Forest Sector Impacts from the Increased Use of Wood in Energy Production in Estonia

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Abstract

According to the directive 2009/28/EC of the European Parliament and of the Council of the European Union, it is mandatory for member countries to work out the action plans to increase the share of renewable energy sources in energy final gross consumption by 2020. Until now the forest sector impacts from the increased use of wood in energy production in Estonia has not been studied. The targets of the current paper are: 1) To assess the impact of the increased use of wood in the energy production to the demand of timber in Estonia; 2) To identify the factors which have influenced the price of fuelwood in Estonia; 3) To analyse the impact of price changes of lower quality timber on the optimal rotation period of the forest management in Estonia. To achieve the targets written down in the Estonian Energy Sector Development Plan until 2020, it is necessary to use additional 1.14 million m^3 of solid wood in the energy sector per year, which forms approximately 15% of total domestic timber consumption in Estonia. The price of the traditional fuelwood has increased significantly (300%) compared to other assortments during the last 20 years in Estonia. The correlation analysis revealed the strongest correlations between the fuelwood price in Estonia and the price changes of globally most important fossil fuels (crude oil and natural gas) as well as domestic demand for wood fuels in Estonia.The price changes of lower quality roundwood assortments (fuelwood and pulpwood) do not have significant impact on the stands net revenue maturity age.

Key words: bioenergy, wood supply, fuelwood, timber prices, rotation period

Introduction

The directive 2009/28/EC of the European Parliament and of the Council of the European Union sets the similar framework promoting renewable energy sources in member countries. In the light of the positions taken by the European Union, it is appropriate to establish mandatory national targets consistent with a 20 % share of energy from renewable sources and a 10 % share of energy from renewable sources in transport in Community energy consumption by 2020 as well as reduce the emissions of greenhouse gas by 20% compared to 1990. According to the directive it is mandatory for member countries to work out the action plans to increase the share of renewable energy sources in energy final gross consumption by 2020 (European Parliament, Council 2009).

By the year 2020 the share of renewable energy sources should form 25% of the final energy gross consumption. In 2005 the share of renewables formed 18% of the final energy gross consumption. At present Estonian power industry is mainly based on fossil fuels (in 2008 91% of electricity was produced from the oil shale and imported natural gas formed 50% in the production of the heat energy (Statistics Estonia 2010).

The combined heat and electricity generation based on biomass is the biggest potential of Estonian renewable energy. Since the cultivation of energy crops is not very common, wood is still playing the key role among renewable energy sources in Estonia. In this case, Estonia is rather similar to Nordic countries (Sweden and Finland), where the biomass used in energy sector comes mainly from the forest (Ericsson et al. 2004). In Sweden and Finland approximately 20% of energy is based on forest biomass (Björheden 2006, Hakkila 2006, Rämö et al. 2009).

Wood fuels are mostly used for heating the households in Estonia, but during the last years the remarkable development of combined heat and power stations has taken place, caused by the goals of energy policy mentioned previously.

During the last decade using wood fuels in Estonian energy sector has been increasing, ranged between 3.2 – 3.8 million cubic meters per year (Figure 1).

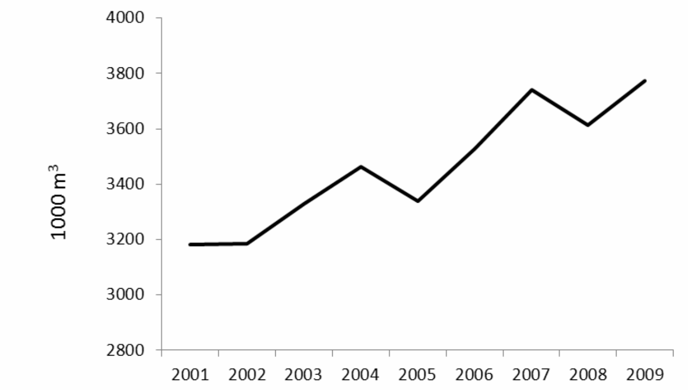

Figure 1. The consumption of wood fuel, wood chips and wastes in Estonian energy sector

The increase in consumption capacity is mainly caused by the development of combined heat and power plants (CHP) based on wood fuels (Fig. 2, Fig. 3).

