Working Papers of the Finnish Forest Research Institute 108

http://www.metla.fi/julkaisut/workingpapers/2009/mwp108.htm
ISBN 978-951-40-2147-3 (PDF)
ISSN 1795-150X

Assessment of Energy Wood Resources in Northwest Russia

Yuri Gerasimov and Timo Karjalainen

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The papers published in the series are not peer-reviewed.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

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

Office
P.O. Box 18
FI-01301 Vantaa, Finland
tel. +358 10 2111
fax +358 10 211 2101
e-mail julkaisutoimitus@metla.fi

Publisher
Finnish Forest Research Institute
Post Box 18
FI-01301 Vantaa, Finland
tel. +358 10 2111
fax +358 10 211 2101
e-mail info@metla.fi
http://www.metla.fi/

Authors

Gerasimov, Yuri & Karjalainen, Timo

Title

Assessment of energy wood resources in Northwest Russia

Year	Pages	ISBN	ISSN
2009	52	978-951-40-2147-3 (PDF)	1795-150X

Unit / Research programme / Projects

Joensuu Research Unit / 7290 Global forest energy resources, certification of supply and markets for energy technology

Accepted by

Leena Paavilainen, Director of Research, 26.1.2009

Abstract

The energy wood procurement possibilities for the eight regions making up Northwest Russia were assessed. Wood byproducts from roundwood harvesting and sawmilling were considered for energy production based on actual harvesting, sawmill and plywood production figures for 2006. Of the total calculated potential of 31 million solid m^3 (62 TWh), nearly 70% (21.8 million m^3) is from harvesting. The remainder (9 million m^3) is from saw and plywood milling. The approximate available energy wood by region would be: 2.3 million m^3 from the Republic of Karelia, 2.7 million m^3 from the Republic of Komi, 5.4 million m^3 from Arkhangelsk, 4.6 million m^3 from Vologda, 3.8 million m^3 from Leningrad, 2.0 million m^3 from Novgorod, 0.8 million m^3 from Pskov, and 41,000 m^3 from the Murmansk regions. There are large differences in the potentials between and within the regions. This is due to the differences in their forest resources; differences in their utilisation of these resources; the available intrastructures; some limitations on wood harvesting. A part of this calculated potential is already utilised, since some non-industrial roundwood from central processing yards sawmills and plywood mills are currently used in energy production.

Nearly 65% of all the potential energy wood from roundwood harvesting is non-industrial roundwood, 19% is spruce stumps removed after final felling, 8% is unused branches and tops, and 8% is defective wood resulting from logging. About 58% of the total potential energy wood from roundwood harvesting is coniferous. However, there are large differences between the regions and within the regions in the species proportions.

Currently about 40% of the allowable cut is used. This means that it would be possible to intensify the utilisation of the forest resources and thereby also to increase the use of wood for energy production. Full implementation of the allowable cut could provide 73.5 million m^3 of energy wood (147 TWh). In addition, if the technical potential for thinnings was utilised, the total potential energy wood provided by roundwood harvesting, saw and plywood milling could be 104 million m^3 (208 TWh).

Keywords

energy wood, logging residues, non-industrial roundwood, wood procurement

Available at

http://www.metla.fi/julkaisut/workingpapers/2009/mwp108.htm

Replaces

Is replaced by

Contact information

Yuri Gerasimov, Finnish Forest Research Institute, Joensuu Research Unit, Yliopistokatu 6
(P.O .Box 68), FI-80101 Joensuu, Finland. E-mail yuri.gerasimov@metla.fi

Other information

Contents

Preface

Growing concern about climate change, as well as current attempts to decrease our dependence on fossil fuels and to increase the security of our energy supply are factors promoting the use of bioenergy and other renewable energy sources. Several studies have indicated that the use of biomass for energy production can be remarkably increased from the current level over the next decades; this is at the same time when fossil fuels become scarce and more expensive. The use of biomass for energy production will be increased in industrialised countries that are aiming to decrease greenhouse gas emissions. Biofuel markets are developing rapidly and becoming more and more international. The trend now in biomass utilisation is towards larger refining units and longer transportation distances. These trends have even lead to the production of bioenergy in several countries being largely based on the importation of biomass. Northwest Russia has substantial forest resources and a relatively low population density, thus it represents a potential supplier of biomass near the European Union. In addition this region is an emerging technology market for modern biomass-to-energy technology.

This study is a follow up to our earlier work on the energy wood resources of the Leningrad region. This work is part of the project "Global forest energy resources, certification of supply and markets for energy technology" done at the Finnish Forest Research Institute (Metla). The aim of the project was to estimate the availability of forest biomass for energy production, and to evaluate the certification status and the long term sustainability of the forest biomass supply. The project was carried out by Metla in cooperation with, the Technical Research Centre of Finland (VTT) and Lappeenranta University of Technology (LUT). It is funded by the Finnish Funding Agency for Technology and Innovation (Tekes) technology programme "Business Opportunities in Mitigating Climate Change" (ClimBus) and is co-financed by John Deere Forestry Oy, Metso Power Oy, Neste Oil Oyj, Pentin Paja Oy, Stora Enso Oyj, and Vapo Oyj.

We thank Mr. Mark Richman for editing the language.

In Joensuu

Yuri Gerasimov and *Timo Karjalainen*

1 Introduction

Fossil fuels such as oil, natural gas, and coal account for 91% of Russia's energy consumption. Their shares of the total supply have decreased less than 2% in the last ten years. Two-thirds of these fossil fuels are sourced from Eastern Siberia, from which they are then delivered to other parts of Russia, which are thus very dependent on Siberia for their energy. In Northwest Russia, which includes: the semi-autonomous regions of the republics of Karelia and Komi; as well as the Arkhangesk, Leningrad, Murmansk, Novgorod, Pskov, and Vologda regions, the energy consumption was 81 Mtoe or 943 TWh in 2006. Fossil fuels also dominate the energy consumption in the Northwest, where the total consumption can be divided into the following shares: natural gas 44%, oil 19%, coal 16%, nuclear 18%, and renewables 2%. There are regional differences, for example in the Republic of Karelia and the Pskov region where the shares of renewables are higher, but still less than 10% (Arabkin 2003; Grigoryev 2007). The population of the Northwest is about 13 million, with over one third living in the metropolitan area of St. Petersburg (Ulyanov et al. 2007). Yet the population density for the whole area is very low, with only 8.4 inhabitants per km^2, in comparison to that of 15.5 inhabitants per km^2 for nearby Finland or the average of 113 inhabitants per km^2 for the whole of the European Union (Eurostat 2009).

Forests cover approximately 52% of Northwest Russia. The total growing stock is estimated at 10 billion m^3, of which nearly 6 billion m^3 is mature and over mature forests. Approximately 29% of the growing stock is pine, 42% spruce, 21% birch, 6% aspen, and 1% other tree species. The annual allowable cut of 106.2 million m^3 under bark (u.b) is defined solely for the felling of mature stands, of this total 56.4 million m^3 are coniferous and 49.8 million m^3 are deciduous tree species (Rosleskhoz 2007). The tree species distribution of the growing stock and the annual allowable cut differ markedly due to the approach used in Russia for calculation of the annual allowable cut. The actual harvest in 2006 of only 50 million m^3 u.b was far below the allowable cut, of which only 40.2 million m^3 was harvested in the felling of mature stands (in Russian – *rubki glavnogo pol'zovania*). Other portions of the actual harvest that are not included in the allowable cut included 5.1 million m^3 from thinnings (*rubki promezhutochnogo pol'zovania*) and 7.7 million m^3 from other fellings (e.g. for road construction and agricultural purposes). The Northwest produces one third of the industrial roundwood in Russia, 61% of the pulp and paper, 37% of the plywood, and 28% of the sawn timber (Ulyanov et al. 2007). This area has a good potential for energy wood production since a large share of the wood resources currently are not utilised by local industry, this refers especially to the deciduous tree species.

The area of forests and the growing stock in Northwest Russia is approximately four times larger than that of Finland, but the intensity of the resource utilisation is lower than in Finland. Harvesting in Northwest Russia is at about 0.4% of the standing volume and approximately 32% of the increment, while in Finland it is 2.9% and 70%, respectively. Although not exactly comparable the annual allowable cut, as defined in Finland is actually harvested at the level of nearly 90%, while in Northwest Russia its allowable cut is used to the level of only 40% (Karvinen et al. 2005; Peltola 2007). The Russian domestic forest industry is based largely on the use of coniferous tree species; domestic demand for deciduous tree species is therefore low. Thinnings, which represent nearly 60% of the area harvested in Finland, are applied far less in Northwest Russia, where they are reported to represent only 12% of the total felled volume (Karvinen et al. 2005; Peltola 2007). Thus in Northwest Russia, from a forest resource point of view, it would at least be possible to expand the use of deciduous tree species and wood from thinnings for modern energy production. There are, however, regional differences in the intensity of utilisation and availability of forest resources.

Another source for biomass from forests for energy production is logging residues. In Russia, the current forest management norms require the collection of logging residues from a site after harvesting. These residues are primarily unused, and even the small portions that are used have traditionally not been used for energy production purposes. How residues are collected varies depending on the different wood harvesting methods used. If the traditional whole tree method and technologies are applied, no additional work in the forest is required to collect residues such as branches and tops, since they are removed and accumulate at central processing yards (in Russian - *nizhniy sklad*). A central processing yard is a place where wood transported from different cutting areas is delimbed and bucked to the desired length and sometimes debarked. If the cut-to-length harvesting method is applied then, although logging residues are collected at the harvest site by law, any further collection or transportation from the site would require special work and costs. These examples indicate how felling methods influence not only the availability of logging residues, but also how their costs are assessed.

The aim here was to estimate the general energy wood potential for the whole of Northwest Russia, as well as more specific potentials for each of its regions. First the methodology that was used for estimating the energy wood resources is described, which includes an estimation of unutilised roundwood potentials that could be used for energy purposes, as well as for manufacturing conventional products in forest-based industries. Next the results of the estimation of the energy wood potential for the whole Northwest is presented. This is followed by presentations of the potentials by region, which include estimations of the energy wood from roundwood harvesting for the forest units of each region known as "leskhozes." The assessment of wood energy resources was limited to forests that are in use and legally available to supply wood, and is based on three possible scenarios for development of roundwood harvesting and wood processing in the Northwest.

2 Material and methodology

Before estimating the potential annual wood fuel supplies of Northwest Russia, it was necessary to analyse the availability of wood byproducts from roundwood harvesting and mechanical wood processing that when combined make up the *energy wood* potential. The availability of energy wood from roundwood harvesting was determined from the central processing yards of logging companies that use the traditional tree-length harvesting method and from harvest sites. All the energy wood from roundwood harvesting was determined as volumes of wood in cubic metres over bark (o.b). The potential energy wood from mechanical wood processing was determined by analysing the availability of the byproducts of sawmills and plywood mills. To approximately convert the calculated volumes of energy wood into energy units it was assumed that the wood had a moisture content of 50%, which according to Hakkila (2004) provides an energy content of 2 MWh/m^3.

The following sections describe the assessment units, data sources, and calculation of energy wood from roundwood harvesting at cutting sites and at central processing yards as well as from mechanical wood processing. Three scenarios for the energy wood potential according to the intensity of forest use are also presented. These scenarios show the quantitative potentials based on variations in the intensity of traditional cutting, implementation of an improved thinning regime, mechanical wood industry expansion based on increased raw material availability, and other specified assumptions.

2.1 Assessment levels

Energy wood potentials for Northwest Russia were assessed for byproducts from roundwood harvesting and mechanical wood processing operations. The potentials were assed at the regional level for the eight regions of the Northwest including: Arkhangelsk, Karelia, Komi, Leningrad, Murmansk, Novgorod, Pskov, and Vologda.

During the Soviet period the forests were often administered, divided, and designated by their planned or related land-use. Thus in Northwest Russia of the total 117.9 million ha of forest area now managed by the forestry administration, 110 million ha is forest land earlier managed in a similar way by the Federal Forestry Agency (*Rosleshoz*), 6.8 million ha were earlier classified as agricultural forests, 0.9 million ha were classified as military forests, while the remainder is composed of small areas that had other classifications (Fomchenkov et al. 2003; Tortsev and Murakhtanov 2004). The data available on forests is still affected by these past designations, therefore the areas previously designated as agricultural forests and other forests were assessed as a regional aggregate. The energy wood potentials from roundwood harvesting operations in each region on forest land that was earlier managed by the Federal Forestry Agency were assessed at the level of the state forest unit (formerly *leskhoz*); this is the most detailed level available for any government statistics on roundwood harvesting. The size of these units varies from 3,200 to 4.2 million hectares (average 0.5 million hectares), with a total of 200 of them in the whole of the Northwest.

For the forest units the potential energy wood from roundwood harvesting was also assessed at the level of species group and type of logging residue. The species grouping constitutes either deciduous or coniferous. The deciduous species are primarily birch and aspen species, with the coniferous group composed mainly of pine and spruce species. Logging residues are described in detail in section 2.3.

2.2 Data sources

The data sources for Northwest Russia on:

- roundwood harvesting came from:
  - unpublished annual statistics provided by the Federal Forestry Agency of the Russian Federation,
  - merchantability tables and standards (Anuchin 1981; Chemodanov and Tsarev 2002; Matvienko 2006; Usoltsev 2002),
  - studies of logging residues (Korobov and Rushnov 1991), and
  - statistics from logging companies (Gerasimov et al. 2005)

- and for mechanical wood processing they came from:
  - the annual statistics of the State Statistical Committee of the regions (Karelstat 2008; (Ulyanov et al. 2007) and
  - Russian roundwood standards (Chemodanov and Tsarev 2002; Kuropteev and Vaskova 1986).

2.3 Roundwood harvesting

Logging is defined as an operation for the felling and extraction of timber from forests (Dykstra and Heinrich 1996). The energy wood potential from roundwood harvesting include: logging residues, spruce stumps removed after final felling, and non-industrial roundwood.

Logging residues resulting from the removal of roundwood in this case are composed of the following components:

- The branches and tops of trees resulting from delimbing and topping. These make up about 8-23% of the stem mass depending on the tree species (Filipchuk 2003). However, during logging operations approximately 11% of this material is used for constructing strip-roads (Korobov and Rushnov 1991), thus only the unused portion can be considered potential energy wood. Hereafter, this portion is referred to as *unused branches*.
- Stemwood damaged by logging operations before or during transport to a central processing yard that results in rendering the quality unmerchantable. The major causes of this damage are improper cutting, skidding, forwarding, and loading onto trucks. This damaged wood can account for 5-7% of the final harvested stem mass (Korobov and Rushnov 1991) depending on the tree species. Hereafter, this portion is referred to as *defective wood from logging*.

Lifted stumps are those stump-root systems, in this case spruce stumps that have been removed after final felling to facilitate site preparation for regeneration and to prevent root rot fungus from spreading, thus aiding in the healing of an infected site (Hakkila 2004). According to earlier studies by the Finnish Forest Research Institute (Laitila et al. 2007), the harvestable mass of a stump-root system is 20-25% of the stem mass.

Non-industrial roundwood is the roundwood that due to natural circumstance (i.e. not damaged during logging) does not meet the standards for use by forest industries, because of its quality, size, or tree species. It is also often regarded as roundwood of traditional firewood quality.

Characteristics and volumes of energy wood from roundwood harvesting depend on:

- Stand composition (i.e. species, age, and quality).
- Harvesting method, which determines the form that wood is delivered from the forest to the roadside (e.g. tree-length method, full tree method, and cut-to-length method) and roundwood harvesting system, which specifies the tools and personnel involved in logging (Pulkki 2003). In the case of the cut-to-length method, all logging residues and non-industrial roundwood are left in the cutting areas. While for tree-length and full tree methods, most logging residues and non-industrial roundwood accumulates at the central processing yards.
- Type of felling (i.e. mature stands or thinning).

The amount of energy wood collected from logging operations at cutting areas was estimated using the calculation method described by Gerasimov et al. (2007) with figures for the forest resource utilisation in Northwest Russia from unpublished annual statistics for 2006 provided by the Federal Forestry Agency.

2.4 Mechanical wood processing

The byproducts of mechanical wood processing include sawdust, veneer cores, slabs, edges, etc. from saw and plywood mills. Wood residues collected from mechanical wood processing were estimated based on annual sawn timber and plywood production for each of the eight regions in 2006. The amount of wood residues from sawmilling operations varies to from 50% to 60% of the sawn timber production (Chemodanov and Tsarev 2002; Kuropteev and Vaskova 1986). For calculating the potential energy wood from saw and plywood mill residues the proportions of 55% and 63% were applied respectively to the production statistics.

2.5 Scenarios

Three theoretical scenarios for the possible development of energy wood resources based on different intensities of forest resource use were examined: "Actual," "Allowable," and "Potential," (Table 1). These scenarios give quantitative potentials based on variations in the intensity of traditional harvest from mature forest, the addition of an improved thinning regime, and the development of the mechanical wood industry.

Table 1. Description of the theoretical scenarios for the intensity of forest resource utilisation in Northwest Russia that were used to assess variations in the potential energy wood production.

Source	Scenario		
	Actual	Allowable	Potential
Felling of mature stands	Actual cut in 2006	Allowable cut	Allowable cut
Thinnings	Actual thinnings in 2006	Actual thinnings in 2006	Full use of mortality
Other fellings	Actual cut in 2006	Actual cut in 2006	Actual cut in 2006
Mechanical wood processing	Sawn wood and plywood production in 2006	Expansion to fully utilise all saw and plywood logs produced	Expansion to fully utilise all saw and plywood logs produced

Scenario “Actual” shows the potential energy wood resources if the recently recorded (i.e. 2006) intensity of harvesting and mechanical wood processing remains constant. The total level of harvesting would then remain at 50.0 million m^3, which is 40.2 million m^3 from the felling of mature stands, 5.1 million m^3 from thinnings, and 4.7 million m^3 from other fellings. The combined sawn wood and plywood production would remain at 7.3 mill. m^3.

The “Allowable” scenario predicts the potential energy wood resources, if there were an increase in the harvest levels from mature stands so that the full 2006 annual allowable cut level (i.e. applicable only to the felling of mature stands) is used; in addition, the saw and plywood mill production levels would also increase to utilise all of the increased supply. Other harvesting levels, like thinnings, would remain at the levels recorded in 2006. The total level of harvesting would then be 116 million m^3; including the full utilisation of the allowable cut of 106.2 million m^3 for the felling of mature stands combined with the 5.1 million m^3 from thinnings and 4.7 million m^3 from other fellings. The combined increased production from saw and plywood mills would then be 13.7 million m^3. The proportional relationship between the amounts of industrial and non-industrial wood produced from the increased harvest volume was kept the same as that which was determined from the “Actual” scenario.

