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THE ANALYSIS OF WOOD FUEL EXPORT THROUGH ESTONIAN PORTS AND AN ASSESSMENT OF ITS EFFECTIVENESS

Magistritöö

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ABSTRACT

The demand for biomass in European market is increasing, due to the use of fossil fuels counts for numerous environmental problems. A new European energy policy has established the strategy of EU’s 20-20-20 for renewable energy sources and greenhouse gas emissions reduction. In spite of other renewable energy source, like wind and hydro, wood fuel is significantly contributing to the generation heat and electricity. The fact that some European countries do not have sufficient resources for sudden demand thus it all depends on imports from other countries. For Estonia there is huge potential for expansion the production of wood fuel for further exports, due to low domestic consumption.

The Renewable Energy Directive 2009/28/EC ("the Directive") established a European framework for the promotion of renewable energy, setting mandatory national renewable energy targets for achieving a 20% share of renewable energy in the final energy consumption and a 10% share of energy from renewable sources in transport by 2020.

The thesis analyzes the profitability exports of wood fuel through Estonian ports and an assessment of its effectiveness. Germany market as one of the main wood fuel consumer was taken into consideration, to see topicality and suitability of wood fuel export to EU countries with opportunities to increasing value-added services for Estonian ports.

Firstly, the main production centers of wood fuel are analyzed and their most efficient routes to Estonian ports. Secondly, three main harbours were overvied, where the wood fuel export is going, their terminals, facilities, capabilities for cargo handling and costs. Thirdly, were presented charter conditions and type of vessels for estimating shipping suitability. Fourth, calculated transportation costs by sea to find out opportunities to export wood fuel for more profit. Fifth, the hinterland connection was analyzed as well to determine the final price for end-users. An assessment included financial aspect, such as profit margins, return of investments and NPV with 7% interest rate per annum for estimating capabilities of export. At the same time

provided risks as factors affecting competition for wood fuel production, transportation and trading.

Generally, the trading of wood pellets under appropriate circumstances is economically profitable, but the export of wood chips is not suitable for delivery in small amounts to end-users. The analysis emphasized that much profit could be gained by transportating wood pellets from Paldiski South Harbour to the port of Hamburg on CIF terms and to end-users in Berlin, Germany on DAP terms.

The comparative efficiency of country's trade logistics chain using benchmarking method is important in enhancing competitiveness of its industry and commerce. In this regard, international differences in trade logistics efficiency determine in large extent the efficiency and sustainability of the economies, thus was analyzed Latvian market and wood fuel export costs through Latvian ports.

With an increase in wood fuel export through Estonian ports, this will have great potential in the extention of the port structure, warehouses development and increasing cargo handling effectiveness to encourage competitiveness. Also given the opportunity for additional investments flow from stakeholders, due to master thesis has practical essence.

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LIST OF ACRONYMS

EN – European Standards

Btu – British thermal unit = approximately 0,3 W/h

CEN – European Committee for Standardization

°C – Celsius

CHP - Combined Heat and Power

CO2 - Carbon dioxide

CIF – Cost Insurance Freight

DAP – Delivery At Place

EU-28 - 28 European Union member states

EPC – European Pellet Council

FOB Free on Board

GJ – Gigajoule

GHG – Greenhouse gas

h – hour

ha – hectare (1 ha = 10 000 square meters)

HFO – heavy fuel oil

IFO - intermediate fuel oil

Kg – kilogram

Kn – know (1,852 km/h)

kWh – Kilowtt hour (3,6 megajoules)

m – meter

m^3 – cubic meter

MDO – Marine gasoil

MWh – Megawatt hour

Mtoe - million tonnes of oil equivalent (11630Gw or 1toe = 11,63 MWh)

Nm – nautical mile (1 Nm = 1,852 km)

NPV – Net Present value

NT – Net tonnage

PJ - Petajoule (=1015 Joule, = 277778 million kWh)

ROC - Renewable Obligations Certificates

ROI – Return of Investments

t – tonne

VAT – value added tax

INTRODUCTION

An export of goods from Estonia is an essential part for the development and sale of goods, increase the number of customers, and of course grow the country's economy. Exporting firms will increase their profits and will be more competitive with respect to other countries. The essence of this thesis will allow traders to see the real opportunities of buying Estonian wood fuel and profitability of this product. In 2014, development of the world's wood fuel is growing rapidly and the peak of consumption would be reached within a few years. Consequently, this study will carry the practical character. Likewise it would be a good impetus of wood fuel export through Estonian ports. Moreover, exports through Estonian ports give value-adding capabilities and the future perspectives of development.

The qualitative and statistics research methods used in the master thesis. Additionally, included benchmarking for presenting more precise data related the export of wood fuel. Object of study is wood pellets and wood chips, accordingly to European commission they are one of the renewable energies. Under the qualitative research method author has interviewed with enterprises, where the main business is wood fuel production, trading and handling. The feedback from interview was recieved by following persons:

- Siim Liblik –Storan Enso Supply Chain manager;
- Melanie Zenker – Manager, C.A.R.M.E.N e.V Energy-Department;
- Dmitri Nikitin – Sales manager, Mariter Ltd;
- Urmas Urgard – Operational manager, ESTEVE Terminal AS;
- Aleksander Nikolajev – Port Kunda director;
- Anton Sudorenko – agent, PakriChart Ltd.

Statistics data was provided by Aime Luik - Senior consultant at Estonia Statistics and Melanie Zenker, Manager at C.A.R.M.E.N e.V. As concern benchmarking, then it relatively important method and usually used by organizations to compare their performance and processes.

This method can focus on performance, in which case one identifies the most important indicators of success and then compares one's own performance with that of others.

The main purpose of the master thesis is to find out under which scenario the profit of wood fuel export from Estonia can be maximized, based on German market.
The second purpose is to analyze the transport and harbours settings according to the most beneficial to the greatest profit of each transport and choosing the efficient port for exporting wood fuel. The third purpose is to find out whether the export of wood pellets besides other fiber based fuels is profitable and will determine what the profit will be. Furthermore, port of Liepaja and port of Riga in Latvia will be benchmarked to assess the competitiveness. Additionally, some aspects for example CO_2 mitigation and energy consumption during transportation will be disregarded.

There would be analyzed four scenarios for evaluating the research questions.

1. Preference of the sourcing of wood fuel;
2. Preference of terminals, ports, shipping;
3. Preference of the vessels specifications;
4. Overview the forms of charter party, which is suitable for shipping cargo.

Hypothesis: „*Wood fuel demand will be increased in Europe, especially in Germany and supply is cost-effective, so it will give an opportunity to enhance the value-added services of Estonian ports through wood fuel export*."

The model of analysis is following:

At the first step, an overview of wood fuel demand Europe through means of statistics. Additionally, the present wood resources and wood prices will be segmented by the different regions of Estonia.

At the second step, the freight expenses will be calculated based on the different cost factors affecting the shipping companies. And such expenses like charter rate, bunker charges, port dues and cargo handling costs.

At the third step, profits will be calculated according to current European selling prices of wood fuel. Therefore using the essential financial formula:

$$\text{Profit} = \text{Revenue} - \text{Costs} \tag{1}$$

The author will subtract by the sum of observed purchasing prices of wood fuel in Estonia and its transport costs to the point of consumption.

At the fourth step, will be calculated ROI, which could be earned on an investment in the trading of wood fuel.

$$\text{Return on Investments} = \frac{V_f - V_i}{V_i} \times 100\% \qquad (2)$$

Where,

V_f – gross profit;

V_i – expenses.

Besides the NPV calculation that will determine cash flow, considering the present value of money today, to the present value of money in the future and also includes returns. Basically NPV could present the cash receipts from the sale of wood fuel, which was purchased from Estonia.

$$\text{NPV} = -C_o + \frac{C_1}{(1+i)^{\frac{T}{365}}} \qquad (3)$$

where,

C_0 – initial investments or initial cash flow;

C_1 – selling price or cash flow;

T – delivery time;

i – the discount rate / interest rate.

The fifth step involves taking into consideration how risk factors affect competition related to production, transportation and market prices would be presented. It gives additional opportunity for reducing negative impact before exporting.

And finally, value-adding capabilities for harbours will be given to enchance competitiveness comparing with other neighboring port.

1. OVERVIEW OF WOOD FUEL DEMAND IN EUROPE

Biomass is already the most important renewable energy source in Europe. It has huge potential for further expansion.[1] Thereby biomass could fulfil the EU's energy targets for 2020. The strategy of EU's 20-20-20 targets were set by EU leaders in March 2007 and it has three key objectives for 2020:

1. A 20% reduction of EU GHG (*greenhouse gas*) emissions from energy compared with 1990 year;
2. Raising the share of EU energy consumption produced from renewable resources to 20%;
3. A 20% improvement in the EU's energy efficiency.[2]

Biomass could make a significant contribution in reducing greenhouse gas emissions in Europe and is unique in its potential to service all three of the major energy demand sectors for heat, electricity and transport fuel.[3] An estimated 12.6 million tonnes of CO2 emissions were avoided in 2008 in EU-27 countries plus Norway and Switzerland, based on a consumption of 8.2 million tonnes of wood pellets and the substitution of coal and heating oil.[4]

Accordingly to the data regarding energy consumption of renewable energy in 2011, biomass applies 68,0% (Wood and wood waste - 47,8%, other biomass and waste – 20,2%) in Europe, see *Figure 1*. And the goal of using renewable energy in dedicated or co-fired power station will be reached to 15,4% by 2015 and to 20% by 2020[5].

[1] Wood fuels handbook, 2013, p.5
[2] The 2020 climate and energy package. EU RES Directive 2009/28/EC
[3] Thornley, P., Cooper, D. – The effectiveness of policy instruments in promoting bioenergy, 2008, p.200
[4] Sikkema, R. - Modelling and Analysis: Wood pellet markets, 2010 p.251
[5] Biomass Energy Center, 2011

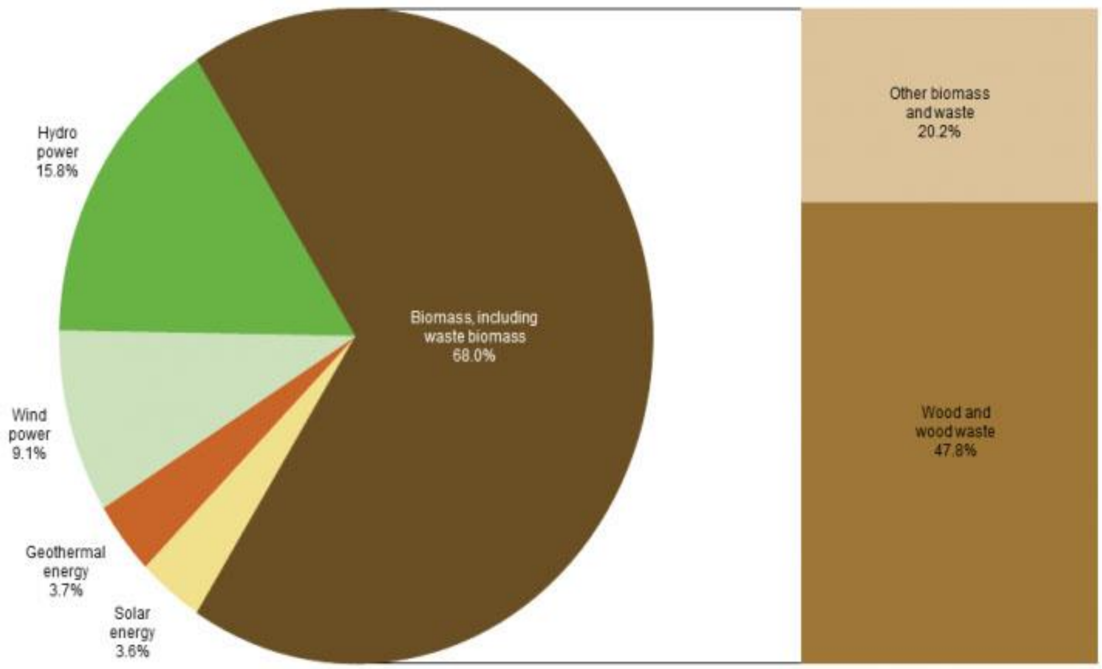

Figure 1. Consumption of renewable energy, EU-28. Source: Eurostat, 28 October 2013.

Between 2011 and 2012 all EU member states have increase their biomass based primary energy production – 82,3 million tonnes of oil equivalent (Mtoe) were produced againsts 78,1 Mtoe in 2011.[6] Beetween 2002 and 2012 ,the quantity of renewable energy produced within the EU-28 increase overall by 81,3%, it is equivalent to an average increase of 6,1% per year. The largest producer of renewable energy in 2012 was Germany, with an 18,6% share of the total.[7] A lot of cities are moving from their fossil-fired power station in Germany and invest in wood fuel boilers. Additionally, energy producers could get a fee for such investments in renewable energy technologies, according to the German Renewable Energy Act. So countries, not even Germany have a strong interest in importing wood fuel for heating and power production.

Furthermore, if we compare competitiveness of others energy carriers with wood fuel prices, and then we could see low volatility of wood fuel prices. *Figure 2* is showing the price development of pellets (premium quality – not industrial pellets), wood chips with water content

[6] The state of renewable energies in Europe, edition 2013 , 13th EurObserv'ER Report, p 132
[7] Eurostat – Renewable energy statistics

35 %), natural gas and fuel oil (consumer prices for little amounts) in Euro per MWh from 2003 to 2014. The pellet and wood chip prices are surveyed by C.A.R.M.E.N. e.V., gas and oil prices were calculated from price indices published by the Federal Statistical office in Germany.[8]

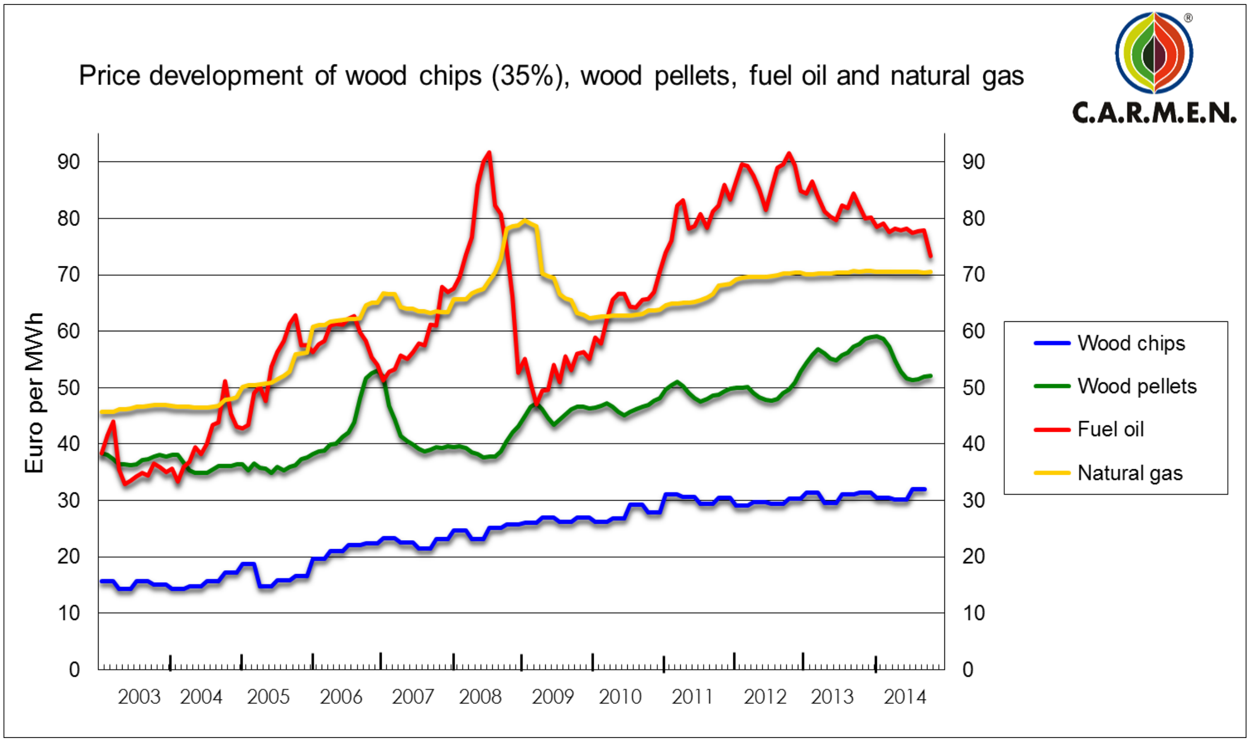

Figure 2. Price development of wood chips, wood pellets, fuel oil and natural gas. Source: C.A.R.M.E.N e.V., 2014

Germany is covered with 11.4 million hectares of forest and such a small amount of hectares could not cover the sudden demand for wood fuel. Thus under these circumstances the German wood fuel imports are expected to be increasing. On the other side Germany are largely self-sufficient, but other markets rely on imports, such as Netherlands, Belgium, Denmark and Italy. And countries like Canada, Russia and the Baltic States rely more on export opportunities mainly to Europe.[9]. But in the National Renewable Energy Action Plan a primary biomass demand of around 1400 PJ by 2020 is assumed, while the domestic biomass contribution supposedly will be limited to 1000 PJ. The difference of 400 PJ may be covered partly by imports from other countries, partly by yield increase and intensified use of residues and wastes.[10]

[8] Interview – Melanie Zenker, C.A.R.M.E.N, 2014
[9] Dale, B. - Biofuels, Bioproducts and Biorefining,2012
[10] Study on Biomass Trade in Germany, Sybille Tempel FFU, 2010, p.4

Likewise Germany depends on the OPEC and Russian supply for gas and oil prices have been increasing considerably due to crisis in Ukraine. But as concern to fresh data, worldwide oil price is significantly reduced and economics is not stable. And finally it could influence the wood fuel price as well.

