ARTICLES

Socio-Economic and Environmental Effects of Wood Fuel Use in Lithuania

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Abstract

The purpose of this study was to assess supply and demand for wood fuel as energy sources in Lithuania and to analyse economic, social and environmental effects of their extensive use. As a result it was stated that the quantities of wood fuel consumed constantly increased. Using of firewood and wood residues for generating energy the capital saved for unimported fuel is estimated at 36.3 million EURO (2003). The new suggested wood cutting technology with wood fuel production allows creating of at least 350 work places for each million m³ of wood fuel. Substitution of fuel oil by wood fuel improves the quality of the environment because of reduction of SO_X by 1.451 kt/PJ and carbon dioxide by 78.8 kt/PJ.

Key words: fuel wood resources, consumption, substitution of fuel oil, socio-economic, environmental effects

Introduction

In the developing countries biofuel is widely applied for producing energy. In the developed countries the part of vegetative biomass in the process of energy production is comparatively insignificant. However, recently an increase in its utilization is noted. Lithuania, as other Baltic states, share in this process an intermediate position.

Acceleration of wood use for energy purposes is crucially affected by many ecological and socio-economic aspects. First of all, in countries that have no fossil fuel wood waste is cheaper fuel than imported fuel. By using wood fuel for energy production in such countries the funds assigned for importing fossil fuel can be saved. Additionally to this, development of the infrastructure of gathering, processing and utilization of wood residues for energy production exerts influence on rural development, allows creation of new work places and decrease unemployment. The use of small–size wood also leads to more profitable forestry, particularly for use of such silvicultural measures as thinnings, intermediate and sanitary fellings. While using wood fuel a decrease in emission in the environment will affect human health resulting in a decrease of morbidity.

Taking into account above mentioned merit factors and current state of wood use in Lithuania the purposes of this study were the following:

1. analysis of supply and demand for fuel–wood as energy sources,
2. assessment of the economic and ecological effects of substitution of conventional fuel (fuel oil, orimulsion) by wood fuel;
3. assessing of the regional social effect for large scale of utilization of marginal wood for energy.

Material and methods

For solution of many economic, environmental and social problems the analysis has been conducted on statistical data of forest inventory, thinning and logging operations, trade of wood products and possible future scenarios of wood use. The requirements for wood fuel, particularly, its consumption for heating in household of rural areas have been assessed using statistical distribution of Lithuanian inhabitants. Economic effect obtained by substituting conventional fuel by fuel oil and orimulsion was calculated by derived formula. Prices of different energy sources have been used as the average for several last years. The values of caloricity have been taken from the literature.

In Rokiškis district a special experiment was performed for assessment of regional social effect of large–scale wood fuel use. Several technologies of gathering logging residues as well as gathering and chipping thinning products have been investigated. Economic efficiency of traditional logging technologies and technologies with wood fuel production was assessed for different kinds of thinnings, sanitary and clear cuttings while comparing the profit. Environmental effect of wood fuel use instead of conventional fuel sources was assessed by comparing burning products (SO_X, NO_X, CO_2, etc.).

Amounts of burning products were calculated using formulas based on common chemical reactions (Gimbutis *et al* 1993). For this, factors were abstracted in previous research (Jes Fenger *et al* 1990) and recommended by the Ministry of Environment of the Lithuanian Republic (Organinio … 1997). The results of calculation were comparable within the limits of confidence because emission factors were based on the same theoretical formulas of oxidation of combustible elements.

Different fuel sources have different emission of combustible elements. This is dependent on fuel elementary composition and conditions of the combustion process. E.g. emission of particles in solid fuel combustion depends on the capacity of combustion system. The summarized data on emission factors are presented in Table 1.

Table 1. Emission factors for various kinds of fuel (European Commission DG1A, 1998)

Fuel	Emission in kg per GJ fuel used			
	NOx	SO_2	CO_2	Particles
Wood	0.050	0.004	0	0.350 Capacity < 1 MW 0.100 Capacity < 2 MW 0.040 Capacity > 2 MW
Peat	0.100	0.004	0	0.220 Capacity < 2 MW 0.040 Capacity > 2 MW
Heavy fuel oil	0.250	1.320	74	0.05
Natural gas	0.190	0	56	0
Coal	0.360	1.020	94	10.20
Nuclear	0	0	0	0

The potential of wood fuel for energy production was assessed according to the EU directives and long-term plans for use of renewable energy. There were analysed the results of research on biofuel use obtained in the Lithuanian research and education institutions. Trends of biofuel use were studied and data presented in different publications. The parameters and trends determined were compared to published data of foreign investigators, and based on analysis of the state and perspectives of Lithuanian renewable energy sources. The dynamics of biofuel use for energy was analysed according to official statistics of the last 4 years. This period was characterized by intensive wood fuel use for primary energy production.

Results and discussion

Possible wood fuel resources and their use

Before World War II in Lithuania mainly solid fuel such as firewood, peat, coal were used. The share of solid fuel in the common balance of energy comprised over 80% (Ecological Sustainability … 1999). Even till 1960 about half of all fuel demand was satisfied using local resources, mainly firewood and logging residues. During the latest decades central heating systems were spread and quite cheap fossil fuel, as coal and oil were used. These changes caused wide use of fossil fuel even for heating private houses in rural areas. Currently the situation is changing back because of increasing prices of fossil fuel.

