Forest Energy Resources and their Utilization in Lithuania

LEONARDAS KAIRIŪKŠTIS[1], BRONIUS JASKELEVIČIUS[2]
[1] *Lithuanian Forest Research Institute, Department of Forest Ecology and Forestry*
Liepų 1, Girionys, LT-4312 Kaunas distr., Phone +370 37 547775, Fax +370 37 547446
[2] *Vilnius Gediminas Technical University. Sauletekio al. 11, LT-Vilnius,*
Phone +370 5 2617709, Fax +370 5 2618464

Kairiūkštis L., Jaskelevičius B. 2003. Forest Energy Resources and their Utilization in Lithuania. *Baltic Forestry*, 9 (2): 29–41.

The results of investigation of wood for fuel in Lithuania and their utilization for energy in historical context are presented. During the logging operations due to specific composition of species fuel wood including technological wood for pulping over the past 40 years constituted 42–58%. Also before W.W.II (1927–1937) there was 39.5% and in 1945–1966 there was 49.5% fuel wood from total removal in state forest.

The goal of this investigation was the current status of wood fuel, its final consumption's expansion at various sectors of economy, its volume and potential resources, the analysis of advantages and disadvantages in utilization. The research of fuel wood and wood residuous in wood industry its cost and those factors that influence its range also are discussed. The current situation and problems of the conversion of boiler–houses, that are adjusted to burn wood fuel, are surveyed. The legal basis of promoting of the wood fuel consumption's development, the causes of inefficiency of enacted legal laws and acts are analysed also.

It is stated that the future of wood fuel consumption is related with huge potential resources in a forest cultivation process and also with the rapidly growing wood processing industry.

Key words: fuel wood, forest resources, wood energy, heat generation, biofuel

Introduction

From time immemorial fuel wood, wood residues are energy sources in the history of humanity. In Lithuania it is traditional and mostly widespread local fuel, which is currently, also widely applied by rural inhabitants. Statistical data indicate that in 1927, 1937 fuel wood comprised 39.5% of the wood produced in state forests. Due to intensive development of production in the second half of the 20th century industrial and power plants started widely using organic fuel: oil products, coal and gas. Apart from the limited amount of oil, Lithuania, however, has no such resources. Therefore, after regaining the Independence (1990) due to higher prices of imported fuel in the local market attention was focused on the kinds of local fuel, its wider use for meeting the demand for energy. The Swedish Administration and Forest Department rendered rather significant help in organizing utilization of wood for fuel in East Lithuania. A bilateral co–operation project named „Swedish Lithuanian Wood Fuel Development Project" (Manager Lars Andersson) has identified the present conditions for the utilization of wood for fuel within several state forest enterprises. By means of demonstrations in the Rokiškis forest enterprise the project attracted the attention not only of the people working in the forestry, energy sectors and municipalities but also the politicians were interested in it.

Currently, the European Union enhances to use more widely local fuel and renewable energy resources due to climate changes in particular. In the Fifth Framework Program project „Wood for energy a contribution to the development of sustainable forest management" (WOOD–EN–MAN) is approved (July, 2001). In the project Denmark (coordinator), Lithuania, Latvia, Estonia, Finland, Sweden and Norway participate. For the Baltic countries, particularly for Lithuania, utilization of local fuel is one of the most important directions. It would enable us considerably to decrease the expenditure for imported fuel, improve the employment of people and socio–economic conditions. Utilization of local energy resources would ensure more reliable work of the energy system, its less dependence on fuel import and disturbances of its supply.

Of importance is the aspect of environment protection. According to UNFCCC activities and the Kyoto Protocol it is the commitment of most countries to reduce GHG emissions 9280. By burning the biomass the environment is less polluted and by far less harm-

ful burning products are emitted in comparison to these by burning oil products and coal. Fuel wood is neutral in terms of carbon dioxide since during burning the amount of emission of CO_2 is equal to that assimilated over the period of tree growth.

The objective of investigation

To analyse the resources (fuel wood, log residues of logging and wood processing) of wood fuel as the most important local renewable energy source, the state of its utilization, clarify advantages and disadvantages of utilization of this kind of fuel, the factors influencing the development, the reasons for insufficient influence of legal basis.

Material and methods

The objective of investigation is the dynamics, the advantages and disadvantages of utilization of wood fuel for producing energy, which is the main kind of renewable energy resources in Lithuania. Also socio–economic effect, political aspects have been assessed.

In the general national socio–economic development context the data on utilization of wood for fuel in the period 1927–2003 were accumulated and analysed. The share of fuel wood in the general wood use in different historical periods was clarified. Preparation of fuel wood during thinnings and intermediate fellings has been analysed. The structure of utilization of wood residues of timber industry, the prediction of fuel wood with respect to scenarios of forest use for the nearest decades and in perspective were analysed.

The dynamics of utilization of wood fuel has been analysed in the general context of the dynamics of the primary energy sources consumed during the last decade in Lithuania. In terms of energy the balance of import–export of wood and its residues over the last several years has been studied.

The equipment of fuel wood burning and boiler plant capacities, technologies of burning, the dependence of calorific value of fuel wood on its moisture, conditional energetic value prices of fuel were analysed. Energy policy of the state and the significance of local fuel for the economy of the country were studied.

In the investigations an analysis of the methods applied in analogical investigations conducted by Lithuanian and foreign scientists, specialists, organizations and institutions has been used. The calorific capacity of the fuel of wood depending upon the moisture has been calculated according to the formula (19) applied by L.Dagys and Jarmokas. The quantity of heat during condensation of vapour in smoke has been estimated by the method (18) used by P.Svenčianas. The predicted quantity of wood fuel for long term perspective has been assessed with the aid of model „Kupolis" constructed by A.Kuliešis and E. Petrauskas.

Results and discussions

General national context as a background for fuel wood consumption

Currently (2002) 33.1% population of Lithuania are living in rural areas. Population density is 53.2 inhabitants in a square kilometer. For rural inhabitants the fire wood is the main heating source.

Until 1989 the economy of the Lithuanian Republic including the forestry sector developed in close collaboration with all the republics of the former Soviet Union. Economic collaboration covered production, technology, finances, credit and producers cooperation. Lithuania's industry has been developing at a greater pace than other branches of the economy. In the period 1960–1980 the Lithuanian share in the gross national product of the former USSR rose from 1.22% to 1.47%. The Lithuanian Republic ranked fourth for particle boards and fifth for sawn lumber and paper, particularly high-grade printing and special paper. From 1,519,000 workers and office employees (1983) occupied in the national economy of the Lithuanian Republic 20.9% were in agriculture and forestry of whom 189,100 were specialists with higher education and 266,400 with special secondary technical education. The rate of growth of gross industrial output in forestry, wood–products, paper and pulp industries according to the existing data (Lithuania, 1986) could be characterized as follows (1950=1): 2.4 – as of 1960, 5.8 in 1970, 10.5 in 1980, 11.7 in 1982.

After the collapse of Soviet Union, since 1989 Lithuanian economy has recorded a decrease in the output in almost all production and non–production spheres. The decrease in industrial production accelerated in 1991 and this trend continued till 1994. The economic crisis in production has been aggravated by a rise in fuel consumption prices. Here can be mentioned that the socio-economic state of Lithuania was quite equal to that of Latvia and Estonia. In particular a decrease has been noted in the production of those industrial branches which use a large amount of imported materials and power resources. Rapid inflation has created an increasing lack of finances in enterprises and plants. The production of many products has diminished to the levels of the 1960s while that of wood

processing industry decreased to the level attained at the beginning of the 1970s. Labour productivity has reduced and the rhythm of work has deteriorated.