In *Figure 3* presented is the demand development of the largest European pellet consumers. For 2020, EPC predicted a higher cumulated pellet demand copared to 2011. The increase affects all countries, but especially for Austria, France, Germany, Italy and Spain a multifold increase is expected.[11]

	2011	**2015**	**2020**
Austria	710.000	1.490.000	3.500.000
Belgium	100.000	150.000	200.000
Denmark	700.000	1.000.000	1.250.000
France	560.000	1.400.000	2.500.000
Finland	70.000	150.000	450.000
Germany	1.400.000	1.900.000	3.500.000
Ireland	40.000	60.000	70.000
Italy	1.900.000	3.100.000	4.250.000
Spain	150.000	450.000	1.150.000
Sweden	1.000.000	1.200.000	1.400.000
Switzerland	160.000	250.000	400.000
UK	50.000	500.000	1.250.000
other	1.100.000	1.600.000	2.200.000
total	7.940.000	13.250.000	22.120.000

Figure 3. Overview of European pellet demand in tons. Source: Martin Hoeft, Project Report on market research, 2013.

German electricity prices from renewable energy facilities and nuclear power station are little bit similar. Furthermore the nuclear reactor accident in Fukushima Daiichi, the German parliament decided in summer 2011 to phase –out nuclear power by 2022.

Berlin and other small cities are trying to produce green electricity connected with district heating. The aim is to replace fossil-fired power plants and invest in boilers for combining energy

[11] Hoeft, M. - Safe Pellets Project Report on market research by, 2013, p.29

production, which could operate on wood chips or wood pellets, e.g Klingeberg CHP within the framework of the climate protection agreement between the city-state of Berlin and Vattenfall, the enterprise's plant well be replaced by a modern gas and steam turbine power plant and two biomass fuel power plants.[12] Therefore, logistic opportunities and financial efficiency of exporting wood fuel through Estonian ports to Germany markets under several scenarios would be analyzed.

1.2 Wood fuel level of development in Estonia and its position in the market

Estonian forest is the main part of its landscape. More than half of Estonia is covered in forests, it accounts for 2 million hectares. As you can see in *Figure 3*, during the last 5 years growing stock has increased significantly.

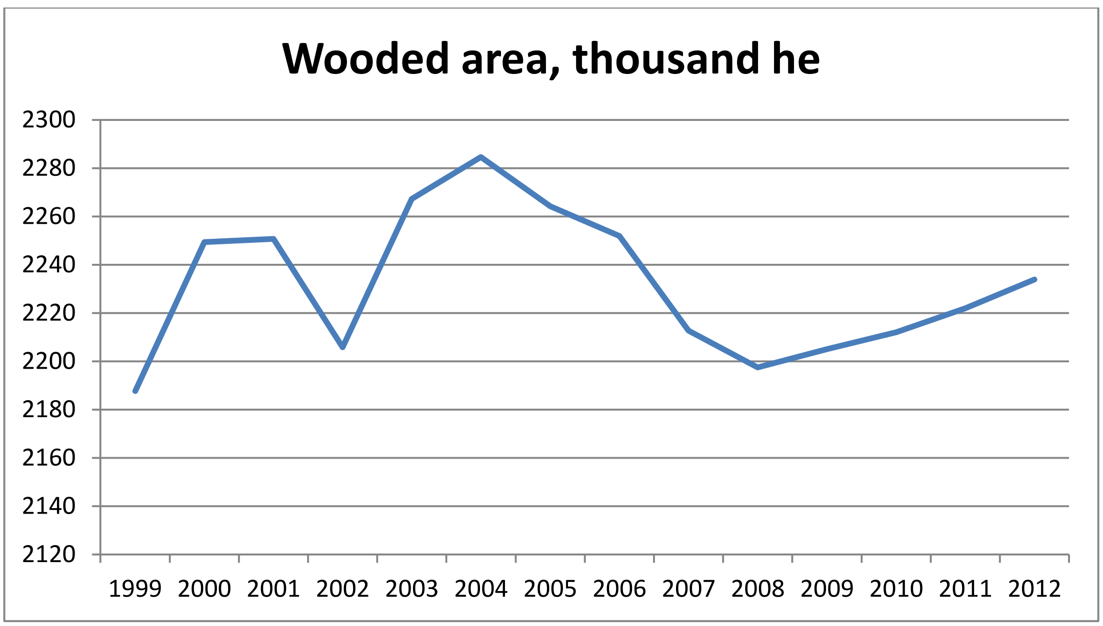

Figure 4. Thousand hectares of wooded area cover Estonia. Source: Stat.ee, 27 November 2014.

Considering the small scale of the Estonian market and its rather limited financial resources, it is kind of difficult to compete with the world's leading forest and wood industries. And respectively it is logical to develop collaboration between different sub-sectors. Estonian

[12] Klingenberg CHP plant – a New generation of power plant for climate protection, 2014

forest and wood cluster will help to find out the success factors for the development of the field in order to allow for the liquidation of bottlenecks of the sectors and magnify the advantages at the national level as well as to provide enterprises with high-quality information for decision making.

Estonian cluster of forest and wood products export accounted 12% of Estonia's exports of goods in 2012. Thus being one of the main stabilizers of Estonian foreign trade. Cluster has created a value, accounting for 4% of gross domestic product in 2011. Therefore forest and wood cluster plays an important part of Estonian economy.[13]

Initially, the low value of the timber e.g. logging waste was originally used commercially for energy purposes in the late 1970s in the Nordic countries, primarily in Sweden. Relatively, this was increasing the environmental awareness and technological progress, which gave an impulse to grow the energy consumption from wood fuel.

In recent years, wood fuel production and processing have also undergone remarkable development in Estonia. And become more efficient and more capital-intensive. Extensive investments have grown and built a number of new production units with applying innovative technologies. Renewable energy policy is relying on increased wood fuel consumption in Estonia and Northern Europe, which has given rise to wood fuel processing for export purposes. The most of intensive investment and production activity is production of wood pellets. It was started by the Danish company AS Eesti Flex Heat in 1999. Already in 2012, there were three larger and twelve smaller companies of wood pellets producing. In 2013, the annual production capacity of wood pellets were 450 000 tonnes a year and have used approximately 1 million meter square of raw material for production.

As shown in *Table 1*, there is one of the biggest producers of wood pellets - AS Graanul Invest. The annual capacity of the company during 2013 year was about 395000 tonnes. Other ones have much lower productivity, however grand total capacity is approximately 705 000 tonnes per year.

[13] Eesti metsa- ja puidutööstuse sektoruuring 2012, p.5

Table 1. The main Estonian wood fuel factories and their annual wood pellets capacity in metric tonnes.

	Capacity (t/year)
AS Graanul Invest	
Imavere	105000
Ebavere	110000
Patküla	180000
Palmako AS	
Kavastu	30000
Laekvere	30000
OÜ Purutuli	
Sauga	120000
AS Stora Enso Estonia	
Imavere	100000
Näpi	30000
Total:	**705000**

Source: Enterprise's interviews, 2014

In accordance with low domestic consumption of wood pellets and wood chips in Estonia, companies are focused primarily on exports. The location of Estonia from other European countries gives a significant advantage in comparison with the other major exporters like Canada, US and Russia. Due to mainly markets of wood fuel are European countries like Denmark, the Netherlands, Germany, Italy and England. Significant amount of wood pellets exporting to Denmark and wood chips to Sweden, accordingly to Estonian statistics, see *Figure 4* and *Figure 5*. They were only taken three years, but they still show that export of wood pellets only growing up. However wood chips are drastically reduced, about 67%, was taken only by the Swedish country.

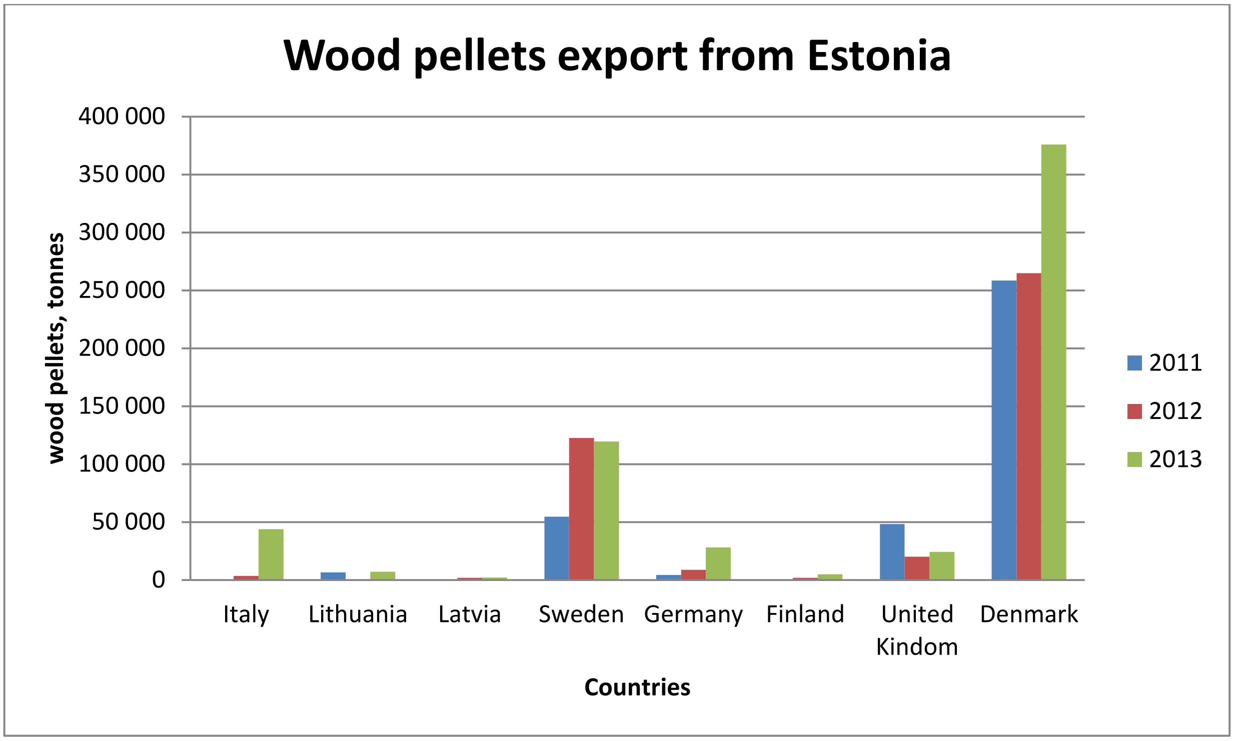

Figure 5. Wood pellets export from Estonia. Source: Statistikaamet, 2014

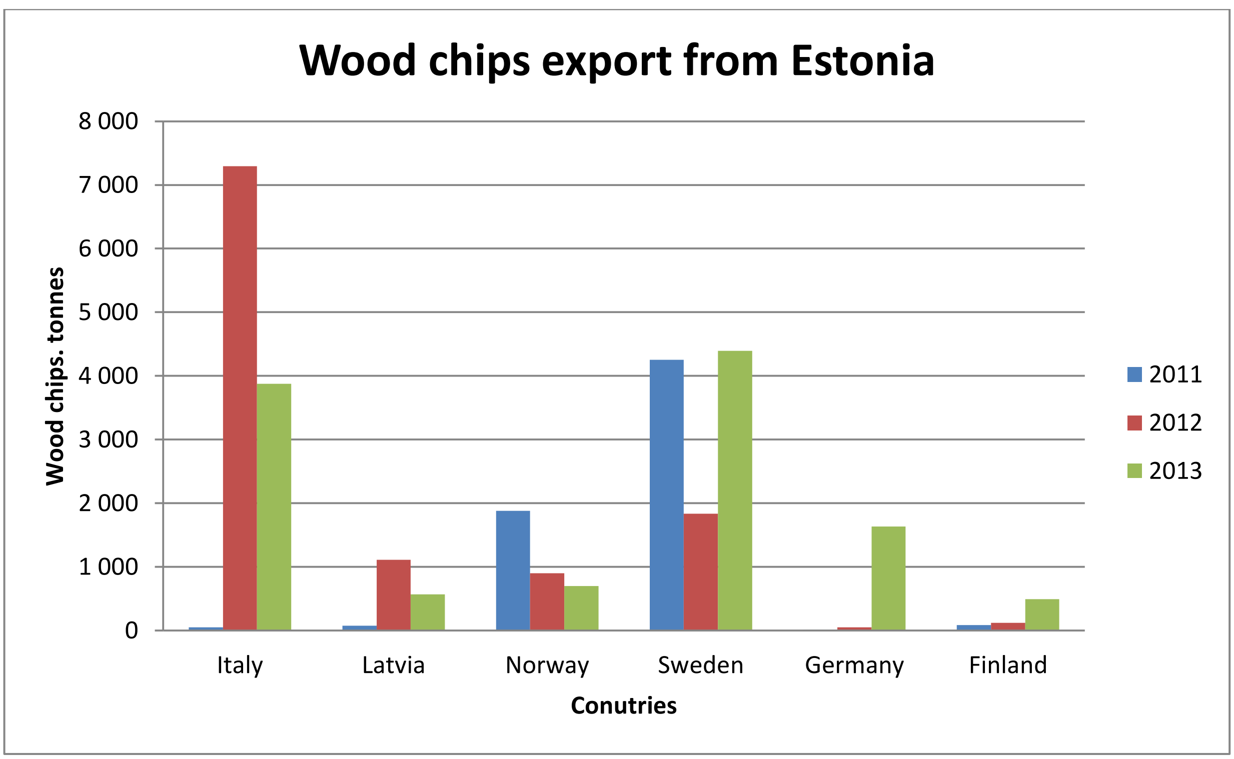

Figure 6. Wood chips export from Estonia. Source: Statistikaamet, 2014

1.1.1 Wood pellets and torrefied pellets

Wood pellet is a solid fuel that is produced by crushing and densifying waste timber like sawdust, forestry residues and industrial by products like old paper and forestry wastes. The length is 1-2 cm and the diameter is generally 6, 8, 10, or 12mm. And it’s possible to produce 25mm wood pellet at maximum. Wood pellet could be handled with variety of existing technologies, such as auguring, pneumatic conveying.

Wood pellets are produced in a relatively simple mechanical process that relies on heat and pressure to form wood particles into a pellet. The raw material arrives in a variety of partially processed states (chips, shavings, sawdust.) from which it must be dried (if needed) and ground into a uniform particle size. After the raw material is dry and uniform in size, it is forced through a press under very high pressure to create the pellet. Then, the pellets are cooled to allow the natural bonding agents to set. Afterwards, the pellets will harden, any loose material is screened out and fed back into the pelleting process and pellets are then ready to be distributed to the market.[14]

In the scope of this system, each group ofwood pellets have their own standards with technical specification and classification. The most significant standards are following:

- EN 14961 – 1 –for general use (includes pellets from different biomass raw materials);
- EN 14961 – 2 for wood pellets for non-industrial use.[15]

Typically standard EN 14961-2 classified premium wood pellets, which is mainly used for the private customers and could be packed in bags for further using in house heating. But pellets with standards EN 14961-1 are using in general purposes. Basically, it is industrial pellets and usually utilizing in electricity and heating plants.

EN 14961-2 wood pellets have an smaller amount of ash content (<0.7 / 1.5), have a good structural strenght in contrast to EN 14961 -1. These wood pellets have high combustion efficiency and a reduced affinity of slagging. Production of EN 14961 – 1 known as Industrial pellets are more easier that others and cheaper. Mostly Industrial pellets are using for the co-

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[14] Karwandy, J - IEA Bioenergy, 2007, p.8

[15] European Pellet Council 2013, p.11

firing with coal, but investments for reconstruction of power stations are very huge.[16] Anyway they could be used such as indirect co-firing form. Main difference of direct co-firing is that biomass has to be gasified before it can be burned and capability to use other biomass could be used. Further in the thesis, author will consider only standard EN 14961 – 1 of wood pellets.

Transportation of wood pellets is more preferable in contras to wood chips, due to its bulk density. So wood pellets bulk density approximately 705kg/m³ with 769 kWh and a bulk stowage factor of about 1.6 m³/t.[17]Another serious advantage of wood pellets are their moisture content. Industrial pellets have got less than 10% of water, whereas wood chips have 50-55%. If we look to the production process of the pellets, then we would see, that pellets are drying, gringing, coditioning anad pelletizing, cooling and screening. Regarding this, the transportation cost and efficiency will be more attracive. Instead of transportation costs, wood pellets have an energy range of approximately 350 000 Btu/ m³, which is much higher than wood chips – ca 80 000 Btu/ m³.

At the moment, an alternative technology to conventional wood pellets has arisen and namely torrefied wood pellets. Torrefied wood pellets are thermal pre-treated pellets with lower moisture content and higher energy density than conventional wood pellets.[18] But nowadays the production of torrified wood pellets are very expensive and has not yet become well developed especially in Estonia. Torrefied pellets are a mild form of pyrolysis at temperatures typically 300 °C[19]

Torrefied material grinds similar to coal. It can be ground in many existing facilities, easing its integration into coal facilities. Torrefied wood burns similar to coal, making it an easy replacement for coal in power plants originally designed to use only coal. A coal power plant recently tested New Biomass Energy torrefied wood pellets. That plant experienced minimal fouling when co-firing 70% torrefied pellets. However, the same plant experienced severe fouling when co-firing industrial wood pellets in excess of 10%.[20] In the near future, the import of torrefied pellets are the best solutions to cover the EU clean energy demand. So these substances

[16] Rakos, C. - Co-firing wood pellets in Europe, 2009
[17] Bioenergy wiki, 2014
[18] Sikkema, R. - The European wood pellets markets:current status and prospects for 2020, 2010 p.266
[19] Kohalike biokütuste tootmisvõimalused Hiiumal, 2012, p.17
[20] New Biomass Holding LLC

have a higher energy density, than wood chips or industrial pellets. Additionally, torrefied pellets are hydrophobic and have better transporting abilities. During the handling, moisture and water from condensation within the holds are not decreasing the value caloric of the cargo. In that way, torrefied material have several advantages against currently traded wood idustrial pellets and wood chips, but at the moment they are still in the laboratory and development phase. Thereby if torrefied pellets are ready for the energy market, it should be proved and if advantages against industrial pellets or wood chips are sufficient to displace thems from Estonian export market. Because of the higher density than conventional wood pellets, torrefied material improves the economics of transportation. Torrefied wood pellets are assumed to have 40% lower transportation costs per unit.[21] Long-distance transportation and easy handling, torrefied wood pellets have advantages over wood chips and wood pellets.