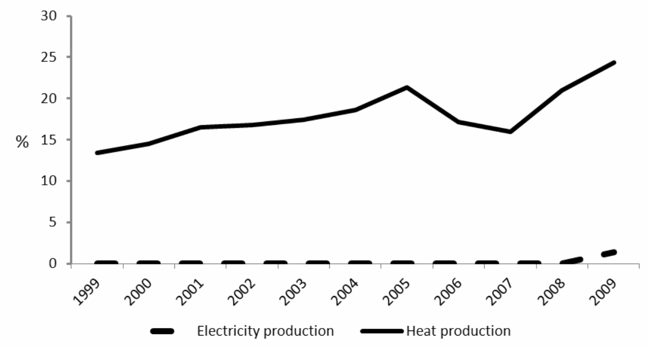

Figure 2. The share of wood fuels in the production of electricity and heat in Estonia

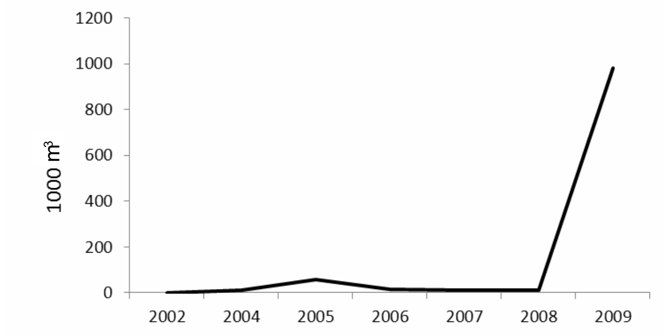

Figure 3. Consumption dynamics of wood chips in combined heat and power plants in Estonia

On the one hand, the situation taking place in Estonia is favourable to forest owners, because the demand for lower quality timber is increasing. However, there is a new competitor on the market for the traditional forest industry companies, using the same raw material. The forest industry has referred to the possible shortage of raw material and to distorted competition between energy and traditional forest industry companies in Estonia. That is because of the subsidies of renewable energy, applied for the energy producers (there is a subsidy of 0.05 EUR/kWh for electricity produced from the renewable energy sources in Estonia) (Elektrituruseadus 2003). So the energy producers have a possibility to pay the higher price for the raw material.

References can be found about similar processes in other countries. UNECE/FAO annual timber market review refers to intensifying competition between the energy and traditional forest industry (paper, pulp and board industries) sector, which are using the same raw material, caused by the subsidies for renewable energy as well as the increasing prices of wood in Europe and North-America (UNECE/FAO 2010).

Until now the potential availability of the resource of wood based fuels has been the main research target in Estonia (Padari, et al. 2009, Kaimre and Vahter 2009), whilst forest sector impacts from the increased use of wood in energy production in Estonia has not been studied yet.

One of the key issues of maximizing the profitability of forest management is the choice of optimal rotation period. The current study is focused on the impact of the price changes of the fuel wood on the estimated net revenue maturity age. While the economy over the rotation period depends on the income, costs and timing of thinnings and final felling (Heikkilä et al. 2007), the impact of the price changes of different roundwood assortments on the net revenue maturity age was tested using different scenarios. The hypothesis that increase in price of fuelwood could shorten the optimal rotation period of forest management was tested. That is because the small-diameter wood, which is used in energy sector can be fell a lot earlier than logs and veneer logs.

The targets of the study are:

1) To assess the impact of the increased use of wood in the energy production to the demand of timber in Estonia;

2) To identify the factors which have influenced the price of fuelwood;

3) To analyse the impact of price changes of lower quality timber on the optimal rotation period in forest management.

Material and methods

In order to achieve the targets of current study three different methods were used:

The impact of the increased use of wood in the energy production to the demand of timber in Estonia

The assessment of the impact of the energy policy targets on the demand of timber is based on:

i) The goals set in Estonian Energy Sector Development Plan until 2020. For the year 2010 5.1% of electricity should be produced from the renewable sources (15% in 2015), also 20% from the gross electricity consumption should be produced in combined heat and power stations (CHP). In addition to that, reducing the emission of CO_2 derived from the energy sector by 50% by 2020 (7.85 million tons) compared to 2007 (15.7 million tons) and reducing the importance of the oil shale based electricity production (Majandus- ja Kommunikatsiooniministeerium 2009).

ii) The statistics about the consumption of wood based fuels in the Estonian energy sector, published by the Estonian Statistical Office.

The basis of the analysis is the consumption of the wood fuels in the Estonian energy sector in 2009, and it was assumed that the renewable energy targets in Estonian Energy Sector Development Plan until 2020 (20% from the gross electricity consumption should be produced in combined heat and power stations) will be achieved by using wood as a source of energy. In calculations the same amount of calorific value of wood was used as implemented by the Estonian Statistical Office (the average calorific value of wood: 1m^3 = 7.5 GJ). The average electricity production efficiency of combined heat and power stations (CHP) was considered as 30%.

