Working Papers of the Finnish Forest Research Institute 189
http://www.metla.fi/julkaisut/workingpapers/2011/mwp189.htm
ISBN 978-951-40-2282-1 (PDF)
ISSN 1795-150X

Efficiency of forest chip transportation from Russian Karelia to Finland

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METLA www.metla.fi

Working Papers of the Finnish Forest Research Institute publishes preliminary research results and conference proceedings.

The papers published in the series are not peer-reviewed.

The papers are published in pdf format on the Internet.

http://www.metla.fi/julkaisut/workingpapers/
ISSN 1795-150X

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Title

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Year	Pages	ISBN	ISSN
2011	42	978-951-40-2282-1 (PDF)	1795-150X

Regional unit / Research programme / Projects

Finnish Forest Research Institute, METLA, Joensuu / 7337

Accepted by

Timo Karjalainen, Professor, 13 January 2011

Abstract

Nowadays the development of bioenergy in Russian Karelia is hindered by various factors. However, the development of modern cut-to-length harvesting techniques, available wood resources and Russian customs policy have created opportunities to export forest chips from Russian Karelia to Finland. An important factor for the export is the total supply cost of Russian forest chips to Finland. This depends to a large degree on the costs of transportation of the forest chips. In this study the efficiency and costs of cross-border transportation of forest chips were analysed and compared with the efficiency and costs of transportation of forest chips of Finnish origin.

Data collected from various companies involved in forest chip production and their supply from Russia to Finland were used to calculate the costs of cross-border transportation of forest chips and to estimate the average productivity of chip trucks delivering from Russia to Finland. These outputs were compared with the transportation costs and productivity of chip trucks within Finland and Russia.

Truck drivers involved in cross-border transportation of forest chips were also interviewed to determine factors affecting the efficiency of forest chips transportation.

In addition, the quality characteristics of the Russian forest chips being supplied to Finland were analysed.

Analysis of transportation costs showed that the highest costs for the 80 km reference distance are those within Finland – 4.7 €/loose m^3, the costs on the cross-border route studied, from Lendery (Republic of Karelia) to Lieksa (Finland) through the Inari border crossing point, are 3.4 €/loose m^3 and transportation costs within Russia are 3.5 €/loose m^3.

Transportation costs as a proportion of the total supply costs were highest for forest chips imported from Russia at 26%, whereas in Finland and Russia they were 23% and 19% respectively.

According to the results of the interviews, bad road conditions and idle time on the border were recognized as the main factors decreasing the efficiency of cross-border transportation.

Analysis of the quality characteristics of forest chips exported from Russia to Finland did not reveal major differences compared to forest chips of Finnish origin.

If the factors mentioned above are adequately taken into account in the decision-making process, this should improve the efficiency of forest chips export from Russian Karelia to Finland as well as its cost-competitiveness with other competing fuels.

Keywords

export of forest chips, quality, productivity, transportation costs

Available at

http://www.metla.fi/julkaisut/workingpapers/200x/mwp189.htm

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Preface

The project “Wood harvesting and logistics in Russia – Focus on research and business opportunities” studies the current state and the future development of wood procurement in Northwest Russia to strengthen the business positions of the project’s stakeholders on the emerging Russian market. The project is financed by Tekes, the Finnish Funding Agency for Technology and Innovation, and a consortium of Finnish companies. As one of the results of the project, this publication presents an analysis of the efficiency of forest chip transportation from Russian Karelia to Finland, as well as the quality characteristics of the chips.

1 Introduction

1.1 The Republic of Karelia in brief

The Republic of Karelia is part of the Northwest Federal District of the Russian Federation and represents 1.06% (180 500 km^2) of the country's territory. The western border of Karelia is the state border between the Russian Federation and Finland (Figure 1).

Figure 1. The Republic of Karelia (based on Bing maps).

The population of the Republic of Karelia is about 688 000 inhabitants, with over 75% living in the urbanized areas (Kareliastat 2009). There are three main towns in Karelia: Petrozavodsk (283 000 inhabitants), Kostomuksha (32 500 inhabitants) and Sortavala (20 200 inhabitants). The population density in the Republic of Karelia is only 4 inhabitants per km^2 (The Republic of Karelia in brief 2010). For comparison, in Finland the population density is 16 inhabitants per km2 (Eurostat 2009).

1.2 Forest Resources of the Republic of Karelia and the status of bioenergy

The total forest area of Karelia is about 14.9 million ha, with a growing stock of 946 million m^3. Forests cover approximately 53% of the territory (Kareliastat 2008). The annual allowable cut is 8.8 million m^3, whereas the total actual cut was about 5.7 million m^3 in 2009. (Ministry of the Forest Complex of the Republic of Karelia 2010) Hence, the utilization rate of annual allowable cut is about 65%, which is the highest in the Russian Federation.

The main harvesting methods used in Karelia are cut-to-length, tree-length and full-tree methods (Syunev et al. 2009). The cut-to-length method is relatively new for Karelia, but its share has grown rapidly and recently it has become the dominant harvesting method. In 2009 the share of the cut-to-length method reached 93% of the total harvested volume, whereas in 2000 it was 42% (Ministry of the Forest Complex of the Republic of Karelia 2010).

The Republic of Karelia has high potential for intensification of fellings and as a result production of forest chips can be also increased. According to Gerasimov and Karjalainen (2009a), the potential volume of energy wood[1] from harvesting in Karelia is 2.3 million m^3, which includes non-industrial roundwood (62%), lifted stumps (18%), unused branches (9%) and defective wood from logging (11%). There are estimations (Regional'naya tselevaya programma... 2007) showing that it is feasible to harvest about 26% of all logging residues, including unused branches, defective wood and non-industrial wood, for energy purposes.

Forest chips could be a source of energy for many communities and industries in Russia. However, the domestic use of bioenergy resources is hindered to some extent by the current policy of expansion of gas pipeline networks to the regions and also by the intensification of energy generation from other renewable sources, mainly hydro energy (Energeticheskaya strategiya… 2009). At the same time, regions which are not connected to the natural gas grid are dependent on highly priced fossil fuels. The long transportation distance is the major factor that dramatically increases the total cost of fossil fuels in Russia (OECD/IEA 2003). Many fossil-fuel-deficient regions face frequent shortages of fuel supplies due to weather and transportation conditions and suppliers' preference for exporting fossil fuels. But now the situation is gradually changing. The government of the Republic of Karelia launched two programmes aiming to increase the proportion of locally produced fuels (e.g. firewood, forest chips and peat) in energy production and decrease the dependence on fossil fuels (Regional'naya celevaya programma... 2007, Regional'naya strategiya razvitiya... 2010).

In Karelia, woody biomass is a relatively new fuel in larger scale municipal and industrial energy production, but in the form of firewood it is a common energy source for households, especially in rural areas.

Besides private households, forest industry companies and municipal heat plants are the main users of woody biomass in Karelia (Raitila et al. 2009, Gerasimov & Karjalainen 2009b). Usually, the forestry companies work together with municipalities and supply wood fuel to the municipal power plants. The pulp and paper industry has about 30 woody biomass steam boilers in Karelia (Raitila et al. 2009). Existing biofuel power plants use mainly forest chips and sawmill residues. However, sawdust has been increasingly used for pellet production in Northwest Russia and because there has been very little demand on the local market for advanced wood fuels, the Russian biofuel industry has so far been mostly export-oriented (OECD/IEA 2003). However, domestic consumption of pellets in Russia is growing (Rakitova et al. 2009).

The use of woody biomass for energy production in Karelia contributes 10% of total energy supply and most of the energy wood is combusted for heat generation (Grigoryev 2007). However, at the same time about 54% of all the heat plants in the Republic of Karelia use, at least in part, local biofuels, including firewood, forest chips and peat (Regional'naya celevaya programma... 2007, Regional'naya strategiya razvitiya... 2010). In some districts of the Republic of Karelia energy wood is used more widely – in Kostomukshsky, Muezersky and Kalevalsky districts firewood consumption is about 23% of primary energy consumption (Raitila et al. 2009). For the whole Russian Federation the use of energy wood is much lower and represents only 3% of the total energy generation. The relatively low utilization rate of wood biomass for energy purposes is caused by uncertainties concerning the costs of supply and its availability at a reasonable price level (Gerasimov & Karjalainen 2009b).

[1] Energy wood – woody biomass used for production of wood-based fuels

In addition to the increased use of wooden biomass locally, there is potential to export forest chips from Russian Karelia to Finland. The current weak local demand for low-quality roundwood from final fellings and thinnings in Karelia makes large volumes of raw materials available for chipping at a reasonable cost, while in neighbouring Finland the demand for forest chips and their utilization is high. In addition, customs duties for forest chips are lower than for other assortments, e.g. saw logs and pulp wood, accounting for only 5% of their export value (Federal Customs Service of Russia 2009).

Figure 2 shows the dynamics of forest chip export from the Republic of Karelia to Finland.

As it can be seen, the export of forest chips increased substantially in 2009. This may be explained by the high customs duties set for pulp wood. Besides that, the demand for energy wood has also increased in Finland.

Relatively poor preconditions for domestic utilization of forest chips and the significant resource potential create good opportunities for the export of forest chips from Karelia to Finland, where the current energy and climate strategies support the use of forest chips for energy generation. (Renewable energy policy review 2009, Ministry of Trade and Industry 2000). In the past, use of forest chips on a large scale has been less common in Finland (Ranta 2005) and has traditionally been locally-oriented (Heinimo 2008). The forest chips boom started in Finland at the end of 1990s, when the Wood Energy Technology Program 1999-2003, aimed at the development and commercialisation of the use of forest chips, was launched as one of the Government's tools for implementation of the Action Plan for Renewable Energy Sources (Hakkila 2004). As a result of this program, the competitiveness of chips as a fuel significantly improved. The use of forest chips has grown from 1.7 million m^3 in 2001 (Hakkila 2004) to 6.1 million m^3 in 2009, and it is expected that 13.5 million m^3 of forest chips will be used in 2020 (Puun energiakäyttö 2010).

In Finland, forest chips for energy purposes are mainly produced from logging residues, and pruned and unpruned small-size trees (Hakkila 2004), and only a minor part is made of large size roundwood, stumps and roots. On the contrary, in the Republic of Karelia, due to the local features, a better raw material for chipping is roundwood, which is widely available at reasonable cost. Therefore, in Karelia logging residues and small-size trees, raw materials with low bulk

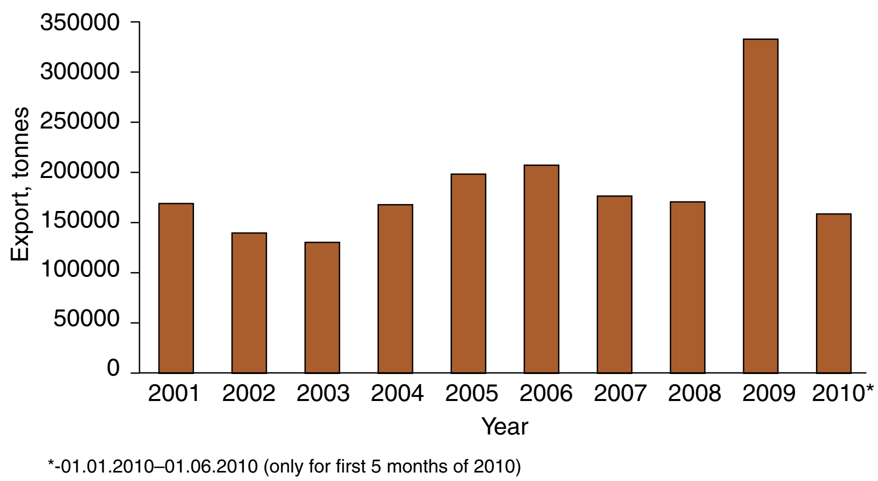

Figure 2. Export of coniferous forest chips from the Republic of Karelia to Finland (Kareliyastat 2010).

density, are not used for chipping. Due to the higher bulk density of roundwood, its harvesting, transportation and chipping are more efficient than that of uncompacted logging residues and small-size trees. Besides, the quality characteristics of chips produced from logging residues or roundwood may differ. For example, forest chips produced from logging residues can be contaminated with soil and stones.