The data on statistical wood fuel use are shown in Table 2. The rate of an increase in wood fuel use in different sectors is different. A particularly significant increase in this kind of fuel is noted in the sector of energetics. In 2000 in power plants wood fuel comprised only 6.4% or 203 thousand m³ (Statistic… 2004) while in 2003 it attained 16.8%. More significant consumption of wood fuel for energy generation was noticed after reconstruction of many boiler plants for burning wood fuel and after construction of new boilers for burning wood. The governments of other countries as well as firms rendered financial support for Lithuania. In 2003 nearly 70 boilers using wood fuel were in action and their total capacity exceeded 250 MW (Markevičius, Katinas 2003; Katinas, Markevičius 2003). In 2003 the total capacity of boilers heated by wood fuel increased up to 320 MW (Vrubliauskas, Kavaliauskas 2004). The amount of used wood fuel was equivalent to 660 thous. tones of oil. Statistical data (Statistic Lithuania 2002, 2003, 2004) of Lithuania indicate that (in 2000–2003) the quantities of wood fuel consumed in the country constantly increased and nearly 4 million m³ of wood were burned. Nevertheless, a decrease in wood fuel use in trade, in the sector of service and household is observed.

Wood fuel consists of firewood, wood processing and logging residues. Now all the components of wood fuel are used. In the period of the last five decades the state of Lithuanian forests constantly improved: the forest cover of the country increased 8%, the area of productive forests enlarged by 390 thousand hectares and reached 2.0 mill. hectares, wood volume increased by 246 million m³ and reached 384 mill. m³ (Lithuanian Forests Chronicle 2003). Consequently, wood removal – 6.46 mill. m³ (2003) in-

Index	2000	2001	2002	2003	An increase 2003/2000, %
Total consumption	3162.3	3339	3513.7	3623.8	14.6
Transformed in power and boiler plants	203.1	350.0	500.6	610.6	200.6
Final consumption	2957.7	2986.4	3008.0	3013.2	1.9
In industry	148.4	221.0	383.0	469.4	216.3
In construction	12.2	14.5	23.9	28.4	132.8
In agriculture	33.2	46.4	66.0	63.5	91.3
In trade and in the service sector	207.7	202.5	183.6	170.9	–17.7
In household	2556.2	2502.0	2351.5	2281.0	–10.8

Table 2. Total balance of firewood and wood residues used in 2000–2003, thousand m³ (Statistic Lithuania 2002, 2003, 2004)

creased twice. There are the forecasts for state and private forests of III–IV group (Kuliešis, Petrauskas 2000) allowing to increase yearly harvest of industrial wood for the second decade by 16% and for the third decade by 28%. The available quantities of wood fuel are expected to grow too: for the second decade by 14% and for the third decade by 23%. Taking into account that forests of III–IV group comprise only 85.6% of all forests the theoretically available amount of fuel wood removal was calculated. As the background for calculation was taken into account that the total wood use intensity in the next three decades will grow much more in private forests with less percent of conifers and less percent of industrial wood. It has shown that amounts of wood for energy from forest logging including salvage cuttings, thinnings and wood processing residues during the three coming decades (2005–2025) will comprise 4.6–5.3 million m³ per year (Table 3). The calculations by Abaravičius (2002) have shown that 4.9 million m³ of wood fuel equivalent 9.8 TWh can be used.

Table 3. Approximate available annual wood fuel resources in Lithuania (mill. m³)

Wood Fuel	2003	2005	2015	2025
Firewood from final cutting	1.3	1.4	1.5	1.6
Forest logging residues	0.7	0.8	0.8	0.9
Precommercial thinning, salvage cuttings	1.2	1.2	1.3	1.4
Processing industry residues	1.1	1.2	1.3	1.4
Total	4.3	4.6	4.9	5.3
Possible heat energy generation*, TWh			9.8	

* It is assumed that 1 m³ of wood fuel gives approximately 2 MWh of heat energy. Such approximately amount is commonly used while calculating heat energy from unknown species composition and moisture of wood fuel

In case the Ignalina Nuclear Power Plant is closed as it is aimed by the EU, the demand for fuel for energy in Lithuania will increase. The use of wood fuel will become more relevant. There is installed capacity for 252 MW (2003). A foreseen increase in the use of this kind of fuel is unquestioned. However, the presented rates of growth are different (Kairiukstis, Jaskelevicius 2003). Renewed and specified national energy strategies also corrected the figures of biofuel consumption. The data with a certain prediction are presented in Table 4. The available data (Kairiukstis, Jaskelevicius 2003) show, that by using wood fuel in nearest two decades it is feasible to generate 9.8 TWh of energy. The study carried out at the institute of Energetics (Markevičius, Katinas 2003) and the comprehensive analyses of possible wood fuel use for energy production recently conducted by Danish Energy Authority A/S (2003) have proved this prediction. According to Danish analysis use and perspective of local renewable energy sources potential of 9.8 TWh in the nearest two decades seems to be quite real. However, extensive use of wood fuel needs additional investments about 38 mill. EURO. Investments are related to conversion of the existing heating plants to the use of wood fuel as well as for installation additional capacities. Projected and really largest energy generation 9.8 TWh may be achieved using nearly 5 million m³ of wood (Table 3).

