities of the modes used throughout Canada for transporting hog fuel—specifically truck, rail, and barge transportation.
- Establish the range of applicability, limitations, and fixed infrastructure requirements of each transportation mode.
- Determine what developments would be needed to improve the costs and productivities of the transportation modes.

Methods

During the fall and winter of 2004/05, FERIC researchers canvassed companies engaged in the supply, transportation, or use of hog fuel (Appendix I). The companies were located in Alberta, British Columbia, Ontario, Quebec, and the northeastern United States. FERIC distributed a questionnaire (Appendix II) to these companies to gather information on the following:

- hog fuel suppliers and their loading infrastructure
- hog fuel transportation modes and costs
- hog fuel unloading infrastructure

As well, FERIC researchers visited twelve of the companies that completed questionnaires to observe their hog fuel loading, unloading, and transportation facilities and activities. Information and knowledge gained from previous work related to transportation and biomass research were utilized as well (Forrester 1996, 2003, 2004; MacDonald 2001).

To supplement the information collected, FERIC developed spreadsheet models to provide cost trend estimates for the western Canadian hauling options and for various eastern Canadian truck/trailer configurations. These models incorporated data from questionnaires (load/unload time, tire weights, hog fuel density and moisture content), truck operating and ownership costs (FERIC's database of equipment costing and truck/trailer manufacturers), and highway/road descriptions (distance and travel speed by road class).

Table 1. Hog fuel transportation questionnaire responses

Contact	Responses East (no.)	Responses West (no.)
Supplier of hog fuel	11	12
Hauls hog fuel	0	2
End user of hog fuel	11	5
Currently burns wood waste/hog	0	8
No excess hog for transport	0	1
Total	22	28

Results

All fifty of the companies contacted returned the questionnaires (Table 1), but the responses to the questionnaires were often incomplete. The explanations for the unanswered questions ranged from "do not know" to "cannot tell (for reasons of confidentiality)". In other cases, information was not available for individual units delivering or receiving hog fuel to/from specific plants. Eastern Canadian respondents in particular

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were reluctant to provide information on costs. The information from the responses is summarized for the hog fuel suppliers (Table 2) and users (Table 3).

Costs to haul hog fuel are difficult to obtain because of the competitiveness in the transportation industry and regional differences. Companies may deliberately choose to haul for less than actual costs to remain in the business or as a bargaining tool to obtain a more lucrative haul for another area. Also, companies may decide to depreciate tractors and trailers over different periods of time. Regional differences in the purchase price for tractors and trailers, fuel costs, operator wages, overtime payment, overhead (e.g., supervision and shop facilities), insurance, loading and unloading facilities, road standards, and vehicle weight and dimension regulations will also contribute to differences in hauling costs.

Of the 28 companies contacted in western Canada, 8 were hog fuel users who burned their residues in olivine-type burners (Figure 1) and 12 were hog fuel suppliers. Four of the hog fuel burners estimated that their annual residue production ranged from 51 500 to 122 500 green metric tonnes (gmt)[1] and averaged 76 700 gmt per year. Two of the suppliers barged the hog fuel and the remaining 18 transported the hog fuel by truck. Table 2 shows the range of volumes supplied and bulk densities of hog fuel delivered by the suppliers. Truck haul distances ranged from 1 to 330 km. Because hog fuel is not moved by rail in western Canada, the distances estimated for pulp chip deliveries were used to develop the costs.

Of the 22 companies contacted in eastern Canada, 11 were cogeneration or power station facilities that received residues, and 11 supplied residues to a pulp mill or power plant for conversion to electricity and steam. All but one of the companies contacted hauled residues using truck transportation, while one company loaded three to four railcars a day with residues for hauling to a mulch plant in the northeastern United States. Residue consumption at the cogeneration and power station facilities ranged from 95 000 to 800 000 gmt/year and the suppliers provided 8000 to 205 000 gmt/year of various sawmill residues to the pulp mills and power plants. Table 2 shows the range of volumes supplied and bulk densities of hog fuel delivered by the suppliers. Truck haul distances ranged

Table 2. Characteristics of hog fuel produced by supplies

	Annual production (gmt)	Bulk density (kg/m³)	Annual operating hours (h)	Distance to unload site (km)
Western Canada				
Maximum	254 000	1 000 [a]	8 712	330
Minimum	18 500	250	2 500	0.8
Average	124 000	667	5 151	73
Eastern Canada				
Maximum	205 000	n/a	n/a	850
Minimum	8 000	n/a	n/a	<10
Average	57 800	n/a	n/a	192

[a] Represents hog fuel derived from logs recovered from water storage facilities in coastal British Columbia.

Table 3. Hog fuel user summary

	Annual production (gmt)	Suppliers (no.)	Hog fuel holding area (ha)
Western Canada			
Maximum	523 000	n/a	1.21
Minimum	41 700	n/a	0.13
Average	238 940	n/a	0.71
Eastern Canada			
Maximum	800 000	35	0.25
Minimum	48 000	12	6.00
Average	335 730	n/a	

Figure 1. Olivine burner (circled) at a sawmill.

[1] Green metric tonnes: the weight of wet hog fuel in tonnes.

Figure 2. Side-dump B-train trailer dumping hog fuel into receiving pit.

Figure 3. Overhead bins for pulp chips (left) and hog fuel (right).

Figure 4. Side-by-side hog fuel tippers and B-train.

Figure 5. Live-floor trailer dumping onto a converyor.

from less than 10 km to 465 km, and the single rail haul was 850 km.

Western Canada

Various truck and trailer combinations are used to transport hog fuel in western Canada, but the most common is a 16.2-m (53-ft.) trailer (Appendix III, Figure III-a) equipped with a live floor. B-trains (Appendix III, Figure III-b), super B-trains, and side-dump B-trains (Figure 2) are also used. Loading times average 22 minutes and range from 10 to 30 minutes, depending on trailer configuration and loading method. Little information on delays and idle time was obtained, but information from industry contacts suggests 10 to 100 minutes per load. Payloads range from 22 to 30 gmt for the live-floor-equipped trailers to 37 to 39 gmt for the B-train configurations, and vary depending on configuration, species (wood density), and moisture content of hog fuel. Round-trip cycle times range from 30 minutes for a 0.85 km haul to 11.2 hours for a 330 km trip.