Scenario “Potential” predicts energy wood resources when there is an increase to the full utilisation of the 2006 annual allowable cut level for harvests in mature stands, in addition the level of thinnings would be increased to make full use of the calculated mortality level for 2006, based on the use of the cut-to-length technology used in Finland. Sawn timber and plywood production would also be increased to fully utilise new levels of supply. Other harvesting would remain at the recorded 2006 levels. The total level of harvesting would then be 164.0 million m^3, including 106.2 million m^3 from the felling of mature stands, 53.1 million m^3 from thinnings, and 4.7 million m^3 from other fellings. The combined sawn wood and plywood production would increase to 18.0 million m^3. The proportional relationship between the amounts of industrial and non-industrial wood produced from the increased harvest volumes was kept the same as that which was determined by the “Actual” scenario. Some time after the implementation of this intensive level of forest management the wood quality would improve and there would be a decline in the proportion of traditional non-industrial roundwood; this would then also mean a decrease in the energy wood available.

3 Northwest Russia's estimated energy wood resources from roundwood harvesting and mechanical wood processing

Based on the 50.0 million m^3 actual cut in 2006 (scenario "Actual" in Table 2), the potential for energy wood production from roundwood harvesting operations in Northwest Russia would have been 21.8 million m^3/year, which is equal to about 43.6 TWh of energy. Byproducts from mechanical wood processing, based on the 2006 production data, would have totalled 9.1 million m^3, this would then represent approximately 30% of the 30.9 million m^3 (61.8 TWh) of potential energy wood resources that were available in the Northwest in 2006.

Two theoretical scenarios were prepared to show the levels of potential energy wood that could be available if certain forest management measures were implemented (Figure 1). According to scenario "Allowable" the annual potential energy wood available from roundwood harvesting and mechanical wood processing could be as high as 73.5 million m^3, this is if the entire annual allowable cut were utilised. The total could even be nearly 103.9 million m^3 according to scenario "Potential," were in addition to full utilisation of the allowable cut, thinnings were done according to their full technical potential. These scenarios thus show that the energy wood potential could be 2.4 to 3.4 times what was actually available in 2006. In practice the "Allowable" scenario would mean that the annually harvested stemwood volume from the felling of mature stands would increase from the 2006 level of 40.2 million m^3 to 106.2 million m^3, which is an increase of 164%. For the "Potential" scenario in addition to this increase in the fellings from mature stands there would also be an increase in thinnings, from the 2006 level of 5.1 million m^3 to 53.1 million m^3, which is about a tenfold expansion.

Table 2. Potential energy wood from Northwest Russia based on the source and the intensity of forest resource use.

Source	Scenario					
	Actual[1)]		Allowable[2)]		Potential[3)]	
	million solid m^3	TWh	million solid m^3	TWh	million solid m^3	TWh
Roundwood harvesting	21.8	43.6	55.4	110.8	80.6	161.2
Mechanical wood processing	9.1	18.2	18.1	36.2	23.3	46.6
Total	30.9	61.8	73.5	147.0	103.9	207.8

1) based on actual harvests (40.2 mill. m^3 of fellings from mature stands, 5.1 mill. m^3 of thinnings, and 4.7 mill. m^3 of other fellings) and actual mechanical wood processing (7.3 mill. m^3 of sawn wood and plywood)
2) same as the "Actual" scenario, but with full utilisation of the annual allowable cut (106.2 mill. m^3 of fellings from mature stands) and increased capacity for mechanical wood processing (13.7 mill. m^3 of sawn wood and plywood)
3) same as the "Allowable" scenario, but with full utilisation of thinnings (53.1 mill. m^3 of thinnings) and increased capacity for mechanical wood processing (18.0 mill. m^3 of sawn wood and plywood)

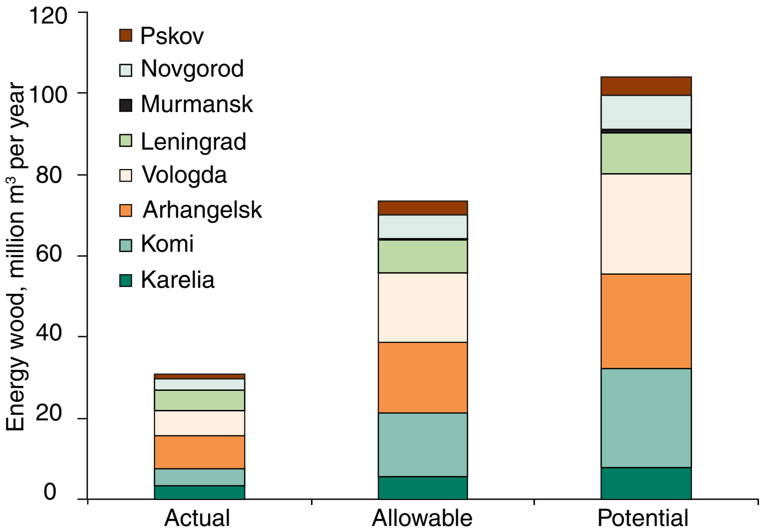

Figure 1. Potential energy wood from Northwest Russian by region and according to three scenarios for the intensity of forest resource use.

Table 3 and Figure 2 show the results for the eight regions of Northwest Russia, of the potential energy wood available from roundwood harvesting according to the three scenarios for the intensity of use of their forest resources. It can be seen that forest resources and their utilisation vary considerably within the Northwest Russia. From the point-of-view of the current availability ("Actual" scenario) of energy wood, there are five dominate regions: there is about 5 million m^3 available from both the Arkhangesk and Vologoda regions, and about 3 million m^3 each available from the Leningrad region and the Republics of Komi and Karelia. Due to the varying history of forest use in each region, the structure of the forest resources, and thus the possibilities to increasing the use, also varies between the regions. In the regions of the extreme west the annual allowable cut is utilised to the largest extent, with 63% of it used in Republic of Karelia and 58% in Leningrad region. In other regions the utilisation is much lower, with only 23% of it used in Republic of Komi, 39% in Vologda, and 41% in Arkhangelsk regions. The full utilization of the allowable cut assumed in the theoretical scenarios of "Allowable" and "Potential" would thus provide much more energy wood; compared to the "Actual" scenario for the whole of the Northwest Russia, nearly 33.7 million m^3 and 58.8 million m^3 more energy wood annually could be provided respectively by the "Allowable" and "Potential" scenarios. Due to the current low utilisation levels of forest resources in the eastern regions of Arkhangelsk, Komi, and Vologda, each of these regions have a vast untapped energy wood potential from roundwood harvesting ranging to as much as 18-20 million m^3 per year.

Table 3. Potential annual energy wood production from roundwood harvesting by Northwest Russian region according to three scenarios for the intensitiey of forest resource use.

Region	Scenario (million solid m^3 o.b per year)		
	Actual	Allowable	Potential
Karelia	2.3	3.6	5.7
Komi	2.7	11.0	17.9
Arkhangelsk	5.4	12.6	17.6
Vologda	4.6	13.8	20.0
Leningrad	3.8	6.5	8.2
Murmansk	0.04	0.3	0.5
Novgorod	2.0	4.8	7.0
Pskov	0.8	2.8	3.7
Total (% increase over "Actual")	21.8	55.4(+155%)	80.6(+270%)

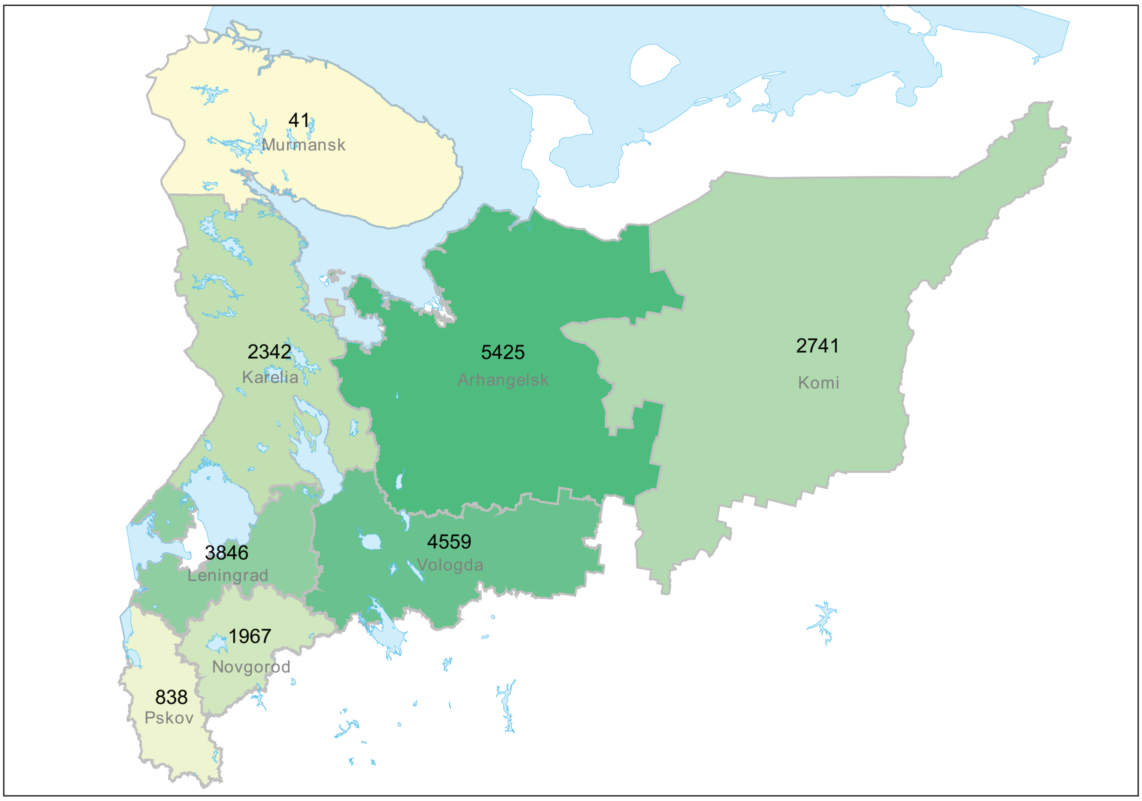

Figure 2. Potential energy wood from roundwood harvesting for Northwest Russian regions based on the actual harvest in 2006 (scenario *Actual*), 1000 m^3 o.b per year.

The actual distribution of the potential energy wood from roundwood harvesting according to tree species group for the regions of the Northwest Russia is presented in Table 4 and Figure 3. In total, 58% (12.7 million m^3) of this potential energy wood is coniferous and 42% (9.1 million m^3) is deciduous species. The coniferous proportion decreases to 51% while the deciduous proportion increases to 49% for the "Allowable" and "Potential" scenarios. There is a variation in the proportion of species among the regions; currently (scenario "Actual") conifers dominate the northern regions of Murmansk (100%), Komi (82%), Arkhangelsk (76%), and Karelia (75%); while deciduous species are more common in the southern regions of Novgorod (72%) and Pskov (65%). In scenarios "Allowable" and "Potential" where the harvest levels are increased, the deciduous proportion of the total regional potential energy wood significantly increases, especially for the Vologda (72%) and Pskov (79%) regions. The reason for this is that logging companies currently work selectively with a preference for coniferous stands. In the future, however, they will have to harvest all available forest resources to maintain the harvesting volumes.

Table 4. Potential energy wood for Northwest Russia from roundwood harvesting according to species group and three scenarios for the intensity of forest resource use.

Species group	Scenario (million solid m^3 o.b per year)		
	Actual	Allowable	Potential
Coniferous	12.7	28.0	41.5
Decidious	9.1	27.4	39.1
Total	21.8	55.4	80.6

In the whole of the Northwest Russia in 2006 (scenario "Actual"), of all the potential energy wood that would have been available at cutting areas and central processing yards: 65% (14.2 million m^3) was non-industrial roundwood, while 8% (1.8 million m^3) each was available as defective wood from logging and unused branches (Table 5 and Figure 4). An additional 19% (4.0 million m^3) of the total potential would have been available as lifted stumps located only in the cutting areas (Table 5 and Figure 4). Due to differences in tree species composition between the regions, there was a larger share of the regional total potentials composed of non-industrial roundwood in the southern regions, like Novgorod with 77% and Pskov with 78%; whereas, in the northeast relatively high proportions of the regional potentials were composed of lifted stumps, for example Komi with 28% and Arkhangelsk with 27%. For the same reason there were lower proportions of the total regional energy wood potentials composed of non-industrial roundwood in the northern regions of Arkhangelsk (58%) and Komi (55%), and of lifted stumps in the southern regions of Novgorod (8%), Pskov (7%), and Murmansk (6%).

Table 5. Potential energy wood from roundwood harvesting in Northwest Russia according to type of logging residue and three scenarios for the intensity of forest resource use.

Type	Scenario (million solid m^3 o.b per year)		
	Actual	Allowable	Potential
Non-industrial roundwood	14.2	38.3	62.2
Lifted stumps	4.0	8.6	8.6
Unused branches	1.8	4.6	4.6
Defective wood from logging	1.8	3.9	5.2
Total	21.8	54.4	80.6

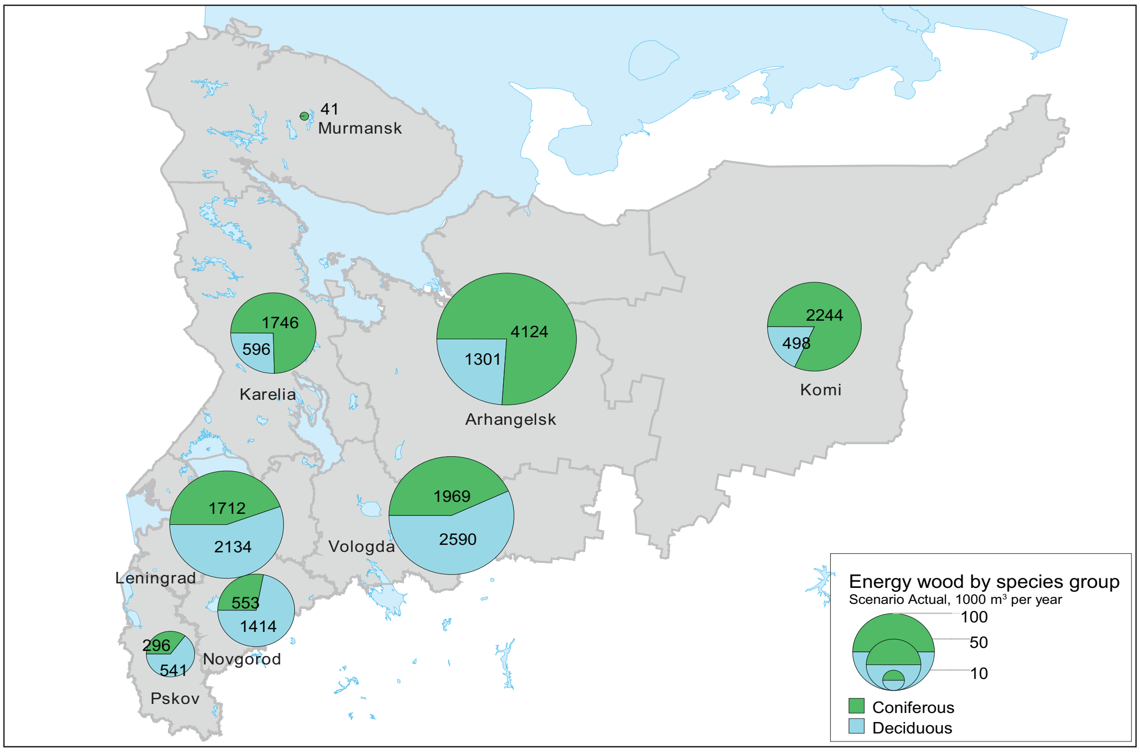

Figure 3. Potential energy wood from roundwood harvesting for Northwest Russian regions based on the actual harvest in 2006 (scenario *Actual*) presented according to species group.

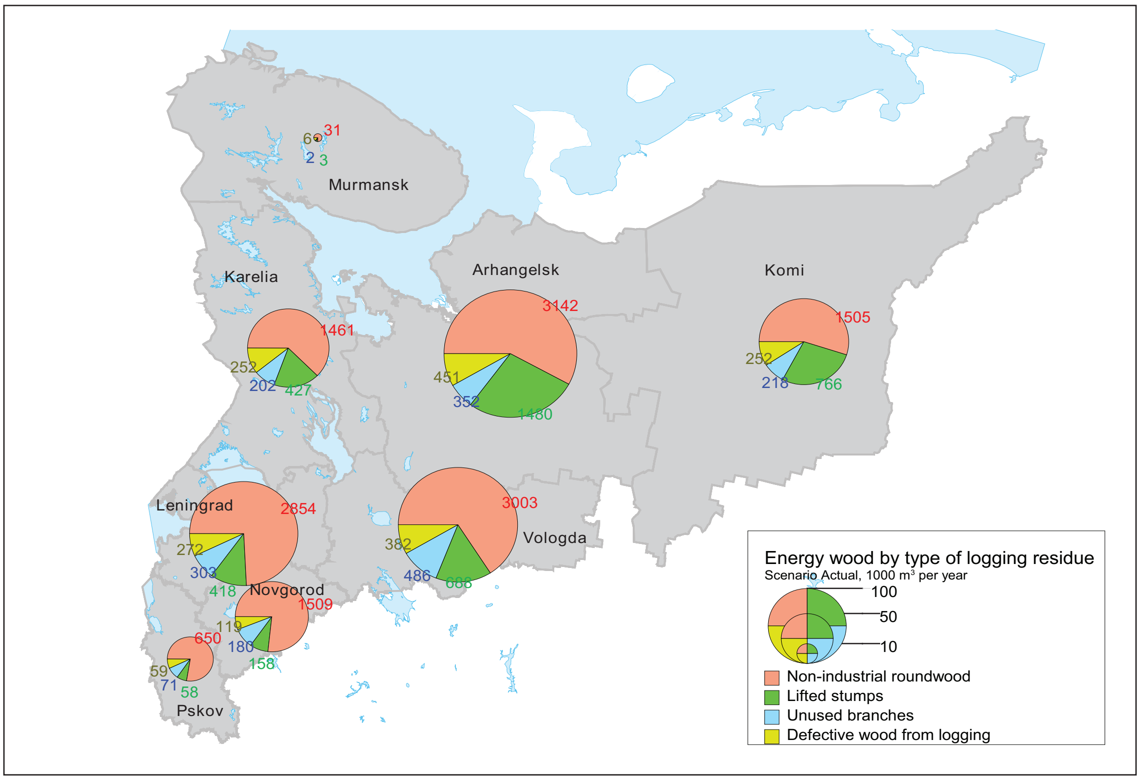

Figure 4. Distribution of potential energy wood from roundwood harvesting for Northwest Russian regions based on the actual harvest in 2006 (scenario *Actual*) presented according to type of logging residue.