Table 4. Consumption of local and renewable resources and their prognoses

Kind of renewable energy sources	Energy generation, TWh/year			
	2000	2010*	2020*	Possible energy generation
Local and renewable resources	7.5	9.6	10.74	
Wood fuel	7.2	8.57	9.8	
	Percent in fuel and energy balance, %			10.3
Local renewable resources	9	12	12.5	
Wood fuel	8.5	10.7	11.4	

* Predicted data

While discussing about long–term fuel wood resources and its utilization not only energetic sector should be taken into consideration. There are competitors for small size wood from pulp mill industry. After closing pulping industry in Lithuania round wood export (mainly for pulp industry) from Lithuania increased from 0.89 mill. m³ (1994) to 1.77 mill. m³ (1995) and remains till now at a very high level (1.1 mill. m³/year). There is also some preliminary documentation about the possibility to establish pulp mill in Lithuania (prepared by Japanese institutions, JICA) by consuming about 2.4 mill. m³ of wood. It means a new actor for competition on small size wood can appear. But it is a matter of prices.

The market for wood for energy

The demand for wood fuel in Lithuania was assessed analysing resident population and economic development. Also final energy demand confirmed in the National Strategy of Energy (2002) was allowed for.

Currently in rural areas there are 33% or 1,145 mill. of the Lithuanian population (Statistic… 2003), where nearby 447 thous. live in households. Approximately two thirds of it around 300 thous. use wood fuel for heating. As for each family household heating 10–14 m³ fuel wood have been used annually the demand for fuel wood for households only in rural areas (villages, settlements, small towns) can be estimated around 3.5 mill. m³ per year. The demand for energy wood for industry, district heating etc. will largely depend upon prices. By assessing current trends preliminary it can be estimated from 1.6 to 2.0 mill. m³. Therefore the most probable in nearest future requirement of wood will be about 5–5.5 mill. m³ per year. The amount will hardly satisfy local supply. This can be illustrated by examination of the wood consumption balance. For example, in 2003 total industrial wood removal in Lithuania was 6.46 mill. m³ plus 0.08 mill. m³ import and round wood export – 1.43 mill. m³. According to the data of „Lietuvos mediena“ (2004) home market used 5.11 mill. m³ of wood. Wood industry from this amount consumed 3.61 mill. m³ including sawmills 2.8 mill. m³; board industry – 0.3 mill. m³; plywood – 0.15 mill. m³; other industry – 0.36. Boiler houses and households directly from total wood removal used only 1.5 mill. m³. Other part (2.1 mill. m³) of energy wood used for heating consisted of wood industry residues (1.71 mill. m³), briquette and pellets (0.01 mill. m³) as well as unaccounted cuttings in the private forest sector. According to the current plans of wood industry its requirements till 2010 will increase by 1.34 mill. m³ and will exceed possible supply around by 1.0 mill. m³, but industrial residues will increase only by 0.4 mill. m³.

The situation described above may be considered as some kind of prognoses which can be changed in the future. The availability of such residues my be significantly influenced by the changes in the forest industry sector – bigger quantities of processing residues may be needed for generation of heat for drying kilns in sawmills (and less left for other consumers), increasing quantities of sawdust may be used for production of pellets, new board factories may start operation, etc.

Taking into account the needs of pulp industry or even needs to maintain small size wood export much more difficulties can appear to fulfill local requirements for fuel wood. Such a situation can press on marginal wood prices and will create a new possibility for better management of conventional forest (thinning; sanitary cutting) afforestation as well as still not properly used agricultural land.

Use of biofuel for energy production is greatly affected by its production costs and prices. In Lithuania price of wood fuel is appraised by market transaction between seller and buyer. The average prices of different sorts of wood fuel are presented in Figure 1.

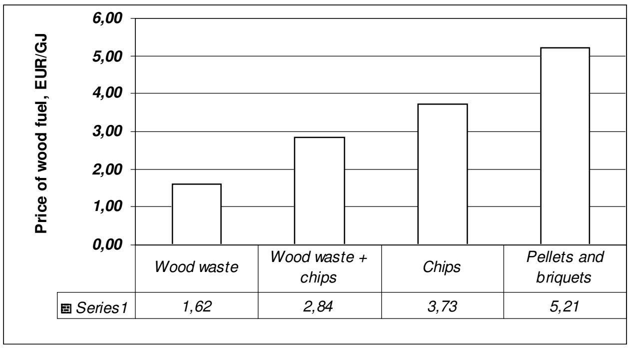

Figure 1. Average prices of different sorts of wood fuel (*source: Lithuanian Energy Institute, May 2003*)

Prices of different wood fuel (Fig. 1) are expressed in EURO per GJ for better comparability. It shows great dependence of wood fuel on the caloricity of fuel. The prices of wood briquettes depend on the season. In the summer time it fluctuates from 1,22 to 4,63 EURO/GJ, while during winter time it is higher from 5,44 to 5,79 EURO/GJ) (Renewable energy Lithuania). The differences in prices of wood fuel throughout Europe are shown in Table 5.