At that time in agriculture the situation became alarming. The enacted laws appeared to be inadequate for carrying out agricultural reform. Agricultural enterprises were liquidated. The land was imprudently returned to the owners (this process is not finished, 2003) and the former economic structure was destroyed. Instead of large (1.5–3.0 thousand ha) former collective farms the average size of a farm became approximately 15 ha crop area per one farm (2008). As seen from the Statistical Year book of Lithuania (Lietuvos, 2001), there has been a decrease in grain production, which comprises 17%, in milk 45% and in meat 65% as compared with 1990. Unemployment rose 4.4 times. In 1992 there were nearly 250,000 unemployed workers, while in 2001 the unemployed made up 223 thousand people.

Independent Lithuania has taken resolute steps in transiting to market economy and the first results appeared in 1994–1995 when GNP started to grow, but difficulties still arise as in many post–communist countries. Finally Lithuanian economy after two main falls in 1990–1993 and 1997–1999 is recovering (Table 1). In the last two years GNP increases 6–8% per year, unemployment started to decrease, small capital investment, which was the main bottleneck of the economy started to increase. Therefore, good conditions have appeared to form a balanced policy, which will take account of the environmental demands and the need for increased wood production, as well as utilization of marginal wood for energy purpose.

Forest resources ownership and wood removal

Development of the forestry and forest industry sectors in Lithuania always was and remain an important factor for the development of the country economy, for the trade balance and for the welfare of the people. Despite the previous crisis the situation in the economy as a whole and basic conditions in the forest sector remain favourable. There are sufficient forest resources (the productive forest area consists of 1,938 thous. ha, the growing stock per capita is 0.57 ha and 106 m³, respectively (2002) and can provide the growing forest industry and growing demand for fuel wood. The educational level in the forest sector is high, and the infrastructural facilities are fairly satisfactory. Total growing stock of Lithuanian forests is permanently increasing: 125 mill. m³ (1948), 198 mill. m³ (1973), 334 mill. m³ (1993), and 378 mill. m³ (2002). The average rate of the growing stock per hectare also increases: in 1959 – 104 m³/ha, in 1972 – 145 m³/ha, in 1983 – 175 m³/ha, in 2001 – 193 m³/ha. The average rate of the growing stock in mature stands also slightly increases: 219 m³/ha – in 1966, 242 m³/ha – in 1978 and 251 m³/ha – in 2001 year. Pine comprises about 37% of the growing stock, spruce – 24%, birch – 19%, black alder – 6%, asps – 5%, grey alder – 4% and other trees – 5%. Total annual increment (u.b.) is estimated 11.9 mill. m³; about 60% of total annual increment is coniferous and the remaining trees are non coniferous. The average rate of the annual current increments is 6.1 m³/ha.

Forest area in the future can also be enlarged by about 400–500 thou. ha due to afforestation of marginal former agricultural land.

Table 1. General economic state of Lithuania (total area 65.3 thou. km²)

	1995	1996	1997	1998	1999	2000	2001
Population, thou.	3643	3615	3588	3562	3536	35121	3476
Labour force, thou. of which employed	1753	1783	1774	1770	1796	1791	1745
Capital investment at current prices, mill. EURO	916	1269	1589	1979	1827	1899	
Gross domestic product (GDP), mill. EURO at current prices	6918	9143	11104	12450	12354	13076	13892
GDP changes, % as compared to the previous year at constant prices 1995	3.3	4.7	7.3	5.1	– 3.9	3.8	5.9
Employed in forestry, logging and related service, thou.	16	15	14	13	11	10	9
Employed in paper, wood and furniture industry, thou.	34.5	34.7	38.9	38.1	34.9	38.1	38.2
Average monthly gross earnings in whole economy (Euros)	139	179	226	270	286	281	287
Average monthly gross earnings in agriculture and forestry (Euros)	84	111	150	175	188	173	216
Average monthly gross earnings in forestry, logging and related service (Euros)	170	208	239	267	269	264	326
Average monthly old–age pension (Euros)	43	55	70	83	90	90	92

*) 1 EURO=3.4528 Lithuanian Litas

Forest ownership is rapidly changing. Before W.W.II (1938) state forests of the Lithuanian Republic made up 84%, private and others 16%. During the Soviet time state forests occupied 67% and forests of collective farms and others 33% (1988) of the forest area. In 1990, when Lithuania regained its independence, forest land restitution started. In 1997 the Government of the Republic approved the list of forests (955.5 thou. ha), which would remain state owned. In the year 2001 private forest land already amounted to 502.5 thou. ha (24.9%). There are only slight differences in distribution of the growing stock and wood structure between ownership sectors. But there are very significant differences in the size of holdings. There are 156,3 thou. forest owners. The average size of a private holding is 3.2 ha while the size of a state forest enterprise on average is 22.5 thous. ha. Forests privatisation process still is going on and in nearest future can reach 33–36% of the whole forest area. The average size of private forest holding has a tendency to increase. Cooperation of forest holdings is underway, 14 cooperative units are already established. But this process is hindered due to mistakes in laws enacted in the early 1990s, due to weak organizational structure of self-governing of private foresters, due to little attention from state Government and due to psychological effect. Difficulties in this process also arose due to distribution of private forest owners by place of residence: 45% of owners live in cities and only 55% in villages. All these obstacles hinder to introduce sustainable forest management in private forests and also hinder proper utilization of marginal wood for energy purposes.

At the same time the restitution and privatisation of forest land have increased twice the removal of roundwood and output of processed timber for sale, especially for export. The annually accepted logging volume calculated according to the recommendation and guidelines of scientific organizations approved by the Ministry of Environment Forest department who is responsible for the Forest Act. In the last decade there was nearly 6 mill. m³ and fully provide local wood processing enterprises with domestic raw material. According to the forecast of forest growing and alternative (29) use in Lithuania the annual allowable cut in nearest 30 years can be increased 31% from 6.8 to 8.9 mill. m³/year (including protective forests).

The largest part of wood about 4.5–6.0 mill. m³ is foreseen to be obtained from the final cutting and 2.9–3.7 mill. m³ from the intermediate use. The largest part of merchantable wood is foreseen to be obtained from industrial (IV group) and slightly protective (III group) forests, which occupy 87% of the forest land.

Fuel wood sources and its potential

Traditionaly by the main sources of fuel wood in Lithuania were salvage cuttings in private and state forests because about 57% of all removals by these cuttings are fuel wood. Different kinds of thinnings and intermediate cuttings are second fuel wood sources. According to the data of special analyses of 0.6 mill. m³ wood removed from thinnings [31], 76.9% from the whole tree cut in the thinning operations was fuel wood, including 7.7% of axe-chop-wood, 10.5% of bush wood (having demand). Other biomass includes 8.0% of branch-twigs, which until now have no demand and about 15% can be considered as industrial wood.

Next firewood source is also the main forest cuttings. Among the merchantable wood removed by final cuttings the firewood in the future according to calculation (29) will comprise 1.25–1.5 mill. m³ (Table 2). But taking into consideration that 2.0 mill. m³ counted as industrial wood will be thinner than 13.5 cm they can be also used as fuel wood if appropriate prices are established. Practice of felling in the past corroborated it. During the logging operations due to specific composition of species (lots of mixed soft-deciduous forests) fuel wood (technological wood for pulping included) over the past 40 years constituted 42–58% (30). In the middle and northern regions of Lithuania also limited amounts of firewood of white alder (*Alnus incana*) managed on short rotation (10 – 15 years) are prepared in private forests.