The accumulation of types of logging residue between cutting areas and central processing yards within the regions of the Northwest differs. The reason for this is that a large share of thinning operations are performed with cut-to-length technology on the Karelian Isthmus, as well as in the rest of the Republic of Karelia, and near the city of Saint-Petersburg in the Leningrad region. These operations are in contrast to those performed in the other regions of the Northwest, where there are few or no thinning operations with the harvesting concentrated on mature stands and including the use of traditional full-tree technology.

The potential energy wood from the byproducts of large and medium size mechanical wood processing enterprises located in the regions of Northwest Russia is shown in Table 6. Most of the mechanical wood processing capacity is concentrated in a few administrative regions which have well developed sawmill and plywood industries, these regions include: Arkhangelsk, Vologda, Karelia, and Komi. Based on 2006 production data (scenario "Actual") the byproducts from mechanical wood processing totalled 9.1 million m^3 (Kareliastat 2008). The theoretical increases in total harvest levels for scenarios "Allowable" and "Potential" would supply more raw materials (i.e. saw and plywood logs) for the mechanical wood processing industry and allow its expansion, so that there would be increases in products and byproducts. The total potential energy wood from these increases would be 18.1 million m^3 and 23.3 million m^3 respectively for the "Allowable" and "Potential" scenarios.

Table 6. Potential energy wood from mechanical wood processing by region of Northwest Russia according to three scenarios for the intensity of forest resource use.

Region	Scenario (million solid m^3 o.b per year)		
	Actual	Allowable	Potential
Karelia	1.0	1.9	2.3
Komi	1.5	4.9	6.3
Arkhangelsk	2.7	4.6	5.7
Vologda	1.7	3.3	4.6
Leningrad	1.0	1.7	2.0
Murmansk	0.0	0.2	0.2
Novgorod	0.9	1.1	1.5
Pskov	0.3	0.5	0.7
Total (% increase over “Actual”)	9.1	18.1(+100%)	23.3(+156%)

4 Estimates of Northwest Russian regional energy wood resources from roundwood harvesting and mechanical wood processing

4.1 Republic of Karelia

The total forest area managed by the forestry administration of the Republic of Karelia is 14.9 million ha, with a growing stock of 946 million m^3. Forest land covers approximately 53% of Karelia (Kareliastat 2008).

Based on the Karelia region's total actual harvest in 2006 of 6.5 million m^3 (scenario "Actual" in Table 7), the potential for energy wood production from roundwood harvesting operations would be 2.3 million m^3/year, which is equal to 4.7 TWh. Byproducts from mechanical wood processing, based on 2006 production data, totalled 1 million m^3, which represents approximately 30% of Karelia's total potential energy wood resources (3.3 million m^3) in 2006.

Two theoretical scenarios were also calculated to show the potential energy wood that could be available if certain forest management measures were implemented in Karelia. According to scenario "Allowable" the annual potential energy wood available from roundwood harvesting and mechanical wood processing could be as high as 5.5 million m^3, this is if the entire annual allowable cut were utilised and the increased supply of industrial roundwood was processed locally. The regional total could even be nearly 8 million m^3 according to scenario "Potential," were in addition to full utilisation of the allowable cut and increased industrial processing, thinnings were also done according to their full technical potential. These scenarios thus show that the potential energy wood available in Karelia could be 63% to 137% more than the amounts available in 2006. In practice scenario "Allowable" would mean that the annually harvested stemwood volume from the felling of mature stands would increase from the 2006 level of 5.5 million m^3 to 8.9 million m^3, which is a 62% increase. For scenario "Potential," in addition to the increase in the fellings from mature stands, there would also be an increase in the thinnings, from the 2006 level of 0.5 million m^3 to 4.5 million m^3, which is about a nine-fold expansion.

Table 7. Potential energy wood in the Republic of Karelia based on the source and intensity of forest resource use.

Source	Scenario					
	Actual[1)]		Allowable[2)]		Potential[3)]	
	1000 solid m^3	TWh	1000 solid m^3	TWh	1000 solid m^3	TWh
Roundwood harvesting	2342	4.7	3614	7.2	5690	11.4
Mechanical wood processing	1000	2.0	1861	3.7	2281	4.5
Total energy wood	3342	6.7	5475	11.0	7971	15.9

1) based on actual harvests (5.5 mill. m^3 of fellings from mature stands, 0.5 mill. m^3 of thinnings, and 0.5 mill. m^3 of other fellings) and actual mechanical wood processing (0.8 mill. m^3 of sawn wood and plywood)
2) same as the "Actual" scenario, but with full utilisation of the annual allowable cut (8.9 mill. m^3 fellings from mature stands) and increased capacity for mechanical wood processing (1.5 mill. m^3 of sawn wood and plywood)
3) same as the "Allowable" scenario, but with full utilisation of thinnings (4.5 mill. m^3 of thinnings) and increased capacity for mechanical wood processing (1.8 mill. m^3 of sawn wood and plywood)

The estimated availability of energy wood from roundwood harvesting within the Karealian forest units, according to the three scenarios for the intensity of the use of their forest resources, are presented in Table 8 and Figure 5. The availability of forest resources and their potential for utilisation vary considerably within Karelia. In the western and southern forest units, the annual allowable cut is utilised to a large extent: with 99% of it used in Lakhdenpokhsky, 94% in Sortavalsky, 85% in Suoyarvsky, and 80% in Porosozersky. For these units scenario "Allowable" would not provide much of an increase in the energy wood available. However, for the whole region, this scenario would provide an annual increase of nearly 1.3 million m^3 of energy wood over the 2006 harvest levels. In addition, the Karelian forest units have very good opportunities to increase the amount of energy wood available through the "Potential" scenario's increased thinning operations. This scenario would provide nearly 3.3 million m^3 more energy wood annually than the actual harvests in 2006.

Table 8. Potential annual energy wood production from roundwood harvesting for the forest units of the Republic of Karelia according to three scenarios for the intensity of forest resource use.

Forest unit	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Sosnovecky	32	64	109
Sumsky	12	45	69
Yushkozersky	35	76	140
Kalevaljsky	64	118	212
Kemsky	19	58	91
Kondopozhsky	95	144	239
Spasogubsky	21	51	73
Kostomukshsky	68	118	223
Lakhdenpokhsky	90	91	127
Pyaozersky	51	221	365
Chupinsky	1	47	87
Zaonezhsky	56	115	161
Medvezhjegorsky	161	249	406
Muezersky	162	235	394
Porosozersky	79	95	160
Sukkozersky	92	104	172
Olonecky	146	186	251
Pitkyarantsky	93	115	153
Ladvinsky	109	182	272
Petrozavodsky	44	78	101
Pryazhinsky	137	186	282
Shuyjsko-Vidansky	63	69	105
Pudozhsky	303	489	777
Pyaljmsky	77	72	110
Segezhskyj	37	54	97
Sortavaljsky	116	121	168
Suoyarvsky	162	177	281
Other	17	54	65
Total (% increase over "Actual")	2342	3614(+54%)	5690(+143%)

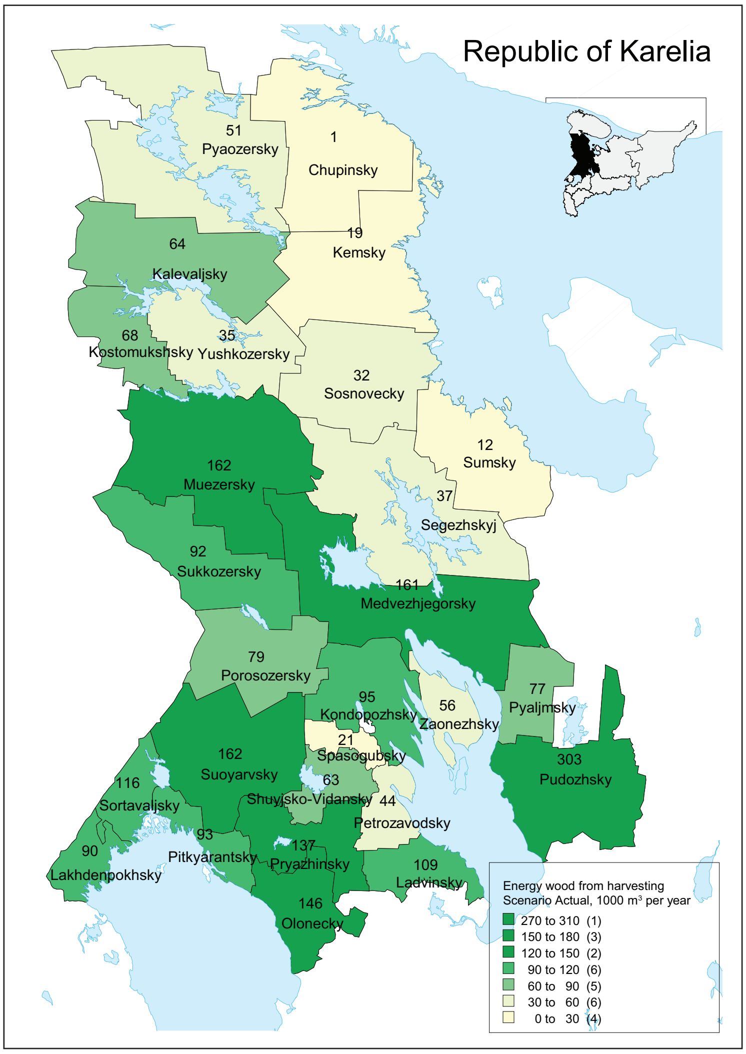

Figure 5. Potential energy wood from roundwood harvesting based on the actual 2006 harvest in each forest unit of the Republic of Karelia (scenario *Actual*).

The distribution of energy wood from roundwood harvesting in 2006 according to tree species group is presented in Table 9 and Figure 6. The total energy wood potential for Karelia in 2006 was composed 75% (1.7 million m^3) of coniferous and 25% (0.6 million m^3) of deciduous species. A slightly smaller share of conifers is projected for the two theoretical scenarios (Table 9). The species proportions differ among the Karelian forest units. There are larger coniferous proportions, of almost 100%, among the northern forest units of Sumsky, Yushkozersky, Kalevaljsky, Kemsky, and Kostomukshsky. Yet, deciduous species dominate within a few southern forest units like Pyaozersky (74%) and Oloncky (69%).

Table 9. Potential energy wood in the Republic of Karelia from roundwood harvesting according to species group and three scenarios for the intensity of forest resource use.

Type	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Non-industrial roundwood	1461	2274	4251
Lifted stumps	427	643	643
Unused branches	202	315	315
Defective wood from logging	252	382	481
Total	2342	3614	5690

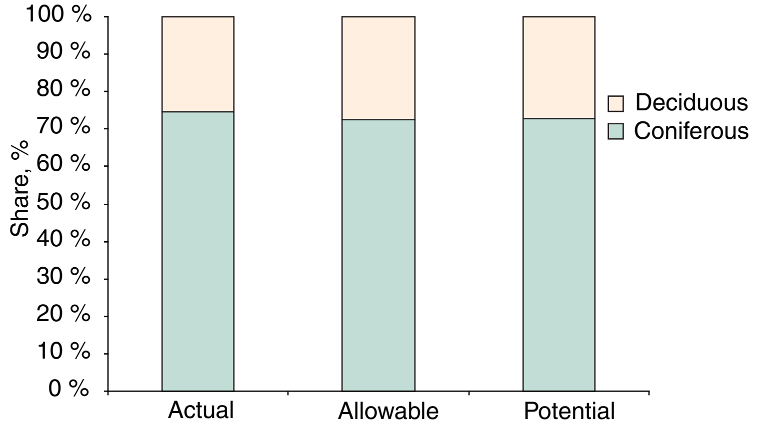

Figure 6. Tree species group proportions of the potential energy wood in the Republic of Karelia from roundwood harvesting according to three scenarios for the intensity of forest resource use.

In 2006 (scenario "Actual," Table 10 and Figure 7), of all the potential energy wood in Karelia that would have been available at harvest sites and central processing yards 62% (1.5 million m^3) was non-industrial roundwood and 11% (0.3 million m^3) was defective wood from logging. In the cutting areas only, an additional 18% (0.4 million m^3) was lifted stumps and 9% (0.2 million m^3) was unused branches. In Karelia, energy wood is concentrated at the harvest sites due to the pre-dominate use of cut-to-length technology by logging companies. The proportions of the types logging residues for scenario "Allowable" would be similar to those for 2006. However, for scenario "Potential" the proportions would be 75% non-industrial roundwood, 11% lifted stumps, 6% unused branches, and 8% defective wood from logging.

Table 10. Potential energy wood in the Republic of Karelia from roundwood harvesting according to the type of logging residue and three scenarios for the intensity of forest resource use.

Type	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Non-industrial roundwood	1461	2274	4251
Lifted stumps	427	643	643
Unused branches	202	315	315
Defective wood from logging	252	382	481
Total	2342	3614	5690

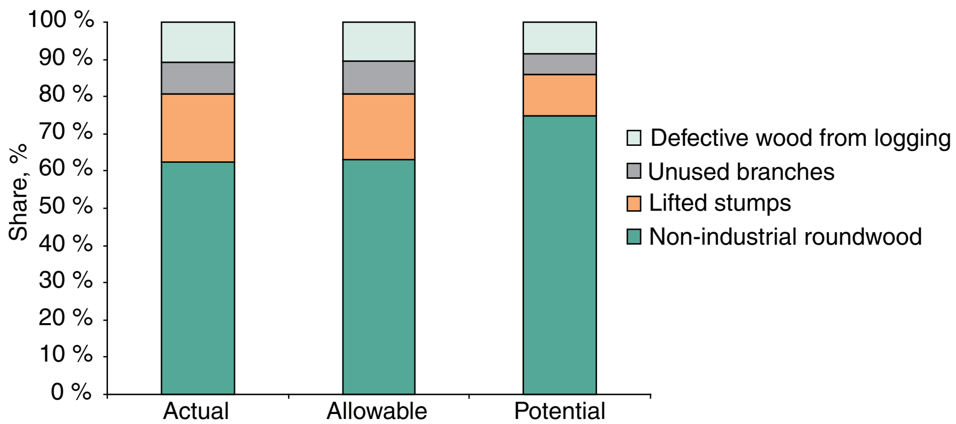

Figure 7. Proportions of the types of logging residue that comprise the potential energy wood from roundwood harvesting in the Republic of Karelia according to three scenarios for the intensity of forest resource use.

4.2 Republic of Komi

The total forest area managed by the forestry administration of the Republic of Komi is 38.9 million ha, with a growing stock of 2,966 million m^3. Forest land covers approximately 72% of Komi (Kareliastat 2008).

Based on the Komi region's total actual harvest in 2006 of 6.7 million m^3 (scenario "Actual" in Table 11), the potential for energy wood production from roundwood harvesting operations would be 2.7 million m^3/year, which is equal to 5.5 TWh. Byproducts from mechanical wood processing, based on 2006 production data, totalled 1.5 million m^3, which represents approximately 35% of Komi's total potential energy wood resources (4.2 million m^3) in 2006.

Two theoretical scenarios were also calculated to show the potential energy wood that could be available if certain forest management measures were implemented in Komi. According to scenario "Allowable" the annual potential energy wood available from roundwood harvesting and mechanical wood processing could be as high as 15.9 million m^3, this is if the entire annual allowable cut were utilised and the increased supply of industrial roundwood was processed locally. The regional total could even be nearly 24.2 million m^3 according to scenario "Potential," were in addition to full utilisation of the allowable cut and increased industrial processing, thinnings were also done according to their full technical potential. These scenarios thus show that the potential energy wood available in Komi could be four and six times more than the amounts available in 2006. In practice scenario "Allowable" would mean that the annually harvested stemwood volume from the felling of mature stands would increase from the 2006 level of 6.2 million m^3 to 26.9 million m^3, which is at least four times more. For scenario "Potential," in addition to the increase in the fellings from mature stands, there would also be an increase in the thinnings, from the 2006 level of 0.3 million m^3 to 13.5 million m^3, which is twenty seven times more.

Table 11. Potential energy wood in the Republic of Komi based on the source and intensity of forest resource use.

Source	Scenario					
	Actual[1)]		Allowable[2)]		Potential[3)]	
	1000 solid m^3	TWh	1000 solid m^3	TWh	1000 solid m^3	TWh
Roundwood harvesting	2741	5.5	11046	22.1	17935	35.9
Mechanical wood processing	1482	3.0	4863	9.7	6309	12.6
Total energy wood	4223	8.5	15909	31.8	24244	48.5

1) based on actual harvests (6.2 mill. m^3 of fellings from mature stands, 0.3 mill. m^3 of thinnings, and 0.2 mill. m^3 other fellings) and actual mechanical wood processing (1.1 mill. m^3 of sawn wood and plywood)
2) same as the "Actual" scenario, but with full utilisation of the annual allowable cut (26.9 mill. m^3 of fellings from mature stands) and increased capacity for mechanical wood processing (3.8 mill. m^3 of sawn wood and plywood)
3) same as the "Allowable" scenario, but with full utilisation of thinnings (13.5 mill. m^3 of thinnings) and increased capacity for mechanical wood processing (5.0 mill. m^3 of sawn wood and plywood)

The estimated availability of energy wood from roundwood harvesting within the forest units of Komi, according to the three scenarios for the intensity of the use of their forest resources, are presented in Table 12 and Figure 8. The availability of forest resources and their potential for utilisation vary considerably within Komi. In the eastern forest units the annual allowable cut is not utilised to a large extent: with only 28% of it used in Koyjgorodsky, 33% in Pomozdinsky, 37% in Priluzsky, and 39% in Sihktihvdinsky. For these units scenario "Allowable" would provide a great increase in the potential energy wood available. For the whole region, this scenario would provide an annual increase of nearly 8.3 million m^3 of energy wood over the 2006 levels. The Komi forest units also have good opportunities to increase the amount of energy wood available through the “Potential” scenario’s increased thinning operations. This scenario would provide nearly 15.2 million m^3 more energy wood annually than the actual harvests in 2006. However, harvesting in Komi is currently limited by a lack of infrastructure and the vast intact natural forest landscapes.

Table 12. Potential annual energy wood production from roundwood harvesting for the forest units of the Komi Republic according to three scenarios for the intensity of forest resource use.