Handling of hog fuel (bark)

Bark from debarking equipment is either discharged and conveyed to an in-line hogger that comminutes the residues for better flow and from there conveyed to overhead loading bins (Figure 3), or it is discharged to an outside stockpile. Outside stockpiles are accumulated on paved or natural surfaces. Truck trailers are loaded either by driving under the overhead bins or by a front-end loader loading trailers from a stockpile of material. Most operations have a bypass system to redirect the hog fuel if the bins are full; the hog fuel would later be loaded out with a front-end loader. Bins can be subject to plugging in cold weather (-20°C) when hog fuel is left in them. Scheduling of trucks so their hog fuel can be dumped before it can freeze is important to ensure the material flows freely.

Two basic unloading techniques are used at the truck terminal locations in western Canada. One technique uses tippers for end-dumps (Figure 4) and side-dumps to upend or turn over trailers, and the other uses a live floor mechanism incorporated into the trailer (Figure 5). The incoming material is generally dumped into a receiving pit and from there conveyed to a disc screen (Figure 6). The accepted fibre is then discharged onto a storage pile or conveyed to the power boiler facility. Oversized pieces from the disc screen are conveyed to a hogger and then discharged onto the "accepts" hog fuel conveyor. In a few cases, properly sized hog fuel is discharged directly onto a storage pile (Figure 7) where a bulldozer or front-end loader piles the material. At the sites where hog fuel is stored, the hog fuel piles occupy areas that range from 0.12 to 1.2 ha.

Barges are loaded by overhead conveyors and take from 4.5 hours to 5 days to fill depending on mill production and equipment availability. Barge sizes are based on capacity of the supplier and range from 775 to 950 gravity-packed units (GPU).[2] Unloading takes 1–2 days to complete and is accomplished with overhead cranes or front-end loaders.

FERIC did not observe any rail operations in western Canada and found the rail companies to be generally unresponsive to requests for information. However, based on discussions with mill staff having experience transporting pulp chips by rail, some general information was collected on the infrastructure required for shipping hog fuel. Access to a rail line and cars capable of carrying hog fuel are clearly required. If hog fuel is transported, rail-line siding infrastructure may need to be expanded or developed to allow the loading of the railcars off the main line. Railcars can be loaded with a front-end loader, excavator, or conveyor. A sufficient volume of hog fuel must be produced to minimize rail-car waiting costs. Unloading facilities would also require access to a main rail line and siding infrastructure. Unloading itself could be as simple as using an excavator equipped with a special bulk-loading bucket for smaller facilities, or as complex as rotary dumpers that can unload unit-trains without detaching cars.

Transportation costs

Questionnaire respondents were either largely unwilling to discuss costs or did not have access to the information. As a result, the cost information collected represents a very small sample.

Figure 6. Disc screen.

Figure 7. Live-floor van dumping on storage pile.

Eleven individuals representing hog fuel trucking companies and two individuals representing companies that barge hog fuel provided information on hog fuel hauling costs, which were converted to $/bdt[3] (Figure 8a) and $/bdt-km (Figure 8b). In addition, the hog fuel hauling costs from two recent FERIC in-woods chipping studies were also included (Forrester 2003). Hauling costs at 6 km from the pulp mill ranged from $7.00 to $9.00/bdt while hauling costs at 85 km were $9.00 to $18.60/bdt.

Although trucking costs varied, the general trend was an increase in cost per unit as distance increased, with a corresponding

[2] A gravity-packed unit is a volumetric unit used in coastal British Columbia that occupies 200 ft.^{3} (5.663 m^3) of space (Nielson et al. 1985).

[3] Bone-dry tonnes: the weight of dry chips. Although the most common measures of chip volumes in western Canada are the gravity-packed unit (coastal British Columbia) and the bone-dry unit (interior British Columbia), the bdt has been used in this report to maintain consistency between western and eastern Canada. A bone-dry unit weighs 2400 pounds (1089 kg) when oven dry (Nielson et al. 1985).

Figure 8a. Transportation costs ($/bdt) in western Canada by one-way haul distance (includes terminal times).

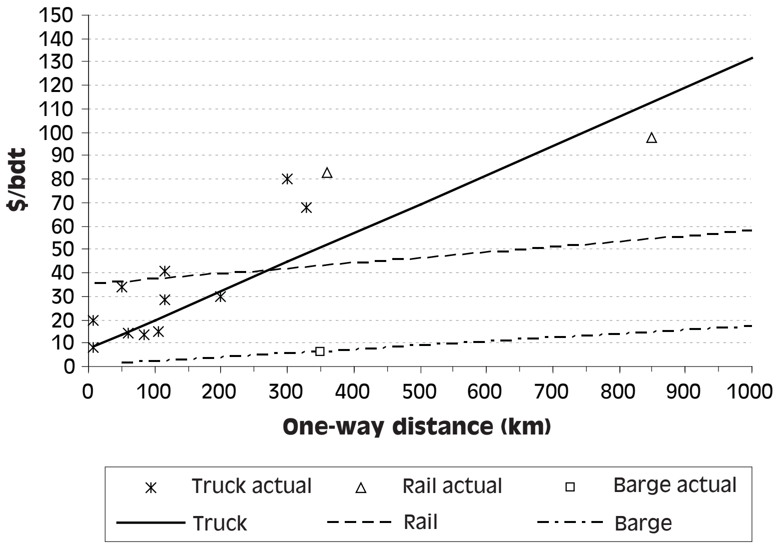
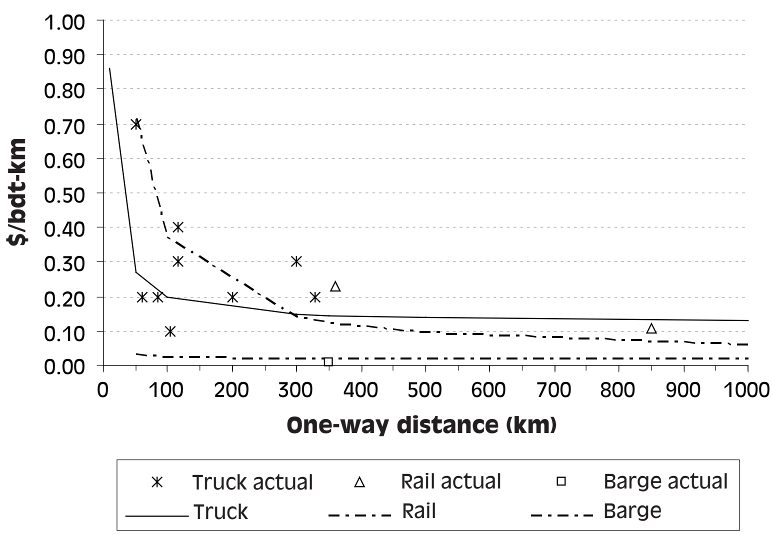