Above-mentioned fuel wood obtained from the cuttings is presented in Table 2. Thinnings and intermediate cuttings over the past several years only from state forests supplied 640-800 thou. m³ of fuel wood yearly. The current amount of fuel wood prepared only in state forests was 1,547 thou. m³ in the year 2000.

Table 2. Fuel wood supply from different cuttings in state forests

	1980	1990	1995	1997	1998	1999	2000
	volume, thou. m³						
Plantation and natural young stands cleaning	63	16	21	21	80	26	27
Pre-commercial thinnings	265	263	182	291	349	279	234
Intermediate cuttings	216	144	129	307	490	499	376
Logging residues*)	314	339	762	634	610	625	679
Fuel wood from final cutting**)	290	310	424	424	427	450	443
Salvage cuttings***)	273	394	848	454	616	485	614
IN TOTAL	1421	1466	2366	2585	2572	2364	2373

*) Logging residues on average calculated 1/3 from total biomass left on cutover and constitute 12.7% from amount of total removal. Residues until now are left on cutover unused.
**) Fuel wood from final cutting approximately constitute 20% from total final cut.
***) On average 57% from normal salvage cuttings are firewood but in 1997 forests were attacked by insects and percentage of firewood was much less (~ 30%)

According to the existing statistics 1.414 mill. m³ of wood was removed from private forests. Practically in private forests wood removal was much more because permission was given to cut 2.160 mill. m³ of wood. Taking in to consideration that in state forests in 1927–1937 there was 39.5%, in 1945–1966 49.5% fire wood from total removal with some probability can be calculated that in private forests for the year 2000 at least 0.9 mill. m³ of fuel wood were removed.

Therefore it is possible to conclude that fuel wood removed from the state and private forests currently amounts to 2.4-2.6 mill. m³.

Given approved rotation period for different species, distribution of stands according to age classes in the future, functional destination of forests removal of wood from commercial and protective forests (III, IV group) was calculated for the XXI century and for the next three decades [29]. The volume of merchantable wood (u.b.) to be removed only from 86.9% state and private forests (1.69 mill. ha) in the next decade already will increase from 6.53 mill. m³/year and in 2021 will reach 8.34 mill. m³/year of merchantable wood (Table 3). Increasing wood removals in the current and next decade also will increase the fuel wood supply from forests. There is preliminary calculation [18] of the merchantable and unmerchantable wood to be removed in forests of III and IV group (Table 4). As seen from the table, about 42% from removed merchantable wood is unmerchantable: branches, bark, small trees, etc. Each year there are about 2.6 mill. m³ of the biomass left on cutovers from which at least 30% (about 0.8 mill. m³) can be used as fuel wood in future if economical and technological problems will be properly solved. Therefore most probaly fuel wood supply in the current decade approximately will increase 0.29 mill. m³ and reach 2.7-2.8 mill. m³, and in the next decade 0.34 mill. m³ and yearly supply can reach 2.8-2.9 mill. m³.

There are also possibilities to increase fuel wood from thinnings and intermediate cuttings. Currently, low intensity of forest management can be compared with that in 1960–1975. Forest stands grow relatively densely. Consequently, the fellings generally yield larger volumes of fuel wood with a limited market. This is a factor reducing not only (10–12%) the current increment of merchantable wood (32) but also reducing profitability of forest management and increasing pressure to reduce the area of thinning. Such a situation may in the long term have a negative effect on the economy of the country. Therefore, current forest policy is directed towards an increase in the amount of cleaning and commercial thinnings (I and II) by 30 - 40% and thinning intensity as well.

In Lithuania there are also 12% (229 thou. ha) of ecosystem-protecting and recreational (II group) forests. At present such forests are excluded from calculations of forest use. In the next two decades lots of stands will reach maturity with the rate of cuttings in II group and may rise up to 0.5 – 0.6 mill. m³ of merchantable wood annually including 0.35 – 0.45 mill. m³ of fuel wood.

Due to an increase in the production in wood processing industry (Table 5) the amount of wood residues increase. Until now only in large enterprises it is possible to get reliable information about its utilization. As seen from Table 6, about 16% of residues is used for production, 9% is taken to dump and the remaining about 75% is used for fuel.

Table 3. Structure of removable growing stock in III–IV group of Lithuanian forests

Forests	Volume of merchantable wood, mill. m³								
	Timber			Firewood			Total		
	2001–2010	2011–2020	2021–2030	2001–2010	2011–2020	2021–2030	2001–2010	2011–2020	2021–2030
State importance	3.17	3.26	3.50	0.65	0.67	0.69	3.82	3.93	4.19
Private and other	2.12	2.90	3.43	0.60	0.68	0.72	2.71	3.58	4.15
Total	5.29	6.16	6.93	1.25	1.35	1.41	6.53	7.51	8.34

Table 4. Distribution of yearly removable wood by fractions (1999 – 2008)

Index		Volume, mill. m³								
		merchantable stem wood (u.b.)	Other parts				Stems in total	Branches	Unmerchantable wood	Merchantable wood
			apical, small stems	stumps	bark	totally				
Wood in all forests	totally	6.20	0.48	0.13	0.86	1.47	7.67	1.11	2.58	8.78
	in state forests	3.80	0.30	0.08	0.53	0.91	4.71	0.69	1.60	5.40
Fuel wood in all forests	totally	0.90	0.05	-	0.43	0.48	1.38	0.32	0.80	1.70
	in state forests	0.40	0.03	-	0.27	0.30	0.70	0.20	0.50	0.90

Table 5. Output of the Lithuanian forest industry 1990–2000

Product	1990	1993	1994	1995	1996	1997	1998	1999	2000
Sawn timber, 1000 m³	776	699	840	1150	1450	1250	1150	1150	1300
Plywood, 1000 m³	21.6	14.8	15.2	14.5	20.7	29.5	35.7	31.5	37.6
Particle board, 1000 m³	176.3	89.6	74.9	69.6	110.3	169.8	159.1	100.3	170.3
Fiber board, mill. m²	26.1	12.4	15.7	18.2	17.0	19.0	20.0	12.2	15.3
Cardboard, 1000 t	100.7			18.3		14.2	19.3	27.7	41.0
Paper, 1000 t	100.7	14.0	13.6	18.3	16.8	14.3	13.3	9.5	12.3
Paper board, 1000 t	116.9	16.5	7.5	9.1	13.9	14.2	19.3	27.7	41.0

Table 6. Utilization of wood residues (thou. m³) in Lithuania (1995-2000)

Year	Industry residues	For production	For fuel and other purposes	Taken in dumps
1995	504.5	104.0	309.3	91.2
1996	666.0	97.7	423.0	145.3
1997	675.9	113.3	432.7	129.9
1998	710.2	134.5	501.1	74.6
1999	892.4	111.9	698.3	82.2
2000	1065.6	172.6	792.8	100.2

According to information sources (MEC) there are 1.5 mill. m³ of wood industry waste, from which 0.25 mill. m³ is sold to heat generation facilities, 0.25 mill. m³ is used for their own heating purposes, 0.7 mill. m³ is sold to local inhabitants and 0.2 mill. m³ is used by the chip industry. In general each year about 1.2 mill. m³ of wood industry residues is used for fuel and this amount tends to increase.

The total amount of fuel wood in Lithuania in the next decade can reach 3.3 – 3.5 mill. m³ as cutting production. But including logging residues (0.6 – 0.8 mill. m³) and wood industry residues (1.2 mill. m³) the total amount of fuel wood in the next couple of decades can be 4.9 – 5.3 mill. m³.