1.3 Aim of the study

The use of different raw materials for chipping makes it very difficult to compare straightforward overall productivity of the Finnish and Russian forest chip supply systems. Therefore, this study focuses on the efficiency of the transportation stage, a parameter which can be compared between the countries irrespective of the raw material used for chipping. The study analyses the efficiency of forest chip transportation by trucks from Russian Karelia to Finland, compared with forest chip transportation within Finland. In addition, the quality of forest chips supplied from Russia to Finland is analysed.

The transportation route for forest chips can be seen in Figure 3, beginning from the Lendery terminal in Russia and ending at the power plant in Finland. The distance from the terminal to the border is 25 km and from the border to the power plant in Lieksa is 57 km, making a total of 82 km.

Specific tasks of the study are:

- Analysis of the efficiency of forest chip transportation by chip trucks from Russian Karelia to Finland based on results of the case study on the forest chip supply from the Lendery wood terminal in the Republic of Karelia to the power plants in Lieksa in Finland;
- Comparison of the efficiency of cross-border forest chip transportation from Russia to Finland with transportation efficiency within Finland in terms of costs and transported volumes;
- Measurement of moisture, calorific value, ash content and particle size variation of forest chips transported from the Republic of Karelia to Finland;
- Interviewing of truck drivers to obtain subjective descriptions of factors affecting the efficiency of forest chip transportation and to identify measures to improve it.

Figure 3. Forest chip transportation route from the Lendery terminal in Russia to the Lieksa power plants in Finland (based on Google maps).

2 Material and methods

2.1 Analysis of forest chips transportation efficiency

The study is focused only on the cross-border transportation of forest chips by trucks. Other types of forest chip transport are not considered here. Cross-border transportation of forest chips is the final stage of the Russian-Finnish forest chip supply chain, which begins in this case from felling sites in the Republic of Karelia and ends at power plants in Finland. In the case study felling, delimbing and cross-cutting is done by harvester, based on the caterpillar excavator Fiat-Kobelco E135SR with the installed harvesting head Kesla 22RH (Figure 4). The haulage of assortments to the roadside is carried by the forwarder Timberjack 1010D (Figure 4) with a payload capacity of about 15 m^3.

Then logs designated for chipping are transported by Volvo log trucks from the roadside, separately from industrial wood, to the terminal in Lendery village. Comminution is done at the terminal as a reasonable compromise between chipping at a landing and at a power plant in Finland, because Russian export duties for roundwood, including energy wood, are higher than export duties for forest chips (Federal Customs Service of Russia 2009). At the same time, for the chip producers it is important that forest chips from Russia to Finland have higher added value than unprocessed roundwood for energy purposes produced in Finland. At the Lendery terminal the logs are chipped into cone-shaped piles by a chipper Heinola 1310RML installed on a truck (Figure 5).

Figure 4. Excavator-based harvester Fiat-Kobelco E135SR (left side, photo: A. Seliverstrov) and forwarder Timberjack 1010D (right side, photo: V. Katarov).

Figure 5. Mobile chipper Heinola 1310RML working on a terminal in the Republic of Karelia, Russia (photo: Y. Suhanov).

The core part of the supply chain is the transportation of forest chips by trucks from the terminal in Karelia to the heat plants in Lieksa, Finland. Loading of the trucks is done at the Lendery terminal by a bucket front-loader. The average loading capacity of the truck is about 100 loose m^3 with trailer and about 40 loose m^3 without trailer. Russian transport norms (Instrukciya po perevozke... 1996) strictly limit the maximum allowable payload on one axle of a chip truck. Therefore, the use of a chip truck with more axles (Figure 6) is more reasonable due to the bigger allowable payload.

On the given transportation route, chip trucks cross the border at a temporary border crossing point located near to the village of Inari. At the crossing point the trucks are weighed and the drivers must present all the documents required by the border authorities, including phytosanitary certificates. The drivers are sometimes also asked to present their trucks for technical inspection. It should be noted that these formalities are not always followed by the border passing point personnel with the same care.

After the border, the trucks drive about 57 km and unload at the Lieksa power plants using a paddle chain system. One of the heat plants in Lieksa is a company-owned boiler house which was initially used only for heat generation for its own sawmill. However, the boiler house is now also used to provide heat for Lieksa municipality. The total annual energy output of this heat plant is 200 000 MWh of primary energy. About 90% of the fuel for energy production comes from its own sources and about 10% comes in the form of forest chips from Russian Karelia.

When examining the cross-border transportation of forest chips, it should be noted that according to the findings from the interviews, the trucks are only fuelled with Finnish diesel, even though the price of Russian diesel is half as much. This is so that the transport company avoids the risks of unplanned repairs caused by low fuel quality.

The volumes presented in this report are given in solid m^3 if not otherwise stated. The conversion factor of 0.40 was used to convert loose m3 to solid m3 of wood chips (Hakkila 2004). When necessary, volume units (m^3) were converted into energy units (MWh) or vice versa, assuming that wood has about 50% moisture content and about 2 MWh/m^3 energy content or 0.77 MWh of energy content per 1 loose m^3. The currency exchange rate of the Central Bank of the Russian Federation at 10 September 2010 was used when it was necessary to convert costs in Roubles to Euros. In the conversion, 39.18 Roubles correspond to 1 Euro.

Figure 6. 7-axles (left) and 6-axles (right) chip trucks.

The estimation of cross-border forest chip transportation efficiency is based on analysis of the following information describing the transportation route from the Lendery terminal (Russia, the Republic of Karelia) to Lieksa (Finland, the Province of North Karelia):

- Run parameters of the studied transportation route
  - Transportation distance from the Lendery terminal to the Inari border crossing point and from there to the unloading point in Finland for each studied delivery.
  - Average driving speed in Russia from the terminal to the Inari border crossing point and average driving speed in Finland from the border to the unloading point for each studied delivery.
  - Average duration of loading/unloading operations
  - Idle time of chip trucks which consists of breaks longer than 15 minutes – time of loading/unloading, time needed to pass all the border formalities at the Inari border crossing point (including time waiting in a queue) and duration of maintenance and repairs.
- Transportation costs and their shares in overall supply costs in Russia, Finland and for cross-border supply.
- Payloads of a forest chip truck in the cross-border transportation

Data regarding transportation distance, average driving time, loading/unloading operations and idle time were obtained from the tachograph recording system installed in the cabin of the truck and covered a total of 6 runs Lendery-Lieksa-Lendery. The 6 deliveries investigated were made in January and February 2010.

Transportation costs correlating with transportation distance are important factors affecting the import of forest chips from Russia to Finland. According to Ranta (2005), in Finland 100 km is considered the maximum economically acceptable transportation distance. Thus, in the case study, 100 km was chosen as the maximum distance for forest chip transportation and it was used for further comparison. Comparative analysis of the transportation costs includes the Russian-Finnish cross-border route, transportation within Finland and within Russia.

One of the aims of the study was to compare the costs of cross-border transportation of forest chips with the costs of forest chip transportation within Finland and Russia. The costs of cross-border transportation were calculated based on the data collected within the study from a transport company delivering forest chips from Russian Karelia to Finland. The data collected are for 2010 and include costs of fuel, labour, service and insurance. Annual payoff, overhead costs and amortisation costs were calculated according to Gerasimov et al. (2009b). The costs of cross-border transportation do not include value-added tax (VAT) on fuel because companies working on cross-border transportation outside the EU are not obliged to pay VAT (Palvelujen ulkomaankaupan arvonlisäverotus 2010). For comparison purposes, the costs of forest chip transportation within Russia and Finland were taken from the literature: the costs within Finland were valid for year 2003 (Ranta & Rinne 2006) and the theoretical costs calculated by Ilavsky et al. (2007) for Tihvin district of the Leningrad region were valid for 2006. The Finnish costs were indexed to the cost level of year 2010 using the 3% average annual increment of transportation costs in Finland (Tilastokeskus 2010). The Russian transportation costs were indexed to the cost level of year 2010 using the data on annual growth of cargo transportation tariffs in the Leningrad region of Russia (FSGS 2010), as presented in Table 1. The costs of forest chip transportation in the Leningrad region were used for the comparison because no reliable data on costs of forest chip

Table 1. Annual growth of cargo transportation tariffs in the Leningrad region (FSGS 2010).

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010
Cost increment, in %	18.6	13.5	61.3	17.3	13.17	9.8	30.13	-4.52	19.91*

*- expected growth calculated based on annual growth during 2002-2009

transportation in the Republic of Karelia were available. Also, it is appropriate to apply this data to the Republic of Karelia because of similarities in road conditions.

The transportation costs were compared as €/MWh at 10 km intervals within a 100 km distance. In order to determine transportation costs at 10 km intervals, the linear interpolation method was used for the theoretically calculated costs in the Tikhvinsky and Boksitogorsky districts of Leningrad region, because the published costs referred only to the 20, 60 and 100 km intervals.

The average delivered payload of the chip trucks involved in cross-border transportation was obtained from the company receiving the chips from Russia at its power plants in Finland. Further, this value was compared with the average delivered payload of chip trucks transporting forest chips within Finland. In addition, data on the forest chip flow from one terminal in Russia to Finland was obtained from a company engaged in cross-border transportation of forest chips.

2.2 Laboratory analysis of the quality of forest chips supplied from Russia to Finland

The fact that in Finland forest chips are mainly produced from logging residues and small-size trees and in Russia only roundwood is used for production of forest chips makes it interesting to compare the quality characteristics of forest chips of different origins. Sampling of the forest chips coincided with a shortage of forest chips at the Lendery terminal due to an interruption in chipping. Because of the study's time limits, it was not possible to wait until chipping at the Lendery terminal began again. For these reasons, samples of the forest chips were taken from two terminals in Värtsilä and Lahdenpohja (Figure 7 and Figure 8) located in the southern part of Russian Karelia. These terminals use material for chipping that is similar to the Lendery terminal – a mix of coniferous and deciduous roundwood supplied from forests of the Republic of Karelia. Therefore the difference in the quality of forest chips between these terminals should be negligible. Their quality parameters were analysed and compared with the parameters of forest chips produced from logging residues and small-dimension trees in Finland. Both terminals in Karelia use roundwood as raw material for forest chip production and in both cases it includes a mixture of spruce, pine, birch and aspen. The forest chips samples from the terminals were analysed to compare the following quality characteristics of Russian and Finnish forest chips:

- moisture content
- calorific value
- ash content
- particle size distribution

The samples of Russian forest chips dedicated for supply to Finland were obtained in June 2010 according to recommendations given in the standard CEN/TS 14778-1. According to the

Figure 7. Forest chips pile at the Värtsilä terminal.

Figure 8. Forest chips pile at the Lahdenpohja terminal.

methodology given in the standard, the stock pile of forest chips in both cases was visually divided into three horizontal layers: upper, middle and bottom. The number of samples taken from each layer was in proportion with the volume contained in each layer. Thus, the number of increments in the pile layers for Värtsilä terminal was 2, 3 and 6 and for Lahdenpohja terminal 1, 3 and 5 accordingly. The samples were taken manually by standard-sized shovel systematically (Alakangas 2005) and equally spaced around the circumference of the heap (CEN/TS 14778-1). Taking samples from the very top of the heap and the bottom 300 mm was avoided. Forest chips to be taken as samples were sorted according to the recommendations made by Alakangas (2005) in order to avoid inclusion of visually bigger pieces of forest chips in the samples.