Figure 8b. Transportation costs ($/bdt-km) in western Canada by one-way haul distance (includes terminal times).



decrease in costs per unit-km. The majority of these configurations were 16.2-m vans with live floors, although several B-train units with a greater load capacity than the 16.2-m vans were also noted. The costs to haul hog fuel by the larger units were less than for the smaller units.

To provide some indication of hauling cost trends, FERIC developed an independent spreadsheet model for western Canadian hauling options. Figures 8a and 8b (see Appendix IV, Tables IV-a to IV-d) show the expected costs per bdt and bdt-km, respectively, for hauling by truck, rail, and barge. Equipment costs developed from previous FERIC trucking work (MacDonald 2004, 2006), and cost estimates for infrastructure, production, and terminal times obtained from industry comments were used in the model. Readers are cautioned to view the information simply as providing relative relationships for the costs associated with transporting hog fuel by truck, rail, and barge, and not as providing accurate specific unit costs.

In general, the actual costs of trucking hog fuel were widely scattered and generally higher than the model suggests. This is attributed to the lack of precise information on costs and distances that the contacts wished to provide, a variety of truck configurations, and competition in hauling that may result in some hauls being more expensive to offset lower-cost hauls.

Rail costs estimated by the model for distances between 100 and 1000 km appear to be considerably lower than costs provided from the questionnaires. This is attributed to the small amount of data available to generate a model.

Truck transportation costs on a bdt basis increased faster as distance increased compared to the estimated rail costs, and intersected between 250 and 300 km. Although the costs on a bdt basis to barge hog fuel are less than for truck and rail, there are few, if any, opportunities for barging to replace the other methods. Over distance, the truck and rail costs per bdt-km decreased measurably while barging costs appeared to be flat.

Observations and discussion

Currently, the pulp and paper mills in western Canada mainly rely on purchased chips produced as residues from sawmilling and few operate in-house woodrooms where hog fuel can be produced. Consequently, hog fuel is purchased and delivered from sawmills. Along the British Columbia coast, hog fuel is generated at sawmills and shake mills located around the southern mainland and Vancouver Island. This hog fuel, along with pulp chips, is transported by tug and barge to the pulp mills, which have traditionally used a combination of hog fuel and bunker-C fuel oil to power their boilers.

In the past, when sawmills were located away from the British Columbia coast, residues were burned or landfilled. The latter option was also employed in logyards and isolated locations where wood residues from log upgrading were produced.

In the British Columbia interior, Alberta, and Saskatchewan, pulp mills have also reduced the amount of chips produced in their woodrooms and are relying on purchased chips from sawmills for their furnish. One pulp mill has converted to an in-woods chipping operation where chips are produced at the harvest site or satellite yards, and trucked to the pulp mill. Pulp mills in this region traditionally relied on natural gas for their power boiler needs, but in recent years the focus has shifted to increasing the amount of biomass (i.e., hog fuel) consumed to offset the escalating costs of petroleum and natural gas energy.

In recent years, cogeneration plants have been built at several centres that utilize the waste wood residues produced by the local milling industry. As the size of the cogeneration plants has increased from the 7 to 60 MW range, the demand for hog fuel and the transportation distances have increased. Also, the types of trailers in certain areas such as Grande Prairie, Alta. are changing, with B-train end dumps and B-train side dumps becoming more common because of their bigger payload. The side dumps are also reputed to have good cycle times on short hauls, and reduce the need for sophisticated truck-dumping installations at the receiving site.[4]

Eastern Canada

Trucking is the main transportation mode used for hauling bark in eastern Canada. Transport is usually carried out by independent transport companies under contract to either the supplier or the cogeneration facility. For hauling bark, transport companies use the same truck configurations as for hauling wood chips, which are B-train and semi-trailer configurations (Appendix III, Figures III-b and III-c). Rules for vehicle weight and dimensions vary from one province to another, with Manitoba being the most restrictive. In general, Manitoba, Ontario, and the Maritimes use tri-axle semi-trailers (Appendix III, Figure III-a) with a box length of 14.6, 15.5, or 16.2 m. Box lengths of 15.5 m are the most common in these provinces, since 16.2-m boxes cannot be fully loaded without exceeding the weight limit for this configuration. In Ontario and New Brunswick, 4-axle semi-trailers are accepted with a special permit delivered under an agreement with the province of Quebec and are becoming more and more popular. In Quebec, the 4-axle semi-trailer with a 15.5-m box is standard (Appendix III, Figure III-c). The 4-axle semi-trailer can be used with a 16.2-m box if equipped with a self-steering axle. This latter configuration is gaining popularity as it permits an extra 1 to 2 tonnes of payload compared to the regular configuration.

B-train configurations (Appendix III, Figure III-b) are also used for hauling bark but are not that common. Most tippers used at cogeneration facilities do not have the capacity or length to unload B-train configurations in one step. Therefore, operators have to unload their trucks in two steps which takes longer. Some people interviewed mentioned that because bark is heavier than wood chips it can damage the trailer, in particular the doors of the first trailer, when unloading the B-train in one step. This is

[4] Dennis Young, Weyerhaeuser Company Limited, personal communication, August 2005.

another reason why transport companies prefer semi-trailer configurations to transport bark.