Table 5. Minimal, maximal and average prices of wood fuel in different countries of Europe (Biofuel use in European countries in 1999)

Wood fuel type	Price in EURO per GJ					
	Minimal		Maximal		Average	
Logging residues	1.02	Germany	8.33	Italy	3.42	
Wood processing residues	0.58	Romania	9.07	Poland	2.38	
Firewood	1.01	Slovakia	14.00	UK	5.26	
Wood waste	– 4.00	Ireland	3.31	Poland	0.97	

For production of briquettes and pellets additional costs are needed for drying and pressing. It increases the price of fuel. In comparison to non–processed wood fuel they have lower moisture content and consequently higher energy value. For the burning of briquettes and pellets lower investment to boilerhouse conversion is needed because simpler and cheaper boilers are used. The last very important issue is that briquettes and pellets may be easily kept packed and they need fewer places for storage comparing to unprocessed wood fuel.

Production of briquettes in Lithuania was started in 1994, while the production of pellets – in 1999. Both fuel sources are produced by 18 producers (*Medienos* ... 2004). In 2003 30,000 tones of briquettes and 46,000 – tones of pellets were produced. The use of briquettes and pellets for energy production in Lithuania is low, because 85% of briquettes and almost all pellets are exported to Denmark, Finland, Germany, Norway, Sweden and UK. The annual production dynamics of briquettes and pellets is shown in Figure 2.

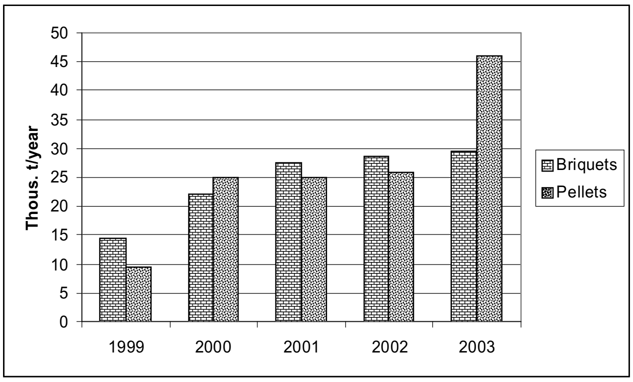

Figure 2. The production of briquettes and pellets in 1999–2003 (Katinas, Markevičius 2003)

Economic effect

According to the data from Table 2 on statistical wood use, the prices of fuel oil in the corresponding years and on caloricity of fuel oil and wood fuel* the quantities of imported fuel oil and funds being saved by substituting imported fuel (Table 6) have been calculated.

The quantities of saved fuel oil have been calculated by the formula

$$B = B_1 \cdot Q_1 / Q_2; \qquad (1)$$

where:

B – the quantity of fuel oil substituted by wood fuel, t;

B_1 – the quantity of wood fuel used for generating energy; m³

Q_1 – caloricity of wood fuel, GJ/ m³;

Q_2 – caloricity of fuel oil, GJ/t.

* In this formula the quantity of fuel oil substituted by wood fuel (GJ/m³) is subtracted from actual kind of wood fuel.

Table 6. Economic effect obtained by substituting fuel oil by wood fuel in Lithuania (2000–2003)

Wood use for fuel, years	2000	2001	2002	2003
Total, thous. m³	3162.3	3339	3513.7	3629.0
Energy consumption excluding household, thousand m³	604.6	834.4	1157.6	1342.4
Caloricity of wood fuel, GJ/ m³	8.2	8.2	8.2	8.2
Caloricity of fuel oil, GJ/t	39.98	39.98	39.98	39.98
The quantities of saved fuel oil, thousand t	124	171	237	275
Possible saving of fuel oil by substituting it by the whole wood fuel used, thousand t	649	685	721	744
The average price of imported fuel oil, EURO/t	145	116	106	132
Capital saved for unimported fuel oil (thousand EURO)	17956	19776	25167	36300

By calculating the whole wood fuel used including that used in household, which would substitute fuel oil or other fossil fuel by the fuel oil equivalent we would obtain large figures. However, a large amount of wood fuel – such as firewood is used in household. In this sector wood almost does not substitute fuel oil. Therefore net economic effect has been calculated for those sectors in which fuel oil being burned may be substituted by wood fuel. Then the quantity of imported fuel being saved in 2003 attains 275 thousand t of fuel oil.

A change in the average prices of fuel oil in 2000–2003 has been assessed. According to prices of fuel oil the funds saved for buying this kind of fuel is presented. It is seen that while using wood fuel and wood residues for generating energy over 36 million EURO are saved. Consequently, these funds could be used for creating rural infrastructure and developing the wood fuel production chain.