The samples obtained at each terminal were immediately placed in 7 litre transparent plastic bags (Figure 9) and isolated from outside conditions to maintain stable moisture content. Each bag was labelled with identification of location, position in the pile and serial number (CEN/TS 14778-1). After delivery to the laboratory of the Finnish Forest Research Institute, the samples were kept out of direct sunlight and stored below 5 °C in order to decrease biological activity before laboratory tests (Figure 10).

The samples were obtained, prepared and stored according to CEN/TS 14778-1 and CEN/TS 14780 for determination of moisture content, ash content, calorific value and particle size distribution, based on CEN/TS 14774, CEN/TS 14775, CEN/TS 14918 and CEN/TS 15149 respectively.

Moisture content determination required the samples to be dried at 105 °C in air until a constant mass was achieved. The percentage of moisture was then calculated from the mass difference of the samples.

Figure 9. Taking samples at the terminal.

Figure 10. Packed samples for laboratory analysis.

Ash content was determined by calculating the mass of the remaining residue after the sample was heated at 550 °C in air under time-controlled conditions.

Determination of calorific value included pulverizing of samples by Retsch-1 mill with 10 and 0.5 mm bottom sieves. Then samples were pelletized to 14 mm in diameter with the recommended sample size ranging from 0.8-1.3 grams. Prepared samples were placed on the tared crucible of a sample pan for weighing and were entered into the memory of a calorimeter. The crucible was placed in a sample holder of a bomb and a fuse was attached. The sample holder was placed in the combustion chamber and closed with the bomb cap. The bomb was pressurized up to 3 MPa and placed in the vessel compartment where it was automatically surrounded with water of known volume. The sample was ignited and water temperature was recorded by the calorimeter. Based on the temperature profile, the calorimeter calculated the heating value.

For particle size determination and distribution an oscillating screen with apertures of 3.15, 6.3 and 20 mm was used (CEN/TS 15149-1).

2.3 Interviews with forest chip truck drivers

The interviews with truck drivers had the aim of identifying the impact of different factors on the productivity of their trucks and consequently on the efficiency of forest chip transportation from Russian Karelia to Finland. The drivers' views are important in the interpretation of the current situation regarding transportation efficiency and in finding possible solutions to improve the situation.

The interviews were based on a questionnaire designed to obtain individual responses. It was written in Russian (Appendix 1) and Finnish (Appendix 2) versions because it was planned to interview drivers from both countries. The respondents were interviewed by direct questioning, via post and by the phone. The questionnaire started with a description of the main goal and purpose of the study in order to make the potential respondents aware of the importance and significance of the topic. There were 27 questions in total: 5 regarding personal background (i.e. education, experience, etc.) and 22 forming the specific part related to forest chip transportation and technical peculiarities. In every multiple-choice question, only one answer was possible. The 22 questions of the specific part were in a logical order and were to be filled in sequentially to build up a comprehensive picture of the respondent's views. Truthful answers were needed because the reliability of the results is an important issue to rank the main factors influencing transportation efficiency. In total, 10 respondents were interviewed from 4 different companies in both Russia and Finland. Drivers of both nationalities were equally represented, with 5 from each country.

3 Results

3.1 Efficiency of forest chip transportation

The analysis of forest chip transportation efficiency is based on data which describe the qualitative characteristics of the route from the Lendery terminal in Russia to the Lieksa power plant in Finland, including distance, duration of one run, average speed, etc. These data were obtained from the tachograph recording system installed on a chip truck of one of the transporting companies specialising in cross-border transportation of forest chips. Quantitative characteristics of the route, such as average payload of a truck and total volume of forest chips flow, were obtained from the companies supplying chips from Russia to Finland. Table 2 shows the main parameters for the specific route.

The average transportation distance from the Lendery terminal to the Inari border crossing point was 25 km and from Inari to the unloading point at the Lieksa district heating power plant was 57 km, making a total distance of 82 km. This is less than the 100 km maximum transportation limit defined by Ranta (2002) as cost-competitive in Finnish conditions. For comparison, in Russia forest chips are cost-competitive only if the transportation distance is less than 50 km (Goltsev et al. 2010). This is a good illustration of the difference between costs of fossil fuels and forest chips in Russia and Finland.

The average driving speeds from the Lendery terminal to the Inari border crossing point and from Inari to the Lieksa power plant are presented in Table 3.

Table 3 shows that the average driving speed on the Russian side between Lendery and Inari is 34 km/h, whereas on the Finnish side between Inari and Lieksa it is 66 km/h. The average driving speed on the Finnish side is almost twice as high as on the Russian side. The difference between the maximum and the minimum driving speeds is 13 km/h on the Russian side, where the maximum and minimum driving speeds are 43 and 30 km/h respectively. The difference between maximum and minimum driving speeds is 19 km/h on the Finnish side, where the maximum and

Table 2. Observed parameters of the transportation route from the Lendery terminal, Russia, to the Lieksa power plant, Finland.

Parameter	Value
One way run, km	82
Average duration of one run, hours	6:38
Average payload, m^3	100
Minimum-average-maximum volume of forest chip flow over 8 months, m^3/month	327-2770-5217
Total volume of forest chip flow for 8 months, m^3	22157

Table 3. Speed of chip trucks on the transportation route from the Lendery terminal in Russia to the Lieksa power plant in Finland.

Route section	Distance, km	Speed, km/h			Average driving time, h
		Average	Maximum	Minimum	
Lendery ↔ Inari	25	34	43	30	0:42
Inari ↔ Lieksa	57	66	76	57	0:51

minimum driving speeds are 76 and 57 km/h respectively. The average driving time is almost the same for the Russian and Finnish parts of the route, despite the big differences between the transportation distances in Russia and Finland. These figures clearly reflect the difference between driving conditions on Russian and Finnish roads.

Time taken to load in Lendery and unload in Lieksa, the duration of the run on different sections of the route, and idle time consisting of breaks longer than 15 minutes are shown in Table 4. The time consumption was based on the time records provided by an entrepreneur for 6 runs, amounting to 39 hours 45 minutes of working time altogether. Due to the short period of observations, time spent on maintenance and repair is not shown in Table 4.

Table 4 shows that the average time taken by driving in Russia and Finland was 45 and 52 minutes respectively, although the distance on the Finnish side is twice as long as on the Russian side. Crossing the border on average takes 36 minutes, although the maximum and the minimum time spent at the crossing point were 105 and 5 minutes respectively.

Loading at the Lendery terminal was normally done at the end of the truck driver's working shift and the duration of this operation was therefore not recorded by the tachograph system on the 6 observed runs. The average duration of the loading operation was estimated based on the interviews with the transport companies, but it was not possible to estimate the maximum and the minimum duration of loading there. Unloading at the Lieksa power plant on average took 50 minutes, with a maximum unloading time of 60 minutes and a minimum of 30 minutes. Lunch breaks on average took 43 minutes, while the minimum and the maximum were 30 and 60 minutes respectively.

Figure 11 provides average time distribution within one run for each operation in percentages of the total time, estimated based on the time records from the 6 observed runs. The total duration of the 6 recorded runs was 2385 minutes and the average duration of one run was 398 minutes or 6 hours 38 minutes.

Driving takes only 48% of the total time of one run, due to the relatively short transportation distance. About 22% of the total run time was spent driving the 25 km on the Russian side, and this was almost the same time needed to drive the 57 km on the Finnish side. The next most time-consuming operation is crossing the border, which takes 18% of the total run time. Loading and

Table 4. Duration of main operations on recorded routes.

Duration (min)	Average	Maximum	Minimum
Time consumption for driving			
Lendery ↔ Inari	45	50	35
Inari ↔ Lieksa	52	60	45
Time consumption for loading and unloading operations			
Loading (Lendery)*	60	–	–
Unloading (Lieksa)	50	60	30
Idle time			
Border (Inari)	36	105	5
Lunch breaks	43	60	30

* Only average loading time was given by the entrepreneur

unloading operations represent relatively small proportions of the total, 15% and 13% respectively. The smallest proportion, 5% of the total run time, was spent on lunch breaks.

The costs of cross-border transportation of forest chips were compared with the transportation costs within Finland and Russia (Figure 12).

The transportation distance on the cross-border route was 82 km and therefore, for the cost comparison, 80 km was used as a reference distance. According to Figure 12, the transportation costs for cross-border transportation are 3.4 €/loose m^3 or 8.5 €/solid m^3. The total supply costs in the case of cross-border transportation of forest chips is 28.8 €/m^3, which comprises 10.95 €/m^3 for harvesting and forwarding, 3.7 €/m^3 for transportation of logs to the terminal (average transportation distance about 50 km), 6.25 €/m^3 for chipping and 7.93 €/m^3 for other costs. All the expenses are given per solid m^3. Road transportation costs for the studied route are 26% of the total supply costs.

The productivity of trucks delivering forest chips from Russia to Finland is an important factor affecting transportation efficiency. Based on data provided by the company, the average load of the trucks is 90-110 loose m^3 coming from Russian Karelia and 120-140 loose m^3 coming from Finland to the power plant. The difference is due to the legislative limitations set in Finland and Russia, where there are differences in the maximum allowable weight of loaded trucks. In

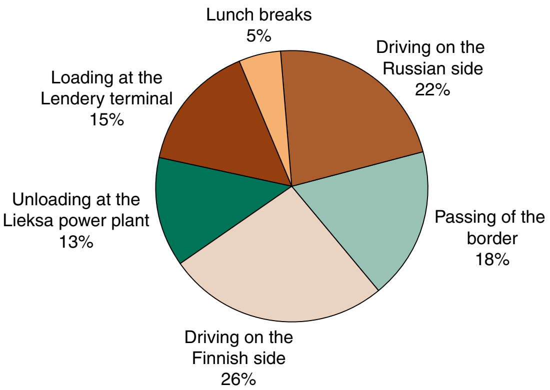

Figure 11. Time distribution on transportation route (based on 6 recorded runs with total time 2385 min).

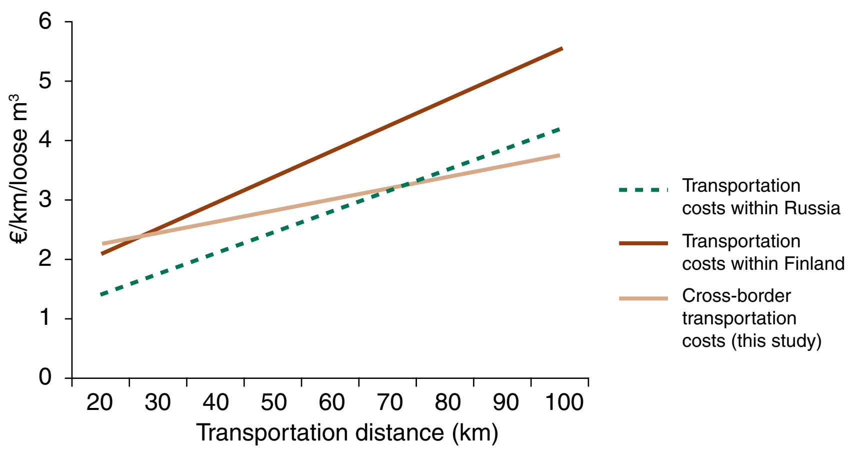

Figure 12. Comparative analysis of costs of cross-border and domestic transportation of forest chips.

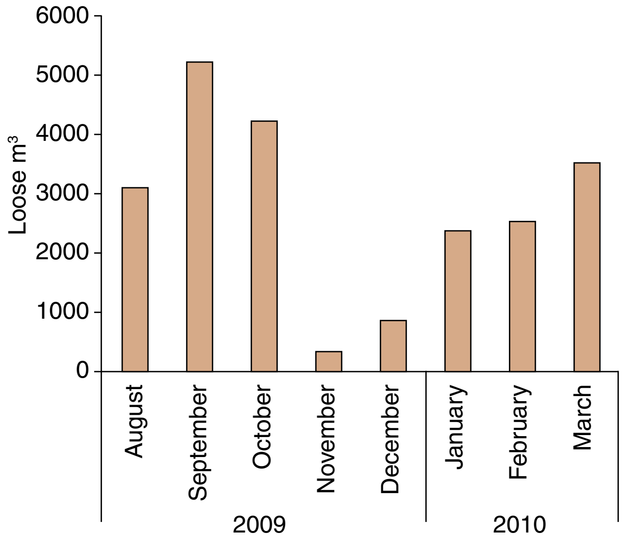

Figure 13. Volumes of forest chips transported throughout the year by the entrepreneur.