Semi-trailers with live floors are common and are used to deliver fibre to facilities that are not equipped with tippers. Live-floor semi-trailers work under the same regulations as regular semi-trailers, although lengths of 14.6 and 16.2 m are more common. The payload of live-floor semi-trailers is usually less than regular semi-trailers because of the live-floor mechanism's space and weight, and therefore lead to higher transporting costs.

Because of the density of bark (reported average moisture content of 55% wet base), most truck configurations reach their weight capacity. Volume transported by semi-trailers varies, at 100 m³ for a straight 14.6-m box; 126 m³ for a 4-axle, 16.2-m semi-trailer with a belly; and 150 to 155 m³ for a B-train. Payloads also differ depending on configuration, at 27 tonnes for a straight 14.65-m semi-trailer; 35 tonnes for a 4-axle, 16.2-m semi-trailer (33 tonnes for a tri-axle); and 40 to 42 tonnes for a B-train.

Transportation by rail is uncommon and only one example of transportation of bark by rail was identified in eastern Canada. Bark was transported by rail over 850 km from Parent in central Quebec to Auburn in southern Maine for production of mulch. U.S. rail transportation costs were high (estimated at US $40/gmt), but it was considered cheaper than truck transportation over the same distance. It is unlikely that rail transportation will expand, as it offers little flexibility and remains expensive.

Figure 9. Front-end loader loading hog into semi-trailer.

Bark is hauled over a wide range of distances. In some areas, bark suppliers are close to the cogeneration facilities and the average hauling distance is relatively short at less than 50 km. In other cases, hauls are up to 465 km. Haul distances appear to depend on the market, i.e., the value of the bark to the user, and the availability of transportation. Because of the growing interest in co-heat and power, bark transportation is expected to increase rapidly.

Handling of hog fuel (bark)

At sawmill facilities, bark is usually not hogged at the source and most of the bark handling is done with a front-end loader. Front-end loaders are common equipment in sawmill yards and the handling of bark is only a part of their work. Bark from debarkers usually falls on a conveyor that directly transports the material outside. A front-end loader equipped with a bucket is then used to clear the area under the conveyer drop-off and to transport the bark to a nearby pile. The bark is usually piled directly on dirt-surfaced ground, but in some places, bark is stored on concrete-surfaced pads to avoid contamination with dirt and rocks. Some sawmills use old beehive burners to store bark, but this is rather uncommon. Front-end loaders are also used to load semi-trailers with bark (Figure 9). Reported loading times vary between 10 and 20 minutes.

At the Chapais sawmill, located north of the Lac St-Jean area in Quebec, a hopper was installed at the sawmill by the thermal power centre that takes delivery of the sawmill's bark. The hopper is owned and maintained by the thermal power centre. Although other sawmills around Lac St-Jean are also equipped with hoppers, the use of hoppers is generally uncommon. Hoppers permit the loading of semi-trailers directly without handling the bark and this system reduces the amount of contaminants from the storage surface. However, hoppers do not have large capacities and truck loading needs to be constantly synchronized with the production of bark. In Chapais, loading time with the hopper was close to one hour. No information on loading time was gathered from other locations with hoppers.

Most cogeneration facilities and thermal power plants are equipped with tippers (Figure 10). Unloading with tippers is usually done within 30 minutes, including weighing the truck before and after unloading. Waiting time can be longer if several trucks arrive at the same time. In some places, unloading took close to an hour and was considered a problem that needed to be corrected.

Semi-trailers with live floors deliver bark to cogeneration or thermal power plants not equipped with tippers. Personnel reported that unloading time with a live-floor semi-trailer is approximately 20 minutes.

The yards at thermal power plants are usually covered with a membrane to contain leachates and surface water run-off. Large-capacity front-end loaders place bark into different piles to mix the bark from different sources. Bark is then fed to the power mill via conveyors or augers located under the pile or by a front-end loader feeding a conveyor. Cogeneration and thermal power centres usually run 24 hours a day year-round. One or two front-end loaders, and/or sometimes a bulldozer (Figure 11), are used 24 hours a day. Bark feeding the mill passes through magnetic rollers, metal detectors, and screens, while oversized material is fed to a hogger (Figure 12). Some problems reported by the cogeneration centres were long wood pieces passing through the screens, rocks jamming augers, and bark contaminated with dirt.

Transportation costs

FERIC developed a cost model for truck transportation based on the data collected for eastern Canada and FERIC costing databases. Figures 13a and 13b (see Appendix IV, Table IV-e for data) show the expected costs per bdt and bdt-km, respectively, for a range of transportation distances for various trailer configurations. As expected, the units with larger payloads experienced lower costs. This model is based on limited hauling production data and may not indicate the actual cost differentials in truck/trailer configurations. For example, experience in western Canada suggests B-train configurations become much more attractive at longer distances compared to 15.5 m (51-foot) live-floor configurations.[5]

Figure 10. Unloading hog using a tipper.

Figure 11. Crawler tractor pushing hog into mill infeed conveyor.

Figure 12. Hog at mill infeed.

Observations and discussion

The market for hog fuel in eastern Canada has developed considerably since the first

[5] W. Mercer, Tembec Industries Inc., personal communication, August 2005.

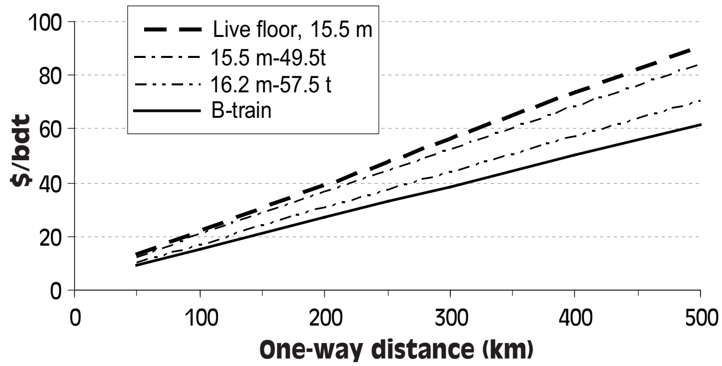


Figure 13a. Transportation costs ($/bdt) in eastern Canada by one-way haul distance (includes terminal times).

