

Regional Profile of the Biomass Sector in Slovakia

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Zvolen 21.6.2013

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1. Introduction

Slovak republic is a state in Central Europe. It has population over five million and an area of about 49,000 square kilometres. The country is among the most forested in Europe – about 41% of its territory. The area of forest holdings is continually increasing to its current 2011 million ha. Since 1950 the forest crop land grew by 175 000 ha (Table 1). After 1990 there was a change in ownership relations and now there are more than 50 % of forests in non-state ownership. During this period there was a significant decrease of state financial support and increase of size of protected areas that limit production possibilities of forestry. In the last decades, proportion of salvage felling increased and currently ranges from 50 % to 70 %. By the year 1990 production of energy was almost exclusively oriented on the use of fossil fuels. Wood waste was used in bigger wood processing enterprises to cover their own technological consumption of heat. Interest in the use of biomass for energy generation particularly in the form of firewood and fuel chips has increased after the liberalization of fuel prices and energy after 2002. Gradually there is an increase in production of liquid fuels mainly from oil-seed rape and production of electricity from biogas, which source is an agricultural biomass and sledge from waste water treatment plants.

Table 1. Changes in forest area and forest crop land

Type	Year							
	2005	2006	2007	2008	2009	2010	2011	2012
	Area (ha)							
Forest area	2006172	2007006	2006601	2007441	2009264	2010817	2011467	2012414
Forest crop land	1931645	1932049	1932942	1933591	1937685	1938904	1940108	1940300
Forest area without crop	74527	74957	73659	73850	71579	71913	71359	72114

2. Condition and structure of Slovakia forests

2.1 Geography and topography

In term of natural landscape types, Slovakia is extremely varied. The structure of landscape is also determined by topography and climate. Slovakia can be divided by altitude in to roughly four type landscape:

- lowlands including of moderately warm valleys between 95 and 300 m above sea level which make 40 % of Slovakia total area, but only 16,1 % of its forests (average forest cover 16,5 %),
- uplands and low hills 300 and 800 m above sea level which represent 45 % of country area, but shelter 61,8 % of its forest (average forest cover 61,8 %),
- highlands between 800 and 1500 m above sea level which make up 14 % of Slovak territory and 21,7 % of its forests (average forest cover 63,4 %),
- alpine mountains over 1500 m above sea level, which cover 1 % of Slovak area and 0,4 % of its forests (average forest cover 18,5 %).

The topography of a forested area in Slovakia is mainly characterized by mountains and steep slopes. Use of harvesters, processors and forwarders is limited and possible in only 45 % of forest area (Table 2). The majority of felling have to be carried out manually with chain saw and hauled by means of tractors or by cable cranes, which incurs higher harvesting and transport costs.

Table 2. Slope gradients in Slovak forest

Gradient (%)	Share on total forest area (%)
0 – 10	0,6
11 - 20	10,9
21 - 30	18,0
31 - 40	21,0
41 - 50	18,0
51 - 60	11,3
61 - 70	6,3
71 - 80	3,3
81 - 90	1,0
91 - 100	0,3

2.2. Forest conditions

Slovak forests are species diverse – both conifer and broad-leaf species are abundantly present. The commonest tree species include beech (32,2 %), spruce (24,9 %) and oaks (10,6 %).

Table 3. Main tree species

Tree species (%)									
Norway spruce	Pine	Silver fir	European larch	Dwarf pine	∑ Conifers	European beech	Oak	Hornbeam	Turkey oak
24,9	6,9	4	2,4	1,1	39,3	32,2	10,6	5,9	2,5
Sycamore/Maple	Black locust	Ash	Birch	Alder	Hybrid poplars	Domestic poplars	Lime tree	Other broad leaf	∑ Broad leaf
2,1	1,7	1,5	1,5	0,8	0,5	0,4	0,4	0,4	60,7

Source: Compendium of Slovak Forestry Statistic, NFC-IFRI Zvolen, 2013

A well-balanced age structure of forest resources is vital for sustainable timber production, delivery of other forest services and stable economic conditions for continual forest production. At present, the majority of commercial forests are between 60 and 110 years old – a well above the level of normal (theoretical) area of age classes.