Forest unit	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Ayjkinsky	46	175	291
Vuktihljsky	7	431	692
Ertomsky	103	387	673
Zheleznodorozhnihy	63	332	538
Izhemsky	19	371	567
Kadzheromsky	2	226	366
Kazhimskoy	47	178	262
Koyjgorodsky	161	358	695
Komsomoljsky	27	347	613
Kortkerossky	108	220	353
Letsky	183	374	617
Lokchimsky	113	260	430
Mezhdurechensky	164	420	695
Methursky	13	388	623
Pechoro-Ilihchsky	7	607	843
Pechorsky	19	271	382
Pomozdinsky	141	330	591
Priluzsky	282	672	1131
Pruptsky	44	418	692
Sosnogorsky	33	386	639
Storozhevsky	91	448	735
Sihktihvdinsky	237	302	490
Sihktihvkarsky	49	93	139
Sihsoljsky	315	650	1039
Troicko-Pechorsky	46	318	536
Udorsky	52	493	819
Usinsky	19	18	14
Ustj-Kulomsky	92	240	381
Ustj-Nemsky	136	652	1125
Ustj-Cilemsky	35	34	2
Ukhtinsky	47	527	813
Chernamsky	33	58	73
Other	7	62	76
Total (% increase over “Actual”)	2741	11046(+303%)	17935(+554%)

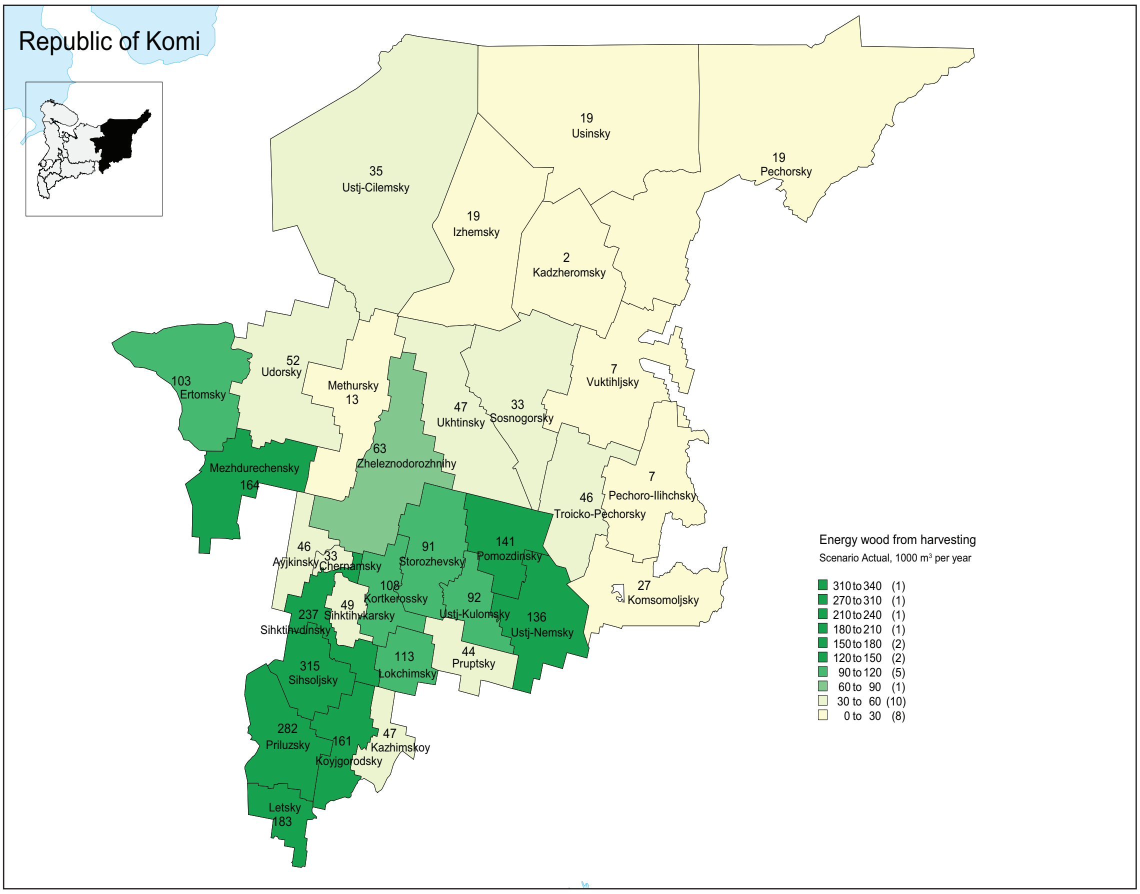

Figure 8. Potential energy wood from roundwood harvesting based on the actual 2006 harvest in each forest unit of the Komi Republic (scenario *Actual*).

The distribution of energy wood from roundwood harvesting in 2006 according to tree species group is presented in Table 13 and Figure 9. The total energy wood potential for Komi in 2006 was composed 82% (2.2 million m^3) of coniferous and 18% (0.5 million m^3) of deciduous species. The proportions for the theoretical scenario "Allowable" are similar to those for 2006, while for the "Potential" scenario the proportions change to 75% coniferous and 25% deciduous. The species proportions differ among the Komi forest units. There are larger coniferous proportions, of almost 100%, among the northern forest units of Methursky, Pechoro-Ilihchsky, Ertomsky, and Pechorsky. Yet, deciduous species dominate within a few southern forest units like Letsky (67%) and Priluzsky (59%).

Table 13. Potential energy wood in the Komi Republic from roundwood harvesting according to species group and three scenarios for the intensity of forest resource use.

Species group	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Coniferous	2244	8824	13535
Decidious	497	2222	4400
Total	2741	11046	17935

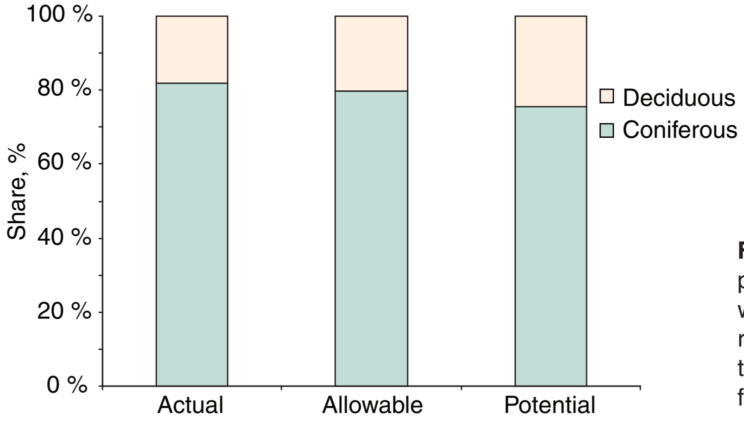

Figure 9. Tree species group proportions of the potential energy wood in the Komi Republic from roundwood harvesting according to three scenarios for the intensity of forest resource use.

In Komi in 2006, energy wood could have been collected both from harvest sites and central processing yards, since there is an equal share of Nordic cut-to-length and traditional tree-length and full-tree technologies used by logging companies there. Of all the potential energy wood that would have been available at harvest sites and central processing yards in 2006 (scenario "Actual," Table 14 and Figure 10): 55% (1.5 million m^3) was non-industrial roundwood, 9% (0.3 million m^3) was defective wood from logging, and 8% (0.2 million m^3) was unused branches. In the cutting areas only, an additional 28% (0.8 million m^3) was available as lifted stumps. The proportions of the types logging residues for scenario "Allowable" would be similar to those for 2006. However, for scenario "Potential" the proportions would be 70% non-industrial roundwood, 17% lifted stumps, 5% unused branches, and 8% defective wood from logging.

Table 14. Potential energy wood in the Komi Republic from roundwood harvesting according to the type of logging residue and three scenarios for the intensity of forest resource use.

Type	Scenario 1000 solid m^3 o.b per year		
	Actual	Allowable	Potential
Non-industrial roundwood	1405	6014	12574
Lifted stumps	766	3021	3021
Unused branches	218	967	967
Defective wood from logging	252	1044	1373
Total	2741	11046	17935

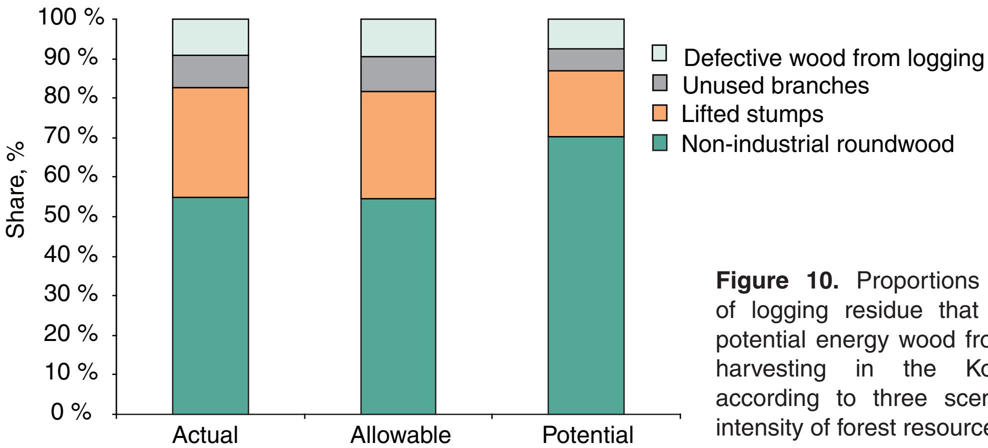

Figure 10. Proportions of the types of logging residue that comprise the potential energy wood from roundwood harvesting in the Komi Republic according to three scenarios for the intensity of forest resource use.

4.3 Arkhangelsk region

The total forest area managed by the forestry administration of the Arkhangelsk region is 29.5 million ha, with a growing stock of 2,522 million m^3. Forest land covers approximately 54% of the region (Kareliastat 2008).

Based on the Arkhangelsk region's total actual harvest in 2006 of 12.0 million m^3 (scenario "Actual" in Table 15), the potential for energy wood production from roundwood harvesting operations would be 5.4 million m^3/year, which is equal to 10.9 TWh. Byproducts from mechanical wood processing, based on 2006 production data, totalled 2.7 million m^3, which represents approximately 33% of Arkhangelsk region total potential energy wood resources (8.1 million m^3) in 2006.

Two theoretical scenarios were also calculated to show the potential energy wood that could be available if certain forest management measures were implemented in Arkhangelsk. According to scenario "Allowable" the annual potential energy wood available from roundwood harvesting and mechanical wood processing could be as high as 17.2 million m^3, this if the entire annual allowable cut were utilised and the increased supply of industrial roundwood was processed locally. The regional total could even be nearly 23.3 million m^3 according to scenario "Potential," were in addition to full utilisation of the allowable cut and increased industrial processing, thinnings were also done according to their full technical potential. These scenarios thus show that the potential energy wood available in Arkhangelsk could be twice or even nearly three times more than the amounts available in 2006. In practice scenario "Allowable" would mean that the annually harvested stemwood volume from the felling of mature stands would increase from the 2006 level of 9.0 million m^3 to 22.2 million m^3, which is 2.5 times more. For scenario "Potential," in addition to the increase in the fellings from mature stands, there would also be an increase in the thinnings, from the 2006 level of 1.5 million m^3 to 11.1 million m^3, which is a nearly a ten fold expansion.

The estimated availability of energy wood from roundwood harvesting within the forest units of the Arkhangelsk region, according to the three scenarios for the intensity of the use of their forest resources, are presented in Table 16 and Figure 11. The availability of forest resources and their potential for utilisation vary considerably within Arkhangelsk region. In the eastern and northern forest units the annual allowable cut is not utilised to a large extent: with only 10% of it used in Vihyjsky, 11% in Sursky, 17% in Vilegodsky, and 18% in Severodvinsky. For these units scenario "Allowable" would provide a great increase in the potential energy wood available. For the whole region, this scenario would provide an annual increase of nearly 7.2 million m^3 of energy wood over the 2006 levels. The Arkhangelsk region forest units also have good opportunities to increase the amount of energy wood available through the "Potential" scenario's increased thinning operations. This scenario would provide nearly 12.2 million m^3 more energy wood annually than the actual harvests in 2006. However, harvesting in the northeast of Arkhangelsk region is currently limited by a lack of infrastructure and the vast intact natural forests.

Table 15. Potential energy wood in the Arkhangelsk region based on the source and intensity of forest resource use.

Source	Scenario					
	Actual[1)]		Allowable[2)]		Potential[3)]	
	1000 solid m^3	TWh	1000 solid m^3	TWh	1000 solid m^3	TWh
Roundwood harvesting	5425	10.9	12591	25.2	17625	35.3
Mechanical wood processing	2673	5.3	4620	9.2	5676	11.4
Total energy wood	8098	16.2	17211	34.4	23301	46.6

[1)] based on actual harvests (9.0 mill. m^3 of fellings from mature stands, 1.5 mill. m^3 of thinnings, and 1.5 mill. m^3 of other fellings) and actual mechanical wood processing (2.1 mill. m^3 of sawn wood and plywood)
[2)] same as the “Actual” scenario, but with full utilisation of the annual allowable cut (22.2 mill. m^3 of fellings from mature stands) and increased capacity for mechanical wood processing (3.6 mill. m^3 of sawn wood and plywood)
[3)] same as the “Allowable” scenario, but with full utilisation of thinnings (11.1 mill. m^3 of thinnings) and increased capacity for mechanical wood processing (4.5 mill. m^3 of sawn wood and plywood)

Table 16. Potential annual energy wood production from roundwood harvesting for the forest units of Arkhangelsk region according to three scenarios for the intensity of forest resource use.

Forest unit	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Arkhangelsky	112	194	212
Bereznikovsky	344	939	1256
Veljsky	152	265	427
Verkhnetoemsky	288	690	974
Vilegodsky	80	111	235
Vihyjsky	108	658	953
Emecky	177	261	372
Kargopoljsky	161	280	438
Karpogorsky	242	384	579
Konoshsky	145	332	472
Kotlassky	260	266	401
Krasnoborsky	317	494	711
Leshukonsky	23	1095	1548
Mezensky	32	33	8
Nyandomsky	187	282	457
Obozersky	116	189	204
Onezhsky	209	523	863
Pinezhsky	112	276	410
Plesecky	42	110	142
Priozerny	159	439	644
Puksoozersky	38	92	119
Severodvinsky	127	334	496
Solovecky	0	1	1
Sursky	69	367	538
Ustjyansky	260	504	764
Kholmogorsky	150	234	358
Shenkursky	243	484	676
Yarensky	161	319	523
Other	1111	2435	2844
Total(% increase over “Actual”)	5425	12591(+132%)	17625(+225%)

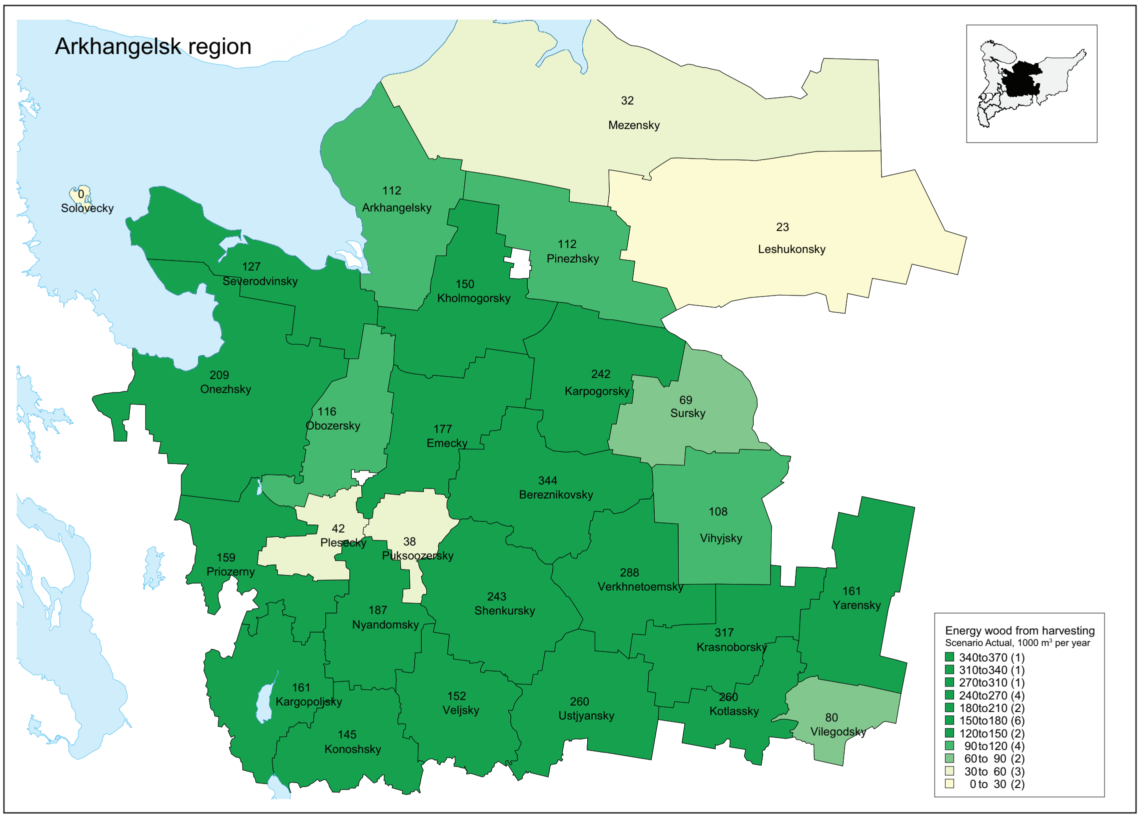

Figure 11. Potential energy wood from roundwood harvesting based on the actual 2006 harvest in each forest units of the Arkhangelsk region (scenario *Actual*).

The distribution of energy wood from roundwood harvesting in 2006 according to tree species group is presented in Table 17 and Figure 12. The total energy wood potential for Arkhangelsk in 2006 was composed 76% (4.1 million m^3) of coniferous and 24% (1.3 million m^3) of deciduous species. The species proportions for the theoretical scenarios would change to 67% coniferous and 23% deciduous for the "Allowable" scenario, and 70% coniferous and 30% deciduous for the "Potential" scenario. The proportions also vary between the Arkhangelsk forest units. There are presently larger proportions of conifers in the northern and eastern forest units of Arkhangelsky, Pinezhsky, Severodvinsky, Emecky, Onezhsky, and Sursky, where almost 100% of the actual harvest is coniferous.

Table 17. Potential energy wood from roundwood harvesting in the Arkhangelsk region according to species group for three scenarios for the intensity of forest resource use.