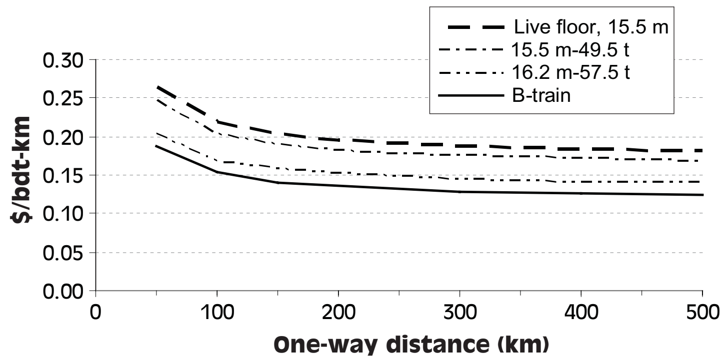


Figure 13b. Transportation costs ($/bdt-km) in eastern Canada by one-way haul distance (includes terminal times).

co-heat and power and thermal power centres were built a decade ago. Although once considered as waste requiring inexpensive means of disposal, bark is rapidly becoming a source of revenue for some sawmills. Some sawmills in remote areas, though, still have to pay to dispose of their bark. In some regions (Eastern Townships and Lac St-Jean areas in Quebec, and northwestern New Brunswick), all bark produced by sawmills is sold on the market and additional bark is imported from other regions at higher costs to the users. With the rising price of fossil fuel and electricity, the demand for hog fuel will increase, thus initiating opportunities to recover harvest residues from the forest as part of harvesting operations. This recovery is already occurring in northwestern New Brunswick and southern Quebec.

Interest may turn again towards recovering the huge piles of bark that have accumulated in sawmill backyards and landfills over the years. These piles have been ignored because too many materials contaminate the fibre, such as scrap metal and chemical residues from the mill. If the material is to be used in co-heat and power plants, then specialized decontamination equipment and sorting processes are required. In addition, the heating value of older material will also have to be carefully assessed to determine whether it is cost-effective to recover.

Discussion and implementation

The knowledge the Canadian forest industry has developed for shipping pulp chips by rail can be transferred to the shipment of hog fuel. As well, the expertise of coastal British Columbia fibre shippers/users could be utilized to develop an efficient water transportation system in eastern Canada. Even with the inaccessibility of ports along fresh-water waterways during the winter, year-round opportunities may exist around the Maritimes and the mouth of the St. Lawrence River. While the current hog fuel values may not justify shipping fibre long distances, circumstances may change in the future as the cost of petroleum and natural gas increases. Local workshops that introduce the concepts of rail and barging would generate new ideas.

The following summarizes the questionnaire responses and FERIC's interpretation of the limitations associated with the current infrastructure. The information is grouped into benefits, disadvantages, and technological improvements suggested for truck, rail, and barge transportation.

Truck transportation

Benefits

- Haul distance ranged from less than 20 km to 330 km in western Canada and less than 50 km to 465 km in eastern Canada.
- Cost per bdt-km appears to remain constant beyond 250 km.
- The trucking industry is well established and has a variety of truck/trailer combinations to accommodate hauling needs.

- Truck hauling is extremely flexible—trucks can be quickly diverted to different facilities, different products can be hauled, and alternate transportation routes can be used when highway disruptions occur.
- The infrastructure required for loading is relatively simple—conveyors, ramp, and front-end loader. Front-end loader usage can be shared with other activities.
- Trailer configuration will vary by dumping infrastructure. For example, live-floor and side-dump trailers can discharge directly into a pile or receiving bin, whereas conventional end-dump trailers and B-trains require tipping ramps to discharge into a receiving bin.

Disadvantages
- Cycle times are affected by loading and unloading efficiency.
- Increases in driver wages and fuel costs directly increase truck hauling costs.
- Legal truck configurations and gross vehicle weights vary by provincial regulation.
- Some regions are experiencing driver and truck shortages.
- Emissions associated with individual tractor units could be significant.

Technological and strategic improvements
- Technological developments that offset increasing fuel costs include fuel additives, dual-fuel engines and reduced emissions, and driver training and awareness programs and workshops.
- New materials for truck frames and trailers can reduce net vehicle weight and increase payload. The use of these materials needs to be demonstrated.
- Back hauling can increase truck/trailer utilization. Opportunities for backhauling of biomass need to be identified.
- Scheduling and communication tools can allow truck locations to be identified in real time to aid dispatching and unloading.
- The potential of side-dump and end-dump trailers should be further examined.
- Standardization of recognized truck configurations and load volumes across Canada can result in efficiencies when hauling across provincial borders.

Rail transportation

Benefits
- Haul distance ranged from 360 to 3300 km in western Canada for hauling pulp chips, and was 850 km for the rail operation identified in eastern Canada for hauling hog fuel.
- Costs per bdt-km beyond 110 km appear to be relatively flat based on the information collected.
- Large quantities can be moved and delivered in one shipment.
- More use of rail transport would lead to fewer trucks hauling on congested or low-class highways.
- Vehicle emissions and fuel usage will be less when compared to hauling a similar volume by trucks.

Disadvantages
- Access is limited to existing rail lines and large capital investment is required for new rail siding and terminals.
- A continuous large supply of hog fuel is required to supply a minimum number of cars.
- Waiting time for loading and switching cars needs to be carefully monitored to contain costs.
- Routes may experience blockages due to weather or track maintenance.
- High-volume traditional users may receive higher priority when engines or cars are in demand.
- Moving hog fuel by rail is uncommon and, therefore, there is little experience with this method.
- Rail companies do not consider the forest industry a large client and are, therefore, inflexible in rate negotiations and routes.