In the perspective due to closure of the Ignalina nuclear power plant the consumption of fuel for energy generation will increase. Thus, the expenses for the import of fuel will increase. In order to use the funds more economically different sources of local fuel and renewable energy sources will be used more widely. Attention will be focused on wood fuel, the use of which will increasingly grow. By using wood fuel the indicated 9.8 TWh energy generation will be exceeded. According to the adopted strategy of energetic development in Lithuania and according to the predicted data on wood fuel use, which are shown in the scheme presented in Table 6, predicted saved quantity of fuel oil was calculated for the first quarter of the XXIth century (Figure 3).

Due to saved fuel oil the funds will not be allocated for the import of fossil fuel. Therefore they can be used for creation of wood fuel supply infrastructure and wood fuel production containing forest logging residues. The predicted saved funds will be rather significant (Figure 4).

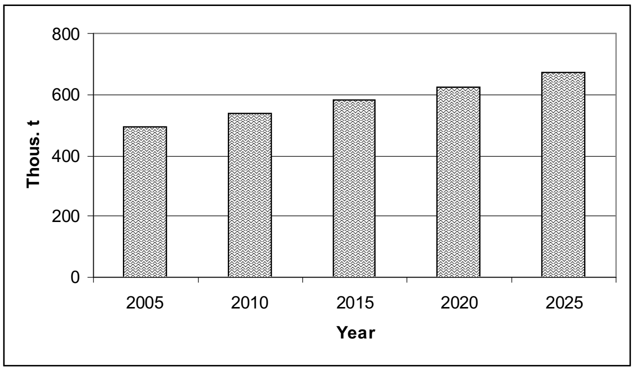

Figure 3. The prediction of saved fuel oil in 2005–2025 in case it is substituted by wood fuel

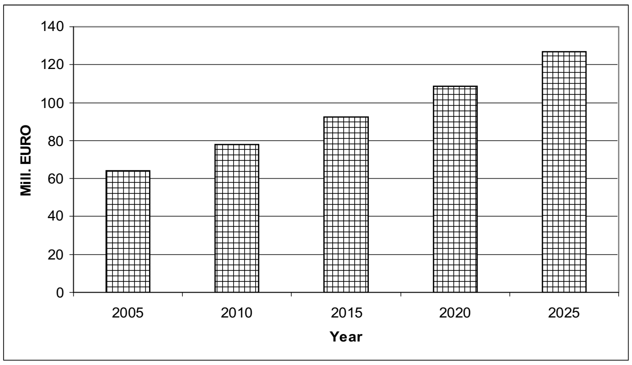

Figure 4. The predicted saved capital in case fuel oil is substituted by wood fuel

Regional social effects

The use of wood fuel instead of oil is not only economically reasonable but also enables improvement of the social situation of rural population. First, for wood fuel preparation and use we need the creation of infrastructure. The gathering chopping, transporting, storing and market of felling residues are impossible without such an infrastructure. This infrastructure is impossible without additional work places. According to the statement of the Ministry of Economics (Abaravičius 2002), the launching of one boiler plant will result in creating additional. Besides, in the country the production of burning equipment starts developing. In the factories of boilers rather many places of work will be available because these boilers need to be constructed, produced, installed, cared and repaired. Consequently, new opportunities and challenges for both forest owners and industry will be offered.

There are some very important social factors influencing the development of the wood fuel business and its influence on rural development at a regional level. It is large–scale investments into machinery like drum chipper, forwarders, market intelligence, information systems, wood fuel production related legislation, and finally a change in traditional thinking. It is not easy to convince country people to change their traditional thinking and look at marginal wood and forest residues like an additional fuel source. This marginal wood in some cases is also subject to competition between woodworking industry and wood fuel consuming boilers.

For analyses of regional social effects of extensive wood fuel use Rokiškis region has been chosen. Its are a comprises nearly 180.6 thous. hectares with total population of 41.7 thous. The employed people comprise 17.6 thous. and jobless 3.1 thous. Nearly half of inhabitants – 49% – live in rural areas. Forest area in this region makes up 49.89 thousand hectares (2003) what attributed to population is 1.03 ha or 200.5 m^3 of the growing stock per capita which means twice as much as compared to the average in Lithuania (0.54 ha and 100 m^3). In this region old traditions of firewood use in household exist. Additionally, in the last decade 7 central heating plants using wood fuel have been installed.

State forests in the region constitute about 39% of the whole forest area, private and other forests comprise nearby 41%. Annual average wood cutting in the region for 2001–2010 is 186 thous. m^3/year, from which 61% is final cutting volume. Private forest owners increase cuttings in their forests and reach quite the same level of wood supply as from state forests. As to wood fuel use, this region has some preference because soft deciduous species amount to 61% even from the total volume of the final cuttings. Proper forestry technologies are needed for collection of marginal wood from selected area of forest cuttings. Only limitation for the wood fuel production is soil condition – in wet soils lots of the marginal wood and even firewood are used for improvement of logging conditions on technological corridors.

In this region the investigation has been conducted on the socio–economic efficiency of technology with integrated wood fuel production versus traditional technology. By using different cuttings income, cost and profit of wood fuel production was investigated. As to efficiency of fuel wood production, most promising appear clear cuttings and commercial thinnings in which efficiency of wood fuel production is estimated at 400–200% (Table 9). More detailed data are published in study report (Integration… 2002).