Species group	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Coniferous	4124	8485	12252
Deciduous	1301	4106	5373
Total	5425	12591	17625

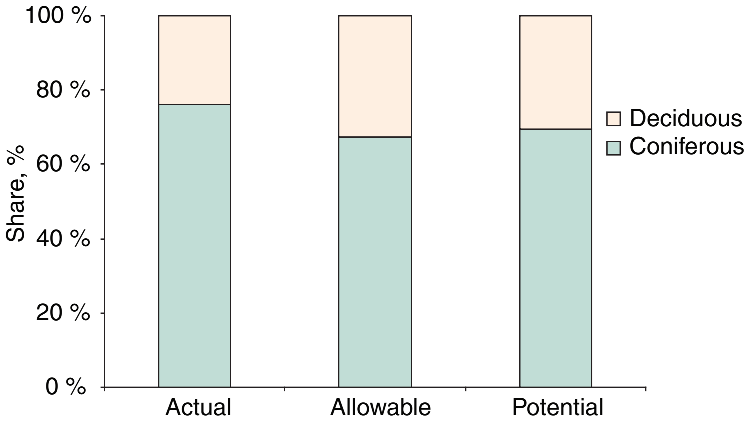

Figure 12. Tree species group proportions of the potential energy wood in the Arkhangelsk region from roundwood harvesting according to three scenarios for the intensity of forest resource use.

In the Arkhangelsk region in 2006, energy wood could have been collected both from harvest sites and central processing yards, since there is an equal share of Nordic cut-to-length and traditional tree-length and full-tree technologies used by logging companies there. Of all the potential energy wood that would have been available at harvest sites and central processing yards in 2006 (scenario “Actual,” Table 18 and Figure 13): 58% (3.1 million m^3) was non-industrial roundwood, 8% (0.5 million m^3) was defective wood from logging, and 7% (0.4 million m^3) was unused branches. In the cutting areas only, an additional 27% (1.5 million m^3) was available as lifted stumps. These proportions for scenario “Allowable” would be 63% non-industrial roundwood, 23% lifted stumps, 7% unused branches, and 7% defective wood from logging. For scenario “Potential” the proportions would be 72% non-industrial wood, 16% lifted stumps, 5% unused branches, and 6% defective wood from logging.

Table 18. Potential energy wood from roundwood harvesting in the Arkhangelsk region according to the type of logging residue and three scenarios for the intensity of forest resource use.

Type	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Non-industrial roundwood	3112	7973	12766
Lifted stumps	1480	2882	2882
Unused branches	352	817	817
Defective wood from logging	451	919	1160
Total	5425	12591	17625

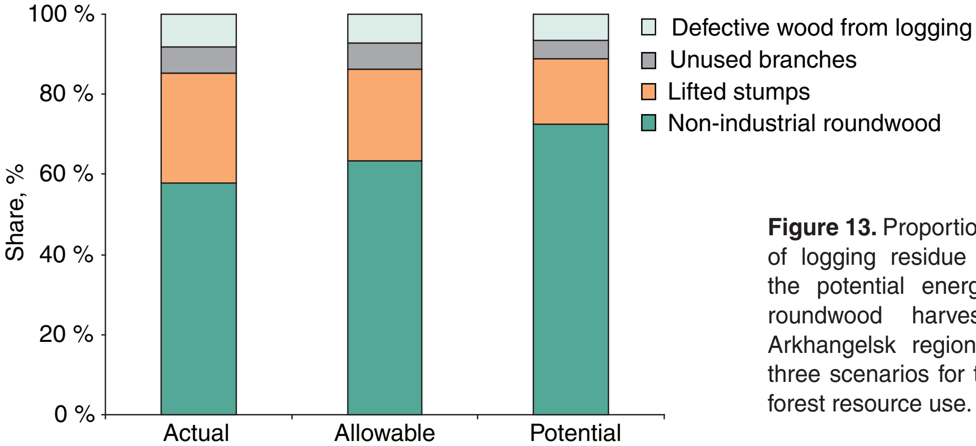

Figure 13. Proportions of the types of logging residue that comprise the potential energy wood from roundwood harvesting in the Arkhangelsk region according to three scenarios for the intensity of forest resource use.

4.4 Vologda region

The total forest area managed by the forestry administration of Vologda region is 11.7 million ha, with a growing stock of 1,602 million m^3. Forest land covers approximately 70% of the region (Kareliastat 2008).

Based on the Vologda region's total actual harvest in 2006 of 10.6 million m^3 (scenario "Actual" in Table 11), the potential for energy wood production from roundwood harvesting operations would be 4.6 million m^3/year, which is equal to 9.1 TWh. Byproducts from mechanical wood processing, based on 2006 production data, totalled 1.7 million m^3, which represents approximately 27% of the Vologda region total potential energy wood resources (6.3 million m^3) in 2006.

Two theoretical scenarios were also calculated to show the potential energy wood that could be available if certain forest management measures were implemented in the Vologda region. According to scenario "Allowable" the annual potential energy wood available from roundwood harvesting and mechanical wood processing could be as high as 17.1 million m^3, this is if the entire annual allowable cut were utilised and the increased supply of industrial roundwood was processed locally. The regional total could even be nearly 24.6 million m^3 according to scenario "Potential," were in addition to full utilisation of the allowable cut and increased industrial processing, thinnings were also done according to their full technical potential. These scenarios thus show that the potential energy wood available in the Vologda region could be nearly three to four times more than the amounts available in 2006. In practice scenario "Allowable" would mean that the annually harvested stemwood volume from the felling of mature stands would increase from the 2006 level of 9.6 million m^3 to 25.1 million m^3, which is about three times more. For scenario "Potential," in addition to the increase in the fellings from mature stands, there would also be an increase in the thinnings, from the 2006 level of 0.6 million m^3 to 12.6 million m^3, which is more than a twenty-fold expansion.

The estimated availability of energy wood from roundwood harvesting within the forest units of the Vologda region, according to the three scenarios for the intensity of the use of their forest resources, are presented in Table 20 and Figure 14. The availability of forest resources and their potential for utilisation vary considerably within the Vologda region. In the western forest units the annual allowable cut is utilised to a large extent: with 77% of it used in Andomsky, 71% in Kovzhinsky, 68% in Babaevsky, and 67% in Verkhovazhsky; while in other forest units its utilisation is very low, for example only 5% of it is used in Totemsky, 8% in Mezhdurechensky, 15% in Kirillovsky, and 14% in Nyuksensky. For these units scenario "Allowable" would provide a great increase in the potential energy wood available. For the whole region, this scenario would provide an annual increase of nearly 9.2 million m^3 of energy wood over the 2006 levels. The Vologda forest units also have good opportunities to increase the amount of energy wood available through the "Potential" scenario's increased thinning operations. This scenario would provide nearly 15.4 million m^3 more energy wood annually than the actual harvests in 2006.

Table 19. Potential energy wood in the Vologda region based on the source and intensity of forest resource use.

Source	Scenario					
	Actual[1)]		Allowable[2)]		Potential[3)]	
	1000 solid m^3	TWh	1000 solid m^3	TWh	1000 solid m^3	TWh
Roundwood harvesting	4559	9.1	13772	27.5	19988	40.0
Mechanical wood processing	1707	3.4	3302	6.6	4612	9.2
Total energy wood	6266	12.5	17074	34.1	24600	49.2

1) based on actual harvests (9.6 mill. m^3 of fellings from mature stands, 0.6 mill. m^3 of thinnings, and 0.4 mill. m^3 of other felling) and actual mechanical wood processing (1.3 mill. m^3 of sawn wood and plywood)
2) same as the "Actual" scenario, but with full utilisation of the annual allowable cut (25.1 mill. m^3 of fellings from mature stands) and increased capacity for mechanical wood processing (2.3 mill. m^3 of sawn wood and plywood)
3) same as the "Allowable" scenario, but with full utilisation of thinnings (12.6 mill. m^3 of thinnings) and increased capacity for mechanical wood processing (3.4 mill. m^3 of sawn wood and plywood)

Table 20. Potential annual energy wood production from roundwood harvesting for the forest units of the Vologda region according to three scenarios for the intensity of forest resource use.

Forest unit	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Andomsky	130	169	268
Babaevsky	118	161	230
Babushkinsky	66	501	777
Belozersky	159	237	381
Borisovo-Sudsky	187	343	551
Vashkinsky	74	163	255
Velikoustyugsky	205	413	782
Verkhovazhsky	147	218	347
Vozhegodsky	96	221	390
Vologodsky	33	111	170
Vihtegorsky	146	233	418
Gryazovecky	51	254	410
Kadnikovsky	88	185	294
Kaduyjsky	23	85	148
Kirillovsky	22	109	175
Kichmengsko-Gorodecky	203	419	635
Kovzhinsky	111	145	245
Mezhdurechensky	18	158	254
Nikoljsky	274	620	921
Nyuksensky	47	257	491
Syamzhensky	111	250	429
Tarnogsky	110	264	450
Totemsky	48	644	1095
Ustj-Kubinsky	26	52	85
Ustyuzhensky	38	85	125
Kharovsky	64	114	199
Chagodothensky	28	56	108
Cherepovecky	152	477	712
Sheksninsky	28	63	63
Other	1756	6765	8580
Total (% increase over "Actual")	4559	13772 (+202%)	19988 (+338%)

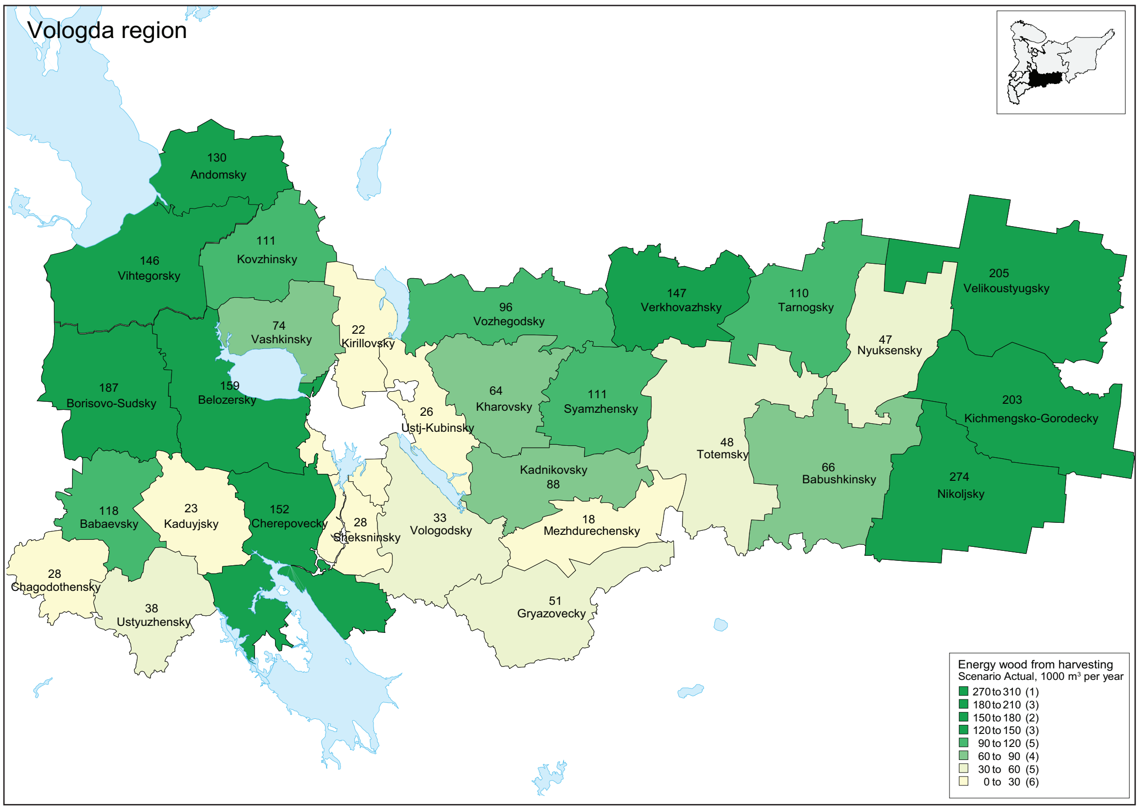

Figure 14. Potential energy wood from roundwood harvesting based on the actual 2006 harvest in each forest units of the Vologda region (scenario *Actual*).

The distribution of energy wood from roundwood harvesting in 2006 according to tree species group is presented in Table 21 and Figure 15. The total energy wood potential for the Vologda region in 2006 was composed 43% (2.0 million m^3) of coniferous and 57% (2.6 million m^3) of deciduous species. The two theoretical scenarios (“Allowable” and “Potential”) would change the species proportions to 28% coniferous and 72% deciduous. The proportions also vary between the Vologda forest units. Conifers presently dominate the northern units, with 80% in Ustyuzhensky, 71% in Chagodothensky, and 69% in Babushkinsky. The central forest units are dominated by deciduous species, the deciduous proportion is 93% in Gryazovecky, 87% in Cherepovecky, 86% in Vologodsky, and 83% in Kadnikovsky.

Table 21. Potential energy wood from roundwood harvesting in the Vologda region according to species group for three scenarios for the intensity of forest resource use.

Species group	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Coniferous	1969	3916	5784
Decidious	2590	9856	14204
Total	4559	13772	19988

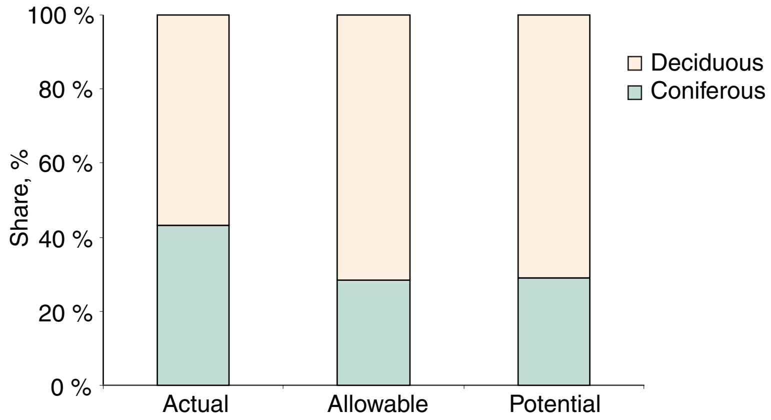

Figure 15. Tree species group proportions of the potential energy wood in the Vologda region from roundwood harvesting according to three scenarios for the intensity of forest resource use.

In the Vologda region in 2006, energy wood could have been collected both from harvest sites and central processing yards, since there is an equal share of Nordic cut-to-length and traditional tree-length and full-tree technologies used by logging companies there. Of all the potential energy wood that would have been available at harvest sites and central processing yards in 2006 (scenario "Actual," Table 22 and Figure 16): 66% (3.0 million m^3) was non-industrial roundwood, 11% (0.5 million m^3) was unused branches, and 8% (0.4 million m^3) was defective wood from logging. In the cutting areas only, an additional 15% (0.7 million m^3) was available as lifted stumps. Proportions for these types logging residues for scenario "Allowable" would be 77% non-industrial roundwood, 8% lifted stumps, 10% unused branches, and 6% defective wood from logging. For scenario "Potential" the proportions would be 83% non-industrial roundwood, 5% lifted stumps, 7% unused branches, and 5% defective wood from logging.

Table 22. Potential energy wood from roundwood harvesting in the Vologda region according to the type of logging residue and three scenarios for the intensity of forest resource use.

Type	Scenario (1000 solid m^3 o.b per year		
	Actual	Allowable	Potential
Non-industrial roundwood	3003	10590	16509
Lifted stumps	688	1089	1089
Unused branches	486	1305	1305
Defective wood from logging	382	788	1085
Total	4559	13772	19988

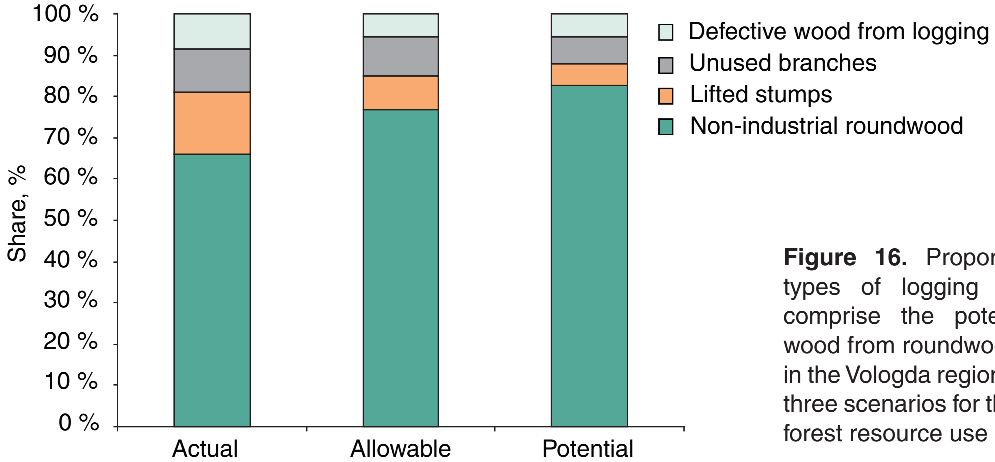

Figure 16. Proportions of the types of logging residue that comprise the potential energy wood from roundwood harvesting in the Vologda region according to three scenarios for the intensity of forest resource use

4.5 Leningrad region

The total forest area managed by the forestry administration of the Leningrad region is 5.9 million ha, with a growing stock of 825 million m^3. Forest land covers approximately 56% of the region (Kareliastat 2008).

Based on the Leningrad region's total actual harvest in 2006 of 8.3 million m^3 (scenario "Actual" in Table 23), the potential for energy wood production from roundwood harvesting operations would be 3.8 million m^3/year, which is equal to 7.7 TWh. Byproducts from mechanical wood processing, based on 2006 production data, totalled 1 million m^3, which represents approximately 21% of the region's total potential energy wood resources (4.9 million m^3) in 2006.

Two theoretical scenarios were also calculated to show the potential energy wood that could be available if certain forest management measures were implemented in the Leningrad region. According to scenario "Allowable" the annual potential energy wood available from roundwood harvesting and mechanical wood processing could be as high as 8.2 million, this if the entire annual allowable cut were utilised and the increased supply of industrial roundwood was processed locally. The regional total could even be nearly 10.3 million m^3 according to scenario "Potential," were in addition to full utilisation of the allowable cut and increased industrial processing, thinnings were also done according to their full technical potential. These scenarios thus show that the potential energy wood available in the region could be more than twice the amounts available in 2006. In practice scenario "Allowable" would mean that the annually harvested stemwood volume from the felling of mature stands would increase from the 2006 level of 5.3 million m^3 to 9.6 million m^3, which is an enhancement of 81%. For scenario "Potential," in addition to the increase in the fellings from mature stands, there would also be an increase in the thinnings, from the 2006 level of 1.4 million m^3 to 4.8 million m^3, which is an increase of more than three times.

The estimated availability of energy wood from roundwood harvesting within the forest units of the Leningrad region, according to the three scenarios for the intensity of the use of their forest resources, are presented in Table 24 and Figure 17. The availability of forest resources and their potential for utilisation vary considerably within the region. In the western forests units the annual allowable cut is already utilised to large extent: with 100% of it used in the units of Roschinsky and Severo-Zapadny and 94% used in the units of Priozersky and Sosnovsky. For these units scenario "Allowable" would not provide any increase in the potential energy wood available. Yet, for the whole region, this scenario would provide an annual increase of nearly 2.6 million m^3 of energy wood over the 2006 levels. All the Leningrad region forest units do, however, have good opportunities to increase the amount of energy wood available through the "Potential" scenario's increased thinning operations. This scenario would provide nearly 4.4 million m^3 more energy wood annually than the actual harvests in 2006.