Technological and strategic improvements

- Simple low-cost methods for loading and unloading rail cars that do not require large capital costs would make this option more viable.
- Implementing back-hauls would increase rail car utilization.
- A better understanding of the rail transportation business would facilitate use of the system.
- If direct rail access is not available, hog fuel may be delivered by trucks to a railhead for loading or may be offloaded into trucks for delivery to a user facility; however, this reloading will increase costs.

Barge (water-based) transportation

Benefits

- Haul distance ranged from 90 to 270 km in western Canada.
- Costs per bdt-km beyond 300 km appear to be relatively flat based on the information collected.
- Large quantities can be moved and delivered in one shipment.
- More use of barge transport would lead to fewer trucks hauling on congested or low-class highways.
- Vehicle emissions and fuel usage are less when compared to hauling a similar volume by trucks.

Disadvantages

- Access to a water route and loading/unloading terminals are needed to handle the tugs and barges utilized.
- Investment is needed in tugs and barges, dock/wharf facilities, and loading/unloading infrastructure if these are not already available.
- A continuous large supply of hog fuel is needed to supply a minimum number of barges.
- Waiting time for loading and switching barges needs to be carefully monitored to contain costs.
- Weather-related delays may occur, such as fresh-water waterways being unavailable in the winter due to ice.
- If direct water access is not available, hog fuel may be delivered by trucks to a wharf for loading or offloaded into trucks for delivery to the user facility; however, this reloading will increase costs.
- Moving hog fuel by barge is uncommon in eastern Canada and, therefore, there is little experience with this method in this region.

Technological and strategic improvements

- A better understanding of water transportation in eastern Canada may increase the potential for use of this method.
- Integration of water transport with trucking should be considered.

Conclusions

The results of the surveys and interviews indicate that truck transportation is the most common transportation mode in Canada of hog fuel. Barge transportation of hog fuel using the coastal waterways of British Columbia is well established due to regional preference based on historical practices and the limited highway access for direct shipments. Rail transportation, while common for shipping pulp chips within regions and inter-provincially, is uncommon for shipping hog fuel. Most plants base their capacity on a regional supply of fibre, and large-scale demand has not yet developed. If this changes, rail transport may become more common.

The methods of transporting and handling hog fuel across Canada are not expected to change much in the future as the equipment required is generally of low technology. Truck transportation, because of its versatility, low capital requirements, and flexibility, is likely to remain the most widely used method for delivering hog fuel to user facilities. Other forms of bulk transportation may become profitable for specific hauls if large deposits of bark in sawmill yards and landfills in eastern Canada are reclaimed, or if low-value stands (e.g., insect-killed, fire-damaged, or underperforming in-growth), and logging waste are harvested as biomass.

Selecting the most economical transportation system will depend on the following:

- volume and rate of hog fuel supplied, and onsite storage capacity
- volume and rate of hog fuel consumed, and onsite storage capacity
- loading and unloading times and costs
- fuel costs and driver wages
- distance from the supplier to the user
- availability of alternate transport methods (i.e., availability of water or rail access)
- investment required in new infrastructure

Recommendations for further work

To produce this report, FERIC collected much detailed information and identified several contacts with expertise in the transportation of hog fuel. Much of the information has been summarized in this report, and the information has also increased FERIC's existing database of research related to the production and transportation of hog fuel. This data could provide the basis for a model to explore various transportation options for specific projects. The model could also be used to explore the potential for integrating two or more transportation methods, and to demonstrate the economic feasibility of modifying loading and unloading infrastructure to reduce cycle times. However, more information on the specific costs associated with rail and barging infrastructure facilities is needed.

Research also needs to be undertaken to ensure that truck transportation is efficient. New truck designs incorporating lightweight composite materials need to be demonstrated to assess their reliability and performance. Innovative driver-friendly displays of loaded weights need to be developed to ensure drivers are operating at maximum efficiency. GPS real-time tracking and dispatching tools can reduce delay times associated with truck queuing at loading and unloading facilities. Driver awareness and education programs for optimizing fuel usage, along with innovative methods to reduce emissions and decrease fuel consumption, should be reinforced, developed, and demonstrated.

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Appendix I

Cooperating companies

	Western Canada (British Columbia and Alberta)		
	Company	Location	Facility type
1.	Sunpine Forest Products Ltd.	Sundre, Alta.	Sawmill
2.	Alberta-Pacific Forest Industries Inc.	Boyle, Alta.	Pulp mill
3.	Whitecourt Power	Whitecourt, Alta.	Cogeneration plant
4.	Ainsworth Lumber Co. Ltd.	Grande Prairie, Alta.	OSB mill
5.	International Forest Products Limited	Adams Lake, B.C.	Sawmill
6.	Weyerhaeuser Company Limited	Kamloops, B.C.	Sawmill
7.	Millar Western Forest Products Ltd.	Boyle, Alta.	Sawmill
8.	Downie Timber Ltd.	Revelstoke, B.C.	Sawmill
9.	Sundance Forest Industries Ltd.	Edson, Alta.	Sawmill
10.	Millar Western Forest Products Ltd.	Whitecourt, Alta.	Sawmill
11.	Ainsworth Lumber Co. Ltd.	Lillooet, B.C.	Sawmill
12.	Louisiana-Pacific Canada Ltd.	Radium, B.C.	Sawmill
13.	Canadian Forest Products Ltd.	Howe Sound, B.C.	Pulp mill
14.	Glen Transport Ltd.	Skookumchuck, B.C.	Trucking/custom hog fuel
15.	T-Joe Contracting Ltd.	Chilliwack, B.C.	Trucking/custom hog fuel
16.	Tolko Industries Ltd.	Lavington, B.C.	Sawmill
17.	Alberta Plywood Ltd.	Slave Lake, Alta.	Plywood mill
18.	Tolko Industries Ltd.	Slave Lake, Alta.	OSB mill
19.	Vanderwell Contractors (1971) Ltd.	Slave Lake, Alta.	Sawmill
20.	Slave Lake Pulp Corporation	Slave Lake, Alta.	Pulp mill
21.	Tolko Industries Ltd.	Armstrong, B.C.	Sawmill/plywood mill
22.	Mostowich Lumber Ltd.	Fox Creek, Alta.	Sawmill
23.	Alberta Newsprint Company	Whitecourt, Alta.	Newsprint mill
24.	Daishowa-Marubeni International Ltd.	Peace River, Alta.	Pulp mill
25.	Federated Cooperatives Ltd.	Canoe, B.C.	Sawmill
26.	Caribou Pulp & Paper Company	Quesnel, B.C.	Pulp mill
27.	Weyerhaeuser Company Limited	Drayton Valley, Alta.	Sawmill
28.	Northland Power Chips	Port McNeill, B.C.	Satellite chipping