Also additional amount of work, necessary to produce specific wood fuel was calculated. For this purpose we used estimated amounts of wood fuel in Rokiškis forest enterprise (Table 10). The data show essential increase in the available wood fuel amount in both state and private forests. Private forests will play a very important role in the wood fuel production because in these forests wood fuel comprises more than half of all forest raw materials.

Calculated work expenditures for preparation and extraction of traditional assortment and wood fuel, wood fuel chipping and wood fuel transportation to boiler–house are presented in Table 11. Most of the time is consumed while cutting in collection operations, which comprises almost 80 % of all the work time. The chipping and transportation are less time consuming and both comprise about 20 % of all work time. However, calculation parameters will significantly differ and work time for chipping and transportation will have much higher variation compared to work time for cutting and all logging operations.

While using the above mentioned data additional work expenditures, necessary to produce wood fuel and supply it to boiler–house were calculated. If one

Table 9. Economical efficiency of forest fuel production (EURO/ha) if compared traditional technology and technology with wood fuel production

Cutting category (Trial No)	With forest fuel production			Traditional technology			Efficiency of wood fuel production
	Income	Cost	Profit	Income	Cost	Profit	
Pre–commercial thinning (R)	632	707	–75	–	92	–92	18
Pre–commercial thinning (M)	632	828	196	–	138	–138	–58
Commercial thinning (1E)	571	222	349	518	202	316	33
Commercial thinning (2E)	2000	733	1267	1758	690	1069	199
Commercial thinning (3E)	2065	776	1288	1759	568	1191	97
Sanitary cutting (1S)	2220	698	1521	2117	650	1468	54
Clear–cutting (3P)	6557	123	4406	5448	1442	4006	400
Clear–cutting (2P–1)	6455	1633	4822	5908	1344	4564	257
Clear–cutting (2P–2)	6418	1506	4912	5790	1124	4666	247

Note: Manual tools used (R); Motor–saw aggregated with hand felling (M)

Table 10. Available volume of wood fuel (logging residues+ firewood) in forests of Rokiškis region

Object	Volume, in thous. m³	
	Final cuttings	All cuttings
	2001–2010	
State forests	9.8–12.5	15.2–31.2
All forests	25.3–31.3	39.6–60.0
	2011–2020	
State forests	12.0–15.8	18.4–28.4
All forests	33.5–40.7	49.5–71.5

Table 11. Minimum expenditures for the work necessary to produce available amount of wood fuel in Rokiškis forest enterprise on working days

Object	Cutting			Other logging operation			Chip–ping**	Transporta-tion***	Total
	Final cuttings	Interm. cuttings	All cuttings	Final cuttings	Interm. cuttings	All cuttings			
				2001–2010					
State forests	397	242	**639**	162	116	**278**	**114**	**118**	**1148**
All forests	1025	640	**1665**	417	307	**725**	**371**	**307**	**3068**
				2011–2020					
State forests	486	286	**772**	198	138	**336**	**138**	**143**	**1389**
All forests	1357	716	**2073**	553	344	**897**	**371**	**384**	**3724**

* if logged at 201 – 500 m distance with "Valmet 840Y".
** if chipped the drum chipper "BRUKS 604 CT", with an agricultural tractor "K–700" and chipping productivity is 20 m³/hour.
*** if transported at 5,1– 10,0 km distance with tractor "T – 150" aggregated with trailer (load 25,3 loose m³)

working place uses 220 working days, then in nearest future in Rokiškis region it is possible to have at least 5 additional work places in state forests and at least 14 working places in all the forests. Now all the cuttings in Rokiškis forest enterprise are done by different entrepreneurs employing local people. About half of new working places will be used for harvesting of the wood fuel and the remaining ones – for extraction, chipping and transportation to the boiler–house. Emphasis should be placed, that in all chains of fuel wood supply workers of high professional skill level are necessary, which allow rapid integration of wood fuel production to ordinary forestry. In the best cases it takes one day, while in less favourable cases – 3 to 5 working days.

Thus, the experiment in Rokiškis region has shown that in felling, thinning and preparing wood fuel by a new technology at least 350 places of work can be created for each million m³ of wood fuel. By applying the above technology in Lithuania and by preparing 3.4 million m³ of biofuel (in 2005) more than 1.200 additional places of work could be created.

Above mentioned figures referred to the possibility of fuel wood supply are quite impressive but they may vary by changing cost on fossil fuels, efficiency of wood fuel production and its demand. Timber industry and forest cutting residues and small size wood currently being the main sources of fuel wood in future may be used for other purposes, e.g. particle boards, etc. However, any changes cannot be expected without principal changes in technology development and prices of fossil fuel.

Environmental effect

Along with economic and social influence an increase in the use of wood fuel for energy generation, positively affects the quality of the environment.

This process mostly is caused by reduction of emission of toxic pollutants. We compared the burning products in time span 2000–2003 in case the same quantity of heat had been generated substituting fuel oil by wood fuel. As shown in Figure 5, a decrease in the quantity of sulphur and nitrogen oxides in the environment is essential. Figure 6 shows data foreseen in 2005–2025. Augmentation of the quantity of heavy particles, ash and CO emission raises no problems when wood fuel is used. Wood ash is a non–dangerous residue and may be applied as a fertilizer after processing and conditioning. Heavy particles of fuel oil have admixture of harmful vanadium pentoxide.