At present it is not possible to make a forecast of the amount of fuel wood that will come from afforested marginal agricultural land, as it is still unclear what area of such land will be afforested. Nevertheless, there are the data (29) showing that the forest area has enlarged: 1,888,000 (1998) and 1,928,000 ha (2001) and 1,938,000 (2002) or about 12,500 ha/year which provides the additional possibility of increasing fuel wood production at least by 1% yearly.

Altogether wood fuel in the near future can constitute a substantional part of primary energy sources.

Utilization of Primary energy resources

Since 1990 the structure of primary energy sources used has considerably changed (Table 7). From 1990 the part of organic fuel decreased and in the middle (1996) of the last decade comprised only 62% whereas the part of nuclear energy increased up to 38% (I). A large part of nuclear energetics in the total production (in 1996 – 83%, in 1999 72.9%) of electricity conditioned insignificant emission of pollutans. Carbon dioxide decreased from 40 mill.t/year (1990) to 18 mill.t (1995). Oxides of sulphur and nitrogen, volatile organic compounds and hard particles decreased as well. It abated pollution of the environment.

Due to the peculiarities of the system and objects of national energetics, primary energy sources, consumed quantities of them are specific. During the last decade Ignalina nuclear power plant was of extraordinary importance in supplying electricity for the national economy. It produces more than 80% of the whole electricity and nuclear fuel constitutes 30% of the primary energy sources (Figures 1 and 2).

In the balance of fuel and energy among primary energy sources the part of local fuel (other fuels) constantly increased (Figures 1 and 2) over the last period. These are fuel wood, other primary solid fuel (waste obtained from logging and wood processing,

Table 7. Main energy indices in Lithuania in 1990-2000

Indices		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Electricity Production:	TWh	29,4	18,7	14,1	10,0	13,9	16,8	14,9	17,6	13,5	11,4
Ignalina NPP	-//-	*17,0*	*14,6*	*12,3*	*7,7*	*11,8*	*13,9*	*12,0*	*13,6*	*9,9*	*8,4*
Electricity Export	-//-	12,8	5,3	2,7	-1,1	2,7	5,2	3,5	6,1	2,7	1,3
Heat Production	Pcal	35,4	25,4	20,3	20,5	19,4	19,7	18,3	17,7	14,3	11,6
Crude Oil Processed	Mt	11,7	4,1	5,2	3,9	3,3	4,3	5,6	6,9	4,6	5,0
Oil Products Export	Mt	3,5	-0,4	1,3	0,2	0,1	1,0	2,3	3,2	1,9	2,2
Primary Energy Consumption:	Mtoe	18,5	11,9	9,4	8,1	9,1	9,9	9,2	9,9	8,2	7,2
Oil Products	-//-	*8,2*	*4,5*	*3,9*	*3,7*	*3,2*	*3,3*	*3,3*	*3,7*	*2,9*	*2,2*
Natural Gas	-//-	*4,8*	*2,8*	*1,5*	*1,7*	*2,0*	*2,2*	*2,0*	*1,8*	*1,8*	*2,1*
Coal	-//-	*0,6*	*0,4*	*0,4*	*0,3*	*0,2*	*0,2*	*0,2*	*0,1*	*0,1*	*0,1*
Nuclear energy	-//-	*4,4*	*3,8*	*3,2*	*2,0*	*3,1*	*3,6*	*3,1*	*3,5*	*2,6*	*2,2*
Other fuel	-//-	*0,5*	*0,4*	*0,4*	*0,4*	*0,5*	*0,6*	*0,7*	*0,8*	*0,8*	*0,6*
Final Energy Consumption:	-//-	9,4	6,6	5,2	4,9	4,8	4,7	4,6	4,5	4,1	3,8
Final Fuel	-//-	*5,2*	*3,6*	*3,0*	*2,7*	*2,7*	*2,7*	*2,7*	*2,6*	*2,5*	*2,4*
Final Heat	-//-	*3,2*	*2,2*	*1,6*	*1,6*	*1,5*	*1,4*	*1,3*	*1,3*	*1,0*	*0,9*
Final Electricity	-//-	*1,0*	*0,8*	*0,6*	*0,6*	*0,6*	*0,6*	*0,6*	*0,6*	*0,6*	*0,5*
FE/PE	%	51	55	55	60	53	53	50	46	50	52

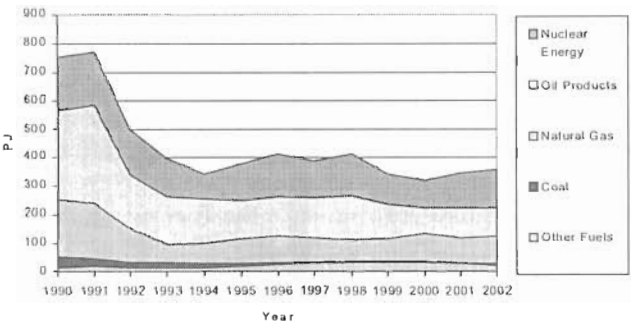

Figure 1. The dynamics of the primary energy sources consumed in Lithuania in 1990–2002

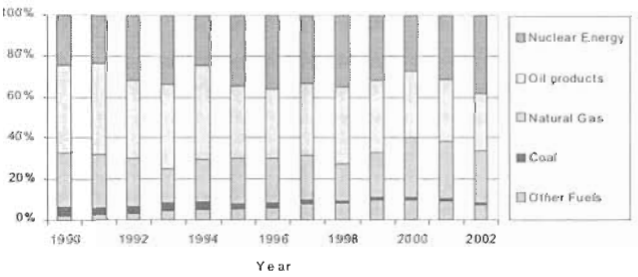

Figure 2. The structure of utilization of the primary energy sources

straw, municipal, industrial and agricultural waste for burning) biogas, dump gas, hydroenergy, local oil and gas that are burned in places of oil obtaining. It is explicitly indicated by an increase in fuel wood consumption: in a period of 10 years fuel wood consumption augmented 4 times (Figure 3).

The tendencies of generation of primary energy over the last period, which characterize the development trends of local fuel use, are shown in Figure 4.

As seen from the Figure, the part of local fuel resources in the total fuel balance annually increases.

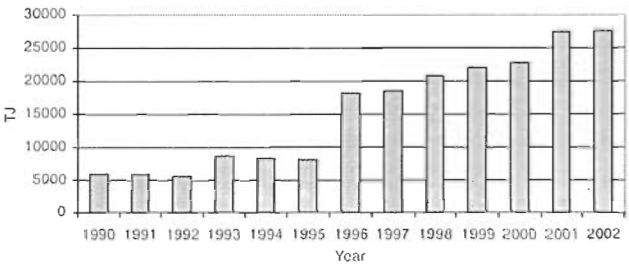

Figure 3. The dynamics of total fuel wood consumption in Lithuania in 1990–2002, TJ

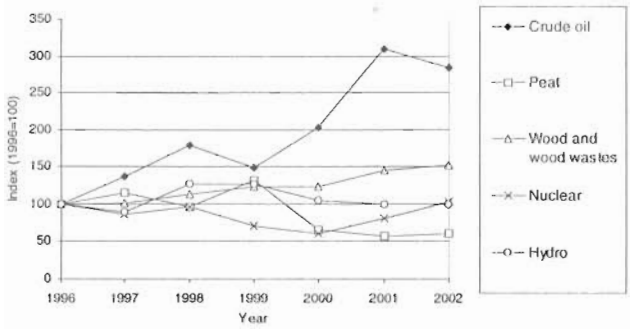

Figure 4. Generation index of primary energy

It augmented from 3% in 1990 to 8% in 2002. However, the contribution of the kinds of local fuel in energetics is unequal and the tendencies of its use are diverse. Recently, consumption of peat and blocks diminished whereas that of fuel wood increased up to 85%. The extent of the part of other primary solid fuel in the total quantity of fuel is an affirmative factor. Since in the content of this primary natural fuel there is waste (marginal wood) of forest felling and wood processing as well as straw etc. an increase in this part of fuel implies an increase in wood waste use in energetics.