Finland, the maximum allowable weight of a truck with 6 axles is 53 tonnes, and for a truck with 7 or more axles it is 60 tonnes (Asetus ajoneuvojen käytöstä.. 1997). In Russian Karelia, the maximum allowable weight of a loaded truck on roads of republic and federal supervision without special permission is 38 tonnes, while with special permission issued by the Republic's road authority FGU Uprdor Kola the maximum allowable weight increases on republic roads to 55 tonnes and on federal roads to 44 tonnes (Instrukciya po perevozke.. 1996). In the case study, on the route from Lendery to Inari the maximum allowable weight can be increased from 38 to 55 tonnes and according to the interviews, drivers receive regularly such permission.

Efficiency of supply is also provided by continuity of forest chip flow. The transport company provided data (Figure 13) on the amounts of forest chip supplied throughout the year from Russia to the Lieksa power plant.

As can be seen in Figure 13, the lowest volumes of forest chips were delivered by the entrepreneur in November and December 2009. This was due to the breakdown of the chipper at the Lendery terminal. Inability to quickly change the source of forest chips made this supply chain vulnerable. This is dangerous especially in winter, when the demand for heat is at its highest.

3.2 Quality of forest chips supplied from Russia to Finland

Laboratory tests have been done to determine the quality parameters of forest chips from the Lahdenpohja and Värtsilä terminals in Russia and to compare them with the official standard CEN/TS 14961. The parameters are compared in Table 5.

Based on the analysis shown in Table 5,the moisture content of the samples is in accordance to the CEN/TS 14961 standard. Forest chips from Värtsilä have 44% moisture content and fulfil the M45 moisture norm and forest chips from Lahdenpohja have 47% moisture content, fulfilling the M50 moisture norm. The net calorific value for the forest chips from Lahdenpohja is 18.7MJ/kg and from Värtsilä 18.4MJ/kg, but neither a net calorific value nor a net calorific value as received is regulated by CEN/TS 14961. The particle size distribution of samples from both locations

Table 5. Quality parameters of the forest chips.

Compared parameters	Lahdenpohja, forest chips	Värtsilä, forest chips	Standard CEN/TS 14961
Moisture content (%)	47	44	M50 (Lahdenponja), M45 (Värtsilä)
Net calorific value (dry matter) MJ/kg	18.7	18.4	-
Net calorific value of fuel as received MJ/kg	8.8	9.2	-
Particle size distribution (%): >20mm; 20-6.3; 6.3-3.15; <3.15	6, 66, 20, 8	7, 70, 11, 10	P45B (Lahdenpohja, Värtsilä)
Ash content (%)	0.5	1.2	A0.5 (Lahdenpohja), A1.5 (Värtsilä)

conforms with the P45B size class of the standard. According to the CEN/TS 14961 standard, the ash content for Lahdenpohja is A0.5 class and for Värtsilä it is A1.5 class.

3.3 Opinions of forest chip truck drivers

The results obtained regarding the respondents' working experience in transportation of forest chips, transportation in general and education indicated high proficiency and long experience in transportation of forest chips. Most of them had worked in forest transportation for more than 5 years, besides which all had more than 10 years of working experience in general transportation. In addition, most of them had completed special education and supplementary courses related to forestry and transportation. Therefore reliable answers to the questions in the specific part of the questionnaire could be expected.

The question regarding the design of trucks used for transportation of forest chips indicated that 50% of the respondents use specially designed trucks, 10% use modified trucks originally designed for other purposes and 40% did not answer. The drivers saw the importance of personal skills as very strong (20%), strong (30%), moderate (50%) and very low (10%) for the transportation productivity of forest chips. A focus on the achievement of the maximum possible productivity was very important for 50% of the drivers, important for 10%, and 40% of the respondents did not answer this question. The interviews did not show clearly how important the achievement of the maximum possible productivity is for the drivers because a relatively large number of respondents did not answer the question. The next question was about the importance of salary as motivation for the drivers to improve their productivity. Salary was a very important motivation factor for 40% of the interviewed drivers, important for 30%, moderate for 20% and 10% did not answer the question. These answers are explained by the fact that 60% of the drivers are on piece-rate wages, only 20% of the drivers have an hourly based salary and 20% get a combination of hourly based and piece-rate wages, depending on work flow and other conditions. Although there was no clear answer to the question about the importance of achieving maximum productivity, the answers regarding the payment system clearly illustrate that the respondents are highly motivated to increase their productivity. The interviews revealed that in the given case, the efficiency of cross-border transportation of forest chips often suffers due to underloading of the trucks. Of the interviewed drivers, 70% had cases of underloading and only 20% had no cases, while 10% did not answer. Half of the drivers felt that underloads have a very strong impact on overall productivity, 20% assumed a strong impact and 30% moderate. The interview showed that 40%

of the respondents were forced to carry out unplanned maintenance or to repair their trucks more than 5 times per year, 50% of the interviewed drivers 2-5 times per year, and only 10% dealt with unplanned maintenance just once a year. For the drivers this means an increase in workload of up to 10% for 30% of respondents, from 10 to 20% for 50% of them, and from 20 to 30% for 20% of them. The drivers pointed out several mechanisms whose breakage strongly affects productivity. About 47% of the respondents mentioned the unloading equipment, as medium maintenance 41% indicated the gearbox, and 6% of the drivers mentioned the fuel supply system and transmission. The results on possible causes of truck breakdown are presented in Figure 14.

As shown in Figure 14, insufficient quality of the road bed is seen as the main cause by 75% of respondents, for 17% high deterioration of base mechanisms is the main factor and the intensive use of the truck is the main reason for just 8%. All the drivers mentioned that the road bed quality and the development of the road network affect transportation productivity very strongly or strongly. In the drivers' opinion, their productivity depends to some extent on the loading method; 20% consider the relation as very strong, 40% as strong and 20% as moderate or low. All the respondents agreed that a front wheel loader is most efficient for loading. The relation between the unloading method and the overall productivity is not clear for the drivers: 30% see a strong correlation, 30% thought it moderate, 10% low and 30% very low. The commonly used chain unloading system is recognised as the most efficient. Regarding the return of deliveries back to Russian Karelia due to bad quality, 30% of the drivers had experienced this while 70% had not. Idle time at the border was recognised by 70% of the drivers as a very important factor affecting overall productivity while 30% considered it an important factor. The majority of the drivers indicated the idle time during loading/unloading operations as a factor with a moderate influence on the overall productivity of their trucks. Thus, all these factors affect the productivity of cross-border transportation of forest chips. The drivers' estimates of the average actual productivity as percentages of the maximum possible productivity are presented in Figure 15.

Figure 15 shows that, in the drivers' opinion, it is not currently possible to fully utilise the capacities of their trucks. Only 10% estimated that they achieve from 81 to 90% of the maximum possible productivity of their trucks. Most of the drivers estimated their productivity as between 51% and

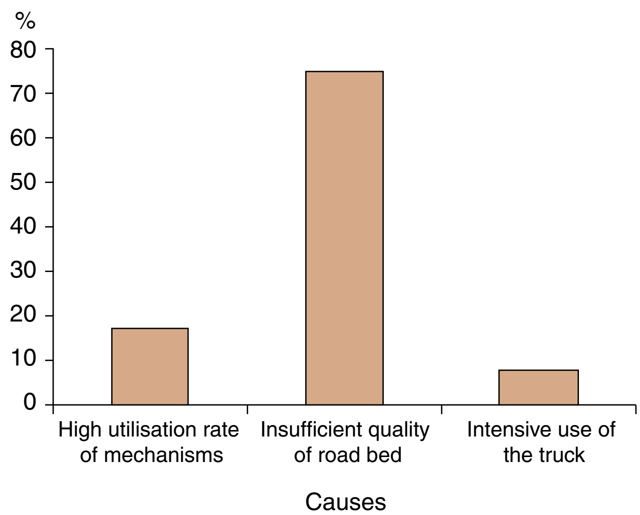

Figure 14. Possible causes of truck breakdown.

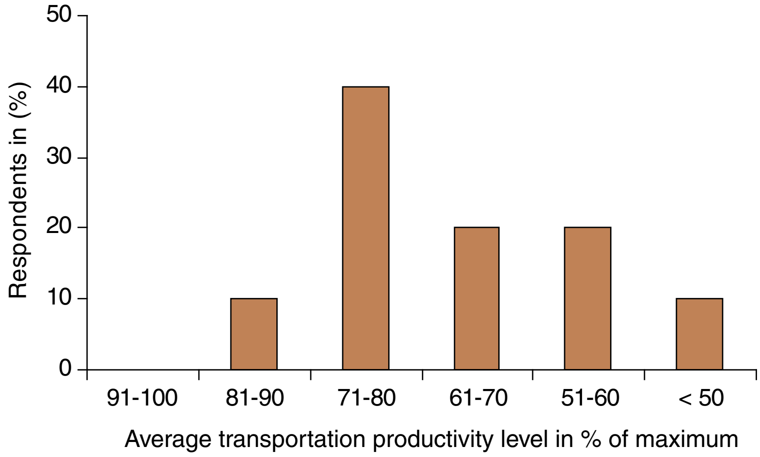

Figure 15. The drivers' estimates of the average actual productivity compared with maximum possible productivity.

80% of the maximum possible. It should be noted that 10% of the respondents felt their current productivity level was less than 50% of the maximum possible.

The drivers pointed out several factors influencing transportation productivity (Figure 16).

About 40% of the respondents underlined idle time at the border as the main factor affecting productivity, while 30% of the respondents pointed to road conditions in Russia. Other factors like idle time during loading/unloading operations, bureaucracy at the border crossing and a combination of different factors were named as the main issues affecting productivity by 15%, 10% and 5% of the respondents respectively.

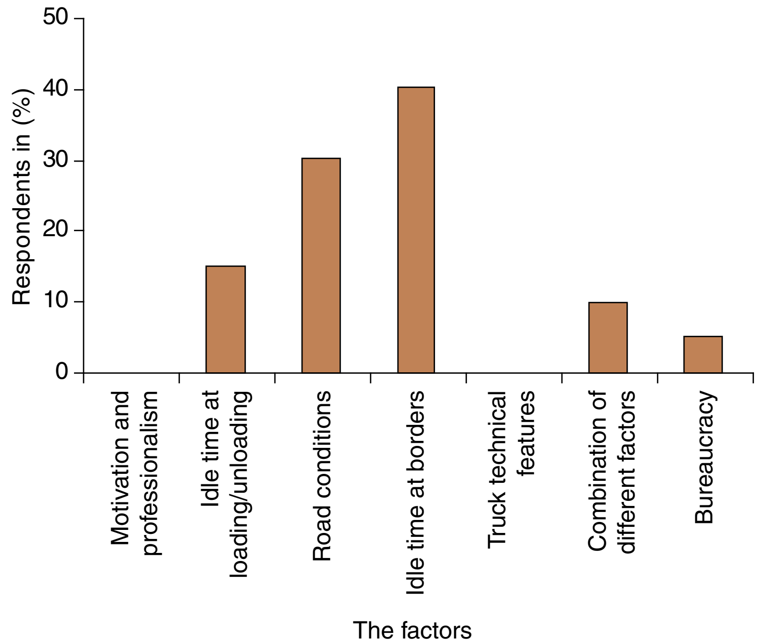

Figure 16. The main factors influencing transportation efficiency.

The drivers were asked to rank the different factors according to their impact on transportation productivity. The results of ranking are presented in Figure 17.