We analysed also the case in Lithuania by comparing situations when orimulsion has been used for heating as energy sources. Orimulsion is a new kind of fuel which contains more different toxic elements.

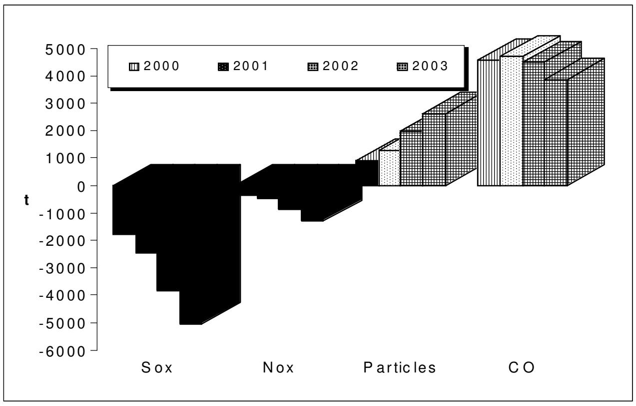

Figure 5. The formation of burning products (t) in 2000–2003, their change after fuel oil is substituted by wood fuel

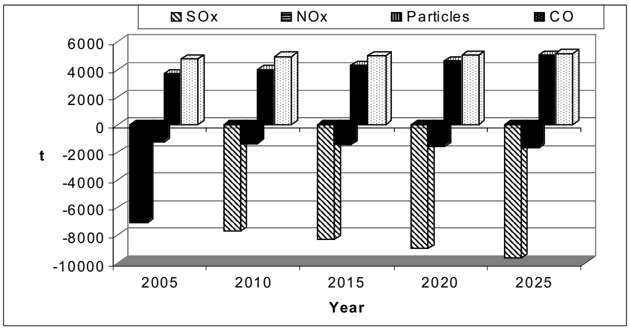

Figure 6. The prognosis of a change in burning products (t) in 2005–2025 after fuel oil is substituted by wood fuel

It was analysed because Lithuania had signed previously contracts and imports this less expensive fuel from Venezuela. Since the caloricity of orimulsion is less than that of fuel oil for the generation of the necessary quantity of energy it will be necessary to burn 1.5 times more orimulsion. It implies that there will be by far more pollutants. Orimulsion also contains 3 times more vanadium, which can get into the environment after burning the fuel. Due to significant toxicity additional negative problems may arise. In comparison to fuel oil, the total atmospheric pollution by orimulsion smoke is 1.46 times more considerable. By burning orimulsion heavy particles increase 4 times. Therefore more essential solution would be to substitute not fuel oil but orimulsion by wood fuel. Then the protective effect of the environment would be more significant (Fig. 7).

A very important phenomenon is also the variation in the balance of carbon dioxide in case conventional fuel as fuel oil and orimulsion or wood fuel are used. During burning of wood fuel the formed CO_2 is not included in the total quantity of gas causing greenhouse effect because wood fuel is considered to be

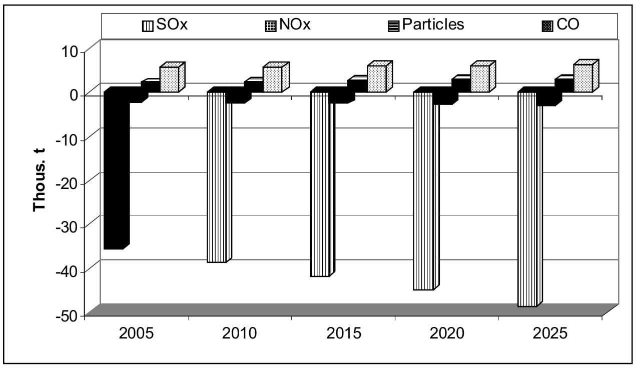

Figure 7. The prognosis of a change in burning products in 2005–2025 after substituting orimulsion by wood fuel

neutral with respect to CO_2. It is consumed by plants for producing new biomass. By using wood fuel the final result is significant abatement of carbon dioxide emission (Fig. 8). Therefore in this case the protective effect of the environment is very significant. It may favour the implementation of the requirements of the Kyoto protocol. This problem will appear for Lithuania very sharp following the closure of the Ignalina nuclear power plant when the whole quantity of electricity will be generated by heat power plants using much fossil fuel. Therefore, the Lithuanian government should change the policy facilitating utilization of marginal wood for energy purposes.