According to TNS Emor statistics, in september 2014, wood pellets retail price with tax was 203 €/t in Estonia market. Additionally, the chart interperts enough rising due to demand for wood fuel, see *Figure 7*.

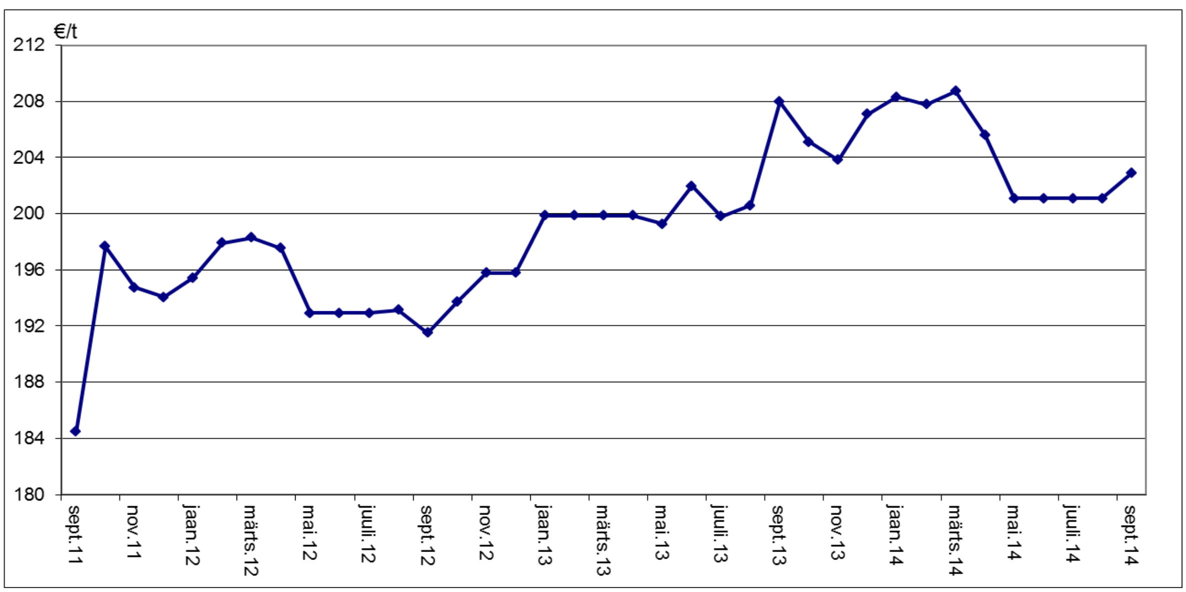

Figure 7. Fluctuation of the wood pellets average retail prices (with Tax) during three years. Source: TNS Emor, 2014

[21] Senechal, S., Grassi, G. - Logistic Management of Wood Pellets; Data Collection on Transportation, Storage & Delivery Management, 2009, p.53

Graanula Invest AS company shows market prices for two sorts of wood pellets. Industrial pellets cost approximately 192 eur/t and 204 eur/t for premium wood pellets, accordingly to their webpage data. Unfortunately, the wholesale price of industrial pellets termed FOB harbours, Graanula Invest would not like to show referring to the commercial information. However, the second enterprise Stora Enso has given prices termed FOB harbours for wood pellets. Actually, purchasing wood fuel depending on the season. Estonian market prices of wood pellets termed FOB Kunda, FOB Paldiski South harbour and FOB Pärnu are approximately 120 – 130 €/t[22]

In Germany, the Energy Wood and Pellet Association (DEPV) has reported an average cost of 243 EUR a ton (t) of wood pellets in August. Larger quantities (26 t) were traded during the three years to the following conditions:

Month / year	2012 [€ per ton]	2013 [€ per ton]	2014 [€ per ton]
January	225.24	246.67	267.74
February	225.14	253.09	267.96
March	224.58	256.87	258.27
April	214.42	254,22	241.98
May	212.06	250.21	237.69
June	211.12	249.05	234.55
July	210.59	257.22	232.83
August	214.66	259.02	231.54
September	219.26	261.75	233.69
October	227.27	268.00	237.13
November	232.44	268.10	236.89
December	239.24	271.13	238.92

Figure 8. Wood pellets price indexed supply including VAT in Germany. Source DEPV, 2014 [23]

In further analysis will be used Germany average price of wood pellets without VAT (19%).

[22] Interview – Siim Liblik, Stora Enso Eesti AS, 2014
[23] The Bioenergy Gateway, News and Facts – German pellet prices ,2014

1.1.2 Wood chips

Wood chips vary in quality and application depending on their source material. High quality pulp chips are directly derived from roundwood; wood chips for energy purposes are mainly based on harvesting or processing residues i.e. branches, tree tops, thinnings, other inferior wood not suitable for material or pulp and paper production, and recovered wood.[24]

Wood chips could be classified by moisture content, bulk density, energy density and net caloric value. By the way properties of this product are specified in the standard CEN/TS 14961[25] There are also different sorts of wood chips, e.g fresh wood chips – 350 kg/ m³, dry wood chips – 150kg/ m³. Basically, the water content is usually too high for using wood chips directly as a fuel for generation electricity and heating. So the drying process takes high costs and sometimes it does not become economically profitably.Storing wood chips in a pile could be heated up, but then it may lose up to 25% of energy.[26] For the transporation and costs calculation, wood chips should be dried up till water content reaches approximately 30%-40% (3.45 MWh/t).[27].Or if wood chips have 50% of moisture so it is equals to transport 500 kg of water for every 500 kg of wood. It is essential to know, that water content and the caloric value could determine the price of wood chips . It is more important for consumer, as for trader, the price detemines by terms of shipping contract with seller and ship owner.

The stowage factor of wood chips are about 2,5 m³/t. In comparsion coal has 1.10-1.36 m³/t.[28] The moisture content and stowage factor of chips depends entirely upon the kind of wood, site, season and weather conditions. Wood chips are a very bulky cargo compared with the other cargoes transported by the usual bulk carriers.[29] Usually the cost of shipping and handling account by the loaded volume. Shipowners get paid per m³ space utilized in the vessel's holds. Using containers are not profitably, because of not fully loaded container (about 6 tons will be unused). The major consumer of wood chips are Denmark, so Estonia is one of exporter to

[24] Lamers, P. - Global wood chip trade for energy, 2012, p.3
[25] Kalligeros, S. – Standardization of Solid Biofuel, 2009, p. B-417
[26] Kofman, P. - Harvestign / Transportation No.6. p.2
[27] Pasila, A. - Changes, challenges and opportunties in the wood energy supply chain, 2013, p.530
[28] Interview - Pakrichart Agency, Sudorenko, 2014
[29] Wood chips production, handling, transport, 1976 p.59

Denmark, but author of thesis will analysis an economical profitability of shipping to Germany as third huge importer of biomass.

Estonian average market prices for wood chips are approximately 9 €/m³. And the price termed FOB Kunda is equal to 13,5 €/MWh.[30] 1 bulk m^3 of wood chips (*spruce*) with 30% mositure have a mass of 223kg and energy density of 769kWh.[31] So through the simple arithmetic was found that price termed FOB Kunda is 10,4 €/m^3. Moreover, wood chips transportation by truck are suitable up to 90 km. Any other distances exceeded 90 km is not economically profitably for trucks.[32] Only railway transport is very suitable for transport of great quantities over long distances. But in the author's thesis there will be analyzed approximately price termed on FOB and distance are not longer than 90 km till the harbour.

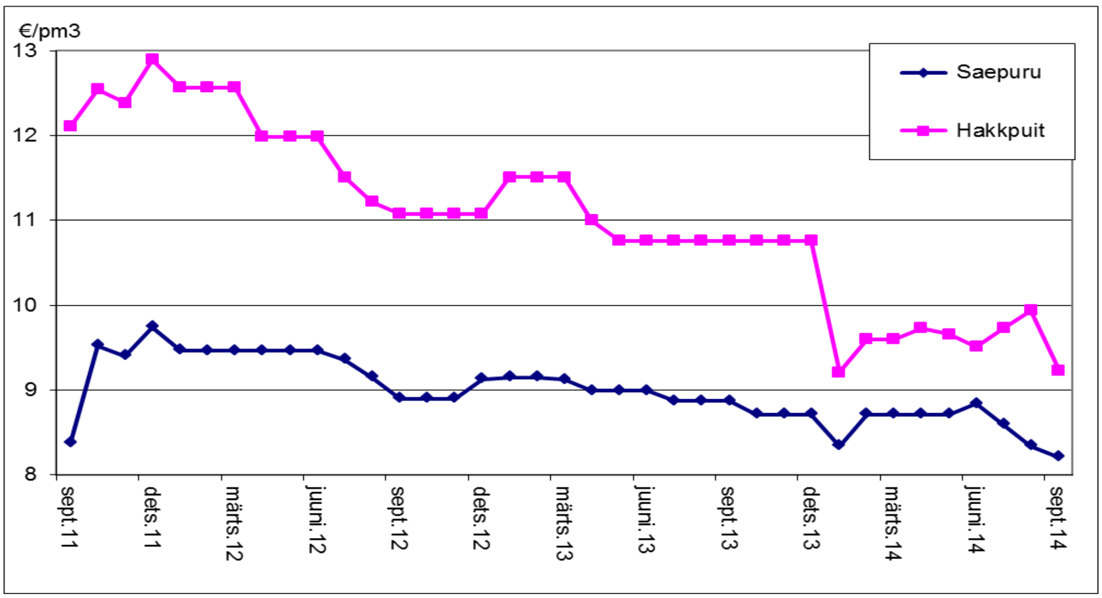

Figure 9. The prices of sawdust and wood chips without tax. Source: eramets-ee - EKI, TNS Emor, 2014

[30] Interview – Mariter ltd, Boris, 2014
[31] Francescato, V., Antonini, E. – Wood fuel handbook, p.27
[32] GOCT 15815-83 – Technological chips, Specifications,1985

As we compare with wood chips prices in Germany, so in Estonia is much cheaper price per cubic meter. Below, author of thesis shows average prices for wood chips for the past five years:

2009: 82,63 €/ t

2010: 85,94€/ t

2011: 94,59 €/ t

2012: 92,19 €/ t

2013: 95,80 €/ t

VAT and delivery expenses included.[33] And in further analysis will be also used price without VAT (19%) in Germany.

[33] Interview - Melanie Zenker, C.A.R.M.E.N, 2014

2. THE ANALYSIS OF WOOD FUEL TRANSPORTATION

In modern conditions of logistics development, problems for defining sustainable transportation options for cargo owners are always appearing. The choice of transportation process, type of transport and the carrier are depending on a complex variety of factors such as the availability of accessible modes of transport, the value of transport costs, transportation speed, reliability, delivery and etc. To carry out any transport operation requires coordination of a number of elements:

1. Technical - agreement of any technical parameters of the goods with the technical and operational parameters of vehicles;
2. Technological - definition technology and shipping methods;
3. Economic - transportation planning, pricing, calculations, determine the effectiveness of tranposrtation;
4. Legal - accordance with international legal regimes;
5. Organizational - provision of information, solution of management tasks.

2.1 Comparative characteristics for delivery wood fuel directly to Estonian ports

The terms of Incoterms are set of rules defining the rights and obligations and take an important place for any traders. Furthermore give an opportunity for price formation in spite of water content, value caloric, volume, and the type of wood fuel. The most significantly in this thesis is to overview export on FOB and CIF terms.

In *Table 2*, the main producers of wood pellets and wood chips are presented. Following a simple map has resulted in calculated different routes to Estonian harbours. According to the location of harbours, have taken only three main ports, where they are specializing in handling wood fuels: Port Kunda, Paldiski South harbour and Port of Pärnu. Main differences between the routes are not so high and one of them could be used to delivery cargo to port. But terminal handling costs and port dues in each harbours should be considered. Additionally, to improve efficiency and reduce costs tof storage, facilites near harbours are quite important. It could also reduce the time from order to destination by moving product closer to consumer.

Table 2. Capacity, route distance and time to three harbours.

	Capacity (t/year)	**Harbours**		
AS Graanul Invest		**Kunda**	**Paldiski**	**Pärnu**
Imavere	105000	130 km (1h 50min)	150 km (1h 54min)	107 km (1h 32min)
Ebavere	110000	62 km (60min)	153 km (2h 21min)	150 km (2h 18min)
Patküla	180000	227 km (3h 17min)	248 km (3h 20min)	115 km (1h 43min)
Palmako AS				
Kavastu	30000	171 km (2h 28min)	251 km (3h 17min)	195 km (2h 56min)
Laekvere	30000	65 km (1h)	182km (2h 30min)	170 km (2h 30min)
OÜ Purutuli				
Sauga	120000	192 km (2h 58min)	132km (1h 52min)	12km (12min)
AS Stora Enso Estonia				
Imavere	100000	62 km (60min)	153 km (2h 21 min)	150 km (2h 18min)
Näpi	30000	26 km (39min)	154 km (1h 55min)	180 (2 h 40min)
Total:	**705000**			

Source: provided by author, 2014

2.2 Port of Loading

Efficient handling of bulk cargo requires the use of special equipment, as well as experience and skills. The final products have to be delivered to consumers or to the sea ports, which are usually located at a considerable distance from the wood fuel plants. Most of consumed wood pellets in Western Europe are shipped from factories and delivered to consumers by bulk. This provides maximum flexibility for logistics operations at minimal cost.on delivery of wood pellets and wood chips.

2.2.1 Paldiski South harbour

New and modern terminal ESTEVE are situated in Paldiski South Harbour. There are 19 quays, three of them have 13.5 m in depth, which allows to take vessels of handysize with deadweight up to 50 000 t. Over the years, terminal has successfully handled millions of tons of bulk cargoes as well as wood fuel. Terminal ESTEVE have an experience in storage and handling the wood pellets and wood chips. According to the interview with Urmas Urgard, operation manager of ESTEVE terminal, the harbour visits General cargo vessels with 5000 – 6000 dwt. And the terminal loading rate by scheme Warehouse – Vessel is approximately 4000t/12h, sometimes it could be much faster. Cargo loading implemented by grab and bulk handling equipment,but using conveyor could significantly reduce loading rate.

The price of handling could not be showed due to commercial information. The terminal handling costs consist with weightening, make a pile from unloaded wood fuel, haulage to the berth, loading vessel, berth cleaning. Truck costs including loading time, transport to harbour, unloading. As the trade of wood fuel is termed FOB, so cargo handling fees will not directly influence the transportation costs.

2.2.2 Port Kunda

Port Kunda known as AS Kunda Nordic Tsement. Operator of the port managing and organizing work in the port, he is also liable for general safety and maintenance, and representing the port before national insitution.[34] Also in contrast to Paldiski South harbour with ESTEVE terminal, Port Kunda has only four berths with heighst depth 9,3 m. In spite of this, the harbour could load vessels with 3000-6000 dwt and draught up to 7,0-8,0m.

Actually, port Kunda is opened enterprise and information might be taked by everyone, means all the statistics, rules, port dues and charges could be easily found. It is very easy and simple to observe the harbour’s activities and give opportunities for investing and exporting through this port.

[34] Port rules of Kunda harbour,2013 p.4

Coming back to port Kunda, the cargo turnover of the port has analyzed, see *Table 3*. In regards to wood pellets export, then it is extremely falling down. But turnover of wood chips on the contrary rising.

Table 3. Cargo turnover of Kunda harbor (tons)

Cargo	2011	2012	2013	2014	changed %
Wood pellets (t)	102456	89583	120754	109180	-22.2
Wood chips (t)	177967	157107	218769	222981	-9.8

Source: knc.ee, 2014

Returning to interview with Aleksander Nikolajev, Director of Port of Kunda, who provided me with extensive and interesting information related to the wood pellets and wood chips.

First of all, the harbour provides the whole service of wood chips. It means, storing at open terminal, transport to quay and loading vessels with cargo. The port only provides direct loading. The operator has two large warehouses for wood pellets storing and delivering cargo to quay.Wood chips for energy purposes are usually exporting in small quantities, approximately 20 000t or 67 000 m^3. Other kind of wood chips are dedicated to the cellulose factories and its export through port of Kunda counts much higher.

Secondly, the minimum loading rate is 150 t/h and 500m^3/h for wood fuel. Actually in practice, the real loading rate takes about 1000t/4h.

The third thing is that, prices of stevedoring operations and services have different particularities. Wood chips handling prices per m^3 are following:

1. Terminal handling costs – 0,33 eur/ m^3 (including square rent – approximately 0,26 eur/ m2). Additionally, if vessel is visiting harbour once a month for 4200m3, then square rent will not include. But basically, the price for 1000m2,which could accommodate approximately 5000 m^3 of wood chips is 260eur/month.
2. Wood chips loading price - 0,81 eur/ m^3.

Unfortunately, Port of Kunda does not have an important service like trimming in vessel's holds. Dues for direct vessel loading is 2.70 eur/t. Storing of wood pellets provides PK terminal Ltd.[35]

[35] Interview – Aleksander Nikolajev, Director of Port of Kunda

Finally, the total price for wood chips are 1,14 eur/ m³ excluding trimming in vessel's hold and weighing. And 2,70 eur/t for loading wood pellets excluding storing, weighing and handling in terminal. And additionally, the prices could be changed due to fluctuating oil prices. In accordance with news, PK Terminal Ltd. has built new warehouse with 6000 m2 in Port Kunda, so export of wood pellets will be incresed significantly. Rain Rannala, CEO of PK Terminal claimed that the company will increase export up to 250 000 tonne annualy in port Kunda.[36] It is important investment for port, due to wood fuel demand.

2.2.3 Port of Pärnu

It is the small harbour with 24 berths, but with length 40-100m and depth 4-6m. Vessels over 6000 dwt cannot be fully loaded. During the winter, port of Pärnu is covered with ice and complicates vessels traffic in the water area. In spite of drawbacks, Stora Enso is exporting wood chips and wood pellets from this port. Furthermore the terminal facilities at port of Pärnu includes conveyor for loading vessels quickly. Additionally, there are special warehouses for wood pellets like in Paldiski South harbour and port Kunda.