Eastern Canada (Ontario and Quebec) and northeastern United States

	Company	Location	Facility type
1.	Kruger Inc.	Parent, Que.	Sawmill
2.	Kruger Inc.	Parent, Que.	User
3.	Barrette-Chapais ltée	Chapais, Que.	Supplier
4.	Bois Franc St-Charles	Drummondville, Que.	Supplier
5.	Boralex - Chateaugay Power Station	Chateaugay, N.Y.	Cogeneration plant
6.	Boralex - Dolbeau Power Station	Dolbeau, Que.	Cogeneration plant
7.	Boralex - Fort Fairfield Power Station	Fort Fairfield, Maine	Cogeneration plant
8.	Boralex - Secure	Montréal, Que.	Cogeneration plant
9.	Boralex - Senneterre Power Station	Senneterre, Que.	Cogeneration plant
10.	Boralex Stratton Energy Inc.	Stratton, Maine	Cogeneration plant
11.	Les Chantiers de Chibougamau ltée	Chibougamau, Que.	Supplier
12.	Chapais Énergie Inc. / Proben Power	Chapais, Que.	Cogeneration plant
13.	Domtar Inc.	Windsor, Que.	User
14.	Fraser Inc.	Edmundston, N.B.	User
15.	Transylve Inc.	St-Louis-de-Blandford, Que.	Supplier
16.	Domtar Inc.	Elk Lake, Ont.	Supplier
17.	Domtar Inc.	Timmins, Ont.	Supplier
18.	Domtar Inc.	Nairn, Ont.	Supplier
19.	Domtar Inc.	Ostrom, Ont.	Supplier
20.	Domtar Inc.	White River, Ont.	Supplier
21.	Kruger Inc.	Longlac, Ont.	Supplier
22.	Chapleau Co-generation Ltd.	Chapleau, Ont.	Cogeneration plant

Appendix II

Hog fuel transportation options questionnaire—listing of headings

1. Identification
    1.1. Company name, address, telephone number, fax number
        1.2. Contact name, telephone number, e-mail

2. Hog fuel hauled
    2.1. Location of loading site
        2.1.1. Product; volume (weight or units) per year; days per month
        2.1.2. Bulk density of hog fuel (range)
        2.1.3. Hours (days) of work per year
        2.1.4. Distance to unload site

3. Loading infrastructure
    3.1. Area of facility
        3.1.1. Surface type and area
        3.1.2. Buildings
        3.1.3. Number of staff (excluding mobile equipment operators)
    3.2. Fixed equipment
        3.2.1. Conveyors
        3.2.2. Hogger
        3.2.3. Screens
        3.2.4. Energy source
        3.2.5. Other
    3.3. Mobile equipment
        3.3.1. Loader; fuel usage

4. Hauling/transport
    4.1. Truck haul
        4.1.1. Number of trucks by configuration; engine size
        4.1.2. Rate to haul hog fuel per unit distance
        4.1.3. Percentage of haul cost attributed to fuel
        4.1.4. Cycle time; trips per day; operating days per year
        4.1.5. Van size; payload (net)
        4.1.6. Time to load each truck
        4.1.7. Time to unload each truck
    4.2. Barge fleet
        4.2.1. Cycle time; trips per year
        4.2.2. Rate to barge hog fuel per unit distance
        4.2.3. Percentage of haul cost attributed to fuel
        4.2.4. Barges per cycle
        4.2.5. Barge size
        4.2.6. Tug size (kW/hp)
        4.2.7. Time to load each barge
        4.2.8. Time to unload each barge

- 4.3. Train car
  - 4.3.1. Cycle time; trips per year
  - 4.3.2. Rate to haul hog fuel per unit distance
  - 4.3.3. Percentage of haul cost attributed to fuel
  - 4.3.4. Number of cars per train
  - 4.3.5. Number and size (kW/hp) of engines per train
  - 4.3.6. Time to load each car
  - 4.3.7. Time to unload each car

5. Unloading infrastructure
   - 5.1. Area of facility
     - 5.1.1. Surface type and area
     - 5.1.2. Buildings
     - 5.1.3. Number of staff (excluding mobile equipment operators)
   - 5.2. Fixed equipment
     - 5.2.1. Dumping equipment
     - 5.2.2. Conveyors
     - 5.2.3. Hog fuel
     - 5.2.4. Screens
     - 5.2.5. Energy source
     - 5.2.6. Other
   - 5.3. Mobile equipment
     - 5.3.1. Loader; fuel usage

Appendix III

Trucking configurations

Figure III-a. Example of a tri-axle semi-trailer configuration.

Trailer length is 14.65, 15.5, or 16.2 m; overall length of tractor with 16.2 m trailer is 23 m.

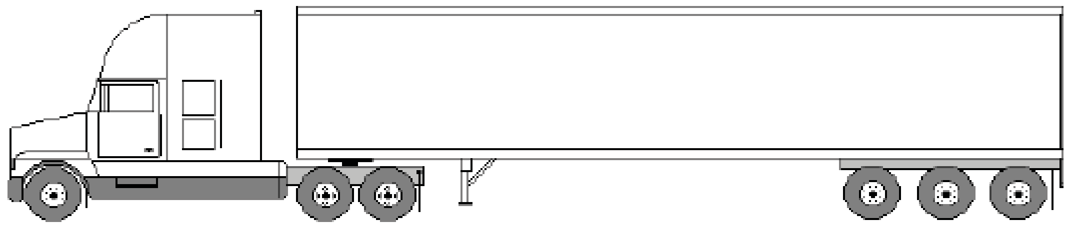


Figure III-b. Example of a B-train configuration with a total of eight axles.