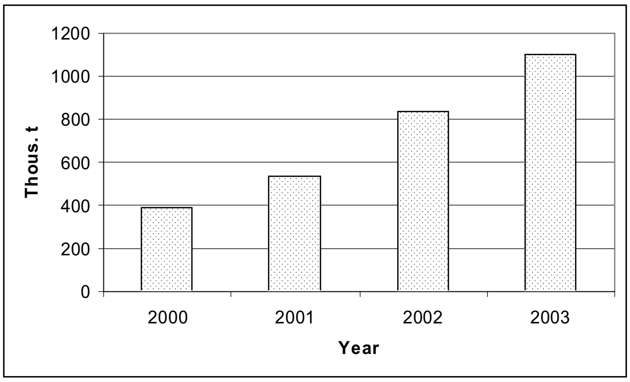

Figure 8. Amount of CO_2 emission („neutral“) after substituting fuel oil by wood fuel

As we have calculated the substitution of fuel oil by wood fuel will improve the quality of the environment. Along with reduction of emission of toxic substances (Figure 5, 6), emission of carbon dioxide in the atmosphere will be considerably diminished. Abatement of the quantity of the major compound causing greenhouse effect by nearly 4 million tons per year in the future can be a certain of contribution to Lithuania for mitigation of GHG effects (Figure 9).

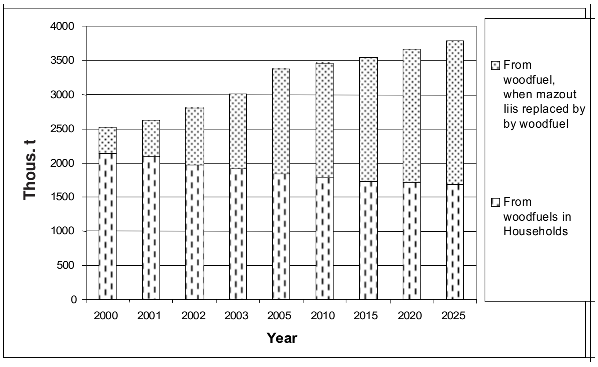

Figure 9. Emission of carbon dioxide in 2000–2003 and prediction till 2025 in case wood fuel is used in household and in case fuel oil is substituted by it

The presented material shows that extensive use of wood fuel for generating energy has a positive trend. This trend favours the efforts of Lithuania to stabilize export–import balance of the country, to increase sustainability of forests, to improve social conditions of rural development, to improve the environment quality, to contribute to the mitigation of greenhouse effect. Due to shortage of investment this process is rather slow (even research in this sector currently is financed insignificantly (about 0.2 mill. Euro/year)). Therefore, it is imperative that with the aid of political and economic means more favourable conditions be created for development of the infrastructure for extensive use of local and renewable sources.

Conclusions

1. The quantities of wood fuel consumed in Lithuania during 2000–2003 constantly increased. In 2003 about 3.5 million m^3 of wood was burned.

2. Amounts of fuel wood from final cuttings, thinnings and salvage cuttings as well as from residues of logging and wood processing industry in time span 2005–2025 will increase from 3.6 to 5.3 million m^3 per year.

3. Burning of briquettes and pellets would be valuable in comparison to non–processed wood fuel as firewood and wood chips. This is caused by lower moisture, higher energy value and easier handling of briquettes and pellets.

4. Using of fire wood and wood residues for generating energy in 2003 allowed saving of over 36 million EURO. Consequently, these funds could be used for developing the wood fuel production – supply chain and for creating infrastructure, conversion of existing capacities and installing of new energy generation capacities.

5. Felling, thinning and preparing of wood fuel by applying a new technology allow creating of at least 350 work places for each million m³ of wood fuel.

6. Substitution of fuel oil by wood fuel will improve the quality of the environment because reduction of SO_X by 1.451 kt/PJ and carbon dioxide by 78.8 kt/PJ in the atmosphere will result in abatement of the quantity of greenhouse gases by nearly 4 million tons per year. It can be a certain Lithuanian contribution for mitigation of GHG effects.

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ЭКОНОМИЧЕСКИЙ, СОЦИАЛЬНЫЙ И ЭКОЛОГИЧЕСКИЙ ЭФФЕКТ ИСПОЛЬЗОВАНИЯ ДРЕВЕСИНЫ В ЭНЕРГЕТИКЕ В ЛИТВЕ

Л. Кайрюкштис, Б. Яскелевичюс, И. Саладис

Резюме

Использование дров, мелкомерной древесины, порубочных остатков и отходов деревоперерабатывающей промышленности в энергетике в Литве находит все большее применение. В этих целях в 2003 году использовано 3,2 мил. $м^3$ древесины.

В статье анализируются экономические, социальные и экологические последствия широкого использования древесины в энергетике. Установлено, что использование дров, порубочных остатков и отходов деревоперерабатывающей промышленности позволяет сэкономить около 36 мил. Евро (2003 г.) за счет снижения импорта топливного мазута. Разработана новая технология рубок, включающая одновременно заготовку энергетической древесины, позволяет создать 350 дополнительных рабочих мест на каждый 1 мил. $м^3$ энергетической древесины, что положительно влияет на развитие сельских районов. Замена мазута или оримулсии древесными энергоносителями позволяют снижать эмиссии основных загрязнителей воздуха, например, SO_X на 1,451 кт/PJ, учитываемой углекислоты (Kyoto 1997) на 78,8 кт/PJ, что улучшает окружающую среду.

Ключевые слова: древесина в энергетике, древесные отходы, замена мазута древесным энергоносителем, социальный эффект, экологический эффект.