2.3 Dry bulk carriers

Dry bulkers are most suitable for shipping wood chips and industrial pellets. Typically the smallest category of the dry bulkers, known as "*minibulkers*".And their traditional name in the Baltic Sea is Baltic coasters.

As a rule this class is designed more for European trade and could carry the small amounts of cargo, due to their low draft. Basically, Baltic coasters transport cargo to the Scandinavian countries, the UK, Germany and the Netherlands.

Commonly Baltic coasters are operating as feeders and sail between hub ports. They could visit small commercial harbours and can serve other dry bulkers at the hub ports. Thus, Baltic coasters could be used for the collection of commodities from small commercial harbours

[36] Content Marketing - PK terminal investeeris Kunda sadama laohoonetesse, 2014

and also could be used to make lighter arriving bulkers distribute the load. *Handysize* vessel's type is not necessary to overview, due to their high deadweight 10 000 – 35 000. Estonian's wood fuel enterprises do not have sufficient volume for loading such vessels.

Additionally, every bulk carrier has special class notation for the different densities of bulk cargo. The purpose of the class notation is to give a standard Bulk Carrier reasonable loading/discharging flexibility. Such vessels are designed to take full cargo deadweight, where some cargo holds empty.[37]

- BC-A Strengthened to carry dry bulk cargoes with cargoes of cargo density 1.0 t/ m^3 and above with specified holds empty;
- BC-B Strengthened to carry dry bulk cargoes with cargoes of cargo density 1.0 t/ m^3 and above with all cargo holds loaded;
- BC-C Strengthened to carry dry bulk cargoes with cargoes of cargo density less than 1.0 t/ m^3;
- BC-B* Strengthened to carry dry bulk with cargoes of cargo density 1.0 t/ m^3 and above with any hold empty and have double hull construction.[38]

Above mentioned Class Notation could help to select suitable vessel for wood fuel shipping. According to wood pellets density 705kg/m^3 or 0,705 t/ m^3, which is less than 1.0 t/ m^3, the vessel with class BC-C will perfectly approach transport cargo. As for wood chips (e.g spruce) density is 0,223 t/m^3 and the same vessel class will be suitable for this cargo. Additionally, vessels could be equipped with cranes, which gives opportunity to load or discharge cargo itself. But their freight is a little bit higher than ungeared vessels. Also new innovation certainly developed and continue to developing cranes on the shore with high speed loading and discharging rate than geared vessels.

[37] DNV Class Notations, 2014
[38] DNV General Regulations Class Notations 2012, p.9

2.4 Charter Party

As already have known during studies in the Maritime Academy, that usually dry cargos such as millet, grain are shippen in the tramp shipping. There are two types of shipping – tramp shipping and line shipping. In comparison to liner shipping, tramp is the irregular shipping of freight from port of loading to port of discharding. It is usually used by three types of charter parties. The vessel could be chartered by time charter, voyage charter or bareboad charter.

Voyage Charter are used for one or more trips to one/two directions. It is especially easy for charterers or sellers/buyers, due to all costs takes shipowner. All costs include cargo handling costs at both port – loading and discharging, port dues, pilotage, mooring ship's propulsion expenses and daily operating costs. According to daily operating costs it includes crew costs, insurances for vessel- P&I clubs and repair expenses. The whole freight rate of the voyage charter could be paid per tonne of cargo or lump sum by charterer. Usually shipowners prefers money per tonne of cargo. Moreover different cargo has own stowage factor, which is necessary to remember. And some shipowners would like to calculate for specific cargo the payment of m^3.[39]

Time charter party could be ideally suitable for the companies with enough cargo volume and have long terms contract with buyers.For example, one company has cargo in point A, B, C, D. Then it is suitable to take vessel on time charter for series of voyages, due to the vessel have work for delivery cargo between these points. Under time charter party, charterer should pay freight rate per day and but there is no lump sum payment for whole series of voyages. Undoubtedly the charterer will bear cargo handling costs, port dues and propulsion expenses of the ship. And the shipowner will handle daily operating costs.

In contrast to a voyage charter and time charter parties the bareboat charter party is quite less common in shipping, due to large expenses. But practically it is becoming more interesting for companies, who would like to purchase vessels in the future. Sometimes, shipbulding companies build vessels for customers, who are ready to pay enough money for such a ship. All contracts are signed in, but in the future, nobody knows what will happen with the customer,

[39] Interview - Pakrichart agent A. Sudarenko, 2014

maybe the company will be bankrupt. Thus other companies are ready to take new vessel under bareboat charter party conditions for future redemption.

For wood fuel export the bareboat charter party is not essential, due to costs for charterers. The charterer could lead only the hull of the vessel for several years, so he will bear all costs related to port dues, cargo handling, crewing, daily operating costs and the propulsion of the ship.

In conclusion, for research will be taken Voyage charter party for Baltic coasters with 5000-6000 dwt, which is ideally suitable for wood fuel transport with low expenses for producers/exporters.

2.5 Costs analysis for maritime shipping

During this thesis, the author will provide the basic calculation of freight costs in shipping, which will help understand its concepts . All intents and purposes shipowner and charterer should use special formulas for calculation.

First of all, the important item is to find a suitable vessel. At the moment author will take merchant vessel Paula Vindo IMO 9436783. Also the current ship has 5487 dwt, 4102 GT and draught 5.6 m, which is perfectly suited for shipping wood pellets and wood chips, full specification of the vessel could be found in *Appendix 1*. Furthermore, the author will analyze the voyage distance and duration. As for this, special interactive software will be used. In thesis, distance and duration from three main port of loading to port of discharging in Hamburg, Germany was overviewed, see *Table 4*.

Table 4. Distance and duration from Estonian port to Hamburg, Germany.

	Paldiski South harbour	**Port of Kunda**	**Port of Pärnu**
Distance	1151nm	1260nm	1112nm
Distance (through Kiel chanel)	675nm	726nm	650nm
Speed	8kn	8kn	8kn
Duration	6days	6h 6	5d 8 h
Duration (through Kiel chanel)	3d 12h	3d 18h	3d 2h

Source: http://ports.com/sea-route and http://www.sea-distances.org/

Accordingly, in the above mentioned table there are no big differences between distances of harbours. As a matter of fact, for reducing sailing days and delivery in time, Kiel canal are perfectly suited for reaching port of Hamburg in Germany for discharging wood fuel.The speed of the vessel is usually 8 kn sometimes it could reach 10kn. As for the concern of Kiel canal, so there are some restrictions and allowing max. speed of approximately 5-6kn. Is spite of this, Kiel canal has a transit fees, which will be taken into consideration during calculation costs for maritime shipping.

As for further analyzing, would be taken average voyage duration at sea 7 days. Besides, loading and discharging time are not included. Consequently, Paldiski South Harbour has 4000t /12h or 333 t/h, port Kunda has 1000 t/4h or 250t/h and port of Pärnu has 350 – 400t/h. As for vessel Paula Vindo with 5487dwt, will be loaded 4000t of wood pellets with stowage factor 1.6 m^3/t, and as for wood chips with stowage factor 2,5 m^3/t, it will be approximately 2513 t or 6283 m^3.

Loading rate for 4000t of wood pellets and 2513 of wood chips are following:

1. 12h/8h in Paldiski South harbor;
2. 16h/10h in Port of Kunda;
3. 10h/6h in Port of Pärnu.

For the discharge, the cost for the discharging process bears cargo owner or forwarder, who is nominated by cargo owner, as the trade is termed FOB. Thus, cargo owner or forwarder should pay for the duration of the discharging process, as concerned running time of chartered vessel and the berthing time of the terminal for cargo handling.

In this thesis, terminal handling costs and port dues are included as a lump sum and equals to 8500 € in the port of Hamburg. The discharging rate has reached to 11 700 m^3/d providing by port facilities in Hamburg. Also it depends on the facilities of the terminal, where the vessel will be berthed. Therefore, 6283 m^3 of wood chips could be discharged within 13 hours. And 4000 t of wood pellets can be discharged within 13 hours.[40] Besides freight rates bunker costs play an important role for the overall costs of shipping cargo. In the next step, fuel oil consumption of vessel m/v Paula Vindo would be calculated. Usually bulkers, but only for Baltic coasters with building year 2013 have a main engine and several smaller auxiliary diesel engines. Typically,

[40] Interview - Pakrichart agent A. Sudarenko, 2014

the main engine consumes heavy fuel oil. Heavy fuel oil is the residue of distilled crude oil and it has some harmful ingredients such as sulphur, sodium, vanadium and rust. However, HFO has one great advantage, it is much cheaper than marine gas oil and marine diesel oil and has a lot of drawbacks that could be reduced and overcome during heating, additives, cleaning. There are different grades of HFO and have a different chemical composition. Grades of HFO are distinguished by the amount of marine diesel oil (MDO) mixed in. The HFO most commonly used — known as IFO 380 (IFO is intermediate fuel oil) — is a mix of 88 percent residual oil and 12 percent distillate (usually a diesel-type oil). By comparison, IFO 180 is composed of 98 percent residual oil and only 2 percent distillate.[41] Coming back to the daily consumption of minibulkers, they are usually using IFO 180, and their consumption is approximately 8-9 t/day during sailing and for auxiliary engines 1 t/day of MDO during loading or discharging. But if the vessel is using marine diesel oil, it will consume around 5 mt/d during the voyage.[42] Additionally current prices are very unstable for fuel oil, due to world economics. Today's prices of fuel are very low in contrast with one and two years ago. And author will take approximately price for HFO180 – 346 USD/mt and MDO – 550 USD/mt.[43]

The new legislation, Directive 2012/33/EU amending Directive 1999/32/EC, was published in the Official Journal of the European Union on 17 November 2012, and the deadline for bringing Member States' legislation into compliance was 18 June 2014. As of 1 January 2015, EU Member States have to ensure that ships in the Baltic, the North Sea and the English Channel are using fuels with a sulphur content of no more than 0.10%. Higher sulphur contents are still possible, but only if the appropriate exhaust cleaning systems are in place.[44] And thus calculations using only MDO will be provided by this thesis as well.

Currently, the daily price of using minibulkers or coasters in the Baltic States with deadweight 5000 – 7000 dwt is approximately 2800 – 3200 USD/twenty-four hours. The numbers in *Figure 10* is quite precise, due to information being received from real shipbrokers.

[41] Walsh, G. - Economical heavy fuel oil finding its way into the tugboat industry, 2008
[42] Interview - Pakrichart agent A. Sudarenko, 2014.
[43] Bunkerworld.com 13.12.2014
[44] Official Journal of the EU - Directive 2012/33/EU of the European Parliament and of the Council of 21 November 2012

12.12.14 10:08

Тип судна	Ставка, $/сутки	Изм. за неделю
Азовское, Черное и Средиземное моря		
Сормовский, Омский	3100 - 3700	+50
Волго-Дон	3800 - 4200	+50
Волга	4100 - 4600	+50
морские суда дедвейтом 3-4 тыс. тонн	1900 - 2300	=
морские суда дедвейтом 5-7 тыс. тонн	2300 - 2600	=
Балтийское и Северное моря		
коастеры дедвейтом 3-4 тыс. тонн	2100 - 2500*	+100
коастеры дедвейтом 5-7 тыс. тонн	2800 - 3200*	+100
Дальневосточный бассейн		
Сормовский	2400 - 2600	=
морские суда дедвейтом 5-6 тыс. тонн	3500 - 3700	=

** - €/сутки*

Figure 10. Time-charter freight rates for Baltic coasters. Source: pg-online.ru, 2014

Port charges are paid to port authorities, or other entities, with the objective of covering the costs of provision of port facilities and services. Since port is critical in connecting domestic and overseas distribution system, cargo owners add value to its products simply by sending their cargo to the right ports. The benefit of value creation may be shared and tapped by port authorities through the price for port. In return, port charges could be used to improve the efficiencies of port to satisfy the main port users – cargo owners and ship owners.[45]

Port dues and charges are calculated bsed on the following criterions:

- Tonnage dues;
- Berth dues;
- Channel dues;
- Mooring/Unmooring dues;
- Waste dues;
- Pilotage dues;
- Waterway dues;
- Towage dues.

Appendix 2 shows the required port dues and charges for shipowner at the entrance to the port and leaving the port in Estonia. Additionally *Appendix 2* does not show costs related with unpredictable situation or additional services like using port's auxiliary machine, repairing services, electricity, supplying with necessary goods. Also, this does not include others charges,

[45] Qian, Y. - The wood pellet value chain, 2013, p.32

which may occur during berth shifting, arrival on Holidays or at night time. Some terminals are working time only from 8:00 a.m to 11:00 p.m in port of Pärnu, as a result could appear demurrage, but worst of all, if the vessel does not have time to reach another port of loading. Moreover, discounts from tonnage charge shall be applied to regular visiting the port and valid for every calender year. Also waterway dues may be rejected, if vessel are visiting the port for eleventh time, accordingly to § 50[10]. Reduction of due rates of Estonian law,

(1) Waterway dues shall be paid during a calendar year for a maximum of:

1) 60 times by a passenger ship;

2) 3 times by a cruise ship;

3) 10 times by other types of ship[46]

Towage dues are not compulsory, but in most cases, coasters have not side propeller and center propeller for mooring by themselves, thus extremely important to order towage services for correct berthing. And average time for towage services are approximately 1.5 hours.

Calculation of wood fuel maritime transportation was made in Excel and estimating the freight rates for 4000 t of wood pellets with 6283 m^3 of wood chips from Estonian ports to port of Hamburg are depicted in the tables and could be found in Appendices.

On the whole, the cheapest port of loading for shipowner is Paldiski South harbour, due to lower port dues and charges than other ones. Also Port Kunda and Port of Pärnu have approximately the same costs.

Above all, each vessel has different port dues and charges, due to gross tonnage, length and breadth. As for port of Hamburg, so there would be much higher port dues and charges and is equal to 8500 EUR. Certainly, all depends on terminals.[47]

To sum up, transporting costs accordingly author's calculation are following:

1. Transport prices of wood pellets to port of Hamburg, Germany using HFO fuel:

   a) Appendix 4. Paldiski South Harbour – 28.41 €/t
   b) Appendix 6. Port Kunda – 28.6 €/t
   c) Appendix 8. Port of Pärnu – 28.78 €/t

[46] Maritime Safety Act - Chapter 11[1] Waterway dues [RT I, 31.12.2012, 1 - entry into force 01.07.2013]
[47] Interview – Pakrichart A.Sudarenko, 2014

2. Transport prices of wood pellets to port of Hamburg, Germany using MDO fuel:

a) Appendix 4. Paldiski South Harbour - 27.4 €/t
b) Appendix 6. Port Kunda – 27.62 €/t
c) Appendix 8. Port of Pärnu – 27.8 €/t

3. Transport prices of wood chips to port of Hamburg, Germany using HFO fuel:

a) Appendix 5. Paldiski South Harbour – 18.09 €/m^3
b) Appendix 7. Port Kunda – 18.24 €/m^3
c) Appendix 9. Port of Pärnu – 18.32 €/m^3

4. Transport prices of wood chips to port of Hamburg, Germany using MDO fuel:

a) Appendix 5. Paldiski South Harbour – 17.44 €/m^3
b) Appendix 7. Port Kunda – 17.59 €/m^3
c) Appendix 9. Port of Pärnu – 17.66 €/m^3

Accordingly to the fuel situation in the world, using MDO fuel is more competitive and preferably in SECA area, due to sulphur content is 0.1%.

In practice, the reason for paying double freight rate is that ship owner always has insured risks. It is important to return to the port of loading, even if there is no cargo. In the case of ship owner agreed for freight costs for one way and he does not have cargo somewhere else, so it would not be profitable. Even if shipowner has cargo in other side of the Europe from the place of discharging he should reach it without any expenses. Therefore, double freight cost is the insurance of ship owner for reaching another port and gaining profits.

2.6 Cost analysis for hinterland connections

According to OECD data the competitiveness of Global port-cities the port of Hamburg has the best hinterland connections in contrast with Rotterdam and Antwep. Basically it is important to delivery wood fuel e.g to the electricity and heating power station in Berlin, Wolfsburg, Magdeburg, Hannover and somewhere else with in the industrial regions by railway, truck or barge. Sure if there is connection with water ways and suitable for using barges. Trucks with sliding floor are specially designed for transport wood fuel. Usually such trucks have a maximum capacity of of semi-trailer approximately 90 m³ or 31250kg.[48] Actually, the transportation of wood fuel is rational with route range of around 90 km. In our cases, the author will calculate the amount of trucks that would be needed to transport wood fuel. Therefore, one truck could be loaded with 31t or 50 m³ of wood pellets with stowage factor 1.6 m³/t, and 77,5 m³ of wood chips with stowage factor 2,5 m³/t. Thus, approximately 129 trucks to transport 4000t of wood pellets and 81 trucks for 6283 m³ of wood chips are needed.

The amount of trucks are quite high, thus alternative way to delivery should be found. Tranport by railway or by barge have their advantages, due to econimically profitable at distance with the range of 300 km or higher.

Usually some transport companies are using MWh unit to identify freight cost for trucks and railway. Below mentioned *Figure 8* shows costs for 1 km per MWh,but unfortunately only for wood chips. The word „*Holzhackschnitzel*" means wood chips, „*LWK-Transport*" is truck and as for „*Bahntransport*" means railway. Moreover, during the analysis of the chart for transport cost, the author noticed, that prices are raising, due to increasing the distance. 1 m³ of spruce wood chips is equal approximately to 0,769 MWh with content moisture 30%. Consequently, spruce wood chips volume 8539 m³ equals to 6566MWh.

As concern the formula of price calculation per distance, so it looks:

Transport by truck:

$$K_{Tr1}=0{,}06\ \text{EUR/S} + 1{,}25\ \text{EUR/MWh} \tag{2.6.1}$$

Transport by railway:

$$K_{Tr2}=0{,}02\ \text{EUR/S} + 5{,}14\ \text{EUR/MWh} \tag{2.6.2}$$

Where,

K_{Tr}= transport costs

S = MWh per km

As a result, during calculation would be got following results:

K_{Tr1}= 0.06 * 300 €/MWh + 1.25 €/MWh = 19.25 €/MWh or 14.8 €/m^3

K_{Tr2}= 0.02 * 300 €/MWh + 5.14 €/MWh = 11.14 €/MWh or 8.57 €/m^3

Under these circumstances, author could emhasize that transport for 300 km to Berlin the railway would be advantageous in comparison with truck.