Current use of forest biomass for energy by different consumers

Lithuania has no indigenous fossil fuels therefore they must be imported. Consequently, power saving and use of local and renewable resources is one of the major tasks of the state (Table 8). It could improve the foreign trade balance and provide employment. As seen from the Table, during the last decade fuel wood consumption in different economic sectors varied significantly. In the industrial, agricultural and construction sectors fuel wood consumption is comparatively insignificant and changes are uneven. Over the last three years it increased one and a half time (Figure 5).

Table 8. The general balance of fuelwood

	Wood balance								
	Thou. m³			ktoe			TJ		
	1998	1999	2000	1998	1999	2000	1998	1999	2000
Production	2544.3	2755.3	2747.6	498.7	540.0	538.5	20863	22593	22530
Import	1.5	1.6	0.8	0.3	0.3	0.1	12	13	6
Export	0.5	0.8	1.2	0.1	0.1	0.2	4	6	9
Changes in stocks	-12.5	-66.1	20.4	-2.5	-13.0	4.0	-102	-542	168
Gross consumption	2532.8	2690.0	2767.6	496.4	527.2	542.4	20769	22058	22695
Transformation in CHP and heating plants	44.2	13.5	14.8	8.7	2.7	2.9	362	111	121
Consumption of the energy branch	0.7	0.1	0.4	0.1	0.0	0.1	6	1	4
Non-energy consumption	13.4	0.6	-	2.6	0.1	-	110	5	-
Final consumption	2474.5	2675.8	2752.4	485.0	524.4	539.4	20291	21941	22570
Industry	34.5	34.8	34.0	6.8	6.8	6.7	283	285	279
Construction	7.2	7.5	7.5	1.4	1.5	1.4	59	61	61
Agriculture	22.9	23.4	18.8	4.5	4.5	3.7	188	191	155
Commercial and public services	138.9	197.4	197.5	27.2	38.7	38.7	1139	1619	1619
Households	2271.0	2412.7	2494.	445.1	472.9	488.9	18622	19785	20456

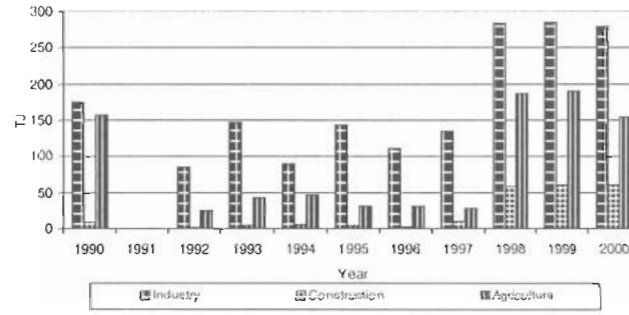

Figure 5. Final fuelwood consumption in industry, construction and agriculture of Lithuania in 1990–2000

District heating is the most important consumer of fuel wood

For the production of thermal power in heat and boiler plants of different capacities large quantities of inorganic fuel are used. For economic purposes it is expedient to use more local fuel. Heat generated and supplied for consumers is presented in Figure 6.

For most of the industrial enterprises the communal sector and for the sphere of public services electric and thermal power are supplied by power and heat plants and regional stakeholders. Recently a combination of factors such as an increase in fuel prices, as well as prices of electricity and heat have led to a decline in power consumption for production unit and for public services. Therefore many boiler plants stopped generating heat. Currently, only 258 power plants and boiler plants remained working and supply the account reports for the Ministry of the Environ-

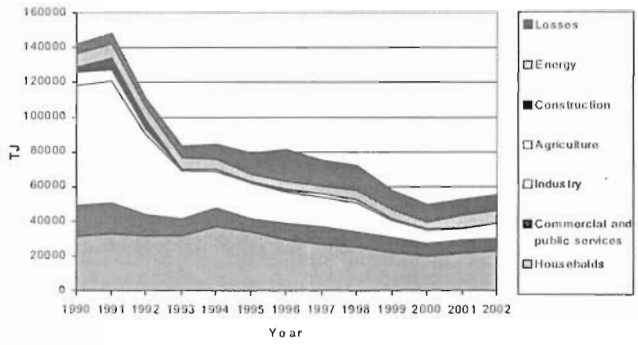

Figure 6. Consumption of thermal power supplied as central heating in 1990–2000

ment. They consume a significant portion of organic fuel while generating electricity and heat. Hitherto, the main fuel consumed in power plants and boiler plants is fuel oil.

Both the heat and boiler plants have seen a steady fuel decline in their heat generation for consumers (Figure 7).

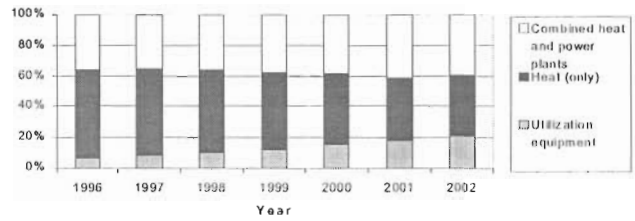

Figure 7. Heat generation, by type of plant

As seen from Figure 8, with decreasing generation of heat in heat plants an increase in heat utilization is noted, i.e. heat is consumed more effectively by using utilization equipment.

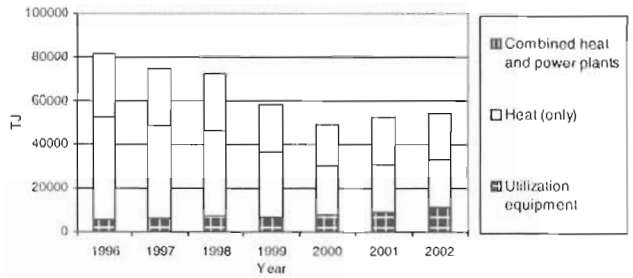

Figure 8. Index of heat generation

A slightly different character of consuming fuel wood is in power plants and boiler plants while transforming it into electric and thermal power (Figure 9). In 1994–1998 fuel wood consumption in power plants and boiler plants increased 3.5 times. However, in 1999–2000 consumption fell to the 1990–1993 level.

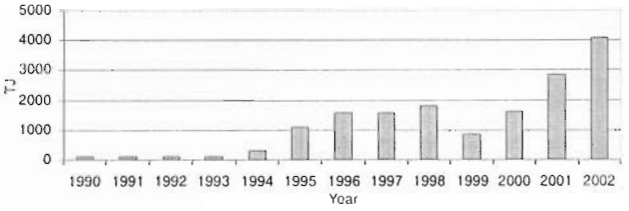

Figure 9. Final fuel wood consumption for transformation of energy in power plants and boiler plants in 1990–2000

Along with fuel wood, another primary solid fuel is used for generating heat. It contains residues (bark, branches, needles, sawdust and its bricks) of logging and wood processing as well as that of agricultural production (reed, straw, boon). This kind of fuel comprises 1% of the total fuel consumed.