Table 23. Potential energy wood in the Leningrad region based on the source and intensity of forest resource use.

Source	Scenario Actual[1)]		Allowable[2)]		Potential[3)]	
	1000 solid m^3	TWh	1000 solid m^3	TWh	1000 solid m^3	TWh
Roundwood harvesting	3846	7.7	6483	13.0	8246	16.5
Mechanical wood processing	1046	2.1	1671	3.3	2040	4.1
Total energy wood	4892	9.8	8154	16.3	10286	20.6

1) based on actual harvests (5.3 mill. m^3 of fellings from mature stands, 1.4 mill. m^3 of thinnings, and 1.6 mill. m^3 of other fellings) and actual mechanical wood processing (0.8 mill. m^3 of sawn wood and plywood)
2) same as the "Actual" scenario, but with full utilisation of the annual allowable cut (9.6 mill. m^3 of fellings from mature stands) and increased capacity for mechanical wood processing (1.3 mill. m^3 of sawn wood and plywood)
3) same as the "Allowable" scenario, but with full utilisation of thinnings (4.8 mill. m^3 of thinnings) and increased capacity for mechanical wood processing (1.6 mill. m^3 of sawn wood and plywood)

Table 24. Potential annual energy wood production from roundwood harvesting for the forest units of the Leningrad region according to three scenarios for the intensity of forest resource use.

Forest unit	Scenario (1000 solid m^3 o.b per year) Actual	Allowable	Potential
Boksitogorsky	191	249	335
Vinnicky	60	170	238
Voznesensky	66	117	166
Volosovsky	177	243	307
Volkhovsky	107	216	307
Vihricky	120	163	203
Gatchinsky	89	99	127
Efimovsky	92	142	216
Kingiseppsky	87	114	137
Kirishsky	126	244	367
Kirovsky	108	143	189
Lisinsky	53	120	145
Lodeyjnopoljsky	151	198	265
Lomonosovsky	60	68	41
Luzhsky	169	245	336
Lyubansky	137	215	302
Oyatsky	52	91	130
Pashsky	32	70	97
Podborovsky	89	157	227
Podporozhsky	200	295	422
Priozersky	88	94	89
Roschinsky	171	170	188
Siverskiyj les	22	38	49
Severo-Zapadny	227	219	212
Slancevsky	61	108	135
Sosnovsky	35	35	35
Tikhvinsky	137	190	263
Shugozersky	180	288	433
Other	759	1982	2285
Total (% increase over "Actual")	3846	6483(+69%)	8246(+114%)

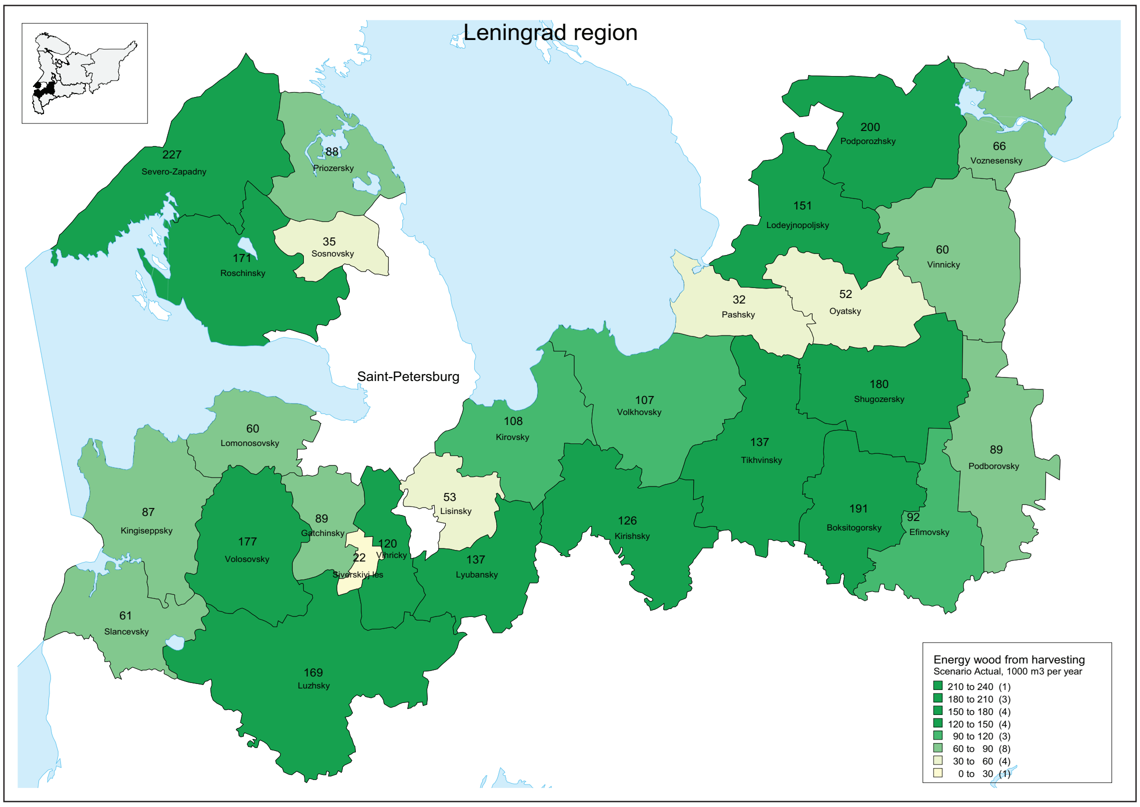

Figure 17. Potential energy wood from roundwood harvesting based on the actual 2006 harvest in each forest unit of the Leningrad region (scenario *Actual*).

The distribution of energy wood from roundwood harvesting in 2006 according to tree species group is presented in Table 25 and Figure 18. The total energy wood potential for the Leningrad region in 2006 was composed 45% (1.7 million m^3) of coniferous and 55% (2.1 million m^3) of deciduous species. The two theoretical scenarios ("Allowable" and "Potential") would change the species proportions to 40% coniferous and 60% deciduous. The proportions also vary between the Leningrad region forest units. There are presently larger proportions of conifers in the forest units of the Karelian Isthmus, with 89% in Sosnovsky and 79% in Roschinsky. In the central forest units the deciduous species dominate, for example this proportion is 91% in Kirovsky, 81% in Lisinsky, 80% in Lyubansky, and 75% in Kirishsky.

Table 25. Potential energy wood in the Leningrad region from roundwood harvesting according to species group and three scenarios for the intensity of forest resource use.

Species group	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Coniferous	1712	2535	3285
Decidious	2134	3948	4961
Total	3846	6483	8246

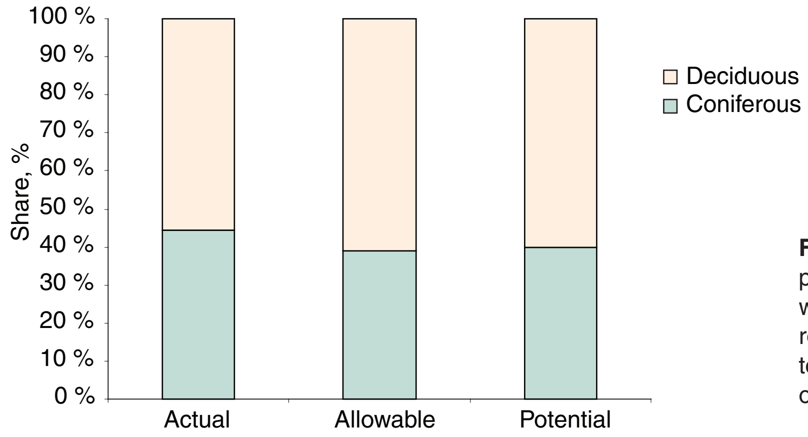

Figure 18. Tree species group proportions of the potential energy wood in the Leningrad region from roundwood harvesting according to three scenarios for the intensity of forest resource use.

In 2006 (scenario "Actual," Table 26 and Figure 19), of all the potential energy wood in the Leningrad region that would have been available at harvest sites and central processing yards: 74% (2.9 million m^3) was non-industrial roundwood and 7% (0.3 million m^3) was defective wood from logging. In the cutting areas only, an additional 11% (0.4 million m^3) was lifted stumps and 8% (0.3 million m^3) was unused branches. In the region, energy wood is concentrated in cutting areas due to the pre-dominate use of cut-to-length technology by logging companies. These proportions for scenario "Allowable" would be 78% is non-industrial roundwood, 9% lifted stumps, 7% unused branches, and 6% defective wood from logging. For scenario "Potential" the proportions would be 81% non-industrial roundwood, 7% lifted stumps, 6% unused branches, and 6% defective wood from logging.

Table 26. Potential energy wood in the Leningrad region from roundwood harvesting according to the type of logging residue and three scenarios for the intensity of forest resource use.

Type	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Non-industrial roundwood	2854	5040	6719
Lifted stumps	418	583	583
Unused branches	303	487	487
Defective wood from logging	272	373	457
Total	3846	6483	8246

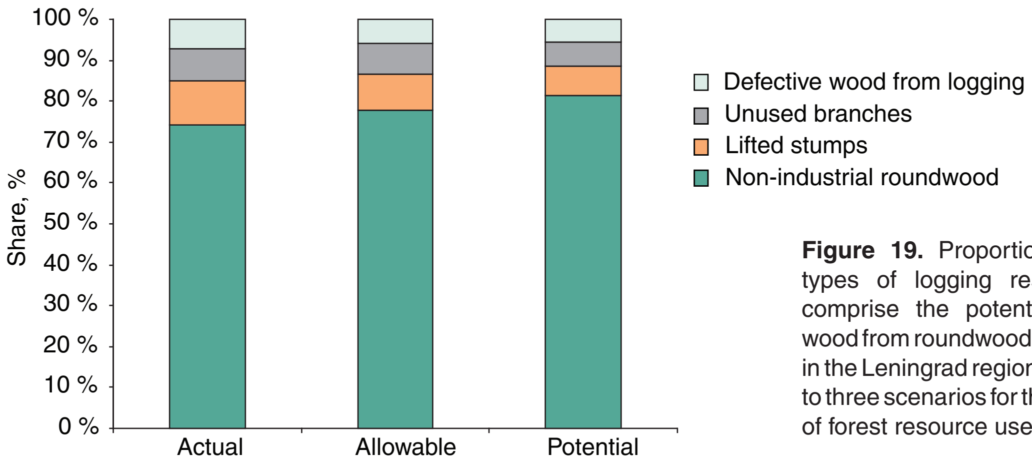

Figure 19. Proportions of the types of logging residue that comprise the potential energy wood from roundwood harvesting in the Leningrad region according to three scenarios for the intensity of forest resource use.

4.6 Murmansk region

The total forest area managed by the forestry administration of the Murmansk region is 10.0 million ha, with a growing stock of only 231 million m^3. Forest land covers approximately 34% of the region (Kareliastat 2008). The climatic conditions of the region are harsh for forestry, therefore forestry activities have much less importance here than in the other regions of Northwest Russia.

Based on the Murmansk region's total actual harvest in 2006 of 149,000 m^3 (scenario "Actual" in Table 27), the potential for energy wood production from roundwood harvesting operations would be 41,000 m^3/year, which is equal to 0.12 TWh. Byproducts from the region's sawmilling operations, based on 2006 production data, totalled 20,000 m^3, which represents approximately one third of the total amount of the Murmansk region potential energy wood resources (61,000 m^3) in 2006.

Two theoretical scenarios were also calculated to show the potential energy wood that could be available if certain forest management measures were implemented in the Murmansk region. According to scenario "Allowable" the annual potential energy wood available from roundwood harvesting and sawmilling could be as high as 451,000, this is if the entire annual allowable cut were utilised and the increased supply of industrial roundwood was processed locally. The regional total could even be nearly 656,000 m^3 according to scenario "Potential," were in addition to full utilisation of the allowable cut and increased industrial processing, thinnings were also done according to their full technical potential. These scenarios thus show that the potential energy wood available in the Murmansk region could be seven to ten times more than the amounts available in 2006. In practice scenario "Allowable" would mean that the annually harvested stemwood volume from the felling of mature stands would increase from the 2006 level of 96,500 m^3 to 720,200 m^3, which is a seven-fold expansion. For scenario "Potential," in addition to the increase in the fellings from mature stands, there would also be an increase in the thinnings, from the 2006 level of 39,300 m^3 to 360,100 m^3, which is an eight-fold enhancement.

Table 27. Potential energy wood in the Murmansk region based on the source and intensity of forest resource use.

Source	Scenario					
	Actual[1)]		Allowable[2)]		Potential[3)]	
	1000 solid m^3	TWh	1000 solid m^3	TWh	1000 solid m^3	TWh
Roundwood harvesting	41	0.1	297	0.6	466	0.9
Sawmilling	20	0.0	154	0.3	190	0.4
Total energy wood	61	0.1	451	0.9	656	1.3

1) based on actual harvests (96,500 m^3 of fellings from mature stands, 39,300 m^3 of thinnings, and 12,900 m^3 of other fellings) and actual sawmill production (16,000 m^3 of sawn wood)
2) same as the "Actual" scenario, but with full utilisation of the annual allowable cut (720,200 m^3 of fellings from mature stands) and increased capacity for sawmill production (117,000 m^3 of sawn wood)
3) same as the "Allowable" scenario, but with full utilisation of thinnings (360,100 m^3 of thinnings) and increased capacity for sawmill production (146,000 m^3 of sawn wood)

The estimated availability of energy wood from roundwood harvesting within the forest units of the Murmansk region, according to the three scenarios for the intensity of the use of their forest resources, are presented in Table 28 and Figure 20. The availability of forest resources and their potential for utilisation vary considerably within the Murmansk region. In all the forests units of region the annual allowable cut is utilised only slightly, with an average of only 13%. Therefore scenario "Allowable" would provide a great increase in the potential energy wood for the whole region. The annual increase would be nearly 256,000 m^3 of energy wood over the 2006 level. The Murmansk region forest units also have good opportunities to increase the amount of energy wood available through the "Potential" scenario's increased thinning operations. This scenario would provide nearly 425,000 m^3 more energy wood annually than the actual harvests in 2006.

Table 28. Potential annual energy wood production from roundwood harvesting for the forest units of the Murmansk region according to three scenarios for the intensity of forest resource use.

Forest unit	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Zasheyjkovsky	7	67	96
Kandalakshsky	10	55	90
Kirovsky	1	1	12
Kovdozersky	3	24	36
Koljsky	5	70	102
Lovozersky	1	2	2
Monchegorsky	0	0	2
Murmansky	0	0	0
Pechengsky	9	15	37
Tersky	5	63	88
Total (% increase over "Actual")	41	297 (+624%)	466 (+1037%)

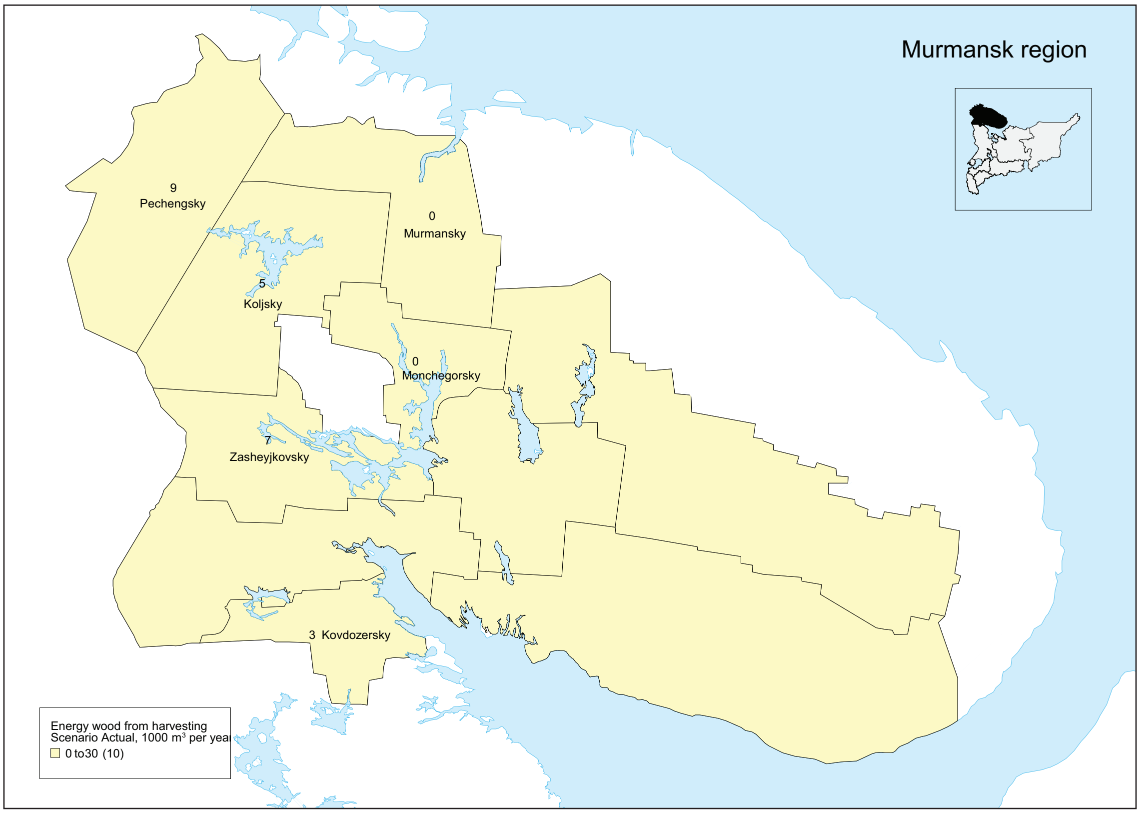

Figure 20. Potential energy wood from roundwood harvesting based on the actual 2006 harvest in each forest unit of the Murmansk region (scenario *Actual*).

The distribution of energy wood from roundwood harvesting in 2006 according to tree species group is presented in Table 29 and Figure 21. One-hundred percent of the energy wood potential for the Murmansk region in 2006 was coniferous species. The species proportions for the theoretical scenarios would change to 63% coniferous and 37% deciduous for the "Allowable" scenario, and 71% coniferous and 29% deciduous for the "Potential" scenario. All the deciduous species available for harvest are considered to be used only for energy wood.

Table 29. Potential energy wood in the Murmansk region from roundwood harvesting according to species group and three scenarios for the intensity of forest resource use.