[48] Welton pro trailer – poolhaagis NS 3 R

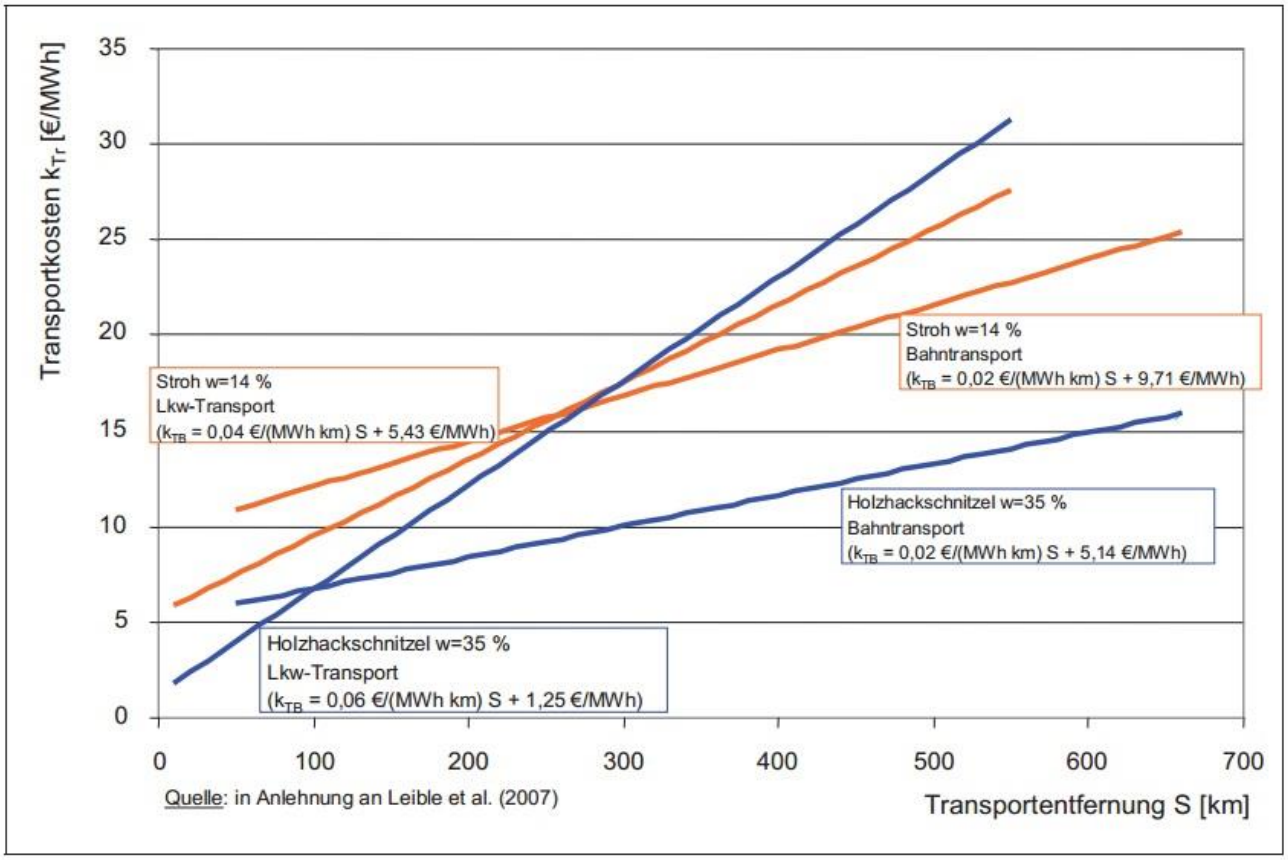

Figure 11. Transport costs for wood chips per km of MWh. Source: Systemanalytische Untersuchung zur Schnellpyrolyse.

Turning to wood pellets, so the transport cost will be 5 – 10 €/t at distance radius 100 km and 10 – 20 €/t with distance radius 300 km.[49] As a result, the freight cost for 4000t of industrial pellets would be around 30 000 € for 100km and 60 000 € for 200km.

Therefore, one train could carry 24 wagons with 113 m³ or 58 t per each wagon. And to delivery all capacity of wood chips, 55 wagons will be needed and it takes approximately 5 days for wood chips delivery to be received by end-users in Berlin.

Another possibility would be the use of barges for shipping wood fuel by water way. In our cases Berlin could be reached by Elbe-Havel canal, which is getting depth of 2 m with and could accomodate vessels of up to 1000 mt.[50] So Europea barges could be with different dwt, but

[49] Glahr & Co. GmbH presentations, p.6
[50] Encyclopedia Britannica, 2014

for Elbe-Havel is suitable barge with 1200 dwt. However, freight cost for barge per one day is unknown, because the data is only for commercial purposes.

3.THE ASSESSMENT OF WOOD FUEL EXPORT EFFECTIVENESS

Wood fuel products of Estonian enterprises in the European market will be competitive in the event that the price for it will not exceed the market price that the consumer is willing to pay under certain conditions of delivery. Terms of competitiveness can be represented as:

$$P_m \geq P_c \tag{3.1}$$

Where,

P_m – market price that the consumer is willing to pay, under certain conditions of delivery, € /t;

P_c – price of wood fuel supposed by seller, € /t.

Competitiveness of enterprises in the market depends on the level of total costs. The cost price of own production can occupy a small proportion, but logistics costs for consumption may be relatively high.

Typically, manufacturers calculate the price of the products from the following formula[51]:

$$P_c = (C + a + g) * (1 + i)^{T/365} \tag{3.2}$$

Where,

C – enterprise's selling price of wood fuel, €/t;

a – costs associated with the transportation of goods and execution of related logistics solutions within a particular transport-technological scheme of delivery, €/t;

g – costs associated with the implementation of the selected transport and technological scheme of delivery, including the cost of logistics intermediaries and compensation of logistics risks, €/t;

i – the annual interest rate on capital, but in the thesis will be 7 % conditional interest rate per annum;

T – delivery time, days.

[51] Smolin, E. - *Маркетинг – теория и практик, ГУУ, Москва* ,2007, p.20

3.1 Overview transportation costs

Organization of wood fuel transportation is to determine a finite number of operations, which will be carried out by the transaction parties and the involvement of intermediaries. Additionally for multimodal transport are the following basic operations:

- Preparation of wood fuel for transportation;
- Preparation of necessary documents;
- Overview and signing of a contract;
- Insurance of tranport;
- Terminal handling services in the port of origin;
- Customs operations;
- Shipping cargo to the port of discharging;
- Discharging in the port;
- Overloading to the next mode of transport;
- Calculation costs by transaction for cargo transportation.

Additionally, could be added the drawing up accompanying documents, make a complaint and solution of conflicts and disputes.

Consequently, the general formula for freight logistics costs will be following[52]:

$$Z= (Z_1+ Z_2+ Z_3) + (Z_4+ Z_5+ Z_6+ Z_7+ Z_8+ Z_9+ Z_{10}) \quad (3.1.1)$$

Where,

Z_1- development costs of transportation scheme of delivery;

Z_2- costs of monitoring and coordinating the movement of cargo;

Z_{3-} insurance organization for cargo during storing and handling in the terminal, maritime shipping to the port of discharging / to end-users;

Z_4- loading and discharging costs;

Z_5- truck delivery costs;

Z_6- temporary wood fuel storing costs;

[52] Kirichenko, A. - *Организация логистических систем для перевозки экпортно-импортных грузов , Спб «Базис»*, 2001, стр.306

Z_7- port dues and charges in the port of loading and discharging;

Z_8- payment of port agents at the port of loading and discharging;

Z_9- costs of drawing up accompanying documents;

Z_{10}- freight costs of shipping wood fuel by sea;

Consequently, (Z_1+ Z_2+ Z_3) – the symbol g and for (Z_4+ Z_5+ Z_6+ Z_7+ Z_8+ Z_9+ Z_{10}) – is symbol a.

However, in the thesis the author emphisize, that the manufacturer has calculated wood fuel delivery termed FOB port, which is equal to an average of 125 €/t for delivery wood pellets and 10.4 €/m^3 for delivery wood chip. FOB term has already included loading on board the vessel, but freight cost for shipping wood fuels and discharging costs is not included.
Freight cost has calculated by above mentioned optimization formula[53]:

$$\mathrm{F_v} = F \times t + \left[\sum_{i=1}^{n}(ab_i + m_i h + k_i) + \sum_{j=1}^{n} m_j h + k_j)\right] \rightarrow min \qquad (3.1.2)$$

F – freight rate per day at shipping market, \$/day;

n – number of shipmnets;

t – total days delivery cargo to the named port of discharging, days;

a – the costs of fuel, EUR/t;

b_i – sailing days to *i* port of discharging, days;

m_i – spending days at *i* port of loading, days;

m_j – spending days at *j* port of discharging days;

h – the costs of fuel, EUR/t;

k_i– port dues and charges in *i* ports of loading;

k_j– port dues and charges in *j* ports of discharging;

The calculation has showed that the most profitable export will be through Paldiski South Habrour. It equals to 28.41 €/t for wood pellets and 18.09 €/m^3 for wood chip according to HFO fuel consumption and 27.4 €/t for wood pellets and 17.44 €/ $m^3$for wood chips, if ship owner use MDO fuel. If author analyze wood fuel delivery to the enterprise for the production of electricity and heat, for example in Berlin, then would be calculated the cost of transportation above mentioned formula (2.6.1) and (2.6.2):

[53] Provided by author of Analysis of wood fuel export through Estonian ports and an assessment of its effectiveness

K_{Tr1}= 126 377 €/m^3 by truck;

K_{Tr2}= 73 179 €/m^3 by train.

Subsequently author will take train for delivery wood chips to end-users in Berlin, due to low transportation costs. As concerns wood pellets the freight cost for 4000t of wood pellets would be around 30 000 € per 100 km and 60 000 € per 200 km.

As it was mentioned before, the distance from port of Hamburg to Berlin is equal to 300km, on this basis was calculated the cost of wood pellets delivery by trucks. Unfortunately, the exact cost of delivery by rail could not be obtained, based on the fact, that the calculation formula is unknown. After all, the rail way wagons should have special design for wood pellets transportation. Judging by the results it is more profitable to carry chips to Berlin by train, and it is needed about 55 cars and takes approximately 5 days. Definitely to this amount have be added freight forwarding inside the port.

As a result, the manufacturer is calculating the final price for wood fuel product on the assumption of above mentioned formula (3.2):

$P_c =(C+a+g)*(1+i)^{T/365}$

Delivery wood pellets to port of Hamburg, Germany concerning consumption of HFO and MDO for maritime tranportation:

- HFO $P_{c3.1}$ = 153.7 €/t;
- MDO $P_{c3.2}$ = 152.68 €/t

Delivery wood pellets using combined transport with radius 200 km in Germany concerning consumption of HFO and MDO for maritime tranportation:

- HFO $P_{c4.1}$ = 168.88 €/t;
- MDO $P_{c4.2}$ = 167.87 €/t

Delivery wood chips to port of Hamburg, Germany concerning consumption of HFO and MDO for maritime tranportation:

- HFO $P_{c5.1}$ = 28.54 €/m^3;
- MDO $P_{c5.2}$ = 27.89 €/m^3;

Delivery wood chips using combined transport to Berlin, Germany concerning consumption of HFO and MDO for maritime tranportation:

- HFO $P_{c6.1}$= 37.16 €/m^3;
- MDO $P_{c6.2}$ = 36.51 €/m^3;

Comparing German market prices with Estonian prices for wood fuel by formula (3.1):

$P_m \geq P_c$

Delivery cargo to port of Hamburg, Germany (CIF):

Wood pellets: 197 €/t > 153.7 €/t and 152.68 €/t

Wood chips: 77,6 €/t or 25,45 €/m^3 < 28.54 €/m^3 and 27.89 €/m^3;

Delivery cargo to end-users in Berlin, Germany (DAP):

Wood pellets: 197 €/t > 168.88 €/t and 167.87 €/t

Wood chips: 77,6 €/t or 25.45 €/m^3; < 37.16 €/m^3 and 36.51€/m^3;

Consequently, the cost of delivery wood fuel to the end-users will be profitable only to transport wood pellets with transshipment through the port to trucks. Concerning wood chips transshipment to train and delivery to end-user in Berlin is not profitable, due to cargo market price in Germany is lower.

3.2 Calculation of profits, return on investments and net present value

One of the most significant financial concepts is computation of gross profit. In the thesis matter profit margins will be calculated according to current European selling prices and using formula (1).

Profits for wood pellets delivery to port of Hamburg, Germany (CIF): 43.3 € and 44.32 €

Profits for wood pellets delivery to end-users (DAP): 28.12 € and 29.13 €

Profits for wood chips delivery to port of Hamburg, Germany (CIF): -3.09 € and -2.44 €

Profits for wood chips delivery to end-users (DAP): -11.71 € and -11.06 €

Following this section will be calculated return on investments, it is showing a rate of return or loss of business, taking into account the amount of investments were made. ROI is usually expressed as a percentage. Consequently, ROI will be found using following formula (2):

ROI of wood pellets delivery to port of Hamburg, Germany (CIF): 28% and 29%
ROI of wood pellets delivery to end-user in Berlin, Germany (DAP): 17% and 17.3 %
ROI of wood chips delivery to port of Hamburg, Germany (CIF): -11% and -9%
ROI of wood chips delivery to end-user in Berlin, Germany (DAP): -31% and -30.3%

Considering the return of investments, was taking into account the average market prices of wood fuel in Germany without VAT. And it could be concluded that the purchase of wood pellets in Estonian and delivery to the end-users in Berlin on CIF terms and it will be received with profit of 28% or 29 % for wood pellets and non-profitable for wood chips -31% or -30.3%. The greatest profit could be gained by shipping to port of discharging in Hamburg, Germany on CIF terms. Certainly, if comparing two kinds of wood fuel, then wood pellets have more percentages of return of investments that make this cargo more profitable to export. At the moment export of wood chips will not bring any profits for business.

In addition, Net Present Value would be calculated, that will show cash flow, considering the present value of money today, to the present value of money in the future and also includes returns. Basically, NPV could present the cash receipts from the sale of wood fuel, which was purchased from Estonia. Under these circumstances, the author took as 7 % as interest rate per annum, and delivery time 10 days to port of Hamburg, Germany and 5 days to end-user delivery. Totally, the delivery time is 15 days.

NPV for wood pellets delivery to port of Hamburg, Germany: 43 and 44
NPV for wood pellets delivery to end-user in Berlin, Germany: 28.57 and 28.6

NPV of wood pellets > 0, the investment would add value to the company and the project may be accepted.

NPV for wood chips and delivery to port of Hamburg, Germany: -3.1 and -2.5
NPV for wood chips and delivery to end-user in Berlin, Germany: -11.8 and -11.1

NPV of wood chips < 0, and means that none of wood chips project inapplicable for its export to Germany.

3.3 Benchmarking Latvian wood fuel export

The comparative efficiency of country's trade logistics chain is important in enhancing the competitiveness of its industry and commerce. In this regard, international differences in trade logistics efficiency determine in large extent the efficiency and sustainability of the economies.

The wood fuel industry in Latvia was started some decades ago, as concern wood pellets so it was beginning time in 1998 and the first factory has built the Swedish company Lantmännen. Therefore some smaller manufacturers were followed and produced wood fuel for the domestic market and for export as well.

Nowadays, Latvian pellet industry is producing a significant amount of wood pellets, see *Table 7*. In contrast to Estonian wood pellet producing capacity, then it is 59% less. And the domestic consumption a total 300000 t/year in Latvia.

Table 5. Factories in Latvian and production capacity (t/year)

Latvian's factories	Location	Capacity (t/year)
AKZ	Aizkraukle	35000
AT Ekogran	Baldone	12000
CED Cesu	Latvia	12000
Ecosource	Alūksne	12000
Frix	Valmiera	24000
Graanul Invest	Inčukalns	180000
Kurzemes	Ventspils	70000
Agroenergi	Laucienes	70000
LatGran	Jaunjelgava	83000
LatGran	Jēkabpils	155000
LatGran	Kraslava	155000
LatGran	Gulbene	160000
Latgranula lncukalna	Riga	30000
Priedaines	Varaklani	12000
Graanul Invest	Launkalne	180000
Total capacity:		1190000

Source: Bioenergy International, 2012

Additionally, Latvia applies a tax deductible for renewable energy to be more competitiveness in comparison with other countries. In order to attract investors Latvia is organizing business incubators related to support green energy, which includes business ideas for production the renewable energy. At the same time, on *Figure 12* is shown location of main producers of wood fuel. Latvian producers have more competitive situation in contrast to Estonian factories.