Factors influencing the price of fuelwood in Estonia

The time series data of eleven years (1999 – 2009) was constructed to identify the main factors which have had an impact on the price of fuelwood in Estonia, which consisted of data about the demand and supply of the wood fuels and the cost of living (inflation) in Estonia as well as the world market prices of alternative fossil fuels.

The Pearson correlation coefficients in the Statistical Analysis System (SAS) were used to identify the potential factors which may have had an impact on the price of the fuelwood in Estonia.

Ten factors were considered to have an impact on the price of the fuelwood in Estonia and these can be grouped:

The demand for wood based fuels:

1. The domestic consumption of the wood fuels in Estonia (m^3);

2. The consumption of the wood fuels in power plants for energy generation (m^3);

3. The final consumption of the wood fuels in households (m^3).

The supply of the wood fuels:

1. Annual felling volume in Estonia (m^3);

2. Import of roundwood (m^3);

3. Import of fuelwood, saw dust and wood wastes (t).

The cost of living:

1. The consumer price index change over the previous year.

The world market prices of the alternative fossil fuels:

1. The world market price of crude oil (Brent) (USD/bbl);

2. The world market price of natural gas (USD/MMBTU).

The production costs:

1. The average felling costs in the Estonian State Forest Management Centre (EEK/m^3).

The impact of price changes of lower quality timber on the optimal rotation period

The net revenue maturity age of stand is the felling age which maximises the long term annual net revenue per hectare over the rotation period. The calculations were made taking into account economically the most important tree species: Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*), birch (*Betula* sp.) and aspen (*Populus tremula*) and all the site classes, assuming the stands to be pure stands.

The theoretical long term average annual production of assortments by forest site types and quality classes were calculated, using the methodology which has been used previously by Padari et al. (2003, 2009). The growth models of stands were used to simulate the growth process (Kiviste 1995, 2009).

The net revenue maturity age of stands was calculated according to the three different scenarios of the roundwood prices:

1. "The basic scenario": the average roundwood roadside prices in the Estonian State Forest Management Centre during the period 1999-2011;

Table 1. The roundwood roadside prices used in the calculations (EUR/m^3)

	1. Base scenario	2. „Increasing fuelwood price"	3. „Decreasing pulpwood prices"
Pine logs	49.8	49.8	49.8
Pine logs d<18cm	45.1	45.1	45.1
Spruce logs	50.3	50.3	50.3
Spruce logs d<18cm	44.2	44.2	44.2
Birch logs	46.6	46.6	46.6
Aspen logs	26.5	26.5	26.5
Pine pulpwood	24.5	24.5	16.6
Spruce pulpwood	26.2	26.2	16.9
Birch pulpwood	25.3	25.3	16.3
Aspen pulpwood	12.4	12.4	8.7
Fuelwood	12.6	25.5	12.6

2. "The scenario of the increasing fuelwood price": It was assumed that due to increased demand for wood fuel the price of fuelwood is increasing (the highest ever fuelwood price in Estonia was used in this scenario).

3. „The scenario of decreasing pulpwood prices": The decreasing pulpwood prices (the lowest pulpwood prices were used in this scenario) were assumed. If the prices of pulpwood were lower than the price of fuelwood, the prices of fuelwood were used for calculations.

Average unit prices of activities in State Forest Management Centre in the period 1999-2009 (Table 2) and cultivation costs by different species were used (Table 3).

Activity	Unit	Cost
Soil scarification	EUR/ha	64.9
Tending of plantations	EUR/ha	55.6
Tending of young stands	EUR/ha	99.8

Table 2. Average unit costs of management activities in State Forest Management Centre

Species	Unit	Cost
Scots pine (*Pinus sylvestris*)	EUR/ha	421.8
Norway spruce (*Picea abies*)	EUR/ha	402.6
Birch (*Betula* sp.)	EUR/ha	325.9

Table 3. Cultivation costs by different species

In felling costs calculations, the following formulas were used:

a. The cost of thinning:

$$HR = (9.20 + 0.1278/(v + 0.01))*1.25 \quad (1)$$

b. The cost of clear felling:

$$LR = 9.20 + 0.1278/(v + 0.01), \quad (2)$$

where v – average stem volume (m^3).