Species group	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Coniferous	41	188	330
Decidious	0	109	135
Total	41	297	465

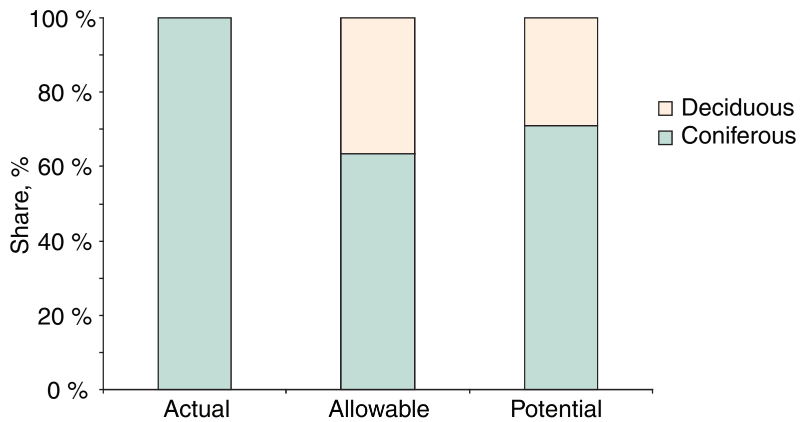

Figure 21. Tree species group proportions of the potential energy wood in Murmansk region from roundwood harvesting according to three scenarios for the intensity of forest resource use.

In 2006 (scenario "Actual," Table 30 and Figure 22), of all the potential energy wood in the Murmansk region that would have been available at harvest sites and central processing yards 75% (30,000 m3) was non-industrial roundwood and 14% (6,000 m3) was defective wood from logging. Available just at the harvest sites was an additional 6% (3,000 m3) as lifted stumps and 5% (2,000 m3) as unused branches. In the Murmansk region, energy wood is concentrated in cutting areas due to the pre-dominate use of cut-to-length technology by logging companies. These proportions of the potential energy wood sources for scenario "Allowable" would be 68% non-industrial roundwood, 17% lifted stumps, 9% defective wood from logging, and 6% unused branches. For scenario "Potential" the proportions would be 77% non-industrial roundwood, 11% lifted stumps, 8% defective wood from logging, and 4% unused branches.

Table 30. Potential energy wood in the Murmansk region from roundwood harvesting according to the type of logging residue and three scenarios for the intensity of forest resource use.

Type	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Non-industrial roundwood	30	189	349
Lifted stumps	3	57	57
Unused branches	2	20	20
Defective wood from logging	6	31	39
Total	41	297	465

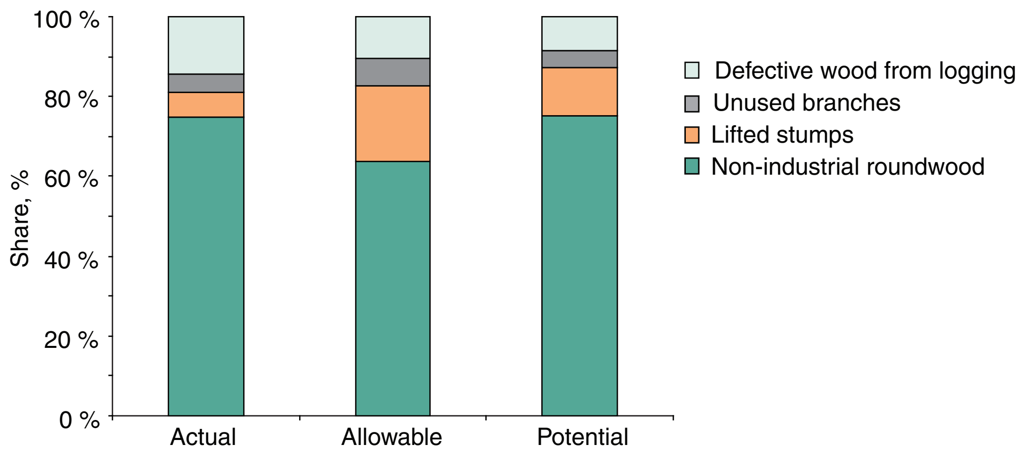

Figure 22. Proportions of the types of logging residue that comprise the potential energy wood from roundwood harvesting in the Murmansk region according to three scenarios for the intensity of forest resource use.

4.7 Novgorod region

The total forest area managed by the forestry administration of the Novgorod region is 4.1 million ha, with a growing stock of 614 million m^3. Forest land covers approximately 64% of the region (Kareliastat 2008).

Based on the Novgorod region's total actual harvest in 2006 of 3.9 million m^3 (scenario "Actual" in Table 31), the potential for energy wood production from roundwood harvesting operations would be 2 million m^3/year, which is equal to 3.9 TWh. Byproducts from mechanical wood processing, based on 2006 production data, totalled 0.9 million m^3, which represents approximately one third of the Novgorod region total potential energy wood resources (2.9 million m^3) in 2006.

Two theoretical scenarios were also calculated to show the potential energy wood that could be available if certain forest management measures were implemented in the Novgorod region. According to scenario "Allowable" the annual potential energy wood available from roundwood harvesting and mechanical wood processing could be as high as 5.9 million m^3, this is if the entire annual allowable cut were utilised and the increased supply of industrial roundwood was processed locally. The regional total could even be nearly 8.5 million m^3 according to scenario "Potential," were in addition to full utilisation of the allowable cut and increased industrial processing, thinnings were also done according to their full technical potential. These scenarios thus show that the energy wood available in the Novgorod region could be two to three times more than the amounts available in 2006. In practice, scenario "Allowable" would mean that the annually harvested stemwood volume from the felling of mature stands would increase from the 2006 level of 3.4 million m^3 to 9.0 million m^3, which is an increase of more than two and a half times. For scenario "Potential," in addition to the increase in the fellings from mature stands, there would also be an increase in the thinnings, from the 2006 level of 0.4 million m^3 to 4.5 million m^3, which is a tenfold expansion.

Table 31. Potential energy wood in the Novgorod region based on the source and intensity of forest resource use.

Source	Scenario					
	Actual[1)]		Allowable[2)]		Potential[3)]	
	1000 solid m^3	TWh	1000 solid m^3	TWh	1000 solid m^3	TWh
Roundwood harvesting	1967	3.9	4799	9.6	6961	13.9
Mechanical wood processing	943	1.9	1054	2.1	1507	3.0
Total energy wood	2910	5.8	5853	11.7	8468	16.9

1) based on actual harvests (3.4 mill. m^3 of fellings from mature stands, 0.4 mill. m^3 of thinnings, and 0.1 mill. m^3 of other fellings) and actual mechanical wood processing (0.7 mill. m^3 of sawn wood and plywood)
2) same as the "Actual" scenario, but with full utilisation of the annual allowable cut (9.0 mill. m^3 of fellings from mature stands) and increased capacity for mechanical wood processing (0.7 mill. m^3 of sawn wood and plywood)
3) same as the "Allowable" scenario, but with full utilisation of thinnings (4.5 mill. m^3 of thinnings) and increased capacity for mechanical wood processing (1.1 mill. m^3 of sawn wood and plywood)

The estimated availability of energy wood from roundwood harvesting within the forest units of the Novgorod region, according to the three scenarios for the intensity of use of their forest resources, are presented in Table 32 and Figure 23. The availability of forest resources and their potential for utilisation vary only slightly within the Novgorod region. In almost all the forests units of the region the annual allowable cut has a low level of utilisation, with an average of only 38%. The exception is the Okulovsky forest unit, which harvests 80% of its allowable cut. Application of scenario "Allowable" to the whole region would thus provide a great increase in the potential energy wood available. This increase would be nearly 2.8 million m^3 of energy wood more annually than the 2006 levels. The Novgorod region forest units also have good opportunities to increase the amount of energy wood available through the "Potential" scenario's increased thinning operations. This scenario would provide nearly 5.0 million m^3 more energy wood annually than the actual harvests in 2006.

Table 32. Potential annual energy wood production from roundwood harvesting for the forest units of the Novgorod region according to three scenarios for the intensity of forest resource use.

Forest unit	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Batecky	53	178	253
Borovichsky	73	225	322
Valdayjsky	22	112	161
Volotovsky	32	64	78
Demyansky	91	249	365
Krestecky	126	317	457
Lyubihtinsky	110	207	296
Malovishersky	140	290	441
Marevsky	87	224	326
Moshenskoy	85	224	326
Nebolchsky	196	334	491
Novgorodsky	63	211	289
Novoselickoye	65	120	176
Okulovsky	190	232	337
Parfinsky	33	125	178
Pestovsky	68	191	266
Poddorsky	32	136	250
Ermolinsky	11	27	31
Solecky	47	146	194
Starorussky	57	221	335
Khvoyjninsky	119	201	301
Kholmsky	89	277	383
Shimsky	54	129	198
Chudovsky	96	258	377
Other	28	101	130
Total (% increase over "Actual")	1967	4799(+144%)	6961 (+144%)

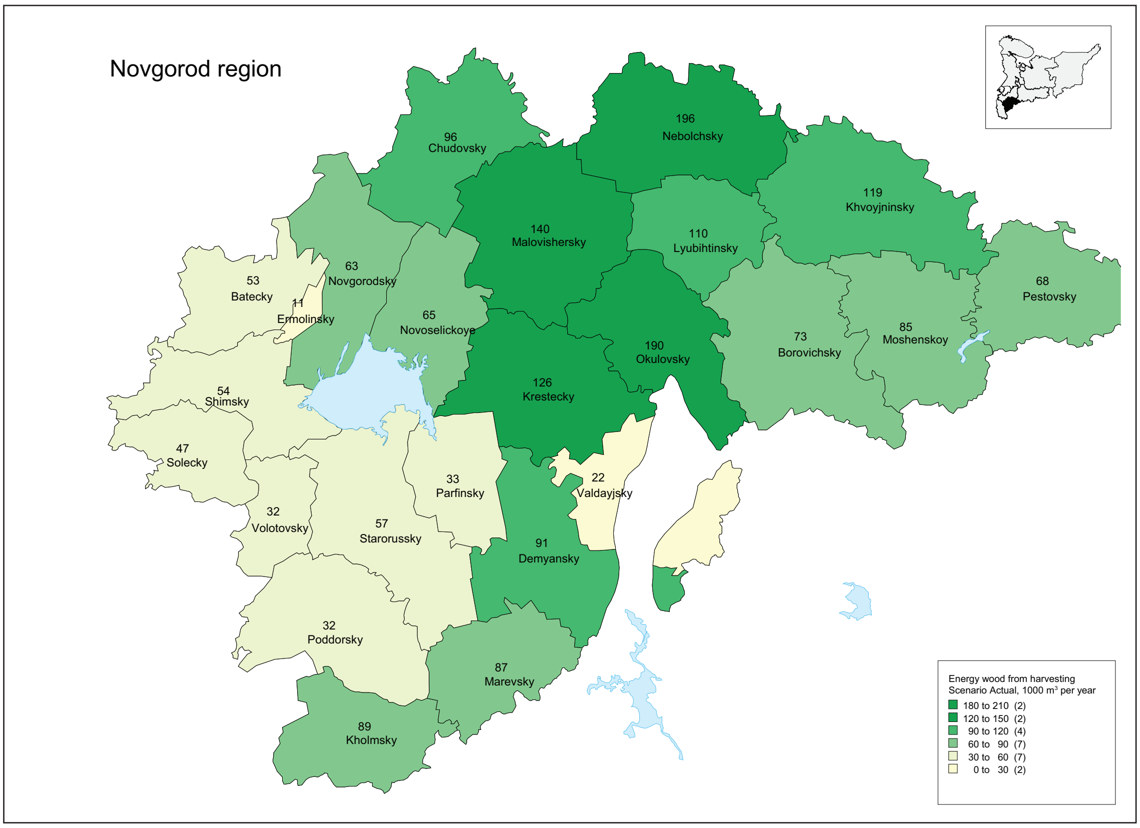

Figure 23. Potential energy wood from roundwood harvesting based on the actual 2006 harvest in each forest unit of the Novgorod region (scenario *Actual*).

The distribution of energy wood from roundwood harvesting in 2006 according to tree species group is presented in Table 33 and Figure 24. The total energy wood potential for the Novgorod region in 2006 was composed 28% (0.6 million m^3) of coniferous and 72% (1.4 million m^3) of deciduous species. The two theoretical scenarios ("Allowable" and "Potential") would change the species proportions to 20% coniferous and 80% deciduous. The species proportions vary between the Novgorod region forest units, with the deciduous species proportion dominate for all but two units, Valdayjsky (36%) and Borovichsky (48%).

Table 33. Potential energy wood in the Novgorod region from roundwood harvesting according to species group and three scenarios for the intensity of forest resource use.

Species group	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Coniferous	553	910	1369
Decidious	1414	3889	5592
Total	1967	4799	6961

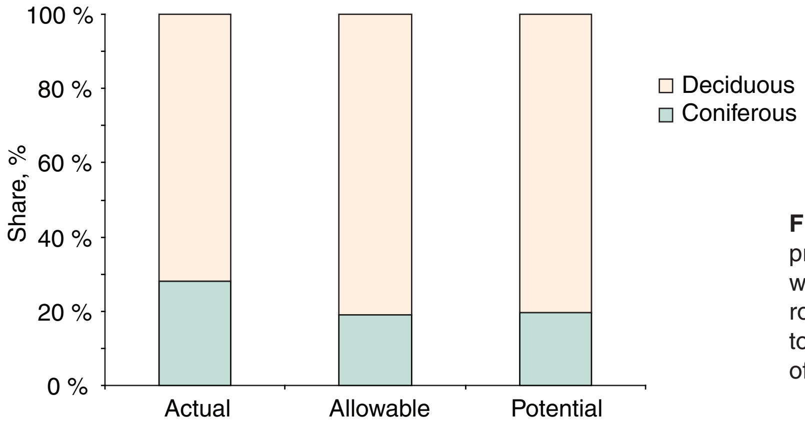

Figure 24. Tree species group proportions of the potential energy wood in the Novgorod region from roundwood harvesting according to three scenarios for the intensity of forest resource use.

In 2006 (scenario "Actual," Table 34 and Figure 25), of all the potential energy wood in the Novgorod region that would have been available at harvest sites and central processing yards 77% (1.5 million m^3) was non-industrial roundwood and 6% (0.1 million m^3) was defective wood from logging. Available just at the harvest sites was an additional 9% (0.2 million m^3) as unused branches and 8% (0.2 million m^3) as lifted stumps. In the Novgorod region, energy wood is concentrated in cutting areas due to the pre-dominate use of cut-to-length technology by logging companies. These proportions of the types of logging residues for scenario "Allowable" would be 79% non-industrial roundwood, 10% unused branches, 6% defective wood from logging, and 5% lifted stumps. For scenario "Potential" the proportions would be 84% non-industrial roundwood, 7% unused branches, 6% defective wood from logging, and 3% lifted stumps.

Table 34. Potential energy wood in the Novgorod region from roundwood harvesting according to to the type of logging residue and three scenarios for the intensity of forest resource use.

Type	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Non-industrial roundwood	1509	3791	5850
Lifted stumps	158	232	232
Unused branches	180	485	485
Defective wood from logging	119	291	394
Total	1967	4799	6961

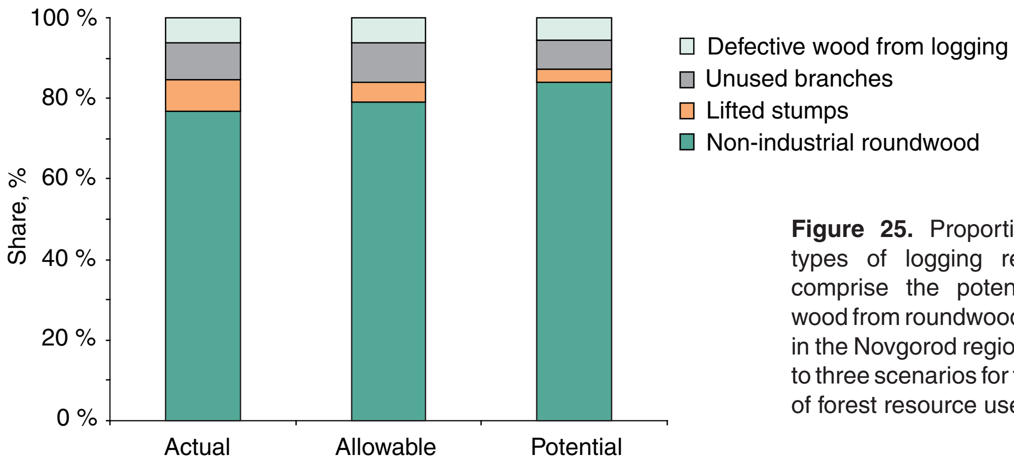

Figure 25. Proportions of the types of logging residue that comprise the potential energy wood from roundwood harvesting in the Novgorod region according to three scenarios for the intensity of forest resource use.

4.8 Pskov region

The total forest area managed by the forestry administration of the Pskov region is 2.5 million ha, with a growing stock of 342 million m^3. Forest land covers approximately 38% of the region (Kareliastat 2008).

Based on the Pskov region's total actual harvest in 2006 of 1.9 million m^3 (scenario "Actual" in Table 35), the potential for energy wood production from roundwood harvesting operations would be 0.8 million m^3/year, which is equal to 1.7 TWh. Byproducts from mechanical wood processing, based on 2006 production data, totalled 0.3 million m^3, which represents approximately 25% of the Pskov region total potential energy wood resources (1.1 million m^3) in 2006.

Two theoretical scenarios were also calculated to show the potential energy wood that could be available if certain forest management measures were implemented in the Pskov region. According to scenario "Allowable" the annual potential energy wood available from roundwood harvesting and mechanical wood processing could be as high as 3.4 million m^3, this if the entire annual allowable cut were utilised and the increased supply of industrial roundwood was processed locally. The regional total could even be nearly 4.4 million m^3 according to scenario "Potential," were in addition to full utilisation of the allowable cut and increased industrial processing, thinnings were also done according to their full technical potential. These scenarios thus show that the potential energy wood available in the Pskov region could be three and four times more than the amounts available in 2006. In practice scenario "Allowable" would mean that the annually harvested stemwood volume from the felling of mature stands would increase from the 2006 level of 1.1 million m^3 to 3.8 million m^3, which is 3.5 times more. For scenario "Potential," in addition to the increase in the fellings from mature stands, there would also be an increase in the thinnings, from the 2006 level of 0.3 million m^3 to 1.9 million m^3, which is an increase of more than six times.

Table 35. Potential energy wood in the Pskov region based on the source and intensity of forest resource use.