As shown in Figure 17, the bad road conditions in Russia and idle time during customs procedures are the most important factors (average ranking 6) affecting transportation efficiency, and those 2 factors also have the smallest range of deviation among the responses. Among the other factors influencing transportation efficiency are technical features of the truck and a combination of different factors (average ranking 5). Motivation and professionalism had an average ranking of 4. It is interesting that the drivers ranked differently the apparently related issues of idle time at the border (average ranking 6) and bureaucracy at the crossing point (average ranking 2).This is because idle time at the border is often caused not by bureaucracy but by the excessively large transport flow at the crossing point.

In addition to these factors, the working schedule of the Inari border crossing point was mentioned as a factor affecting the efficiency of forest chip transportation. This subject was not raised during the interviews but appeared later during the discussion with the director of one of the transport companies working on the cross-border route. The current working schedule at Inari border crossing point is on Mondays 15.00–20.00, Tuesday to Thursday 7.00–19.00, Fridays 7.00–17.00, and on Saturdays and Sundays it is closed. The current working schedule, in the opinion of the transport company, has a negative impact on the transport flow of forest chips and consequently on its efficiency. As a result, in the case being studied the weekly normative plan of 10 round trips to the Lendery terminal was not fulfilled and only 8 round trips at maximum were possible.

On the border between the Republic of Karelia and Finland there are currently two permanent (Kostomuksha and Värtsilä) and eight temporary border crossing points: Korpiselkä, Syväoro, Ristilahti, Kuolismaa, Haapavaara, Voynica, Inari and Mäkijärvi. The temporary border crossing points are difficult in terms of their management and, for many reasons, e.g., road conditions and their remote location, they can be out of service for uncertain periods of time (Prime Minister's... 2008). According to the interviews, this has a negative impact on cross-border trading. The two

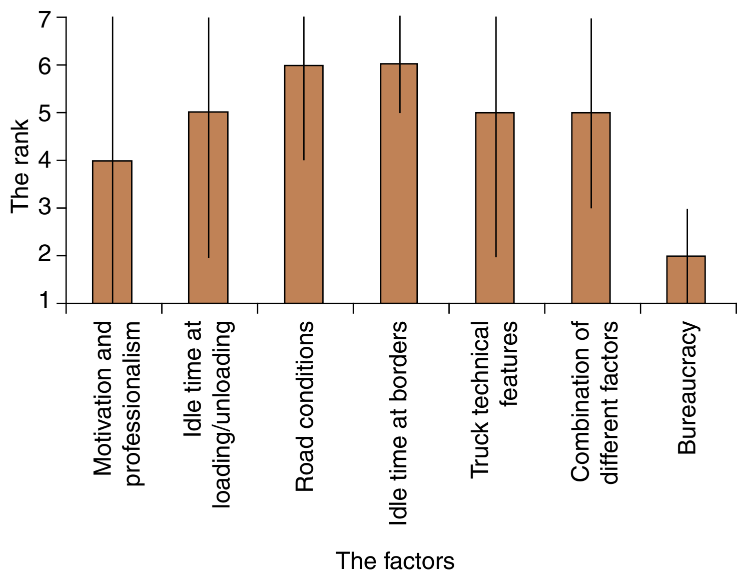

Figure 17. Ranking of the main factors affecting transportation efficiency (1 – least important, 7 – most important; the vertical black line on the each bar indicates the deviation of responses).

permanent border crossing points (Kostomuksha and Värtsilä) are not able to process the traffic flow if the temporary points are closed.

Another factor affecting the cross-border transportation of forest chips is the duration of the slush seasons in Finland and Russia. During the slush season transportation of wood from forests decreases significantly, which can affect the work of chipping terminals if their reserves of wood are not large enough. Moreover, if a terminal is not connected to a road with a hard surface, transportation of forest chips from the terminal becomes impossible. In the Republic of Karelia the slush season is one month longer than in Finland. In Finland the slush season normally starts in the third week of April and lasts for one month on average, while in Russian Karelia it starts a month earlier and lasts a month longer. It is the spring slush season, according to the interviews, that has the biggest impact on road accessibility; therefore, the autumn slush season is not taken into account.

Discussion

This study set out to describe and analyse the productivity of the cross-border transportation route of forest chips from the Lendery terminal in Russia to Lieksa in Finland. Data on the average driving distance, average load of chip trucks, average timing of a work shift including idle time and breaks longer than 15 minutes were collected from 6 delivery runs in winter conditions. However, the situation in summer, regarding road conditions and other factors might be different, affecting the average driving speed, duration of the main operation and distribution of time within a work shift. In order to get a full picture of transportation productivity on the route throughout the whole year, it would be worth collecting and analysing summer data also. Demand for forest chips is relatively low in the summer and, according to data from the company, there were no deliveries at all in summer 2010 on the Lendery to Lieksa route. The reduced chip supply during the summer months, when the field work was done, made it difficult to obtain data on the chip trucks.

The chip truck drivers were interviewed to identify the main factors affecting the transportation productivity of their trucks. However, as well as the obstacles listed in the questionnaire, respondents referred to other factors which were not initially addressed. Unfortunately these factors were fully identified only later during the discussion with transportation company representatives. As it was possible to interview only a limited number of people from these companies, the overall picture regarding the main factors affecting productivity and their ranking might change radically if more respondents were to provide answers.

The representatives of the transport companies mentioned that the potential to increase productivity is limited by the current working schedule of the Inari border crossing point. According to Decree № 142 from 23.02.1994 with amendments from November 2007 (Article 5, paragraph 3), the supervision and regulatory work of temporary border crossing points should be organized by bilateral agreement, in which local authorities and interested parties should be involved. Currently there is demand from transport companies to improve the existing situation. However, at the moment it appears that the opinions and suggestions of interested parties, particularly transportation companies, are not adequately taken into account, and communication between the transportation companies and the local authorities is poor. Therefore certain measures should be taken to improve the operation of the border crossing points. An open discussion process involving all interested parties would therefore help to solve the existing problem and find suitable solutions and compromises.

In addition to the infrastructure, there are other possibilities to improve the efficiency of the cross-border transportation of wood chips. Whereas the minimum reported unloading time was 30 minutes, unloading a modern chip truck with a 100 m^3 load is technically possible in from 30 seconds to 3 minutes, depending on the unloading system used (LIPE 2011). Proper organisation of the unloading process, e.g., decreasing the queueing time, could reduce the unloading time.

Due to the use of different reference years, the costs of forest chips transportation in Russia, in Finland and across the border were recalculated to a price level for 2010. For Finnish transportation costs, the initial data refer to 2003. It was not possible to find information on up-to-date transportation costs in Finland, because such information is a commercial secret. The calculated annual growth of Finnish transportation costs in this study is based on data from Tilastokeskus (2010) and the increase of transportation fuel index is 3% on average. However, in the specific case of the transport by truck of wood logs, which could be considered logistically similar to the transport of forest chips, annual transportation costs for the same period grew on average by 5.7% (Statistical Year Book of Forestry 2009). This means essentially that the actual difference in transportation costs may be nearly double the figure used. This creates uncertainties in the cost recalculation and the probable solution for such a deviation might be to present cost changes in the form of different scenarios. However, another issue to address is how far statistics on wood log transportation costs are in fact applicable to forest chip transportation.

According to Hakkila (2004), the cost of road transportation of forest chips accounts for 35% of the total supply cost when using logging residues as a raw material, and 23% for whole-tree chipping. On average it therefore corresponds to 29% of the total supply cost. At the same time in Russian conditions the cost of road transportation of forest chips is 19% of the total supply cost for final felling and 17% on average for the first and second thinnings (Ilavský et al. 2007). It was found that the cost of cross-border transportation is 26% of the total supply cost. Thus, the proportion of transportation costs in the total supply cost is highest for cross-border transportation at 26%, compared with 23% and 19% in Finland and Russia respectively. These costs were compared at a reference distance of 80 km.

The comparison in Figure 12 showed that the transportation costs of forest chips at 80 km reference distance is the highest within Finland (4.7 €/loose m^3), which is 26% higher than within Russia (3.5 €/loose m^3) and 28% higher than on cross-border transportation (3.4 €/loose m^3). But the cross-border transportation of forest chips is most expensive on the considered routes when the distance is less than 20 km. When the distance is greater than 20 km, their transportation from Russia to Finland is less expensive than within Finland. At 70 km distance the costs of cross-border transportation are equal to transportation costs in Russia and they are even lower at longer distances. This change in the cost-effectiveness of cross-border transportation can be explained by two factors. With short cross-border routes, the increased proportion of delays related to crossing the border affect the productivity of the trucks and consequently the transportation costs. The proportion of fuel costs in the total supply cost increase with distance, but the fuel VAT refund grows also, because transport companies engaged in cross-border transportation do not pay VAT. Also, it should be noted that drivers' salaries are lower in Russia. In addition, transport companies involved in cross-border transportation of forest chips on this route buy fuel only in Finland to avoid risks related to the poor quality of Russian diesel. Thus, the cost disparity may be explained by the difference between fuel prices, labour costs and the maximum allowable weight of trucks.

The road infrastructure and its condition should also be taken into account, as poor road conditions in Russia may cause additional costs.

The transportation distance for forest chips in the Leningrad region of up to 50 km (Goltsev et al. 2010) could be valid also for internal transportation of forest chips within Karelia; nevertheless cross-border transportation is in reality longer and the route studied here is 82 km. This may be explained by higher demand and consequently the better price paid by Finnish consumers.

The statistics provided by the transport company on the forest chip flow from the Lendery terminal to the Lieksa power plant showed that the supply chain is vulnerable due to its dependence on the availability of raw material at the terminal or breakdown of the chipper. Russian forest chips supply 10% of the total energy demand at Lieksa power plant. Storage space at the plant allows for the accumulation of raw material for a certain period of time and creates a buffer in supply in order to decrease the risks from any temporary cuts in deliveries. As an alternative to transportation of forest chips from Russian Karelia to Finland, deliveries of non-merchantable raw material (e.g., firewood logs) could be made and chipping could be organized on the Finnish side. However, according to the interviews, such a scheme has already been tested by the companies and presented many challenges. In particular, one of the main problems was the Russian customs classification of firewood as industrial roundwood. This underlies the difference between customs fees, which for firewood are 4 €/m^3 with bark, and for industrial roundwood, e.g., pulpwood, are 15 €/m^3 with bark (Federal Customs Service of Russia 2009). Thus, this option is considered risky by the company, because it may be required to pay industrial wood customs fees when transporting firewood.

For cross-border transportation of forest chips, the customs fees are the lowest at only 5% of their value, taking into account that Russian forest chips are relatively cheap compared to those of Finnish origin. The price for Russian chips was at the lowest in 2009 when a lot of unclaimed pulpwood was chipped into forest chips on the Russian side and transported to Finland. According to the interviews, the share of pulpwood in 2009 was up to 70% of the total amount of raw material used for chipping by the chip producers. Besides that, delays in payments by Russian pulp and paper companies encouraged forest chip producers to work with Finnish partners buying forest chips for energy purposes. The situation has changed as the general business environment in the Russian wood industry has improved in 2010, and deliveries to Finland are currently dependent upon the accumulation of a sufficient amount of non-merchantable wood for chipping, which consequently again means risks for the continuity of forest chip transportation to Finland.

In Finland logging residues are the main source of raw material for production of forest chips (Hakkila 2004), but in Russia forest chips are mainly produced from roundwood (Gerasimov & Karjalainen 2009b). In order to answer the question “can Russian forest chips substitute in terms of quality Finnish forest chips”, the main quality parameters of forest chips obtained from Värtsilä and Lahdenpohja were compared with those produced in Finland from logging residues and roundwood (Impola 1998), as shown in Table 6.