Results

The impact of the increased use of wood in the energy production on demand for timber

In 2009 10.1% (807 GWh) of electricity was generated from combined heat and power stations (Statistics Estonia 2010). In order to increase the share of electricity produced in combined heat and power stations up to 20% by 2020 it is necessary to increase the electricity production from combined heat and power stations two times, up to 1,600 GWh (assuming the electricity consumption to remain at the same level as in 2009). A new combined heat and power station (using domestic wastes) is being built in Estonia with the electricity production capacity of 125 GWh, therefore it is necessary to produce additional 665 GWh of electricity in the existing combined heat and power stations. Assuming the solid wood to be the resource, it is necessary to use additional 1.14 million cubic meters of wood in the energy sector, which forms approximately 16% of Estonian felling volume and approximately 15% of total domestic timber consumption in 2009.

The factors influencing the price of fuelwood in Estonia

Among the roundwood assortments sold by the Estonian State Forest Management Centre the price of the traditional fuelwood has increased significantly (300%) compared to other assortments during the last 20 years (Figure 4). The price of fuelwood was 95 EEK/m^3 in 1999 and 290 EEK/m^3 in 2011.

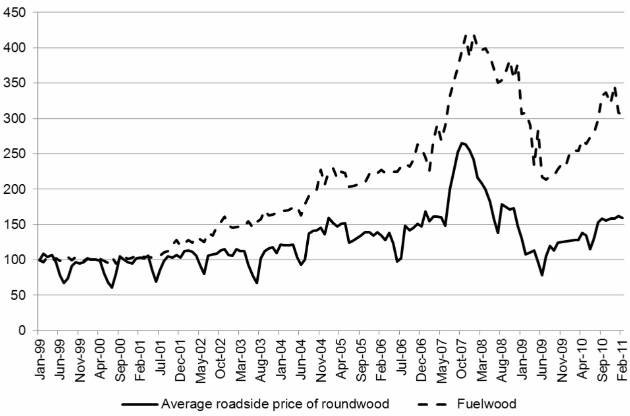

Figure 4. The relative price change in average roadside prices of roundwood sold by Estonian State Forest Management Centre (January 1999=100).

A similar situation is also in Lithuania, where the average price of the fuelwood was 270% higher in 2009, compared to 1999. At the same time the domestic consumption of the fuelwood increased by 30% (3 million m^3 in 1999 and 3.9 million m^3 in 2009) (Ministry of Environment and State Forest Survey Service 2010).

The correlation analysis revealed the strongest correlations between the fuelwood price in Estonia and the price changes of globally most important fossil fuels (crude oil and natural gas) as well as domestic demand for wood fuels in Estonia.

There is a very strong correlation between the Estonian fuelwood price and the world market price of crude oil (r=0.98, p-value <.0001), the average felling cost in Estonia (r=0.94, p-value 0.0002) as well as the world market price of natural gas (r=0.74, p-value 0.009) (Table 4).

There is also a strong correlation between the Estonian fuelwood price and the domestic consumption of wood fuels (r=0.86, p-value 0.0007). In addition to that, a strong correlation was found between the Estonian fuelwood price and the import of the fuelwood, the wood chips and wood wastes (r=0.78,

Table 4. The Pearson correlation coefficients

		The price of the fuelwood (EUR/m^3)
The domestic consumption of wood fuels (m^3)	r	0.86079
	p-value	0.0007
The consumption of the wood fuels in power plants for energy generation (m^3)	r	0.19799
	p-value	0.5595
Final consumption in households (1000 m^3)	r	0.63051
	p-value	0.0375
Annual felling volume (m^3)	r	-0.11750
	p-value	0.7308
Import of roundwood (m^3)	r	0.26909
	p-value	0.4236
Import of fuel wood, saw dust and wood wastes (t)	r	0.78086
	p-value	0.0046
The relative change of consumer price index %	r	0.53131
	p-value	0.0926
The world market price of crude oil (Brent) (US D/bbl)	r	0.97914
	p-value	<.0001
The world market price of natural gas (USD/MMBTU)	r	0.74207
	p-value	0.0089
The average felling costs (EEK/m^3)	r	0.93981
	p-value	0.0002

p-value 0.0046), which can indicate that the demand for wood based fuels during the period 1999 - 2009 has exceeded the domestic supply of wood fuels and felling volume has not covered the consumption of the energy sector in Estonia.