Household from the former time remains the main user of fuel wood

Changes in local fuel consumption in household in the last decade is presented in Figure 10. From the Figure a decrease in peat and mercase consumption is clearly seen. Currently, wood processing residues and wood produced residues during fellings comprise 2.4% in the consumption of wood in household. Herewith strips and chops are mainly used wood residues. Chips and especially pellets are less common in household. They are particularly suitable for automatic feeding of heaters but are not used in private household due to high costs. The cheaper alternatives for household fuels are fuel wood, strips, and sawdust (Table 9).

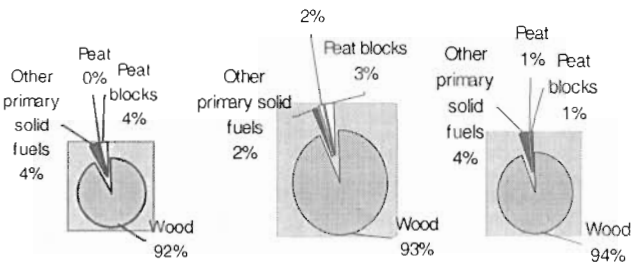

Figure 10. Consumption of the kinds of local fuel in household in 1990 (a), in 1995 (b) and in 2000 (c)

Table 9. Average prices for household fuel

Fuel type	Price	
	EUR/m³ without AC	EUR/m³ including AC
Firewood	6.00	7.10
Strips	3.78	4.46
Chips	11.62	13.70
Sawdust	1.74	2.06

*) AC – additional costs

Cheap wood residues from wood processing enterprises are mostly used in heating boilers. Fuel wood will become more expensive if residues are gathered from cutover and chopped, dried, transported to heating boilers. In this way prepared fuel wood will reach the prices of fuel oil. Prices of fuel wood in different regions of Lithuania depend on changes in supply and demand. As an example the wide range in prices of wood residues over the time is shown in Table 10.

Table 10. Range in prices of wood residues in 2001-2002

Wood residues	2001		2002	
	EUR/m³ without AC	EUR/m³ including AC	EUR/m³ without AC	EUR/m³ including AC
Strips	1.15-3.47	1.36-4.09	2.03-2.9	2.39-3.42
Chips	9.61-13.9	11.34-16.40	11.58-17.09	13.66-20.17
Sawdust	1.73-8.77	2.04-10.35	1.73-10.43	2.04-12.31

As stated above, in Lithuania from the state and private forests together with industrial residues (1.2 mill. m³) 3.6 – 3.8 mill. m³ of fuel wood are used. Nevertheless, in official statistics [16] as for 2001 are given 2.64 mill. m³. For this amount current energy use is calculated (Table 11). For next decades the use of fuel wood will increase up to 5 mill. m³.

Table 11. Current use of forest energy in TWh

	2000	2001
Industry	0.34	0.50
District heating	0.46	0.67
Household	5.83	5.70
Potential	9.8	

Lithuanian energy policy preferences and difficulties in biofuel utilization

The major objectives of energy policy are formulated and presented in the strategy of National energetics [10]: (1) reliable, safe energy supply with least expenses; (2) The enhancing of the effectiveness of energy consumption; (3) Implementation of the principles of market economy in energetics; (4) Reduction of the effect on the environment; (5) Stimulation of investment; (6) Regional collaboration and cooperation; (7) Preparation of Lithuanian energetics for the integration in the European Union; (8) Perfection of managing energetics.

Among the mentioned objectives are the following: a total of 15% of imported energy resources used should be changed over local renewable energy sources. To achieve this goal economic, legal and organizational measures promoting the use of wood, municipal and agricultural waste and other kinds of indigenous fuel are foreseen.

In the Act of Energetics the importance of the use of local fuel, renewable energy sources is indicated. The Act of Biofuel (enacted on July 18, 2000) indicates that biofuel has been accorded the priority. The Ministry of the Environment has prepared and amendment to the Act of Environment Pollution. It involves the mechanism of privileges concerning taxes to the branch of industry using biofuel.

The programme [1] of creation and development of the biofuel industry was launched. It is calculated that potential total quantity of round wood for heat production should be in conformity with boiler plant equipment. As for 2000 year the total capacity of boiler plants using wood fuel exceeded only 110 MW. Therefore it is indicated that in 2001–2003 in the country there will be produced 700 units of boiler plant equipment. Among them 500 units of 20 kW capacity, 20 units – 1,000-1,500 kW, 20 units – 2,000-3,000 kW, 5 units – 3,000-5,000 kW and 5 units – over 5,000 kW capacity. Annual investment 18.82 mill. Euros has been foreseen which secures realization of the above mentioned programme. After implementation of the above plan 2.640 new jobs would be offered and GNP would add 307 mln Euros [3].

Nevertheless, in most cases the energy generated from renewable energy sources entails difficulties. It is expensive and cannot compete with the energy generated from conventional energy sources. Therefore, so called a system of green certificates as in the EU countries are used should be introduced in Lithuania. That will create more favourable conditions for competition in the liberalized energy market. In September, 2001 EU Instructions 2001/77/EU on promotion of energy generation from renewable resources in the domestic market were issued. The Lithuanian Institute of Energetics participates in preparing the proposal for the REGOSUN project – Renewable Energy Guarantee of Origin Synergy project. One of the main objectives of the project is to prepare the system of origin guarantee of the energy generated from renewable energy sources. In perspective this system would provide the foundation for implementation of the green certificate system and join the international trade within EU.

The use of wood fuel and other kinds of local renewable energy sources is approved by the Government of Lithuania, Board of the Programme of Energy Saving at the Ministry of Economy, by the Lithuanian Institute of Energetics, the Lithuanian Forestry Institute, the Commission of Renewable Energy Sources at the Presidium of the Lithuanian Academy of Science and by other institutions and organizations. Conferences, workshops and meetings are held on the issues of the development trends of the use of wood fuel in energetics. Special project WOOD-EN-MAN financed by

EU is developing operational level management guidelines for sustainable utilization of wood based biomass from forests for energy in the Baltic and Scandinavian countries. The activity of the private Forest Owners Association is directed towards it.

Currently, according to the PHARE programme and with the aid of the Governments of other countries the total capacity of boiler plants using this fuel exceeds 110 MW. For fuel oil–fired boiler plants about 100 thousand t of fuel oil would be needed and the expenses for purchasing it would be estimated at 8.7 million Euros. In case wood fuel is used emission of sulphur is not more than 2200 t. Besides, the unemployed are invited to prepare this fuel.

Also Lithuanian–Swedish Wood Fuel Development Project shows what benefit is generated from the use of wood fuel in boiler plants. For example in the boiler plant of Biržai according to the project and by using the equipment made in Sweden wood–fired boiler DE–16–14 has been used for 5 years. A total of 5500 t of fuel oil are saved annually, which costs about 464 thousand Euros, about 200 t of sulphur and 17000 t of carbon dioxide do not get in to the atmosphere. In the regional boiler plant of Moletai according to the project of the firms from Denmark a boiler of 4 MW capacity was installed. Consequently, 3.700 t of fuel oil are saved annually [12].

Some remaining bottlenecks of bioenergy utilization

There are difficulties that hinder wood fuel consumption.

First of all the price of wood fuel is high due to preparation costs.

It is difficult to decribe the price development for wood fuel in the Lithuanian market. There exist no permanent statistics for biofuel that includes the price development. The fuel price is not a public figure since both the buyer and forest owners delivering fuel and companies work on a market with competition. Also the fuel is in most cases contracted in m³ what will make it difficult to compare with price levels from different contractors.