Based on the data shown in Table 6 and Appendix 3 it can be concluded that the calorific value (dry matter and as received) and ash content for both Lahdenpohja and Värtsilä forest chips are within the intervals given by Impola (1998). The net calorific value of fuel as received from both terminals corresponds to the intervals provided by Impola (1998), which is the only reference to be formally compared, because the CEN/TS 14918 standard is currently under revision and minimum calorific value is yet to be stated. The moisture content fulfils the intervals for both

Table 6. Comparison of quality parameters of forest chips with different origin

Compared parameters	Logging residue chips (Impola 1998)	Roundwood chips (Impola 1998)	Forest chips obtained from Värtsila and Lahdenpohja terminals
Moisture content (%)	50–60	45–55	44–47
Net calorific value (dry matter) MJ/kg	18.5–20	18.5–20	18.4–18.7
Net calorific value of fuel as received MJ/kg	6–9	6–10	8.8–9.2
Particle size distribution (%): >20mm; 20–6.3; 6.3–3.15; <3.15	–	–	–
Ash content (%)	1–3	0.5–2	0.5–1.2

categories of forest chip by Impola (1998); forest chips from Värtsilä correspond to the M45 class and forest chips from Lahdenpohja to the M50 class (CEN/TS 14961). The moisture content of samples from both locations is less than 50% and meets the requirement of the K2 norm (Alakangas 2005), ranging from 41 to 50%. Particle size distribution of the samples from both locations conforms with the P2 norm (<45 mm) for 95% of all the particles (Alakangas et al. 2006). However, the biofuel standard has been updated lately (Alakangas 2010), and according to CEN/TS 14961 the particle size distribution of the obtained samples corresponds to P45B size class. According to the standard CEN/TS 14775, ash content for Lahdenpohja corresponds to class A0.5 and for Värtsilä to A1.5, and the ash content is within the intervals provided by Impola (1998). According to laboratory results, the samples of forest chips obtained from the terminals fulfil the quality requirement and European standard (CEN/TS 14961) for wood chips and log fuel. Thereby, Russian forest chips are of the same quality as Finnish one and they can substitute Finnish forest chips.

From the results of the laboratory tests, it was not easy to allocate the samples to the size classes due to discrepancy in the size of the sieving equipment used to determine particle sizes. The sieving equipment used for measurements of the particle size had only three sets of sieving screen apertures: 3.15, 6.3 and 20 mm, so it was possible to separate the chip particles into four size categories: <3.15, 3.15–6.3, 6.3–20 and >20 mm. However, size categories in the CEN/TS 14961 standard are distributed as follows: P16, P45, P63. For each category the particle size is as follows: 3.15≤P≤16 mm, 3.15≤P≤45 mm and 3.15≤P≤63 mm with the dominance of the main fraction for each class >80% by weight (CEN/TS 15149-1). Laboratory analysis showed that 6% of particle sizes for Lahdenpohja and 9% for Värtsilä are within the size category ">20 mm", although the distribution within interval of 16-20 mm is unknown. On the other hand, the suggested normal variation distribution of size makes it possible to indicate that the size class for both samples is P16, although it could be also stated with confidence that the samples fulfil the P45 size standard.

Besides that, the developing standardisation of biofuels made it difficult to allocate quality characteristics of obtained samples to certain classes, e.g., to the CEN/TS 14961 standard, which consists of 6 parts, some of them currently under official voting for approval (Alakangas 2010). Therefore this standard can be considered only as one of the possible options, until it is officially approved.

Conclusions

According to Ranta (2005), the transportation distance, particularly of forest chips, will be the main challenge for efficiency of fuel supply and it is likely to increase in future. As a result, the problems related to transportation cost-efficiency with low-energy intensity will be emphasised. Forest chips are mainly produced from by-products of logging and sawmilling and their procurement operation is quite often integrated with other forestry operations, such as procurement of roundwood or industrial wood waste (Asikainen 2001). The longest economically acceptable transportation distance for wood fuels in Finland has been less than 100 km, which is also valid for forest chips (Ranta 2005). At the same time, in Russia, 50 km is considered as the maximum distance for transportation of forest chips in terms of cost competitiveness with other fuels. The cross-border route studied is 82 km in total and is within the maximum limit of transportation in Finland. Results of the study showed that the transportation costs for forest chips delivered from the Lendery terminal in Russia to the Lieksa power plant in Finland are lower than the cost of forest chips transportation within Finland. In the study it was found that the costs of transportation of forest chips from Russia to Finland are affected by several factors, e.g., the productivity of chip trucks coming from Russia is lower than chip trucks working in Finland, at 90–110 and 120–140 loose m^3 respectively. However, the cost-competitiveness of Russian forest chips in the case considered is supported by lower harvesting costs, lower average salaries in the forest sector and cheaper fuel for forest machinery. Besides that, the relatively weak position of low-quality woody biomass on the Russian domestic market creates a positive precondition for its export to Finland. The limited number of chip producers in Russian Karelia makes the supply chain vulnerable, however, and there are consequent risks related to that. For example, the volume of forest chip flow on the route considered decreased almost ninefold in the 2 months when the chipper at one of the terminals got broken. At the same time, the development of forest chip production in Russia to a large extent depends on external demand because the local demand for forest chips is quite low and conventional firewood is the predominant type of wood fuel used locally (Raitila et al. 2009). Besides, bigger settlements and municipalities in the Republic of Karelia are quite often connected to central natural gas distribution networks or use other fossil fuels for energy generation.

The current weak support for the development of bioenergy in Russia's energy policy hinders the utilization of forest chips in spite of political initiatives related to renewable energy development in the Russian Federation (Energeticheskaya strategiya... 2003). However, in the Republic of Karelia the current policy related to promotion of bioenergy from local sources is promising, but still in the initial stage of development (Regional'naya celevaya programma... 2007, Regional'naya strategiya razvitiya... 2010). By contrast, the situation in Finland is different and there is a common understanding of the importance of bioenergy in the national energy sector and effective support measures have been implemented (Puun energiakäyttö 2010), which also facilitate further development of cross-border trade of forest chips.

The results obtained revealed the difference in average speed within the transportation route studied. The difference is almost twofold, 34 km/h in Russia and 66 km/h in Finland. The transportation distance on the Finnish side is 57 km and on the Russian side 25 km, but in terms of the time structure of a run, the proportion of driving on the Finnish side is 27% and on the Russian side 22%, which is again connected to the average driving speed on both sides. The difference is due to poorer road conditions on the Russian part of the route. The importance of this factor was proven during the identification of the main driving factors influencing the efficiency of forest chip transportation. The respondents indicated that bad road conditions on the Russian side and idle time at the border were among the most important factors influencing cross-border transportation. In addition, other factors affecting transportation productivity, which were not reflected in the questionnaire, were identified during communication with the transport companies. For example, the current working schedules of the Inari border crossing point and the inaccessibility of roads in Russia for at least two months of the year were mentioned by the companies' representatives as factors with a strong impact on transportation productivity. All these factors together decrease the overall productivity of cross-border transportation of forest chips. In the case considered, only 8 of 10 planned round trips by the chip truck were made during one week.

The quality characteristics of the obtained forest chip samples from both terminals in Russian Karelia are similar to those of Finnish forest chips given by Impola et al. (1998). The characteristics of Russian forest chips fulfil the requirements of the quality standards for forest chips "CEN/TS 14961 – fuel specification and classes". Most forest chips produced in Russia are made of roundwood, while in Finland they are made mainly from logging residues or small diameter trees, so procurement costs may differ between the two sources. Taking into account the quality characteristics and costs, it may be concluded that Russian forest chips are cost-competitive and can compete to some extent with Finnish chips.

The competitiveness of Russian forest chips is limited but can be improved. The analysis of domestic and cross-border transportation costs showed that the proportions of the transportation costs in the total supply cost of forest chips are different in all the cases considered. Of the total supply costs of forest chips, the highest proportion of transportation costs were on the cross-border route (26%), while transportation costs were a smaller proportion of the total supply costs in Russia and Finland (19% and 23% respectively). The high proportion of transportation costs in the case of the cross-border route is significant. According to the results of this study, the reasons are poorer road conditions on the Russian side, idle time at the border crossing point and differences between transport legislation in Russia and Finland. The impact of the state of Russian roads on productivity of cross-border transportation of forest chips was revealed when analysing the chip truck runs and further comfirmed in the interviews with the chip truck drivers.

Properly addressed measures can increase overall transportation productivity and reduce transportation costs. Consequently, transportation distances can be expanded to provide large procurement areas for users of Russian forest chips. It is necessary to invest more in the development of the road infrastructure in Russia and improve the border crossing customs formalities and legislation.

References

Alakangas, E. 2005. Properties of wood fuels used in Finland, Technical Research Centre of Finland, VTT Processes, Project report PRO2/P2030/05 (Project C5SU00800), Jyväskylä 2005, 90 p. + app. 10 p.

Alakangas, E. 2010. European standard (EN 14961) for wood chips and hog fuel. VTT Technical Research Centre of Finland. Forest Bioenergy 2010 – Book of Proceedings, p. 329-341.

Alakangas, E., Valtanen, J. & Levlin, J.E., 2006. CEN technical specification for solid biofuels - Fuel specification and classes, Biomass and Bioenergy, Volume 30, Issue 11, Standarisation of Solid Biofuels in Europe, Standarisation of Solid Biofuels in Europe, ISSN 0961-9534. Available at: http://www.sciencedirect.com/science/article/B6V22-4KRY3MK-/2/205497a18d82752e06556f99fb28fef2

Asetus ajoneuvojen käytöstä tiellä annetun asetuksen muuttamisesta. §23 Auton ja perävaunun yhdistelmän koko- naismassa. 1997 Available at: http://www.finlex.fi/fi/laki/alkup/1997/19970670

Asikainen, A. 2001. Design of supply chains for forest fuels. In: Sjöström, K. (ed.). Supply chain management for paper and timber industries. Proceedings of the 2nd World Symposium on Logistics in Forest Sector, 12–15 August 2001, Växjö, Sweden. p. 179–190.

Bing maps. Microsoft Corporation 2010. Available at: http://www.bing.com

CEN/TS 14774-1, Solid biofuels – Methods for the determination of moisture content – Oven dry method - Part 1: Total moisture – Reference method.

CEN/TS 14774-2, Solid biofuels – Methods for the determination of moisture content – Oven dry method – Part 2: Total moisture – Simplified procedure

CEN/TS 14775, Solid biofuels – Determination of ash content.

CEN/TS 14778-1, Solid Biofuels – Sampling – Part 1: Methods for sampling.

CEN/TS 14918, Solid Biofuels – Method for the determination of calorific value

CEN/TS 14961, Fuel specifications & classes

CEN/TS 15149-1, Solid biofuels - Methods for the determination of particle size distribution - Part 1: Oscillating screen method using sieve apertures of 3,15 mm and above.

Decree № 142 from 23.02.1994 with amendments from November 2007 (Article 5, paragraph 3). Russian-Finnish bilateral agreement regarding border crossing points (In Russian.) Available at: http://lawrussia.ru/texts/legal_383/doc383a720x887.htm

Devyatkin, V. (ed.-in-chief). 1999. Sbornik udel'nich pokazateley obrazovaniya otxodov proizvodstva i potrebleniya [Collection of waste generation indexes in production and consumption]. Moscow. State Committee of Russian Federation for Environment. 65 p. (In Russian.)

Energeticheskaya strategiya Rossii na period do 2030 goda [Energy strategy of Russian Federation utill 2030]. Utverzdena rasporyazeniem Pravitelstva Rossiyskoy Federacii ot 13 noyabrya 2009 goda № 1715-r. (In Russian.)

Eurostat 2009. Demographic Outlook – National reports on the demographic developments in 2007. Luxembourg: Office for Official Publications of the European Communities. 65 p.