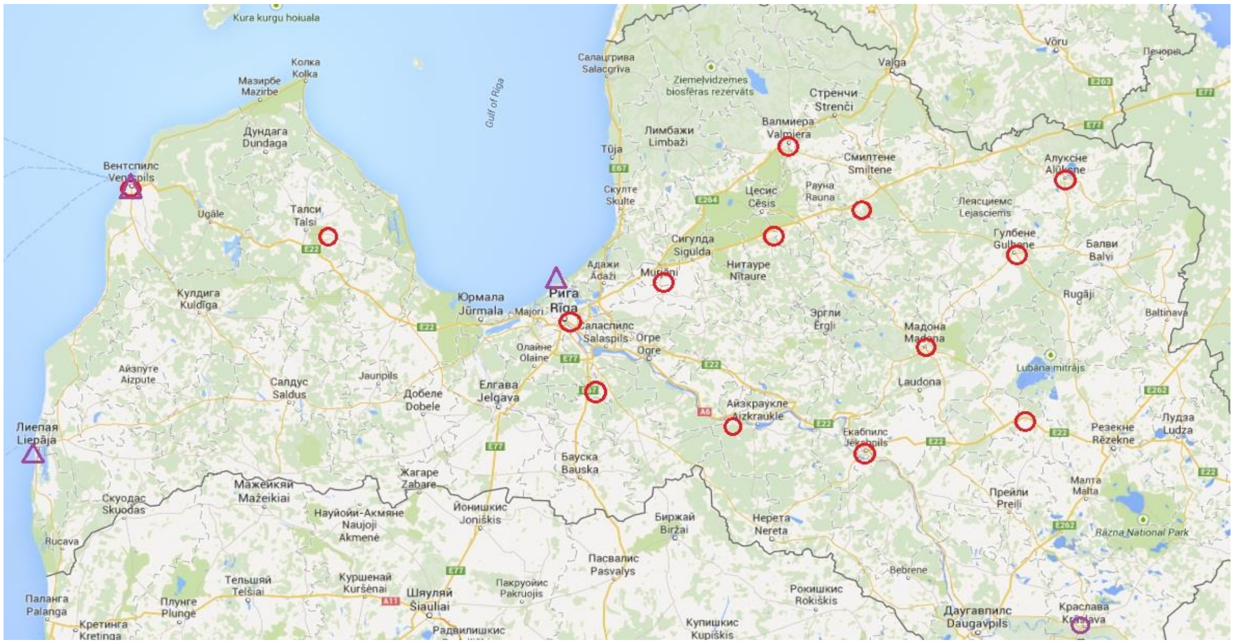

Figure 12. Wood fuel producers in Latvia. Source: Google maps, 18.12.2014

The largest exporting port is Riga port with multiple pellet export terminals, further are going through other ports: Ventspills and Liepaja. They are also using terminals for storing wood fuel.

Accordingly to an interview with Mariter Ltd., trader of wood fuel in Estonia, there was mentioning of main costs for transport wood fuel to harbour, especially to Liepaja and Riga port. Basically, industrial wood pellets prices are termed FOB Liepaja harbour is approximately 115-130 eur/t and FOB Riga harbour is 110 eur/t. Wood chips transport from 200 km inland to harbour would cost around 8 eur/m3.[54]

In comparison to FOB Estonian ports, the prices are the same, but FOB Riga has the winning place, accordingly delivery wood pellets to harbour. Additionally, the prices are varying due to wood pellets specifics, e.g differences between ashes, 0,7% – premium, 1% - good,

[54] Interview – Mariter ltd, trader of wood fuel, 2014

1.5% – medium, also the sizes, density and caloric values. Likewise, related to wood chips delivery are termed FOB is cheaper in Latvia than in Estonia (10 eur/m^3).

Furthermore, have been benchmark port dues and charges in Port of Liepaja and Port of Riga. According to *Appendix 3* data , the charges in Port of Liepaja are significant lower than in the port of Riga. In contrast with port dues and charges in Estonian ports, the author could emphasize, that in Port of Liepaja there are much lower dues according to *Appendix 2* and *Appendix 3*.

Port dues and charges in Port of Riga and Port of Liepaja are not so differ as shown in *Appendix 3*. Futhermore, they are almost identical. Of course, they are not including other dues related with unpredictable situation or additional services like using port's auxiliary machine, repairing services, electricity, supplying with necessary goods, waster removing and etc.

The next step will be calculation shipping cost through the Port of Liepaja and Port of Riga to Hambug, Germany. The distance from the Port of Liepaja and Port of Riga to Hamburh through the Kiel channel are the same and will be around 3 days. The loading rate in the port of Liepaja approximately 2000-3000 t/twenty-four hours for wood pellets, so 4000t will be loaded during 32 hours and 20 hours for wood chips[55] Also documentary process will take about 5 hours, so the whole process will take about 2 days in port Liepaja for loading wood pellets and 1 day in Port of Hamburg. As a concern, loading rate in port of Riga is unknown, due to the absence of necessary information.

Result from calculation shows:

1. Transport prices of wood pellets to port of Hamburg, Germany using HFO fuel:

Appendix 10. Port of Liepaja – 19.6 €/t

2. Transport prices of wood pellets to port of Hamburg, Germany using MDO fuel:

Appendix 10. Port of Liepaja – 19.16 €/t

3. Transport prices of wood chips to port of Hamburg, Germany using HFO fuel:

Appendix 11. Port of Liepaja – 12.48 €/m^3

4. Transport prices of wood chips to port of Hamburg, Germany using MDO fuel:

Appendix 11. Port of Liepaja– 12.2 €/m^3

[55] Interview – Mariter ltd, trader of wood fuel, 2014

Additionally was found Latvian delivery prices of wood fuel to port of Hamburg and to end-users in Berlin, Germany, see *Table 6*:

Table 6. Latvian deivery wood fuel prices with ROI and NPV

	P (prices)	Profits	ROI	NPV (7%)	
Latvian delivery prices through port of Liepaja to port of Hamburg, Germany (CIF) concerning consumption HFO for maritime transportation					
Wood chips P_{c5}	22.91 €/m3	2.54	11%	2.5	Positive
Wood pellets P_{c6}	145 €/t	52	35%	51.8	Positive
Latvian delivery prices through port of Liepaja to port of Hamburg, Germany (CIF) concerning consumption MDO for maritime transportation					
Wood chips $P_{c5.1}$	22.63 €/m3	2.82	12%	2.7	Positive
Wood pellets $P_{c6.1}$	144.3 €/t	52.7	37%	52.5	Positive
Latvian delivery prices through port of Liepaja to end-users in Berlin, Germany (DAP) concerning consumption HFO for maritime transportation					
Wood chips P_{c7}	31.51 €/m3	-6.06	-19%	-6.11	Negative
Wood pellets P_{c8}	160 €/t	37	23%	36.6	Positive
Latvian delivery prices through port of Liepaja to end-users in Berlin, Germany (DAP) concerning consumption MDO for maritime transportation					
Wood chips $P_{c7.1}$	31.23 €/m3	-5.78	-18%	-5.8	Negative
Wood pellets $P_{c8.1}$	159.48 €/t	37.52	23%	37.1	Positive

Source: Provided by author, 2014

As a result calculation is revealed that export through Latvian port of Liepaja is much profitable than through Estonian ports, besides export wood chips to port of Hamburg with further delivery to end-users in Berlin. However, port of Riga will approximately have the same result, author cannot calculate the precise price due to insufficient information. Latvia was always the main competitor for Estonia, and have suitable price for buyers and trader to export and import different cargo type. Certainly for exporting wood fuel, it all depends on location of cargo. Supposedly, that if a factory is located somewhere in center of Estonia, it will be unambiguously the export through Port of Pärnu or Port of Kunda, due to short transportation distances to harbours and quite profitable for producers and traders. The reason is inland transportation costs per tonnes or cubic meters, the greater distance, the higher transport costs.

Latvia export shows great results related to export between 2012 and 2013 yeasr, see *Figure 13*. And it proves that Latvia wood pellet market are well developed in comparsion to Estonian, Lithuanian and Finland market.

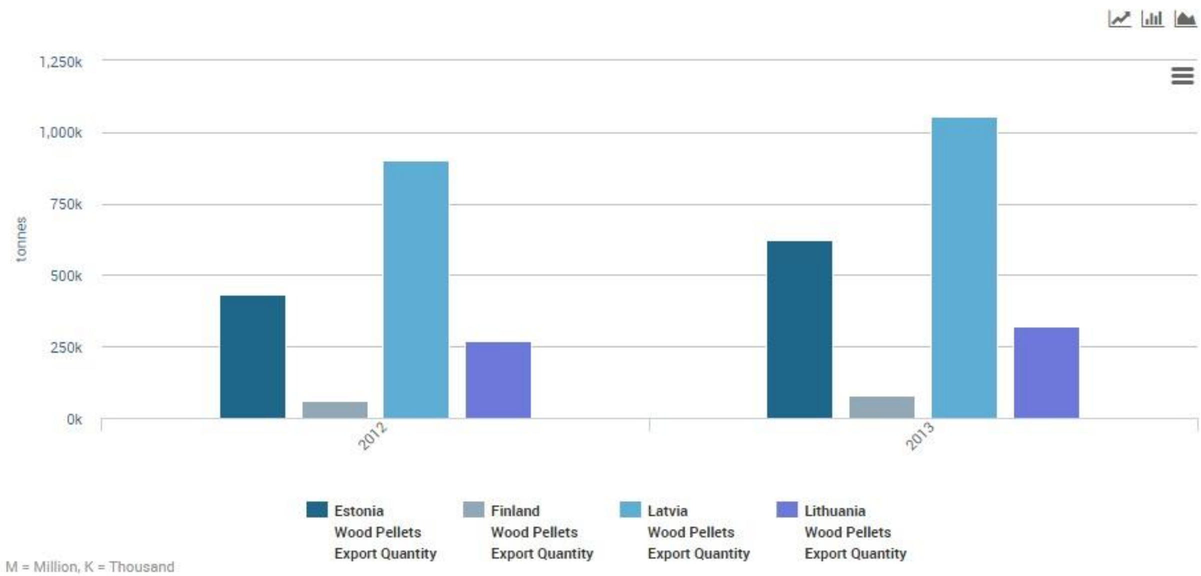

Figure 13. Wood pellets export from Estonia, Latvia, Lithuani and Finland. Source: FAOSTAT[56]

3.4 Risks

3.4.1 Production risks

According to the pellet production process the main risks are the raise of new capital, the investments to obtain a new technology in time, as well as the cost-effective operation. And of course, sufficiently the raw material supply for production of wood pellets and wood chips. Additionally, there could appear to be less demand in EU market, due to warm weather and

[56] Food and Agriculture Organization of the United Nations, 2014

previous wood fuel in Germany have been storing in significant quantities. Therefore, factories are reducing production or searching for new customers.[57]

At the moment, in Estoniam it is not intended to use wood fuel for own commercial energy production. Enterprises are preferring more shale, compared to wood pellets or wood chips. But some technologies for eletricity and heat plants are still in the trial stage and not ready to use fully. However, the view will be changed, when new technology will be ready and tested for using energy production. In that way, Estonia could stop the export of wood fuel to EU countries, and will begin to use for domestically consumption.

3.4.2 Transportation risks

Transportation is highly depending on the load volumes and frequency ability of shipping the wood fuel over the short distances. It is economically profitable to transport with high frequency, due to discounts in the port of loading and discharging, as well as storing discounts. The infrastructure for logistic operations is a crucial aspect with significant cost differences, depending on the availability of suitable port handling equipment as was analyzed in previous chapters. Timely delivery to harbour and loading wood fuel will reduce emergence of vessel's demurrage. The shipping of wood fuel is operated by dry bulk transportation companies and generally underlies extremely fluctuating freight rates, due to new shipping rules, volatility fuel and demand of goods and instability of EU market. These variations influence operating costs for different kind of vessels, fuel, crews as well as the degree of matching supply and demand of transported wood fuel, frequency of transport routes and available ship capacity. For maritime shipping in the Baltic region, the Coaster Freight Index is the common price indicator like the Baltic Dry Index for *Handysize*, *Handymax* and *Panamax* kind of vessels. It records current coaster shipping rates for transporting dry bulk goods on the main and most frequented trade routes.

In the same way, maritime transportation is influenced by some factors related to the shipping costs, which have not been considered in the thesis. Firstly, several ports in EU, especially port of Hamburg have additional surchages for Sundays and holidays. Moreover,

[57] Interview – Mariter ltd, trader of wood fuel, 2014

loading and discharging processes can be prolonged due to unexpected complications related to force majeure such as weather conditions, equipment malfunction and other reasons. Thus, all this options could cause delays for the transport. And the aftermath will push result in additional costs for the demurrage, charter party and other costs.

Unfortunately, there are no any indicators for the EU inland transport by truck and train. In Estonia, wood fuel factories have an own transport to delivery cargo till Estonian ports and using the train is not economically profitable. Additionally, there is a lack of efficient back haul. Competitive shipping rates often depend on shipping companies arranging two way flows of products. This is often impossible and ships return empty, thus placing the costs of a two way trip on one cargo.[58]

3.4.2 Market prices

In the EU market, before wood fuel import, the supply price is determined by exchanges like APX Endex, which reports the actual set market prices in trades and orders for wood pellets since the beginning of 2008 at the ARA ports, see *Figure 14*. It is transparent operating platform and Europe's premier provider of power exchange and clearing services for the wholesale market.[59] In thesis, Estonian's price of wood pellets on FOB term is equal to approximately 26.3 €/MWh and 13.5 €/MWh for wood chips. According to delivery wood pellets on CIF terms the price is 32.35 €/MWh and wood chips (spruce with 30% content of moisture) price is around 37.11 €/MWh.

[58] Logistic management of wood pellets: Data collection on transportation, storage and delivery management, 2009 p.16
[59] APX Group, 2014

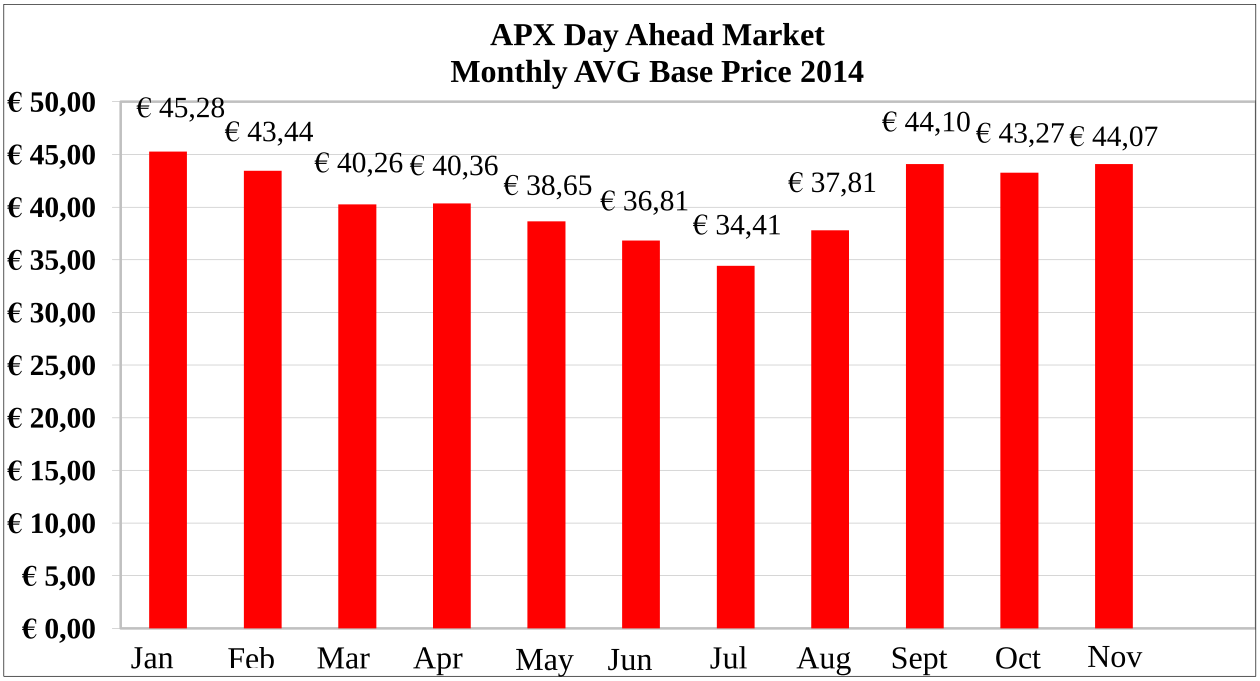

Figure 14. APX Endex average prices of wood fuel EUR/MWh. Source: APX Endex, 2014

Wood fuel prices could be slightly reduced, since the volatility of fossil fuel prices is much stronger and more likely to affect wood fuel prices. As for fossil fuels, pellet supply contracts include a number of provisions with fixed prices, inflators, specific index-based price adjustments or collars. Occasionally, some companies are using their access to financial hedging the freight rate and fuel. Additionally, agreements of supply the wood fuel are mainly made bilaterally directly between producers and traders/buyers. For instance, freight rates are generally fixed between wood fuel buyers and vessel operators, thus the price is effectively uncoupled from the market over this period.[60] Some buyers follow the strategy to diversify supply contracts and use a network of producers from different economies. On the contrary,wood fuel producers should diversify their sales markets. Additionally even price fixed supply from one producer to one end-user bears high price risks when market prices have prohibitively changed after that period. Usually countries, where exporting is well-developed, wood fuel market have benefits from specialised production and logistics. And this allows market actors to offer larger volumes to the market and provide additional flexibility and capabilities to reallocate supply and therefore to stabilise prices. As for suppliers, also regional, neighbouring or closely linked trade markets

[60] Ehrig, R., Behrendt, F., Wörgetter, M., Strasser, C. - Economics and Price Risks in International Pellet Supply Chains, 2014, p. 47-48

like Estonia should be considered to avoid unstable transportation efforts and risks connected with prices fluctuations. Furthermore during growth of the global wood pellet market, producers and buyers is expected to allow for better allocation and stability of its trade.

Additionally, freight rates are very fluctuative, sometimes increasing and decreasing, and it would be interesting to see how react the market for wood fuel and the market for secondary energy. A factor which influences wood fuel market is the increasing pelletizing facilities in Estonia and somewhere in other countries. The perspective increasing industrial pellet supply will not match the increasing European demand.

Furthermore, trading wood fuel is not as dangerous as transporting oil since a nautical accident in the sea can cause an environmental disaster with unexpexted consequential costs to clean the polluted environment.

Also there is factor related to the human’s psychology and should be considered as well. If the European public views of wood fuel production, shipment to EU for burn in cogeneration plants is just unnecessary business and just wasting energy for generation eneregy without low carbon dioxide, so they could change their views and convince governments to stop import of wood fuels. People could go to protest against such intentions.

The European progress on the Renewable Obligations Certificates trade and the decrease of nuclear power supply combined with the development of the European economic growth are factors which can influence the European primary and secondary energy market to unexpected developments. This could result in a new recession period, which increase unemployment, and as a result people plug the nuclear power station again to produce more cheaper electricity for further industry work.

3.5 Value-adding capabilities

In this thesis, it has been pointed out the main links of ports in the transportation chain of wood fuel. The harbours are taking significant strategy to wood fuel export business. And due to two major factors make some ports more favorable than other ones.