The impact of price changes of lower quality timber on the optimal rotation period

In Tables 5 – 8 minimum maturity ages according to the Forest Act (Metsaseadus 2006) and net revenue maturity ages of different tree species by site classes according to different roundwood price scenarios are presented.

The price changes of lower quality roundwood assortments (fuelwood and pulpwood) do not have significant impact on the net revenue maturity ages of stands. The calculations revealed that the change in the fuelwood price does not have an impact on the calculated maturity age in conifer stands, in decidious stands the increase of the fuelwood price rises the calculated maturity age to some extent in better site classes.

The fuelwood price (102% higher than in basic scenario) used for calculations in "Increasing fuelwood price" scenario changed the calculated net revenue maturity age of Scots pine 0-3%, Norway spruce 0-7%, birch 4-16% and aspen 2-22%, compared to basic scenario.

The calculated net revenue maturity age in decidious stands exceeded the maturity age set in the Forest Act (Table 7, Table 8). In case of the coniferous stands, the maturity age of Scots pine set in Forest Act exceeded the calculated net revenue maturity up to 61% (Table 5). Both maturity ages – set in the Forest Act and calculated according to the basic scenario matched only in less fertile site class (V site class), whilst 14.1% of stands with dominance of Scots pine belong to the V site class in Estonia (Keskkonnaministeerium 2010). In case of the Norway spruce, the maturity age set in the Forest Act exceeded the calcu-

Table 5. The maturity ages of Scots pine (*Pinus sylvestris*)

	Site class					
	IA	I	II	III	IV	V
Forest Act	90	90	90	100	110	120
1. Basic scenario	56	65	75	86	99	120
2. „Increasing fuelwood price“	56	65	74	86	99	124
3. „Decreasing pulpwood prices“	59	67	76	90	101	123

Table 6. The maturity ages of Norway spruce (*Picea abies*)

	Site class					
	IA	I	II	III	IV	V
Forest Act	80	80	80	90	90	90
1. Basic scenario	54	60	69	76	88	108
2. „Increasing fuelwood price“	55	60	70	78	94	115
3. „Decreasing pulpwood prices“	56	60	70	75	92	111

Table 7. The maturity ages of birch (*Betula* sp.)

	Site class					
	IA	I	II	III	IV	V
Forest Act	60	60	70	70	70	70
1. Basic scenario	55	57	64	73	85	118
2. „Increasing fuelwood price“	57	61	70	79	99	132
3. „Decreasing pulpwood prices“	59	66	70	79	99	158

Table 8. The maturity ages of aspen (*Populus tremula*)

	Site class					
	IA	I	II	III	IV	V
Forest Act	30	40	40	50	50	–
1. Basic scenario	46	51	55	66	91	146
2. „Increasing fuelwood price“	54	59	67	79	93	116
3. „Decreasing pulpwood prices“	46	51	55	66	91	146

lated net revenue maturity age in better site classes up to 48%. The maturity ages in force and calculated net revenue maturity ages matched only in IV and V site classes, while only 2% of stands with spruce dominance belong to these quality classes (Keskkonnaministeerium 2010).

Discussion and conclusions

The study confirmed the statement that the development of combined heat and power stations, which increases the demand for lower quality timber is also favourable for forest owners in Estonia, as the growing demand increases the prices of lower quality timber (fuelwood) as well. For example, the price of fuelwood has increased 300% during the last 20 years. On the other hand, there is a new competitor on the market for the traditional forest industry companies (board, pulp, paper and pellet producers) using the same raw material. Forest industry has predicted the possible shortage of raw material and referred to distorted competition between the energy and traditional forest industry companies in Estonia, caused by the subsidies for renewable energy, applied for the energy producers. This enables the energy producers to pay a higher price for a raw material. At the moment, there is a subsidy of 0.05 EUR/kWh for the electricity produced from the renewable sources and in combined heat and power stations in Estonia, which means that energy producers have a possibility to pay for the wood in its final terminal up to 33.6 EUR/m^3 (if this subsidy calculated into the amount of money which could be paid for the raw material).

Similar results can also be found in other European countries, for example in Norway (Bolkesjø et al. 2006, Trømborg and Solberg 2010). The increasing importance of wood in the energy production has generally a positive effect on the forestry (for forest owners and saw industries), due to the increasing demand for lower quality timber and saw industries wastes. At the same time it has a negative impact on the board, pulp and paper industries, which are using the same raw material.

Assessing the possible impact of the development of bioenergy on the forest industry and on the forest sector generally in Norway Bolkesjø et al. (2006) have found that increasing consumption of wood fuels in Norway will not only lead to increased felling and import capacities of wood, but also to increase in wood prices. The same tendency can also be seen in Estonia.