Federal Customs Service of Russia 2009. Export statistics. Available at:www.customs.ru

FSGS, 2010. Federal'naya Sluzba Gosudarstvennoy Statistiki. Indeksi tarifov na gruzoviye perevozki osnovnimi vidami transporta. Procent. Leningradskaya oblast'. Avtomobil'niy. Dekabr'[Federal Department of Statistics. Indexes of main transportation tariffs. Percentage. Leningrad region. Motor-car. December.] (In Russian.) Available at: http://www.gks.ru/dbscripts/cbsd/dbinet.cgi?pl=1934004

Gerasimov, Yuri & Karjalainen, Timo. 2009a. Estimation of supply and delivery cost of energy wood from Northwest Russia. Metlan työraportteja / Working Papers of the Finnish Forest Research Institute 123. 21 p. ISBN 978-951-40-2166-4 (PDF). Available at: http://www.metla.fi/julkaisut/workingpapers/2009/mwp123.htm

Gerasimov, Yuri & Karjalainen, Timo. 2009b. Assessment of Energy Wood Resources in Northwest Russia. Metlan työraportteja / Working Papers of the Finnish Forest Research Institute 108. 52 s. ISBN 978-951-40-2147-3 (PDF). Saatavissa: http://www.metla.fi/julkaisut/workingpapers/2009/mwp108.htm

Gerasimov, Yuri, Karvinen, Sari & Leinonen, Timo. 2009a. Atlas of the forest sector in Northwest Russia 2009. Metlan työraportteja / Working Papers of the Finnish Forest Research Institute 131. 43 p. ISBN 978-951-40-2183-1 (PDF), ISBN 978-951-40-2184-8 (paperback). Available at: http://www.metla.fi/julkaisut/workingpapers/2009/mwp131.htm

Gerasimov, Yuri, Sibiryakov, K, Moshkov, S, Välkky, Elina, Karvinen, Sari. 2009b. Raschet ekspluatacionnych zatrat lesosechnych mashin. Finnish Forest Research Institute. ISBN 978-951-40-2174-9. Available at: http://www.idanmetsatieto.info/rus/cfmldocs/index.cfm?ID=683&tiedote=view&tiedote_ID=1799

Goltsev, Vadim, Ján Ilavský, Yuri Gerasimov and Timo, Karjalainen. 2010. Potential biofuel development in Tikhvin and Boksitogorsk districts of the Leningrad region – The analysis of energy wood supply systems and costs. Forest Policy and Economics 12, no. 4 (2010): 308-316.

Google maps. Google, Geocentre Consulting, Tele Atlas 2010. Available at: http://maps.google.com/

Grigoryev, M. 2007. Povishenie roli mestnych toplivo-energeticheskich resursov v obespechenii energeticheskoy bezopasnosti Severo-Zapada Rossii [The increasing role of domestic fuel-ener- gy resources for energy security in Northwest Russia]. Gazovy Business, July-August 2007: 28-34. (In Russian.)

Hakkila, P. 2004. Developing technology for large-scale production of forest chips. Wood Energy Technology Programme 1999—2003, Technology Programme Report 6/2004. Final report. Helsinki 2004. 99 p. Available at: www.tekes.fi/english/programm/woodenergy

Hakkila, P., 2006. Factors driving the development of forest energy in Finland. Biomass and Bioenergy, 30(4), 281-288. Available at: http://linkinghub.elsevier.com/ retrieve/pii/S0961953405001546

Heinimo, J., 2008. Methodological aspects on international biofuels trade: International streams and trade of solid and liquid biofuels in Finland. Biomass and Bioenergy, 32(8), 702-716. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0961953408000111

Ilavský, Ján, Goltsev, Vadim, Karjalainen, Timo, Gerasimov, Yuri & Tahvanainen, Timo. 2007. Energy Wood Potential, Supply Systems and Costs in Tihvin and Boksitogorsk Districts of the Leningrad Region. Metlan työraportteja / Working Papers of the Finnish Forest Research Institute 64. 37 p. ISBN 978-951-40-2074-2 (PDF). Available at: http://www.metla.fi/julkaisut/workingpapers/2007/mwp064.htm

Impola, R. 1998. Puupolttoaineiden laatuohje. (Quality instructions for wood fuels). Jyväskylä, FINBIO, Publication 5. 33 p.

Instrukciya po perevozke krupnogabaritnich i tyazelovesnich gruzov avtomobil'nim transportom po dorogam Rossijskoy Federacii. 1996 [Instruction on transportation of large-sized and heavy loads by trucks in Russian Federation] (In Russian).

Kareliyastat 2009. Республика Карелия в цифрах. Население. Численность постоянного населения. [Population in Republic of Karelia]. [Online Document]. Available at: http://krl.gks.ru/digital/region1/DocLib/dem1.htm

Kareliyastat 2010. Eksport schepy i toplivnoy drevesini iz Respubliki Karelia. [Export of wood chips and fuel wood from the Republic of Karelia]. 2 p.

Kareliyastat. 2008. Lesopromishlenniy kompleks regionov Severo-Zapadnogo okruga Rossii [Forest sector of the federal regions of Northwest Russia]. Petrozavodsk: Karelian Branch of Federal State Statistics Service (Kareliastat). 201 p. (In Russian).

Kofman, P.D. 2007. Ordering and receiving wood chip fuel, COFORD Connects Note Processing/Products nr 8, Dublin, 2007

Lindblad, Jari, Äijälä, Olli, Koistinen, Arto, 2008. Energiapuun mittaus. Available at: http://www.metla.fi/metinfo/tietopaketit/mittaus/aineistoja/energiapuun-mittausopas-2008.pdf

LIPE 2011. Technical specification of the LIPE chip trailers. Available at: http://www.anttiranta.com/pdf/esite/ESITE_LIPE_ENG.pdf

Ministry of the forest complex of the Republic of Karelia, 2010. Official request on data obtaining to the Ministry.

Ministry of Trade and Industry, 2000. Action plan for renewable energy sources. Publications 1/2000.

OECD/IEA, 2003. Renewables in Russia - From Opportunity to Reality. International Energy Agency, 2003. ISBN 92-64-105441.

Palvelujen ulkomaankaupan arvonlisäverotus 1.1.2010 alkaen. 2010. Verohallinto. Arvonlisäverotus/ Kansainvälinen kauppa. Available at: http://www.vero.fi/?article=2483&domain=VERO_MAIN&path=5,40&language=FIN

Prime Minister's Official Internet Portal in Russian Federation, 2008. Available at: http://www.premier.gov.ru/visits/ru/6086/info/2532/

Puun energiakäyttö 2009. Toimittaja: Esa Ylitalo. Metsähakkeen käyttö nousi yli 6 miljoonan kuutiometrin. Metsäntutkimuslaitos, Metsätilastollinen tietopalvelu. Metsätilastotiedote 16/2010, 28.4.2010

Raitila, J., Virkkunen, M., Flyktman, M., Leinonen, A., Gerasimov, Y. & Karjalainen, T. 2009. The pre-feasibility study of biomass plant in Kostomuksha. Research Report VTT-R-08372-08. 54 p.

Rakitova, Olga, Anton Ovsyanko, Richard Sikkema, and Martin Junginger. Wood Pellets Production and Trade in Russia , Belarus & Ukraine, 2009. http://www.forcebioenergy.dk/pelletsatlas_docs/showdoc.asp?id=090520131636&type=doc&pdf=true.

Ranta, T. 2002. Logging residues from regeneration fellings for biofuel production - a GIS-based availability and supply. Thesis for the degree of Doctor of Science. Lappeenranta University of Technology.

Ranta, T. 2005. Logging residues from regeneration fellings for biofuel production–a GIS-based availability analysis in Finland. Biomass and Bioenergy, Volume 28, Issue 2, February 2005, Pages 171-182.

Regional'naya celevaya programma "Aktivnoe vovlechenie v toplivno-energeticheskiy kompleks Respubliki Karelia mestnich toplivno-energeticheskich resursov na 2007-2010 godi [Regional programme aimed on intensive utilization of local fuels in Republic of Karelia in 2007-2010]. The Republic of Karelia State Government Bodies' Official Web Portal, 2010. Available at: http://www.gov.karelia.ru/gov/News/2010/09/0920_02.html

Regional'naya strategiya razvitiya toplivnoy otrasli Respubliki Karelia na osnove mestnich energeticheskich resursov na 2011-2020 godi [Regional strategy on development of energy sector in Republic of Karelia in 2011-2020]. The Republic of Karelia State Government Bodies' Official Web Portal of the Government of the Republic of Karelia, 2010. Available at: http://www.gov.karelia.ru/gov/News/2010/09/0920_02.html

Renewable energy policy review. Finland 2009. In the framework of the EU co –funded project: RES 2020: Monitoring and Evaluation of the RES Directives implementation in EU27 and policy recommendations to 2020.

Roslesinforg. 2008. Svedeniya gosudarstvennogo statisticheskogo nablyudeniya po lesopolzovaniyu za 2007 god [Information about the state statistical monitoring on forest use in 2007]. (In Russian.)

Syunev, Vladimir, Sokolov, Anton, Konovalov, Alexandr, Katarov, Vasily, Seliverstov, Alexandr, Gerasimov, Yuri, Karvinen, Sari & Välkky, Elina. 2009. Comparison of wood harvesting methods in the Republic of Karelia. Metlan työraportteja / Working Papers of the Finnish Forest Research Institute 120. 117 p. ISBN 978-951-40-2162-6 (PDF). Available at: http://www.metla.fi/julkaisut/workingpapers/2009/mwp120.htm

The republic of Karelia in brief. The Republic of Karelia State Government Bodies' Official Web Portal. Available at: http://www.gov.karelia.ru/gov/Different /karelia3_e.html

The Republic of Karelia State Government Bodies' Official Web Portal, 2010. Lesnoy otrasli Karelii udalos' spravitsya s trudnostyami [The forest sector of Karelia has overcome the obstacles] Available at: http://www.gov.karelia.ru/gov/News/2010/02/0218_03.html

Tilastokeskus, 2010. Kuorma-autoliikenteen kustannukset nousivat vuodessa 2,7 procenttia. Kuorma-autoliikenteen kustannusindeksi. Available at: http://www.tilastokeskus.fi/til/kalki/2009/12/kalki_2009_12_2010-01-18_tie_001_fi.html

Appendix 1.

Transportation efficiency of forest chips from Russian Karelia to Finland (Questionnaire form in Russian)

Эффективность транспортировки топливной щепы из Республики Карелия в Финляндию

В настоящее время мы изучаем вопросы транспортировки топливной щепы из Республики Карелия в Финляндию с целью выявить факторы влияющие на эффективность траспортировки щепы. По результатам обработки полученных данных анкетирования, будут разработаны меры направленные на повышение эффективности транспортировки щепы.

Пожалуйста, заполните анкету приведенную ниже. Это займет не больше 10-12 минут. Мы гарантируем респондентам полную конфиденциальность при использовании результатов анкетирования. Персональные данные и индивидуальные ответы респондентов не будут опубликованы.

1. ФИО ____

2. Название компании ____

3. Возраст_________ **лет**

4. Опыт работы в сфере транспортировки (смежной отрасли)

Опыт транспортировки щепы _________ лет

Общий опыт работы на перевозках ______________ лет

5. Образование

☐ Высшее профильное*
☐ Среднее профильное*
☐ Среднее
☐ Высшее другое
☐ Среднее профессиональное другое
☐ Другое _________________________

* профильное образование подразумевает специальности связанные с лесным хозяйством или смежными областями (технология деверообработки, машины и оборудование лесного комплекса и т.д.)

6. Тип (автопоезд, грузовой автомобиль, полуприцеп, подчеркните соответствующий тип), модель, пробег автомобиля и максимальная грузоподъемность щеповоза на котором вы работаете?

Марка ________________. Модель___________________. Пробег _________________ тыс. km. Грузоподъемность автомобиля и объем кузова (м^3) _____________________________, грузоподъемность и объем прицепа (если используется)____________________________, тип механизма саморазгрузки _____________________________________.

7. Является ли используемый щеповоз переоборудованным из грузового автомобиля общего пользования?