The factors are following:

1. FOB price;
2. Port efficiencies.

The main storage facilities as were mentioned above, have to be located at port terminals, which could provide two main advantages. Consequently, it is regular transport with well efficiency and low costs.

It also reduces the time from order to destination by moving the product closer to consumer. For instance, in Riga harbour there are ongoing projects of terminal increasing efficiency of wood fuel handling. It is conveyor belt systems and trials with different equipment setups. Also it shoud reduce costs and increase speed. Simultanepusly, in port of Pärnu the same system for wood fuel handling is implemented.

As concern to prices on FOB terms, it has been discussed as an average export delivery price in *Chapter 1.1.1*. However, in practice the price for delivery termed FOB can vary widely across ports. Estonian’s major wood fuel producers like Graanula Invest and Stora Enso have factories, near the ports with competitive FOB prices, see *Figure 15*.

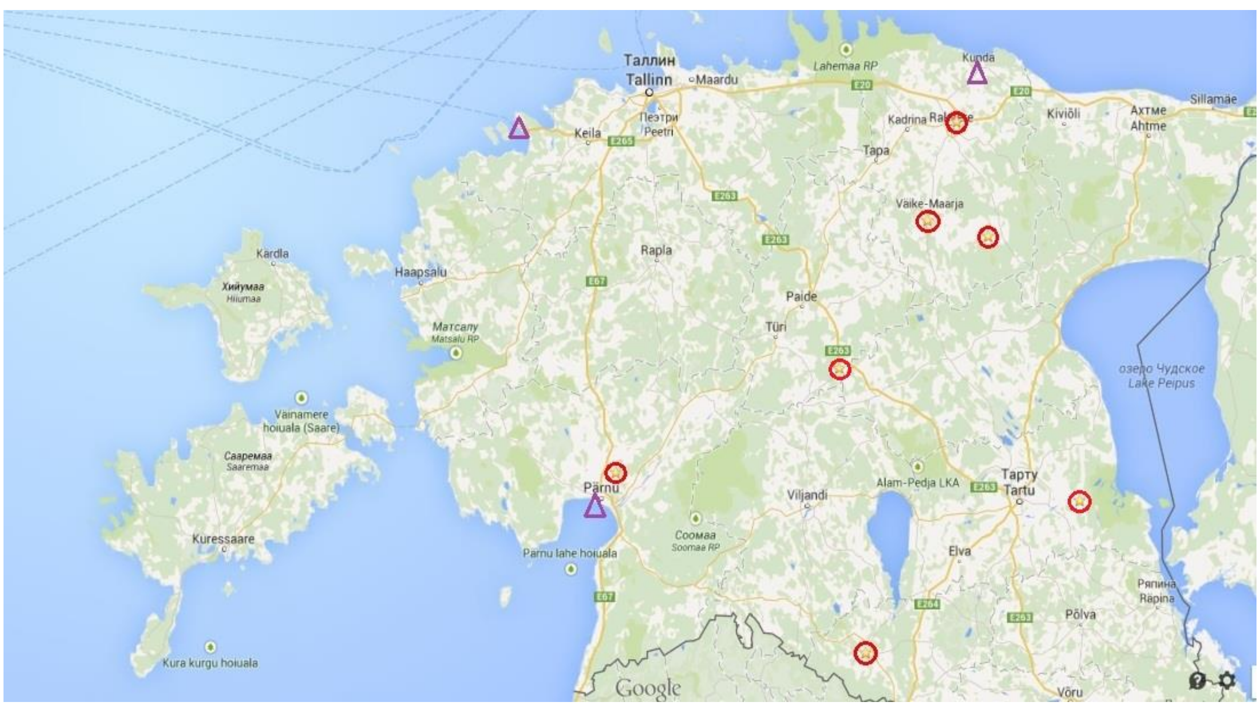

Figure 15. Wood fuel manufactories in Estonia near harbours. Source: Google Maps, 2014

Also each Estonia ports have wide variation in their efficiencies and it could be reflected by dock facilities, connections to inland transportation routes, harbour channel depth and tidal movement, congestion level and other aspects. Port efficiency for port Kunda, Paldiski South Harbour and port of Pärnu could be an important determinant of shipping costs. Some producers of wood fuel, could make a cluster with Estonian ports for increased efficiency and make reduce costs for distribution. Therefore, innovative equipment for handling wood fuel and proximity to Estonian ports with already existed transportation routes should be considered for suitable shipment with reduced termed FOB costs. In *Figure 15* most important Estonian ports are shown, where are usually occuring shipments of wood fuel, more detailed information could be see in *Chapter 2.2*

In the thesis the value-adding process of wood fuel export from Estonian ports to end-users (electricity or heating plant in Germany) are shown, where could be seen in *Figure 16*. Consequently, at the chain started process are given price termed FOB and the end-user price is represented as purchase price of wood fuel. Between delivery of wood fuel to harbour for export and end-users are shown port charges, loading and discharging costs, shipping freight costs and inland transportation costs within Germany area around (300 km). All costs and economically profitablity for exporting wood fuel to end-users in Germany were analized in this thesis at *Chapter 2*.

Figure 16. Value-adding process of wood fuel export, 21.12.2014

3.5.1 Loading and discharging equipment

Wood fuel handling could be a difficult process , especially for wood pellets, due to their fragile characteristics, and could also swell and fall apart because of absorbing water. As for wood chips, then it could change their moisture content and reduce it costs. Handling process also causes a lot of dust, which could be danger for all, due to possibility of flame. Thus, specail designed equipment and measurements have to be involved in harbours for minimizing the impact of handling on wood fuel.

There a lot of new innovative equipment, like pneumatic loading and discharging, which is widely used in dry bulk cargo, however for wood pellets, it is not recommended, so it could be replaced by belt conveyor like in Port of Pärnu. Belt conveyor are most suitable handling method, but on the other hand, it has to be equipped with a special system for overheating to reduce flammable risks. Wood fuel producers may cooperate and create a cluster with ports and terminals for investing in the facilities for handling. Besides, a detailed analysis of wood fuel market for making long-term investments should be done.

3.5.2 Port dues and charges

Port dues could be used to improve the efficiencies of port to satisfy cargo owners and shipowners. As was analyzed in the thesis, port dues and charges play a significant role. For example, *Appendix 3* with Latvian port dues and charges have more competitive dues in comparison with *Appendix 2* - Paldiski South Harbour, Port Kunda, Port of Pärnu dues and charges.

Through Estonian ports is profitably to export wood fuel, if manufacturers are situated near the port. Perhaps in near future, the port dues will be reviewed, especially tonnage dues. Reducing it by 20 % could significant improve competitiveness of Estonian export through its harbours.

CONCLUSION

The European demand for renewable energy is strongly increasing in the course of a new energy policy. The new European policy limits the use of non renewbale energy sources for reaching EU target 20-20-20 by 2020. Furthermore, European countries, in thesis matter some resources in Germany are not sufficient for the unexpected demand and regions relies on imports from other countries. In general, Estonia has a low domestic consumption of wood fuel and opportunity of its export through local ports is the best way for expansion production and increasing economic factors. Additionally, export will be given value-added capabilities for Estonian ports and will enhance its competitiveness.

As a result, accordingly to Estonian statistics, the export of wood pellets from Estonia for 2013 year amounted 623 049 t, which is much more than for 2012 and 2011 year, see *Figure 5*. Also the export of wood chips have reduced significantly, about 13 529 t per 2013 year, see *Figure 6*.

The aim of this thesis was to analyze the profitability of the export wood fuel through Estonian ports and give a valid assessment. In the same way, during this thesis, reader could notice a more profitable kind of wood fuel, harbours and their handling facilities, type of transport, the charter conditions and routes. Also the full cost transportation, current market prices for energy wood, fuel oil prices were submitted too. The analysis focused on the export from Estonia, but in addition benchmarking to Latvian wood fuel producers and transportation through Latvian ports was included.

Additionally, several scenarios were analyzed to define the efficiency of export wood fuel through Estonian ports and to find the most favourable condition. Some aspects, for example CO_2 mitigation and energy consumption during transportation were disregarded.

Main results are as follows:

1. The greatest profit with 7% interest rate per annum could be gain by transporting wood pellets from Paldiski South Harbour, Estonia to the German hinterland with including HFO fuel for maritime shipments. The prices supposed by producers, ROI and NPV are following:
   Delivery to port of Hamburg, Germany (CIF);
   Wood chips: P_{c1} = 28.54 €/m^3 ; Profit = -3.09 €; ROI = -11%; NPV = -3.1;
   Wood pellets: P_{c2} = 153.7 €/t ; Profit = 43.3 €; ROI = 28%; NPV = 43
   Delivery to end-users in Berlin, Germany (DAP);
   Wood chips: P_{c3} = 37.16 €/m^3 ; Profit = -11.71 €;ROI = -32%; NPV = -11.8;
   Wood pellets:P_{c4} = 168.88 €/t; Profit = 28.12 €; ROI = 17%; NPV = 28.57;
2. For comparsion result, additionally was made calculation with 7% interest rate per annum for export wood fule throught Paldiski South harbour to port of Hamburg, but only with using MDO fuel for maritime shipments. Due to Directive 2012/33/EU forced EU Member States to ensure that ships in the Baltic, the North Sea and the English Channel are using fuels with a sulphur content of no more than 0.10% from 1 January 2015. The prices prices supposed by producers, ROI and NPV are following:
   Delivery to port of Hamburg, Germany (CIF);
   Wood chips: $P_{c1.1}$ = 27.89 €/m^3 ; Profit = -2.44 €; ROI = -9%; NPV = 2.5;
   Wood pellets: $P_{c2.1}$ = 152.68 €/t ; Profit = 44.32 €; ROI = 29%; NPV = 44
   Delivery to end-users in Berlin, Germany (DAP);
   Wood chips: $P_{c3.1}$ = 36.51 €/m^3 ; Profit = -11.06 €; ROI = -30.3%; NPV = -11.1;
   Wood pellets:$P_{c4.1}$ = 167.87 €/t; Profit = 29.13 €; ROI = 17.3%; NPV =28.6 ;
   As a result, due to unstability and enormous volatality of fuel oil prices in the world, using MDO for cargo transportation is profitable, but only in this matter, if vessel's MDO consumption is not exceed than 8 t/d during voyage. At the same way wood chips delivery to Gemany are not giving positive results, accordingly to financial indicators of ROI and NPV.
3. More appropriate terminal for handling wood fuel are situated in Paldiski South harbour and could be used for wood fuel export.

4. Wood pellets gives more profits than wood chips, according to calculation results. Moreover, wood pellets are easier to handle and transport, have more value caloric, less water content and low amount of ash. That is why, to make more profitable cargo and shipment more efficient, then wood chips should be converted to wood pellets.
5. Benchmarked result of Latvian market has shown more competitiveness results, due to low port dues and charges and good developed production of wood fuel. Comparing Estonian market to Latvian market, trading wood fuel from Latvia to Berlin via port of Hamburg are following:
   Delivery to port of Hamburg, Germany (CIF):
   Wood chips: P_{c5} = 22.91 €/m^3;Profit = 2.54 €; ROI = 11%; NPV = 2.5;
   Wood pellets: P_{c6} = 145 €/t; Profit = 52 €; ROI = 35%; NPV = 51.8
   Delivery to end-users in Berlin, Germany (DAP):
   Wood chips: P_{c7} = 31.51 €/m^3; Profit = -6.06 €; ROI = -19%; NPV = -6.11;
   Wood pellets:P_{c8} = 160 €/t; Profit = 37 €; ROI = 23%; NPV = 36.6;
   As for using MDO for cargo transporation by sea, results are following:
   Delivery to port of Hamburg, Germany (CIF):
   Wood chips: $P_{c5.1}$ = 22.63 €/m^3; Profit = 2.82 €; ROI = 12%; NPV = 2.7;
   Wood pellets: $P_{c6.1}$ = 144.3 €/t ; Profit = 52.7 €; ROI = 37%; NPV = 52.5
   Delivery to end-users in Berlin, Germany (DAP):
   Wood chips: $P_{c7.1}$ = 31.23 €/m^3; Profit = -5.78 €; ROI = -18%; NPV = -5.8;
   Wood pellets:$P_{c8.1}$ = 159.48 €/t; Profti = 37.52 €; ROI = 23%; NPV = 37.1;

Therefore, the hypothesis „*Wood fuel demand will be increased in Europe, especially in Germany and supply is cost-effective, so it will give an opportunity to enhance the value-added servces of Estonian ports through wood fuel export*." could be confirmed, since the near future demand will increased, accordingly European commission for Renewable energy and analyzed data in *Chapter 1*.

Today's prices for wood fuel are falling down, because of market instability. In spite of this, the main Estonian export aims still to Finland, Sweden, UK, Denmark and Germany markets, which gives Estonian economic stability. During analysis of some scenarios were identified the most significant factors and their changes could affect the overall cost of wood fuel in general.

In thesis matter, the high and important impact to wood fuel export regarding the production, transportation and market volatility is not presented during calculation costs. The changed economic climate has also impact on the development of new renewable energy projects concerning Renewable Energy Progress Report[61] by European Commission. For reducing risks, it is preferrable to hedging the freight rate and fuel. Additionally, agreements of supply the wood fuel are mainly made bilaterally directly between producers and traders/buyers. For instance, freight rates are generally fixed between pellet buyers and vessel operators, thus the price is effectively uncoupled from the market over this period.

With an increase in wood fuel export through Estonian ports, this will have great potential in the extention of the port structure and increasing cargo handling effectiveness for being more competitiveness. Also gives opportunity for additional investments flow from stakeholders, due to master thesis has a practical essence.

[61] Report from the commission. Brussels, 27.3.2013, p.13

RESÜMEE

Magistritöö eesmärk on analüüsida energiapuidu eksporti läbi Eesti sadamate ja hinnata selle efektiivsust. Saadav tulemus annab omakorda võimaluse hinnata, kui kasumlik on eksportida antud tooteliiki ja kuidas see mõjutab Eesti sadamate arengut ning nende infrastruktuuri laiendamist. Samuti aitab see lahendada investeerimisega seotud põhiprobleeme. Potentsiaalsed investorid võivad käesolevast tööst saada ideid uue äriliigi rajamiseks või juba olemasoleva arendamiseks.

Tänapäeval areneb Euroopas aktiivselt taastuvenergia kasutamine. Vastavalt Euroopa statistikale kasvab nõudlus taastuvenergia järele iga aastaga. Aastal 2009 võttis Euroopa Liidu bioenergeetika komisjon vastu taastuvenergia kasutamisega seotud direktiivi 2009/28/EC, mille strateegiliseks eesmärgiks on vähendada aastaks 2020 süsinikdioksiidi heitmeid atmosfääri 20% võrra, suurendada taastuvenergia tarbimist 20% võrra ja parandada ka selle kasutamise efektiivsust 20% võrra. Taastuvenergia allikad on päike, tuul, vesi ning puit. Antud magistritöö uurimisobjektiks on puidust saadav kütus – puidugraanulid või pelletid ja puiduhake. Eesti siseturul kasutatakse puidugraanuleid ja puiduhaket praegu veel vähe, kuid antud kütuseliigi tööstus on kasvuteel. Toodete realiseerimiseks tuleb aga arendada eksporti lääneriikidesse, eelkõige Saksamaale, Rootsi, Inglismaale ja Taani, kus puitkütus on suureahuliselt kasutusel elektri- ja soojusjaamades.

Antud magistritöös on kasutatud nii kvalitatiivset, statistilist kui ka võrdlevat uurimismeetodit.

Kvalitatatiivse meetodi rakendamiseks tehti intervjuud alltoodud ettevõtete spetsialistide ja juhtidega:

- Siim Liblik –Storan Enso logistikajuht;
- Melanie Zenker – vanemkonsultant, C.A.R.M.E.N e.V Energy Department;
- Dmitri Nikitin – Mariter Ltd. müügijuht;
- Urmas Urgard – ESTEVE Terminal AS osakonnajuhataja;
- Aleksander Nikolajev – Port Kunda direktor;
- Anton Sudorenko –PakriChart Ltd. agent.

Statistilised andmed on saadud Eesti Statistikaametist ja Saksamaa Energeetikaagentuuri analüüsist.

Magistritöö esimeses osas on analüüsitud Lääne-Euroopa puitkütuse turgu. Aluseks on võetud Saksamaa turg. Antud analüüs näitab ära turu hetkeolukorra ja selle muutumise tendentsid mõne lähema aasta jooksul. Samuti on analüüsitud ka Eesti turgu, mis võimaldas hinnata tootmise arendamise dünaamikat antud valdkonnas.

Teises osas on iseloomustatud puitkütuse transportimise kogu tsüklit tootmiskohast kuni Saksamaa lõpptarbijani. Lähemalt on vaadeldud kolme puitkütuse veoga tegeleva põhisadama – Paldiski Lõunasadama, Kunda sadama ja Pärnu sadama tööd. Käsitletud on vedamiseks kasutatavate laevade liike, läbi on viidud mereveo analüüs ja arvutatud energiapuidu veoketi kulud alates tootjast kuni lõpptarbijani.

Kolmandas osas on toodud ekspordi efektiivsuse hinnang ja arvutatud järgmised indikaatorid: kasum (*Profit*), investeeringu tõhusus (*ROI*) ja nüüdispuhasväärtus (*NPV*). Tõestatakse, et energiapuidu eksport läbi Eesti sadamate on efektiivne ja võimaldab kasumit teenida. Lisaks võrreldakse Eesti ja Läti puitkütuse eksporditurge, tuuakse välja võimalikud riskid, mis mõjutavad energiapuidu nõudlust, maksumust ja transporti. Pakutakse välja suunad, mis võimaldavad suurendada puitkütuse sadamates käitlemise efektiivsust.

Kõik analüüsi käigus saadud tulemused on suhtelised, sest selliseid riske nagu turu muutus maailmamajanduse ebastabiilsuse olukorras, teiste kütuseliikide hindade muutus, aastaaegade ja inflatsiooni mõju pole võimalik täies ulatuses arvesse võtta.