Assessing the impact of increased consumption of wood in the energy sector on the forest sector in Austria, Schwarzbauer and Stern (2010) have found that competition for lower quality timber and saw industry wastes will increase, which also brings along the rise in prices, which again is positive for forest owners and saw industries and not so favourable for board and pulp industries.

According to the correlation analysis the strongest correlations were found between the fuelwood price in Estonia and the world market price of alternative fossil fuels and also the total domestic consumption of wood in Estonia. The main reason of increasing consumption is the construction of combined heat and power stations in Estonia.

In order to achieve the goal, set up in the Estonian Energy Sector Development Plan until 2020 – to increase the share of electricity generated in combined heat and power stations up to 20% by 2020, it is necessary to use additional 1.14 million m^3 of wood in the energy sector per year.

Although the felling volume has been quite unstable during the last decade, it is necessary to take more Estonian own timber resources into use to fulfil the domestic demand for timber in Estonia. The other possibility is to fulfil the increasing demand raising import capacities. While the remarkable increase in demand for timber is caused by the energy sector, it is reasonable to use economically less valuable deciduous stands which have been underutilized. For example, in the Estonian Forestry Development Plan until 2010 the optimal annual felling volume of grey alder (*Alnus incana*) is 2 million m^3, but the realized average annual felling volume has been approximately 430,000 m^3 (Keskkonnaministeerium, 2010). The similar situation is with aspen (*Populus tremula*). According to the Estonian Forestry Development Plan until 2010 the felling volume of aspen could be approximately 1.8 million m^3 per year, in reality the average felling volume has been only 680,000 m^3 per year (Keskkonnaministeerium, 2010).

Comparing the calculated net revenue maturity ages at the different price scenarios, the price changes of the fuelwood and pulpwood assortments do not have a remarkable influence on the optimal rotation period. It can be explained by the fact that on one hand the share of the fuelwood assortment is probably too marginal in the total hectare volume. On the other hand, however, the price difference between the fuelwood and larger roundwood assortments is rather remarkable. Therefore, the price changes in small-sized roundwood do not have a remarkable influence on the rotation period.

All things considered, it can be stated that the development of the domestic energy sector does not remarkably changed the forest management models in Estonia so far, but it could change due to the demand for lower quality timber in other countries. If the price of the fuelwood is significantly higher in neighbouring countries, the export of the fuelwood can be more active.

Acknowledgements

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ВЛИЯНИЕ ВОЗРОСШЕГО ИСПОЛЬЗОВАНИЯ ЭНЕРГЕТИЧЕСКОЙ ДРЕВЕСИНЫ НА ЛЕСНОЙ СЕКТОР В ЭСТОНИИ

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Резюме

В соответствии с директивой 2009/28/ЕС Европейского Парламента и Совета Европейского союза, для стран-членов обязательным является разработка плана действий по увеличению доли возобновляемых источников энергии в валовом потреблении к 2020 году.

В Эстонии до сих пор не изучено влияние увеличивающегося использования древесины в целях производства энергии на лесной сектор.

Целями данной работы являются:

1. оценка влияния увеличения использования древесины в производстве энергии на спрос древесины в Эстонии;
2. определение факторов, влияющих на цену топливной древесины в Эстонии;
3. анализ влияния изменения цены низкокачественной древесины на оптимальный период оборота рубок в Эстонии.

Для достижения цели, поставленной в плане развития энергетического сектора, к 2020 году необходимо увеличить долю производства тепла и энергии до 20%. Для этого необходимо дополнительно использовать 1.14 млн. м^3 древесины в год, что составляет примерно 15% от общего внутреннего потребления древесины в Эстонии. Предполагаемый спрос сектора лесной промышленности останется на уровне 2009 года. Ежегодный спрос на внутреннем рынке вырастет на 15%.

За последние 20 лет цена на топливную древесину выросла на 300%. В ходе корреляционного анализа была выявлена значительная связь между ценой топливной древесины на эстонском рынке и изменением глобальных цен на ископаемое топливо (сырая нефть и природный газ), а также спросом на древесное топливо в Эстонии.

Колебание цен низкокачественного кругляка (топливная и балансовая древесина) не оказывает существенного влияния на оптимальный период оборота рубок в Эстонии.

Ключевые слова: биоэнергетика, древесина, топливная древесина, цены на древесину, период оборота рубки