□ Да □ Нет □ Сложно ответить

8. Насколько по вашему мнению эффективность транспортировки щепы зависит от навыков (опыта) водителя щеповоза?

□ Очень сильно (Определяющий) □ Сильно □ Умеренно □ Низко □ Очень низко □ Сложно ответить

9. Насколько эффективность транспортировки щепы важна для вас?

□ Очень важна □ Важна □ Умеренно важна □ Слабо важна □ Очень слабо важна □ Сложно ответить

10. Насколько заработная плата мотивирует процесс перевозки?

□ Очень сильно (Определяющий) □ Сильно □ Умеренно □ Слабо □ Очень слабо □ Сложно ответить

11a. Как исчисляется оплата на межграничной перевозки щепы в вашем случае?

□ Почасовая оплата □ Сдельная □ Комбинированная, какая______________________ □ Другая

11б. Как бы изменилась эффективность труда без ущерба для здоровья и общей безопасности при перевозки в случае смены системы оплаты труда с почасовой, комбинированной или другой на сдельную?

□ Повысилась □ Не изменилась □ Снизилась □ Сложно ответить

12б. Насколько по вашему мнению недогруженность щеповоза оказывает влияние на общую производительность?

□ Очень сильно (Определяющий) □ Сильно □ Умеренно □ Низко □ Очень низко □ Сложно ответить

12а. Сталкиваетесь ли вы с проблемой недогруженности щеповоза при перевозках?

□ Да □ Нет □ Сложно ответить

13. Как часто приходиться проводить внеплановый ремонт щеповоза?

□ 1 раз в год □ 2-5 раз в год □ больше 5 раз в год

14. Насколько возрастают трудозатраты связанные с внеплановым ремонтом щеповоза, в процентах от общего рабочего времени?

□ до 10% □ 10-20% □20-30% □ больше 30% □ сколько_____

15. Какие поломки больше всего влияют на производительность транспортировки щепы?

□ Неисправности двигателя □ Топливной системы □ Трансмиссии

□ Ходовой части □ Кузовного оборудования (например, разгрузочных механизмов)

16. Возможные причины технических неисправностей при транспортировке?

□ Высокой степенью изношенности механизмов □ Плохое качество дорожного полотна

□ Другое

17. Насколько качество дорожного полотна и развитость дорожной сети на Карельской территории влияют на производительность транспортировки?

□ Очень сильно □ Сильно □ Умеренно □ Слабо □ Очень слабо □ Сложно ответить

18. Влияет ли по вашему мнению тип загрузки щеповоза на общую производительность?

□ Очень сильно □ Сильно □ Умеренно □ Слабо □ Очень слабо □ Сложно ответить

19. Какой тип загрузки щеповоза по вашему мнению является самым эффективным?

Указать ____

20. Влияет ли по вашему мнению тип механизма саморазгрузки щеповоза на общую производительность?

□ Очень сильно □ Сильно □ Умеренно □ Слабо □ Очень слабо □ Сложно ответить

21. Какой тип механизма саморазгрузки щеповоза является, по вашему мнению, самым эффективным?

Указать ____

22. Были ли случае возврата щепы из-за несоответствия качества при приемки на финской стороне?

□ Да □ Нет □ Сложно ответить

23. Насколько простои на Российско-Финской границе влияют на продуктивность перевозки?

□ Очень сильно □ Сильно □ Умеренно □ Слабо □ Очень слабо □ Сложно ответить

24. Насколько простои при погрузке-разгрузке влияют на продуктивность перевозки?

□ Очень сильно □ Сильно □ Умеренно □ Слабо □ Очень слабо □ Сложно ответить

25. Как вы оцениваете среднюю продуктивность транспортировки на данном щеповозе от максимально возможного?

□ 91-100% □ 81-90% □ 71-80% □ 61-70% □ 51-60% □ менее 50%

26. Какой из факторов по вашему мнению оказывает наибольшее влияние на продуктивность транспортировки?

□ Мотивация и профессионализм водителя □ Простои на таможне

□ Простои при загрузке-разгрузке □ Технические характеристики авто

□ Состояние дорожной сети □ Комплекс различных факторов

□ Другие, какие _______________

27. Проставьте пожалуйста ранги от 1 до 7 в соответствии с предыдущем вопросом (1= самое важное...7=менее важное)

Мотивация и профессионализм водителя ____

Простои на таможне ____

Простои при загрузке-разгрузке ____

Технические характеристики авто ____

Состояние дорожной сети ____

Комплекс различных факторов____

Другие ____

Спасибо вам за уделенное время данной анкете. Нам важно ваше мнение.

Appendix 2.

Road transportation efficiency of forest chips from Russian Karelia to Finland (Questionnaire form in Finnish)

Polttohakkeen kuljetuksen tehokkuus Karjalan tasavallasta Suomeen

Tutkimuksessa selvitetään polttohakkeen kuljetuksen tehokkuuteen vaikuttavia tekijöitä Karjalan tasavallasta Suomeen haketta kuljetettaessa. Kyselytutkimuksen tulosten perusteella laaditaan toimenpide-ehdotuksia hakekuljetusten tehokkuuden lisäämiseksi.

Olkaa hyvä ja täyttäkää kyselylomake. Kysymyksiin vastaaminen vie noin 10 minuuttia. Vastaukset ovat luottamuksellisia. Henkilötietoja tai yksittäisiä vastauksia ei julkaista.

1. Nimi ____

2. Yritys ____

3. Ikä ________ vuotta

4. Kuljetusalan työkokemus

Kokemus hakekuljetuksista ________ vuotta

Kuljetusalan työkokemus ____________ vuotta

5. Koulutus

□ Korkea-aste
□ Opistoaste
□ Lukio
□ Ammattikoulu
□ Peruskoulu
□ Ammatillinen kurssi

□ Muu _______________________________

6. Auton tyyppi (rekka-auto, kuorma-auto, puoliperävaunu, alleviivatkaa sopivin), malli, ajokilometrit ja maksimikuorma?

Merkki _______________ Malli _________________ Ajokilometrit ___________ Vetoauton kantokyky ja tilavuus ________________________ kärryn kantokyky ja tilavuus (mikäli käytössä)______________________ purkulaitteen mekanismi _______________.

7. Onko autonne varustettu hakekuljetuksiin sopivaksi muusta raskaasta ajoneuvosta?

 Kyllä Ei EOS

8. Paljonko mielestänne kuljettajan kokemus vaikuttaa kuljetuksen tehokkuuteen?

 Erittäin paljon Paljon Jonkin verran Vähän Ei vaikutusta EOS

9. Kuinka tärkeä hakekuljetuksen tehokkuus on itsellenne?

 Erittäin tärkeä Tärkeä Jonkin verran tärkeä Vähän tärkeä Ei tärkeä EOS

10. Miten työstä maksettava palkka motivoi työtänne kuljettajana?

 Erittäin paljon Paljon Jonkin verran Vähän Ei vaikutusta EOS

11a. Millä perusteella saatte palkanne rajan ylittävissä kuljetuksissa?

 Tuntipalkka Suoriteperusteinen palkka Yhdistelmä, millainen

____

11b. Miten työn tuottavuus mielestänne muuttuu (yleiset työturvallisuusohjeet huomioiden), jos palkkausperuste muuttuu tuntipalkasta, yhdistelmästä tai vaihtoehdosta muu suoriteperusteiseen palkkaan.

 Kohoaa Ei muutosta Alenee EOS

12b. Miten mielestänne vajaakuormalla ajo vaikuttaa kuljetuksen tuottavuuteen?

 Erittäin paljon Paljon Jonkin verran Vähän Ei vaikutusta EOS

12a. Onko vajaakuormalla ajo ongelma työssänne?

 Kyllä Ei EOS

13. Kuinka usein joudutte tekemään ennakoimattoman huoltotoimenpiteen autollenne?

 kerran vuodessa 2-5 kertaa vuodessa yli 5 kertaa vuodessa

14. Paljonko ennakoimattomat huoltotoimenpiteet lisäävät työaikaa (prosentteina yleisestä työajasta)?

□ < 10% □ 10-20% □20-30% □ > 30% □ paljonko? _____

15. Mitkä viat voimakkaimmin vaikuttavat hakekuljetusten tuottavuuteen?

□ Moottorivaurio □ Polttoaineen syöttö □ Voimansiirto □ Alustan vaurio

□ Korin varustelu (esim. purkumekanismi)

16. Mitkä tekijät aiheuttavat teknisiä vikoja kuljetuksen aikana?

□ Laitteiston kuluneisuus □ Tiestön huono kunto □ Muu

17. Miten tiestö ja päällysteen kunto Karjalan tasavallassa vaikuttavat kuljetuksen tuottavuuteen?

□ Erittäin paljon □ Paljon □ Jonkin verran □ Vähän □ Ei vaikutusta □ EOS

18. Vaikuttaako mielestänne hakeauton lastaustapa tuottavuuteen?

□ Erittäin paljon □ Paljon □ Jonkin verran □ Vähän □ Ei vaikutusta □ EOS

19. Mikä on mielestänne tehokkain lastaustapa?

____

20. Miten lastin purkumekanismi vaikuttaa tuottavuuteen?

□ Erittäin paljon □ Paljon □ Jonkin verran □ Vähän □ Ei vaikutusta □ EOS

21. Mikä on mielestänne tehokkain lastin purkutapa?

____

22. Onko hakkeen vastaanotossa todettu laatuvika aiheuttanut lastin palautuksen?

□ Kyllä □ Ei □ EOS

23. Miten odotus rajalla vaikuttaa kuljetuksen tuottavuuteen?

□ Erittäin paljon □ Paljon □ Jonkin verran □ Vähän □ Ei vaikutusta □ EOS

24. Miten auton lastaukseen ja purkuun kuluva odotusaika vaikuttaa kuljetuksen tuottavuuteen?

 Erittäin paljon Paljon Jonkin verran Vähän Ei vaikutusta EOS

25. Mikä on hakeajoneuvonne kuljetuksen keskituotos 100%:n optimitilanteeeseen verattuna?

 91–100% 81–90% 71–80% 61–70% 51–60% < 50%

26. Mikä seuraavista tekijöistä mielestänne eniten vaikuttaa kuljetuksen tuottavuuteen?

 Kuljettajan ammattitaito ja motivaatio
 Odotus lastattaessa/purettaessa
 Tiestön kunto
 Odotus tullissa
 Auton tekniset ominaisuudet
 Tekijöiden yhteisvaikutus

 Muu, mikä _______________

27. Asettakaa seuraavat kuljetuksen tuottavuuteen vaikuttavat tekijät tärkeysjärjestykseen asteikolla 1-7 (1 = tärkein…7 = vähiten tärkeä).

Kuljettajan ammattitaito ja motivaatio ____

Odotus tullissa ____

Odotus lastattaessa/purettaessa ____

Auton tekniset ominaisuudet ____

Tiestön kunto ____

Tekijöiden yhteisvaikutus ____

Muu ____

Kiitos kyselyyn osallistumisesta. Mielipiteenne on meille tärkeä

Appendix 3.

Table 7. Comparative analysis of quality of forest chips with different standards

Compared parameters	Logging residue chips (Impola 1998)	Roundwood chip (Impola 1998)	Lahdenpohja forest chips	Värtsila forest chips	Standard CEN/TS 14961
Moisture content (%)	50-60	45-55	47	44	M50 (Lahdenponja), M45 (Värtsilä)
Net calorific value (dry matter) MJ/kg	18.5-20	18.5-20	18.7	18.4	–
Net calorific value of fuel as received MJ/kg	6-9	6-10	8.8	9.2	–
Particle size distribution (%): >20mm; 20-6.3; 6.3-3.15; <3.15	–	–	6, 66, 20, 8	7, 70, 11, 10	P45B (Lahdenpohja, Värtsilä)
Ash content (%)	1-3	0.5-2	0.5	1.2	A0.5 (Lahdenpohja), A1.5 (Värtsilä)