Source	Scenario					
	Actual[1)]		Allowable[2)]		Potential[3)]	
	1000 solid m^3	GWh	1000 solid m^3	GWh	1000 solid m^3	GWh
Roundwood harvesting	838	1.7	2830	5.7	3688	7.4
Mechanical wood processing	276	0.6	534	1.1	714	1.4
Total energy wood	1114	2.2	3364	6.7	4402	8.8

[1)] based on actual harvests (1.1 mill. m^3 of fellings from mature stands, 0.3 mill. m^3 of thinnings, and 0.5 mill. m^3 of other fellings) and mechanical wood processing (0.2 mill. m^3 of sawn wood and plywood)
[2)] same as the "Actual" scenario, but with full utilisation of the annual allowable cut (3.8 mill. m^3 of fellings from mature stands) and increased capacity for mechanical wood processing (0.4 mill. m^3 of sawn wood and plywood)
[3)] same as the "Allowable" scenario, but with full utilisation of thinnings (1.9 mill. m^3 of thinnings) and increased capacity for mechanical wood processing (0.5 mill. m^3 of sawn wood and plywood)

The estimated availability of energy wood from roundwood harvesting within the forest units of the Pskov region, according to the three scenarios for the intensity of the use of their forest resources, are presented in Table 36 and Figure 26. The availability of forest resources and their potential for utilisation do not vary much within the Pskov region. For almost all of the forests units of the region the annual allowable cut is used on average to the level of about 29%, the notable exceptions are Opochecky with a utilisation of 61% and Strugokrasnensky and Neveljsky both with utilisations of 57%. Because of this low average level of utilisation scenario "Allowable" would provide a great increase in the potential energy wood available. For the whole region, this scenario would provide an annual increase of nearly 2.0 million m^3 of energy wood over the 2006 levels. The Pskov region forest units also have good opportunities to increase the amount of energy wood available through the "Potential" scenario's increased thinning operations. This scenario would provide nearly 2.9 million m^3 more energy wood annually than the actual harvests in 2006.

Table 36. Potential annual energy wood production from roundwood harvesting for the forest units of the Pskov region according to three scenarios for the intensity of forest resource use.

Forest unit	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Bezhanicky	9	89	146
Velikoluksky	3	79	124
Velikoluksky tekh	11	25	30
Gdovsky	69	112	177
Dedovichsky	7	80	113
Krasnogorodsky	10	31	42
Kunjinsky	16	76	111
Loknyansky	11	107	158
Neveljsky	36	56	67
Novorzhevsky	8	33	44
Opochecky	30	39	51
Ostrovsky	11	24	34
Palkinsky	5	7	11
Pechorsky	8	13	18
Plyussky	40	110	171
Porkhovsky	8	28	44
Pskovsky	18	28	40
Pustoshkinsky	13	26	36
Pushkinogorsky	5	14	16
Sebezhsky	24	52	77
Strugokrasnensky	50	79	122
Usvyatsky	4	30	43
Other	442	1692	2013
Total (% increase over "Actual")	838	2830 (+238%)	3688 (+340%)

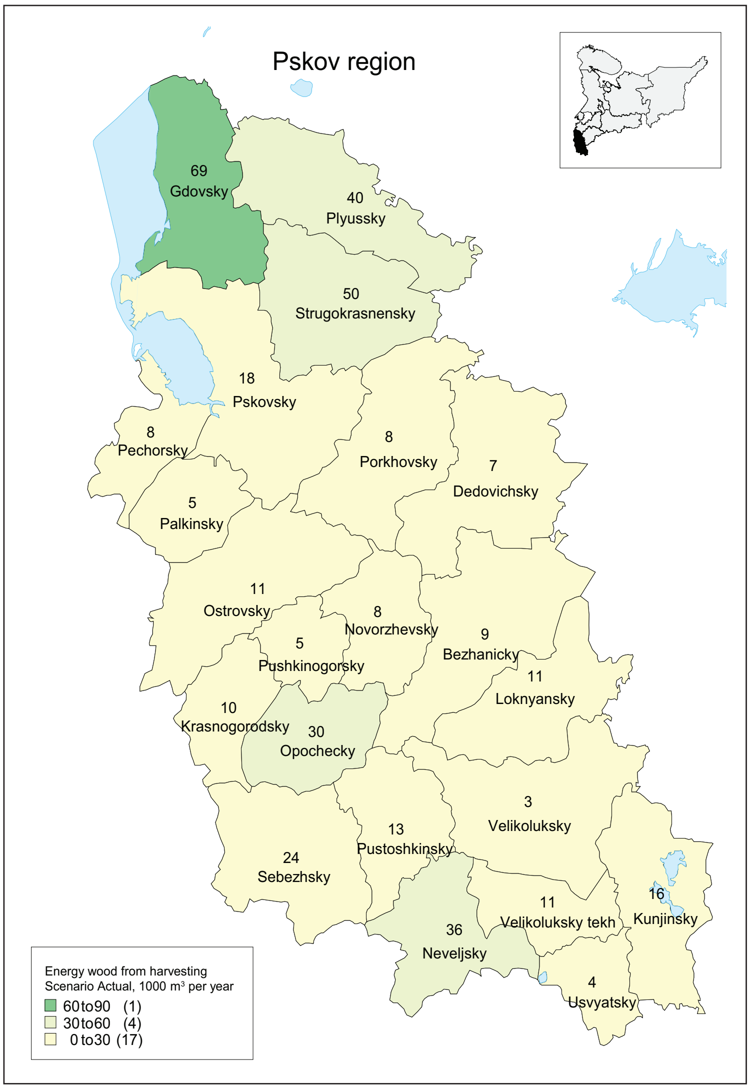

Figure 26. Potential energy wood from roundwood harvesting based on the actual 2006 harvest in each forest unit of the Pskov region (scenario *Actual*).

The distribution of energy wood from roundwood harvesting in 2006 according to tree species group is presented in Table 37 and Figure 27. The total energy wood potential for the Pskov region in 2006 was composed 35% (0.3 million m^3) of coniferous and 65% (0.5 million m^3) of deciduous species. The two theoretical scenarios ("Allowable" and "Potential") would change the species proportions to 22% coniferous and 78% deciduous. The species proportions vary between the region's forest units, with a substantial share of deciduous in some units like Dedovichsky with 92%, while the converse is true of other units like Krasnogorodsky which is 92% conifers.

Table 37. Potential energy wood in the Pskov region from roundwood harvesting according to species group and three scenarios for the intensity of forest resource use.

Species group	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Coniferous	296	598	825
Decidious	541	2232	2863
Total	838	2830	3688

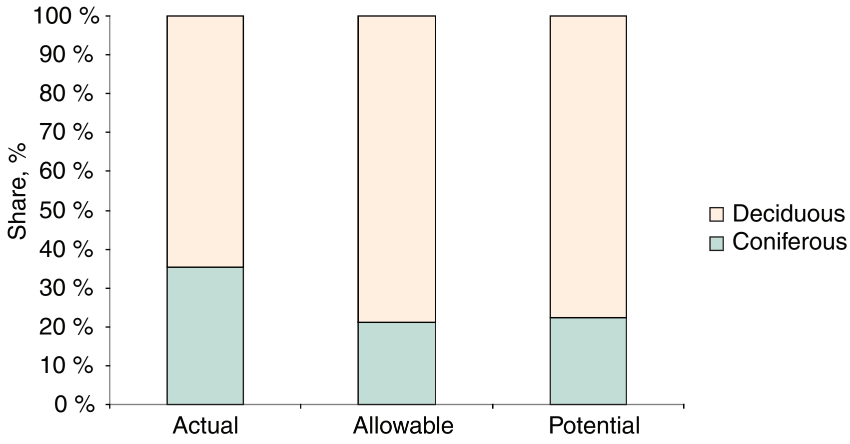

Figure 27. Tree species group proportions of the potential energy wood in the Pskov region from roundwood harvesting according to three scenarios for the intensity of forest resource use.

In the Pskov region in 2006, energy wood could have been collected both from harvest sites and central processing yards, since there is an equal share of Nordic cut-to-length and traditional tree-length and full-tree technologies used by logging companies there. Of all the potential energy wood that would have been available at harvest sites and central processing yards in 2006 (scenario "Actual," Table 38 and Figure 28): 78% (0.7 million m^3) was non-industrial roundwood, 8% (0.1 million m^3) was unused branches, and 7% (0.1 million m^3) was defective wood from logging. In the cutting areas only, an additional 7% (0.1 million m^3) was available as lifted stumps. These proportions of the types of logging residues for scenario "Allowable" would be 85% non-industrial roundwood, 8% unused branches, 4% defective wood from logging, and 3% lifted stumps. For scenario "Potential" the proportions would be 87% non-industrial roundwood, 6% unused branches, 4% defective wood from logging, and 3% lifted stumps.

Table 38. Potential energy wood in the Pskov region from roundwood harvesting according to to the type of logging residue and three scenarios for the intensity of forest resource use.

Type	Scenario (1000 solid m^3 o.b per year)		
	Actual	Allowable	Potential
Non-industrial roundwood	650	2409	3226
Lifted stumps	58	93	93
Unused branches	71	218	218
Defective wood from logging	59	110	151
Total	838	2830	3688

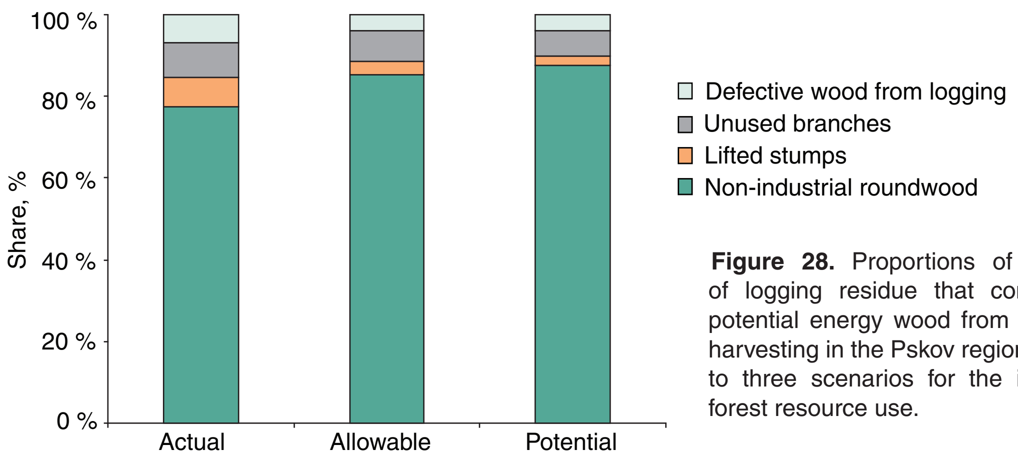

Figure 28. Proportions of the types of logging residue that comprise the potential energy wood from roundwood harvesting in the Pskov region according to three scenarios for the intensity of forest resource use.

5 Conclusions

Northwest Russia has large potential energy wood resources in the form of non-industrial roundwood, unused branches, defective wood from logging, lifted spruce stumps, and byproducts from mechanical wood processing. Based on actual harvests and saw and plywood mill production in 2006, it is estimated that it would then have been possible to collect a total of 30.9 million m^3 (61.8 TWh) of energy wood. About 70% of this total would come from roundwood harvesting and 30% from mechanical wood processing. Utilisation of this amount of wood in energy production would increase the proportion of energy wood as a component of Northwest Russia's total energy consumption (i.e. for 2006) from 1.8% to as much as 6%. For comparison, the use of solid wood fuels for energy generation in Finland in 2006 totalled 19.5 million m^3; this includes use in heating and power plants and also in small-sized dwellings (Peltola 2007).

Because the current harvest in Northwest Russia accounts for only about 40% of the allowable cut, it is possible to intensify the utilisation of the forest resources, which could include an increase in the use of wood for energy production. Full utilisation of the allowable cut in roundwood harvesting and wood processing could provide byproducts of as much as 73.5 million m^3 of energy wood (147 TWh); a supply of this amount of energy could account for 15% of the total energy consumed by Northwest Russia. If in addition to full utilisation of the allowable cut, thinnings were also done according to their full technical potential, then the byproducts available for energy wood could total 104 million m^3 (208 TWh), which could be used to account for 21% of the total energy consumed by the Northwest Russia.

There are large differences in the potentials to supply energy wood between and within the regions of the Northwest Russia. This is due to differences in the forest resources and their utilisation, as well as the availability of infrastructure and limitations on wood harvesting, like bans and other restrictions on cutting in old-growth forests. The calculated energy wood potentials are not for completely unused resources, since a portion of the non-industrial roundwood that accumulates in central processing yards and some of the byproducts from sawmills and plywood mills are presently utilised, for example as traditional firewood. Any competitive use will reduce the potential supply and/or increase the costs for the resource.

Greater utilisation of the thinning potential of the forest resources would imply more harvesting with cut-to-length technology. Although, this would mean that more material for energy purposes would become available, it would also mean that after the harvest of roundwood this material would be concentrated in the harvested areas. This would require additional costs for the collection and transport of the materials. These materials are also less suited to the traditional energy wood production technology. The combination of the post-harvest accumulation location and the unsuitability of the thinning residues to technology currently in place would put an emphasis on the development and utilisation of technology for large scale production, and the use of forest chips.

Based on experiences from Finland, it can be assumed in Northwest Russia, that any increase in the use of energy wood as a local and regional energy source would be good for the local and regional economies. Also like Finland, the increased self-sufficiency in the regional energy supply is an important factor due to the Northwest Russia extreme winter conditions. In these areas, any delays or shortages of energy supply for heating can have serious even fatal implications.

Since the energy wood sector of Northwest Russia is not well developed, its development would then allow a move to the latest technology for the supply and utilisation of energy wood. The regions of the Northwest Russia would then provide new markets for technology and know-how. The use of district heating facilities is available in cities and in most other large residential areas, in addition there are also combined heat and power (CHP) plants available; therefore the basic infrastructure already exists for large scale utilisation of energy wood. The conversion of boilers currently using oil and coal, to biomass like wood, would also reduce the regions net greenhouse gas emissions. The current policy of subsidising prices for oil, coal, and natural gas, may change, this would then make energy wood more competitive. Even if the domestic market for energy wood does not develop, there is currently still unsupplied demand nearby, in the European Union.

References

Anuchin, N. 1981. Сортиментные и товарные таблицы [Assortment and merchantability tables]. Moscow: Lesnaya Promyshlennost (Lesprom). (In Russian).

Arabkin, V. 2003. Жизнь за счет ресурсов [Life at the expense of resources]. Expert Online (Эксперт Online): Expert North-West: 19 (128). Available at: http://www.expert.ru/printissues/northwest/2003/19/19noseco2/ (In Russian).

Chemodanov, A. & Tsarev, E. 2002. Лес и лесопродукция. [The forest and forest products]. Yoshkar-Ola: Mari State Technical University (MarSTU). (In Russian).

Dykstra, D. & Heinrich, R. 1996. FAO model code of forest harvesting practice. Rome: Food and Agriculture Organization of the United Nations (FAO).

Epifanov, A. 1982. Инструкция по проектированию лесозаготовительных предприятий [Guidelines for planning of logging companies]. VCN 01-82. Moscow: Minlesbumprom. (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.

Filipchuk, A. 2003. Справочник лесничего [Forester's reference book]. Moscow: All-Russian Research Institute of Forestry and Forest Mechanization (VNIILM) 640 p. (In Russian).

Fomchenkov, V. et al. 2003. Лесной фонд России [The forest fund of Russia]. Moscow: All-Russian Research Institute of Forestry and Forest Mechanization (VNIILM). (In Russian).

Gerasimov, Y.; Karjalainen, T.; Ilavský J.; Tahvanainen, T.; & Goltsev, V. 2007. Possibilities for energy wood procurement in north-west Russia: Assessment of energy wood resources in the Leningrad region. Scandinavian Journal of Forest Research 22(6): 559-567.

Gerasimov, Y.; Siounev, V.; Chikulaev, P.; Pechorin, V.; Dyakonov, V.; Komkov, V.; Sikanen, L.; & Karjalainen, T. 2005. An analysis of logging companies in the Republic of Karelia. Working Papers of the Finnish Forest Research Institute 16. 39p. Available at: http://www.metla.fi/julkaisut/workingpapers/2005/mwp016.htm

Grigoryev, M. 2007. Повышение роли местных топливо-энергетических ресурсов в обеспечении энергетической безопасности Северо-Запада России [The increasing role of domestic fuel-energy 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. Final report. Helsinki: The Finnish Funding Agency for Technology and Inovation (Tekes). 98 p.

Karvinen, S.; Välkky, E.; Torniainen, T.; & Gerasimov, Y. 2006. Northwest Russian Forestry in a Nutshell. Working Papers of the Finnish Forest Research Institute 30. 98p. Available at: http://www.metla.fi/julkaisut/workingpapers/2006/mwp030.htm

Korobov, V. & Rushnov, N. 1991. Переработка низкокачественного древесного сырья [Processing of non-industrial wood]. Moscow: Ecologia. 288 p. (In Russian).

Kuropteev, P. & Vaskova, G. 1986. GOST 8486-86. Пиломатериалы хвойных пород. Технические условия [Coniferous sawn timber: specifications]. Moscow: Gosstandart. (In Russian).

Kareliastat. 2008. Лесопромышленный комплекс регионов Северо-Западного округа России [Forest sector of the federal regions of Northwest Russia]. Petrozavodsk: Karelian Branch of Federal State Statistics Service (Kareliastat). 201 p. (In Russian).

Laitila, J., Ala-Fossi, A., Vartiamäki, T., Ranta, T. & Asikainen, A. 2007. Kantojen noston ja metsäkuljetuksen tuottavuus. Metlan työraportteja / Working Papers of the Finnish Forest Research Institute 46. 26 s. Available at: http://www.metla.fi/julkaisut/workingpapers/2007/mwp046.htm. (In Finnish).

Matveyko, A. 2006. Технология и оборудование лесозаготовительного производства [Technology and machinery for logging]. Minsk: Technoperspektiva. 447 p. (In Russian).

Peltola, A. (editor-in-chief). 2007. Finnish Statistical Yearbook of Forestry 2006. Helsinki: Finnish Forest Research Institute (Metla). 434 p.

Pulkki, R. 2003. Minimizing negative environmental impacts of forest harvesting operations. In: Towards Sustainable Management of the Boreal Forest, Chapter 15. Adamowicz, W.L. and Burton P (editors). Ottawa: National Research Council of Canada (NRC) Research Press. pp. 581-628.

Ulyanov, I. (editor-in-chief) 2007. Регионы России. Социально-экономические показатели. [Regions of Russia. Social and economical activities]. Moscow: Federal State Statistics Service (Rosstat). 991 p. (in Russian).

Usoltsev, V.A. 2002. Фитомасса лесов Северной Евразии: нормативы и элементы географии [Forest biomass of Northern Eurasia: mensuration standards and geography]. Yekaterinburg: Ural Branch of Russian Academy of Sciences. 762 p. (In Russian).