The data on price of energy when using imported and local fuel (Table 12) have shown that wood chips from local suppliers are comparatively inexpensive primary energy sources it means that broader utilization for heating is rather of energy policy also technological and organizational problem.

In order to use annually 500,000 m³ of wood waste for producing chips in state forests enterprises minimal investment from 11.6 to 14.5 million Euros is indispensable for purchasing technique. For technique renewal not less than 2.3 million Euros would be needed annually.

Table 12. Price of energy when using imported and local fuel

Fuel	Source of supply	Price (Euro/MWh) of energy
Fuel oil – 2.5% S	Mažeikiai	11.8
Fuel oil – 1% S	Mažeikiai	15
Fuel oil – < 3.5% S	in West Europe	15.8
Fuel oil – < 1% S	in West Europe	18.4
Orimulsion	Venezuela	9
Natural gas	Lithuanian gas	12.6
Wood chips	Local suppliers	7.2

In accordance with the calculations made by the specialists of the forest enterprises in 1994–1995 to produce 1 m³ of chips and to carry it 20 km to the boiler plant cost about 11.6–13 Euros. Currently, due to inflation and fiscal policy of the country it costs 16–17.4 Euros.

Having evaluated heat capacity of fine wood waste and other kinds of fuel (gas, oil products) and compared with the level of prices currently JSC of the firm KMW Energy of Sweden has determined that this fuel is most expensive in Lithuania. Therefore, in order to use wood waste from forests for producing chips it is indispensable to impose taxes on boiler plants for polluting, which use other kinds of fuel, or to apply a system of dotation to the producers of heat. Without regulation of prices the programs of utilization of waste from forest will not be vital [9].

An increase in the use of local fuel is hindered by higher and unregulated prices of this fuel, which (for instance, wood chips) already approached the price of imported fuel oil. In case there is no sufficiently developed production of local fuel and infrastructure of use its cost price is high. In the sphere of production of this fuel the relations of market economy have not formed. Unfavourable tax policy (tax imposed on natural resources, value added, environment pollution etc.) conditioned an increase in prices too.

The total calculated average consumption of wood fuel in boiler plants attains 466.4 thousand Mwh or 207. thousand m³. Calculated annual production of wood for fuel wood makes up 0.9–1 million m³. Most of the boiler plants use technological chip and sawdust from wood processing enterprises. Due to reconstruction of sawmills more fuel wood will have to be obtained from forest. It means that a significant increase in the quantity of energy may be achieved only by integrating waste of logging and other non–commercial wood [3].

In the last decade the use of wood waste from wood processing industry noticeably worsened due to considerably decreased demand for chopped wood. During privatization two comparatively large enterprises that had used wood waste were liquidated: Kedain-

iai biochemistry plant and plant of hard fiber stabs at Alytus House building enterprises. In the domestic market the demand for technological chopped wood waste is reduced by considerable supply of technological fuelwood. The use of wood waste, is complicated by a low level of production concentration, particularly in sawmills. The above enterprises were oriented towards complex, closed, non–waste raw material processing. Therefore, the use of wood waste for producing wood communities, apparently, will not increase in the nearest future.

It would be most real that a greater part of wood waste would be used for fuel and for energy production first, in the enterprises of timber industry in thermal boiler plants of small residential areas and in household. Larger enterprises of timber industry might organize the production of fuel blocks and granulated wood from dry fine wood waste if their use would be propagated. Currently, foreign firms produce and propagate many automatic boilers of a different type with storage of granulated wood. Such boilers may be installed in flats, they are of the form of a mantelpiece or may be assigned for the systems of central heating [13].

Service of boilers using wood fuel of insignificant value is more complicated than that of boilers using fuel oil or gas. Therefore, this fuel is avoided by the specialists of energetics.

In order to increase the scope of preparation and use of fuel wood it is necessary artificially to create special conditions and adopt measures, i.e. to introduce the system of economic taxes or subsidies. In Lithuania it should be done gradually.

Although the Government of the Lithuanian Republic (starting in 1992) adopted some Acts, foresaw economic measures stimulating local fuel use, later they were abolished. Currently, such measures practically do not exist. Also there are no structures that might organize wood waste gathering, transportation, preparation for burning in boiler plants.

Now when there is no infrastructure on large forest territories it is expensive and technologically complicated to gather waste. In accordance with the calculation made by foresters the expenses for the production of chips in forests are more significant than the price of purchasing this production. The equipment for chopping of wood waste is needed. Transportation to the energy producers costs too. In order to use wood waste capital investment for purchasing modern technique is needed. The use of wood waste for fuel is feasible only in case taxes are reduced and by presenting favourable credits for the development [12] of the production and use of biofuel.

Conclusions

Currently in Lithuania from the state and private forests together with industrial residues (1.2 mill. m^3) 3.6–3.8 mill. m^3 of fuel wood are used. There is a possibility in next two decades to increase utilization of marginal wood for energy perposes up to 5 mill. m^3 if economical and technological problems will be properly solved.

To improve wood waste use in energetics it is indispensable:

1. To make amendments in the laws being in effect by focusing attention on the system of taxes.
2. To use a part of tax imposed on imported fuel (customs, excise tax) for implementation of energy saving measures, for stimulating the use of local and renewable energy sources, for the equipment necessary to prepare and use these resources and for the development of the production.
3. To seek that the prices of local energy sources might not increase and that the taxes imposed on natural resources and value added might be reduced.
4. To make assumption to attract and use foreign and local private capital for implementation of the measures of saving energy and for the use of local and renewable energy sources.
5. A part of taxes imposed on environment protection must be assigned for the development of the use of renewable energy sources.
6. To determine the quota of the production of energy from local and renewable energy resources.
7. To ensure that the administration of districts and city Councils would pay due attention to the production, supply and use of energy resources and to the use of wood waste and renewable energy sources and that through the budget of the city Council finances would be assigned for support and implementation of the programmes of effective energy supply.
8. In due order to supplement the general programmes of educating students and schoolchildren as to the use of local and renewable energy source.

Acknowledgments

This study was carried out within the project „Wood for energy – a contribution the development of sustainable forest management (WOOD–EN–MAN, QLK5-CT-2001-00527) funded by the European Community under „Quality of Life and management of living resources"

References

Aukland, L., Moura–Costa, P. 2002. Afforestation and Greenhouse Gas Mitigation. Baltic Forestry, 2002. Vol. 8. No 1. P. 79 84.

Aplinkos ministerijos Miškų departamentas. Medienos kuro panaudojimas. 2002. [Forest Department of the Ministry of Environment. Use of Fuel Wood]. Rengėjai: V. Augustavičienė, G.Masaitis, S.Mozgeris. Vilnius (in Lithuanian).

Biokuro panaudojimo Lietuvoje galimybės. Medienos kuro gamybos galimybės septyniose šiaurės rytų Lietuvos miškų urėdijose. 2000. [Possibilities of Biofuel Use in Lithuania. Possibilities of fuel wood production in the seven forest enterprises in northern eastern Lithuania.]. Švedijos nacionalinė energetikos administracija. Kaunas: Technologija.

Dagys, L. 1997. Medienos ir durpių kuras [Wood and Peat Fuel. Science and Arts of Lithuania]. Lietuvos mokslas ,V t. 12 kn. p. 68-79.

Dagys, L.J., Jarmokas, J.R. 1998. Vietinio kuro panaudojimo galimybės šalyje. [Possibilities of use of local fuel in the country]. Vilnius: VĮ „Energetikos agentūra", Energijos taupymo programos direkcija, 15 p.