Trailer length is 20 m; overall length of tractor and trailer is 25 m.

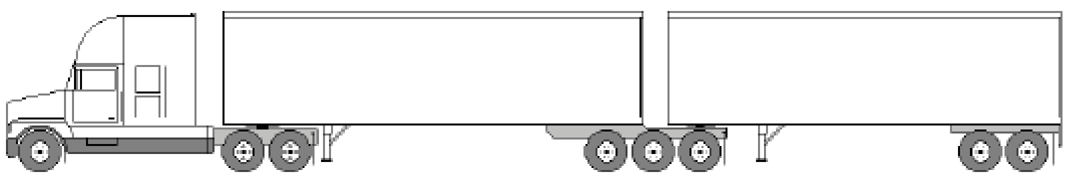
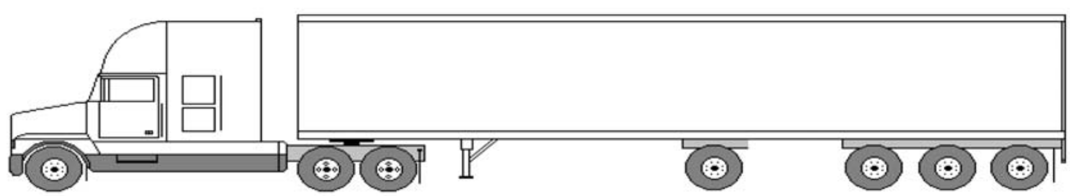


Figure III-c. Example of a four-axle semi-trailer configuration with a lift axle.

Trailer length is 16.2 m; overall length of tractor and trailer is 23 m.



Appendix IV

Data

Table IV-a. Data for Figures 8a and 8b: costs for hauling hog fuel at 50% moisture content by truck in western Canada

One-way haul distance (km)	Average load (t)	Hauling costs			
		$/t	$/bdt	$/t-km	$/bdt-km
6 [a]	26		8.00		1.30
8 [a]	26	10.00	20.00	1.250	2.50
50 [b]	24	17.00	34.00	0.340	0.70
60 [b]	24	7.10	14.30	0.120	0.20
85 [a]	37		13.80		0.20
105 [b]	37	7.50	15.00	0.070	0.10
115 [b]	39	14.40	28.80	0.120	0.20
115 [b]	28	20.30	40.60	0.180	0.40
200 [b]	28	15.00	30.00	0.080	0.20
300 [b]	28	39.90	79.70	0.130	0.30
330 [b]	30	33.80	67.60	0.100	0.20

[a] Costs for transporting hog fuel at this distance were obtained from Forrester (2003).
[b] Costs for transporting hog fuel at this distance were obtained from responses to the questionnaire.

Table IV-b. Data for Figures 8a and 8b: costs for hauling hog fuel at 50% moisture content by rail in western Canada

One-way haul distance (km)	Rail car		Hauling costs[a]				
	$/car	Average load (t)	bdt/car	$/t	$/bdt	$/t-km	$/bdt-km
360	1 656	40	20.0	41.40	82.80	0.12	0.23
850	2 928	60	30.0	48.80	97.60	0.06	0.11
2 214	3 800	53	26.5	71.70	143.40	0.03	0.06
3 305	4 500	53	26.5	84.90	169.80	0.03	0.05

[a] Costs for transporting hog fuel were obtained from Forrester (2003).

Table IV-c. Data for Figures 8a and 8b: costs for hauling hog fuel at 50% moisture content by barge in western Canada

One-way haul distance (km)	Average haul (GPU)	Average haul (t)	Hauling costs [a]			
			$/t	$/bdt	$/t-km	$/bdt-km
350	2 x 875 GPU barges	9,905	3.20	6.4	0.01	0.02

[a] Costs for transporting hog fuel at this distance were obtained from responses to the questionnaire.

Table IV-d. Data for Figures 8a and 8b: costs for hauling hog fuel at 50% moisture content (data from western Canada costing model)

One-way haul distance (km)	Estimated haul cost ($/bdt) Truck	Rail	Barge	$/bdt-km Truck	Rail	Barge
10	8.60	35.00	6.10	0.86	3.50	0.61 [a]
50	13.60	35.90	8.00	0.27	0.72	0.16 [a]
100	19.80	37.00	10.30	0.20	0.30 [a]	0.10 [a]
300	44.60	41.70	19.60	0.15	0.14	0.07
350	50.80	42.80	21.90	0.15	0.12	0.06
500	69.40	46.30	28.90	0.14	0.09	0.06 [a]
1000	131.40	57.90	52.10	0.13	0.06	0.05 [a]
1500	193.40	69.40	75.30	0.13	0.05	0.05 [a]
1600	205.80	71.80	80.00	0.13	0.04	0.05 [a]

[a] Value is outside haul range indicated in questionnaire.

Table IV-e. Data for Figures 13a and 13b: costs for hauling hog fuel at 50% moisture content (data from eastern Canada costing model)

One-way haul distance (km)	Estimated haul cost ($/bdt) B-train	Live floor, 15.5 m	15.5 m, 49.5 t	16.2 m, 49.5 t	$/bdt-km B-train	Live floor, 15.5 m	15.5 m, 49.5 t	16.2 m, 49.5 t
50	9.50	13.30	12.30	10.20	0.20	0.30	0.20	0.20
100	15.30	22.00	20.30	16.90	0.20	0.20	0.20	0.20
150	21.20	30.60	28.30	23.60	0.10	0.20	0.20	0.20
200	27.10	39.30	36.30	30.20	0.10	0.20	0.20	0.20
250	33.00	48.00	44.30	36.90	0.10	0.20	0.20	0.10
300	38.70	56.50	52.30	43.50	0.10	0.20	0.20	0.10
400	50.30	73.70	68.20	56.80	0.10	0.20	0.20	0.10
500	61.80	90.80	84.10	70.00	0.10	0.20	0.20	0.10