Tähtsamad järeldused on toodud allpool:

1. Suurema kasumi annab transportimine läbi Paldiski Lõunasadama Saksamaale (arvutused tehtud eeldusel, et mereveol kasutatakse kütusena HFO-d).

   Veol Hamburgi sadamasse on tulemused järgmised (CIF):

   Puiduhake – P_{c1} = 28.54 €/m^3; Kasum = -3.09 € ; ROI = -11%; NPV = -3.1;

   Puidugraanulid – P_{c2} = 153.7 €/t; Kasum = 43.3 €; ROI = 28%; NPV = 43.

   Veol lõpptarbijani Berliinis (DAP):

   Puiduhake – P_{c3} = 37.16 €/m^3; Kasum = -11.71 €; ROI = –32%; NPV = –11.8;

   Puidugraanulid – P_{c4} = 168.88 €/t; Profit = 28.12 €; ROI = 17%; NPV = 28.57.

2. Tulemuste võrdlemisel arvestati intressimäära 7%, mereveo kütusena aga MDO-d, sest vastavalt EL direktiivile 2012/33/EU peavad kõik Euroopa Liidu liikmesriigid alatest 1. jaanuarist 2015 tagama, et mereveol kasutatud kütuse väävlisisaldus ei oleks suurem kui 0,10%.

   Vedu Hamburgi sadamasse (CIF):

   Puiduhake – $P_{c1.1}$ = 27.89 €/m^3; Kasum = -2.44 €;ROI = -9%; NPV = 2.5;

   Puidugraanulid – $P_{c2.1}$ = 152.68 €/t; Kasum = 44.32 €; ROI = 29%; NPV = 44.

   Vedu lõpptarbijani Berliinis (DAP):

   Puiduhake – $P_{c3.1}$ = 36.51 €/m^3; Kasum = -11.06 €; ROI = -30.3%; NPV = -11.1;

   Puidugraanulid – $P_{c4.1}$ = 167.87 €/t; Kasum = 29.13 €; ROI = 17.3%; NPV = 28.6.

   Kütuseturu muutuste tagajärjel on praegune kütuse hind langenud. Seetõttu on energiapuidu merevedu MDO-d kasutades nüüd efektiivsem, kuid ainult sel juhul, kui laeva kütusekulu ei ületa sõidu ajal 8 tonni ööpäevas.

3. Järeldus: puiduhakke ekspordikasum on liiga väike. Seega on mõttekam vedada puiduhakke asemel pelleteid, mida on laadimis-lossimistöödel kergem käidelda, mugavam ladustada ja mis on ka finantsplaanis kasumlikumad.

4. Eesti ja Läti energiapuidu ekspordi võrdlev analüüs näitab, et veohinnad on erinevad. Põhjused: Lätis on sadamakulud madalamad, vahekaugus Hamburgi sadamaga on väiksem ja energiapuidutööstus on rohkem arenenud, mis teeb kauba saatmise läbi Läti sadamate efektiivsemaks.

Vedu Hamburgi sadamasse (CIF):

Puiduhake – P_{c5} = 22.91 €/m^3; Kasum = 2.54 €; ROI = 11%; NPV = 2.5;

Puidugraanulid – P_{c6} = 145 €/t; Kasum = 52 €; ROI = 35%; NPV = 51.8;

Vedu lõpptarbijani Berliinis (DAP):

Puiduhake – P_{c7} = 31.51 €/m^3; Kasum = -6.06 €; ROI = -19%; NPV = -6.11;

Puidugraanulid – P_{c8} = 160 €/t; Kasum = 37 €; ROI = 23%; NPV = 36.6.

Samuti on tõestatud hüpotees, et Euroopas, eriti Saksamaal, energiapuidu nõudlus suureneb, seega muutub ka tarnimine efektiivsemaks. Siit tulenebki, et Eesti puidueksport võib arendada lisandväärtust Eesti sadamate piirkonnas.

Analüüsides energiapuidu eksporti läbi Eesti sadamate on tuvastatud, et kõige ökonoomsem puidugraanulite vedamise viis pikkade vahemaade taha on meritsi ja isegi kõigi ebasoodsamatel asjaoludel osutuvad puidugraanulite ekspordiga tegelevad ettevõtted kasumlikuks. Investorite kaasamine võimaldaks suurendada puidugraanulite tootmist ning tagada sadamate pideva töö.

Antud magistritöö omab praktilist väärtust ja võib leida kasutust Eesti puitkütuse müügituru arendamisel.

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APPENDICES

Appendix 1. Specification of m/v Paula Vindo

Main dimensions

Length over all	106.86 m.
Length b.p.p.	100.62 m.
Breadth mld.	15.20 m.
Depth mld.	6.60 m.
Depth to upperdeck	8.70 m.
Design draught	5.25 m.
Deadweight	5.400 mtons.
Gross Tonnage	4.102 GT.
Nett Tonnage	1851 NT.
Hold capacity (GR&BL)	6283 m^3
Trial speed at 5.25 m	12.45 knots.

Propulsion

Main engine:	MaK 6M25
Output:	1980/2010 kW
Gearbox:	Renk;Resita
C.P.P. with tunnel:	Berg
Flap rudder:	Barkemeijer
Steering gear:	v/d Velden
Bowthruster:	300kW

Classification

Two cargoholds, covered with 12 steel hatchcovers, handled by a gantry crane.
Box-shaped holds with vertical sides.
Tanktop area 926 m^2

Tank capacities

Fuel oil (IFO 180)	abt. 200 cubm.
Fuel oil (Gasoil)	abt. 30 cubm.
Fresh Water	36 cubm.
Ballastwater	2888 cubm.

Source: Royal Bodewes, 2014

Appendix 2. Port dues and charges of three Estonian ports

Port dues and charges			
	Port Kunda	**Port of Parnu**	**Paldiski South Harbour**
Tonnage dues (4102 GT)	0.36 €/GT (**1476.72**)	-	0.82 €/GT (**3363.64**)
Berth dues (4102 GT)	0.20 €/GT (**820.4**)	0.52 €/GT (**2133.04**)	-
Channel dues (4102 GT)	0.32 €/GT (**1312.64**)	0.52 €/GT (**2133.04**)	-
Mooring and Unmooring dues (3001-5000 GT)	**286.32 €** (+ 25% if M-F 20:00 -08:00 or weekends)	**153.40 €**	**342 €**
Waste dues	0.03 eur/GT (**123.06**)	-	0.017 eur/GT (**69.7**)
Pilotage dues (port waters and outside of it (nm)) (3001-5000 GT)	387 € + 284 € = **671 €**	387 € + 193 €= **580 €**	387 € + 102 € = **489 €**
Waterway dues (for 4102 GT with other ice class or non ice class)	0.35 €/GT (**1435.7**)	0.35 /GT (**1435.7**)	0.35 €/GT (**1435.7**)
Towage dues	**319.56 €/h**	**287 €/h**	**~300 €/h**
Others dues*	**560 €**	**560 €**	**560 €**
Total dues for m/v Paula Vindo	**7,165.18 €**	**7,425.68 €**	**6,710.04 €**

Source: TS, Port Kunda, Port of Pärnu, 2014

Appendix 3. Port dues and charges in Latvian ports

Port dues and charges		
	Port of Liepaja	**Port of Riga**
Tonnage fee (4102 GT)	0.25 €/GT (**1025.5**)	0.8 €/GT (**3281.6**)
Sanitary fee (4102 GT)	0.06 €/GT (**246.12**)	0.1 €/GT (**410.2**)
Berth fee (4102 GT)	0.17 €/GT (**697.34**)	0.085 €/GT (**348.67**)
Canal fee (4102 GT)	0.25 €/GT (**1025.5**)	-
Mooring and unmooring dues (4102 GT)	0.27 €/GT (**1107.54**)	0.17 €/GT (**697.34**)
Pilotage dues (4102 GT)	0.17 €/GT (**697.34**)	**102 €**
Towage dues	**340 €/h**	**350 €/h**
Others dues*	**560 €**	**560 €**
Total dues for m/v Paula Vindo	**5,869.34 €**	**5,924.81 €**

Source: liepaja-sez.lv and rop.lv, 19.12.2014

Appendix 4. Calculation for estimating the freigh rate for 4000 t by coaster from Paldiski South Harbour to port of Hamburg

Voyage charter: daly rate of ship	$/d	3000	27000
Distance	nm		675
Speed	kn/h		8
Cargo	wood chips (t)		4000
Stowage factor	m^3/t	1.6	6400
Duration/sailing time			
Voyage	days		7
Duration loading	days		1
Duration discharging	days		1
Over all duration	days		9
Fuel consumption			
IFO180	t/d for the voyage	9	63
MDO	t/d at berth	1	2
MDO*	t/d for the voyage	5	35
Costs of bunker			
IFO180	$/t	346	21798
MDO	$/t	550	1100
Total	$		22898
Total*	$		20350
Overall costs $	$		49898
Overall costs $*	$		47350
Exchange rate	€/$	1.245	40079
Exchange rate*	€/$	1.245	38032
Kiel canal transit fee	€		1550
Port dues and charges according Appendix 2			
Paldiski South Harbour	€		6710
Port of Hamburg*	€		8500
Total costs	€		56839
Double costs per t	**€/t**		**28.41**
Total costs*	€		54792
Double costs per t*	**€/t**		**27.4**

*using only MDO fuel in SECA area
**lump sum
Source: Provided by author, 2014

Appendix 5. Calculation for estimating the freigh rate for 6283 m^3 by coaster from Paldiski South Harbour to port of Hamburg

Voyage charter: daly rate of ship	$/d	3000	27000
Distance	nm		675
Speed	kn/h		8
Cargo	wood chips (t)		2513
Stowage factor	m^3/t	2.5	6283
Duration/sailing time			
Voyage	days		7
Duration loading	days		1
Duration discharging	days		1
Over all duration	days		9
Fuel consumption			
IFO180	t/d for the voyage	9	63
MDO	t/d at berth	1	2
MDO*	t/d for the voyage	5	35
Costs of bunker			
IFO180	$/t	346	21798
MDO	$/t	550	1100
Total	$		22898
Total*	$		20350
Overall costs $	$		49898
Overall costs $*	$		47350
Exchange rate	€/$	1.245	40079
Exchange rate*	€/$	1.245	38032
Kiel canal transit fee	€		1550
Port dues and charges according Appendix 3			
Paldiski South Harbour	€		6710
Port of Hamburg**	€		8500
Total costs	€		56839
Double costs per m^3	**€/m^3**		**18.09**
Total costs*	€		54792
Double costs per m^{3*}	**€/m^3**		**17.44**

*using only MDO fuel in SECA area
**lump sum
Source: Provided by author, 2014

Appendix 6. Calculation for estimating the freigh rate for 4000 t by coaster from Port Kunda to port of Hamburg

Voyage charter: daly rate of ship	$/d	3000	27000
Distance	nm		675
Speed	kn/h		8
Cargo	wood chips (t)		4000
Stowage factor	m^3/t	1.6	6400
Duration/sailing time			
Voyage	days		7
Duration loading	days		1
Duration discharging	days		1
Over all duration	days		9
Fuel consumption			
IFO180	t/d for the voyage	9	63
MDO	t/d at berth	1	2
MDO*	t/d for the voyage	5	35
Costs of bunker			
IFO180	$/t	346	21798
MDO	$/t	550	1100
Total	$		22898
Total*	$		20350
Overall costs $	$		49898
Overall costs $*	$		47350
Exchange rate	€/$	1.245	40079
Exchange rate*	€/$	1.245	38032
Kiel canal transit fee	€		1550
Port dues and charges according Appendix 3			
Paldiski South Harbour	€		7166
Port of Hamburg*	€		8500
Total costs	€		57295
Double costs per t	**€/t**		**28.6**
Total costs*	€		55248
Double costs per t*	**€/t**		**27.62**

*using only MDO fuel in SECA area
**lump sum
Source: Provided by author, 2014

Appendix 7. Calculation for estimating the freigh rate for 6283 m³ by coaster from Port Kunda to port of Hamburg

Voyage charter: daly rate of ship	$/d	3000	27000
Distance	nm		675
Speed	kn/h		8
Cargo	wood chips (t)		2513
Stowage factor	m^3/t	2.5	6283
Duration/sailing time			
Voyage	days		7
Duration loading	days		1
Duration discharging	days		1
Over all duration	days		9
Fuel consumption			
IFO180	t/d for the voyage	9	63
MDO	t/d at berth	1	2
MDO*	t/d for the voyage	5	35
Costs of bunker			
IFO180	$/t	346	21798
MDO	$/t	550	1100
Total	$		22898
Total*	$		20350
Overall costs $	$		49898
Overall costs $*	$		47350
Exchange rate	€/$	1.245	40079
Exchange rate*	€/$	1.245	38032
Kiel canal transit fee	€		1550
Port dues and charges according Appendix 3			
Paldiski South Harbour	€		7166
Port of Hamburg*	€		8500
Total costs	€		57295
Double costs per m^3	**€/m^3**		**18.24**
Total costs*	€		55248
Double costs per m^{3*}	**€/m^3**		**17.59**

*using only MDO fuel in SECA area
**lump sum
Source: Provided by author, 2014

Appendix 8. Calculation for estimating the freigh rate for 4000 t by coaster from Port of Pärnu to port of Hamburg

Voyage charter: daly rate of ship	$/d	3000	27000
Distance	nm		675
Speed	kn/h		8
Cargo	wood chips (t)		4000
Stowage factor	m^3/t	1.6	6400
Duration/sailing time			
Voyage	days		7
Duration loading	days		1
Duration discharging	days		1
Over all duration	days		10
Fuel consumption			
IFO180	t/d for the voyage	9	63
MDO	t/d at berth	1	2
MDO*	t/d for the voyage	5	35
Costs of bunker			
IFO180	$/t	346	21798
MDO	$/t	550	1100
Total	$		22898
Total*	$		20350
Overall costs $	$		49898
Overall costs $*	$		47350
Exchange rate	€/$	1.245	40079
Exchange rate*	€/$	1.245	38032
Kiel canal transit fee	€		1550
Port dues and charges according Appendix 3			
Paldiski South Harbour	€		7426
Port of Hamburg*	€		8500
Total costs	€		57555
Double costs per t	**€/t**		**28.78**
Total costs*	€		55508
Double costs per t*	**€/t**		**27.8**

*using only MDO fuel in SECA area
**lump sum
Source: Provided by author, 2014

Appendix 9. Calculation for estimating the freigh rate for 6283 m^3 by coaster from Port of Pärnu to port of Hamburg

Voyage charter: daly rate of ship	$/d	3000	27000
Distance	nm		675
Speed	kn/h		8
Cargo	wood chips (t)		2513
Stowage factor	m^3/t	2.5	6283
Duration/sailing time			
Voyage	days		7
Duration loading	days		1
Duration discharging	days		1
Over all duration	days		9
Fuel consumption			
IFO180	t/d for the voyage	9	63
MDO	t/d at berth	1	2
MDO*	t/d for the voyage	5	35
Costs of bunker			
IFO180	$/t	346	21798
MDO	$/t	550	1100
Total	$		22898
Total*	$		20350
Overall costs $	$		49898
Overall costs $*	$		47350
Exchange rate	€/$	1.245	40079
Exchange rate*	€/$	1.245	38032
Kiel canal transit fee	€		1550
Port dues and charges according Appendix 3			
Paldiski South Harbour	€		7426
Port of Hamburg*	€		8500
Total costs	€		57555
Double costs per m^3	**€/m^3**		**18.32**
Total costs*	€		55508
Double costs per m^{3*}	**€/m^3**		**17.66**

*using only MDO fuel in SECA area

**lump sum

Source: Provided by author, 2014

Appendix 10. Calculation for estimating the freigh rate for 4000 t by coaster from Port of Liepaja to port of Hamburg

Voyage charter: daly rate of ship	$/d	3000	18000
Distance	nm		493
Speed	kn/h		8
Cargo	wood chips (t)		4000
Stowage factor	m^3/t	1.6	6400
Duration/sailing time			
Voyage	days		3
Duration loading	days		2
Duration discharging	days		1
Over all duration	days		6
Fuel consumption			
IFO180	t/d for the voyage	9	27
MDO	t/d at berth	1	3
MDO*	t/d for the voyage	5	15
Costs of bunker			
IFO180	$/t	346	9342
MDO	$/t	550	1650
Total	$		10992
Total*	$		9900
Overall costs $	$		28992
Overall costs $*	$		27900
Exchange rate	€/$	1.245	23287
Exchange rate*	€/$	1.245	22410
Kiel canal transit fee	€		1550
Port dues and charges according Appendix 3			
Port of Liepaja	€		5869
Port of Hamburg**	€		8500
Total costs	€		39206
Double costs per t	**€/t**		**19.6**
Total costs*	€		38329
Double costs per t*	**€/t**		**19.16**

*using only MDO fuel in SECA area

**lump sum

Source: Provided by author, 2014

Appendix 11. Calculation for estimating the freigh rate for 6283 m^3 by coaster from Port of Liepaja to port of Hamburg

Voyage charter: daly rate of ship	$/d	3000	18000
Distance	nm		493
Speed	kn/h		8
Cargo	wood chips (t)		2513
Stowage factor	m^3/t	2.5	6283
Duration/sailing time			
Voyage	days		3
Duration loading	days		2
Duration discharging	days		1
Over all duration	days		6
Fuel consumption			
IFO180	t/d for the voyage	9	27
MDO	t/d at berth	1	3
MDO*	t/d for the voyage	5	15
Costs of bunker			
IFO180	$/t	346	9342
MDO	$/t	550	1650
Total	$		10992
Total*	$		9900
Overall costs $	$		28992
Overall costs $*	$		27900
Exchange rate	€/$	1.245	23287
Exchange rate*	€/$	1.245	22410
Kiel canal transit fee	€		1550
Port dues and charges according Appendix 3			
Port of Liepaja	€		5869
Port of Hamburg**	€		8500
Total costs	€		39206
Double costs per m^3	**€/m^3**		**12.48**
Total costs*	€		38329
Double costs per m^{3*}	**€/m^3**		**12.2**

*using only MDO fuel in SECA area
**lump sum
Source: Provided by author, 2014