Daugiala, M. 1999. Medienos atliekų ruošimo ir deginimo technologija. Konferencijos „Medienos atliekų perdirbimas ir panaudojimas kurui" medžiaga.. LEI, Kaunas, 56-62 psl.

Jonaitis, P. 1999. Medienos atliekų perdirbimas ir panaudojimas kurui. Konferencija „Medienos atliekų perdirbimas ir panaudojimas kurui" [Processing of pulp wood and fuel use. Conference "Processing of pulp wood and fuel use"]. Kaunas: Lietuvos energetikos institutas, p. 5-10.

Jarmokas, J.R. 1999. Vietiniai energijos ištekliai šalyje ir jų panaudojimas. Konferencija „Medienos atliekų perdirbimas ir panaudojimas kurui". [Local energy resources in the country and their use. Conference "Processing of pulp wood and fuel use"]. Kaunas: Lietuvos energetikos institutas, p. 21-26.

Kairiūkštis, L. 1968. Forest husbandry in the Lithuanian SSR (in Lithuanian). Vilnius, 220 p.

Kairiūkštis, L. 1968. Forest use: main cutting and thinning. Forest husbandry in Lithuanian SSR. Vilnius, P. 62–92 (in Lithuanian).

Kairiūkštis, L. 1973. Formation and felling of mixed spruce stands. Vilnius, P. 357 (in Lithuanian).

Katinas, V., Markevičius, A.. 2001. Atsinaujinančių energijos šaltinių naudojimo Lietuvoje perspektyvos. Lietuvos energetikos instituto konferencijos darbai 2000. Kaunas: Lietuvos energetikos institutas,. 5-10 p.

Kuliešis, A., Petrauskas, E. 2000. Lithuanian forest resources in the XXI century. Kaunas, 145 p. (in Lithuanian).

Lietuvos ekologinis tvarumas istoriniame kontekste. (Ed. L. Kairiūkštis, Z. Rudzikas). Vilnius: valstybinės mokslo programos „Regiono vystymosi ekologinis tvarumas istoriniame kontekste: Lietuvos pavyzdžiu" (ECOSLIT, 1992-1997) Taryba, 1999. [Ecological sustainability of Lithuania in historical context. State scientific programme "Ecological sustainability of regional development in the historical context: Lithuanian case]. 757 p. (in Lithuanian).

Lietuvos energetika 96. [Lithuanian Energetic]. 1997. Kaunas: Lietuvos energetikos institutas.

Lietuvos energetika 2001. [Lithuanian Energetic]. 2002. Kaunas: Lietuvos energetikos institutas (in Lithuanian).

Lietuvos Respublikos Energetikos įstatymas / IX-884/2002 05 16 [The Law of Energetic of the Republic of Lithuania] (in Lithuanian).

Lietuvos miškų ūkio statistika 2001. [Lithuanian Forest Yearbook]. Vilnius: AM Miškų ir saugomų teritorijų departamentas, 111 p. (in Lithuanian).

LR Seimo nutarimas „Dėl celiuliozės gamyklos statybos Lietuvoje projekto" /IX-917/2002 05 30 [Decree of the Parliament of the Republic of Lithuania "Concerning the project of the Wood-pulp Plant building in Lithuania"] (in Lithuanian).

LR Vyriausybės nutarimas „Dėl teisės aktų, būtinų Lietuvos Respublikos elektros energetikos įstatymui įgyvendinti, patvirtinimo"/Nr. 1474/2001 12 05. [Resolution of the Government of the Republic of Lithuania "Concerning the confirmation of legal acts required for the implementation of the Law of Electric Power of the Republic of Lithuania] (in Lithuanian).

Medžio kuras ir konversijos tyrimas. Ataskaita. [Fuel Wood and Convention Research. Report]. Danijos firma „Carl Bro Energy a/s". 1994

Miškų departamento metraštis (1918–1938). 1940. [Forest Department Yearbook]. Miskų depart. leidinys. Kaunas, 128 p. (in Lithuanian).

Nacionalinė energetikos strategija / IX-1130/2002 10 16 [National Energetic Strategy] (in Lithuanian).

Nacionalinė energijos naudojimo efektyvumo didinimo programa (patvirtinta Lietuvos Respublikos ūkio ministro 2001 m. spalio 26 d. įsakymu Nr. 319).

Pedišius, N. 2000. Katilų, pertvarkytų deginti medienos atliekas Lietuvoje, darbo įvertinimas. Konferencijos „Šilumos energetika ir technologijos" medžiaga. Kaunas, Lietuvos energetikos institutas, p. 163-170.

Sakalauskas, B. 1999. Medienos kuro panaudojimas bei skiedrų gamybos galimybės miškų urėdijose. Konferencija „Medienos atliekų perdirbimas ir panaudojimas kurui". [Use of fuel wood and possibilities of shingle proceeding in forest enterprises. Conference "Processing of pulp wood and fuel use]. Kaunas: Lietuvos energetikos institutas, p. 27-32.

Statistikos departamentas prie LR Vyriausybės. Kuro ir energijos balansas 1990-1995. 1997. [Department of Statistics under Lithuanian Government. Balance of Fuel and Energy]. Vilnius: Statistika (in Lithuanian).

Statistikos departamentas prie LR Vyriausybės. Kuro ir energijos balansas 1996-2000. 2001. [Department of Statistics under Lithuanian Government. Balance of Fuel and Energy]. Vilnius: Statistika (in Lithuanian).

Statistikos departamentas prie LR Vyriausybės. Kuro ir energijos balansas 2001. 2002. [Department of Statistics under Lithuanian Government. Balance of Fuel and Energy]. Vilnius: Statistika (in Lithuanian).

Statistikos departamentas prie LR Vyriausybės. Statistikos metraštis 2001. 2002. [Lithuanian Forest Yearbook 2001. Department of Statistics]. Vilnius: Statistika (in Lithuanian).

Švenčianas, P. 1994. Biosferos apsauga šiluminėje energetikoje. [Biosphere protection in the thermoenergy]. Kaunas: Technologija.

The Kyoto Protocol to the Convention on Climate Change. Geneva: UNEP/IUC, 1998. 34 p.

Wood chips for energy production. Technology – Environment – Economy. Danish Energy Agency by the Centre of Biomass Technology. 1993.

Received 02 October 2003

РЕСУРСЫ МЕЛКОМЕРНОЙ ДРЕВЕСИНЫ И ЕЕ ЭНЕРГЕТИЧЕСКОЕ ИСПОЛЬЗОВАНИЕ В ЛИТВЕ

Л. Кайрюкштис, Б. Яскелявичус

Резюме

В статье на обширном материале рассматриваются ресурсы мелкотоварной древесины (дрова, порубочные остатки, отходы деревообрабатывающей промышленности и другая мелкомерная древесина) и их использование в энергетике в историческом развитии экономики Литвы. Выявлена доля дровяной древесины в общем объеме лесопользования в различных отрезках времени (начиная с 1927 г.) государственного развития. Приводится прогнозы накопления мелкомерной древесины до 2030 г.

Анализируются процессы и технология сжигания дров и древесной щепы в различных котельнях; выявлена относительная ценность используемой в энергетике древесины (PJ), их стоимость по отношении к другим первичным источникам энергетического сырья.

Рассмотрены аспекты энергетической стратегии Литвы в разрезе использования местных восстановимых энергетических ресурсов.

Ключевые слова: дровяная древесина, лесные ресурсы, энергетика древесины, биоэнергетика