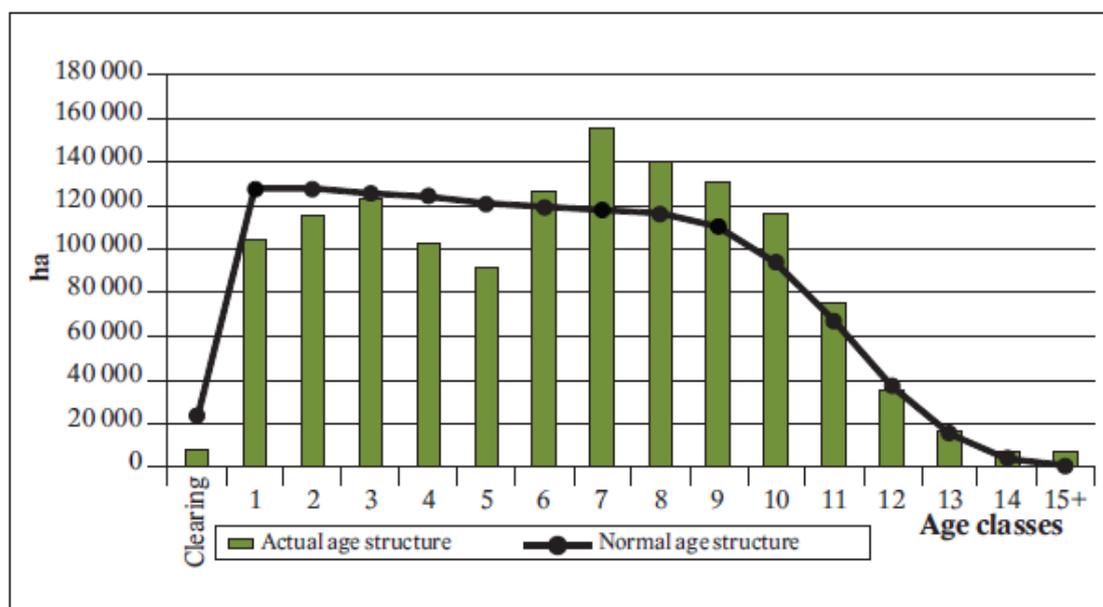


Figure 1. Age structure of commercial forests

Table 4 clearly shows a gradual increase in the average age of main tree species of Slovak forests caused by uneven distribution of particular age classes. A drop in the average age of spruce observed last year is associated with an abnormal level of incidental felling, particularly in older spruce stand.

Table 4. Average age of selected tree species

Year	Tree species								
	Spruce	Fir	Pine	Larch	Oak	Beech	Hornbeam	Sycamore/Maple	Ash
	Age in years								
2005	67,6	76,8	63,8	47,7	75,4	71,0	64,1	51,8	52,6
2008	68,4	77,7	65,2	49,0	77,1	71,5	64,3	52,0	53,7
2009	68,2	77,6	65,6	49,4	77,5	71,5	64,4	51,8	54,3
2012	68,5	77,8	67,1	50,9	79,9	71,5	64,7	52,2	56,1

Source: Compendium of Slovak Forestry Statistic, NFC – IFRI Zvolen,

2.3 Growing stock and carbon in forest

Recent figures suggest a gradual increase in the growing stock available in Slovak forest. Last year, the growing stock reached 472.18 million m³ of timber inside bark. The average stock was 244 m³.ha⁻¹ of timber inside bark.

The growing stock increase is predicted to culminate in 2015 – 2020. After that, growing socks is expected to decrease due to higher presence of younger forest stands.

Table 5. Growing stock 2005 - 2012

Growing stock		Year							
		2005	2006	2007	2008	2009	2010	2011	2012
Total (mil. m ³)	total	438,9	443,8	445,9	452,1	456,4	461,95	466,07	472,18
	conifer	207,35	209,8	209,2	211,2	211,5	212,16	211,93	213,31
	Broad-leaf	231,55	234,0	236,7	240,9	244,9	249,79	254,14	258,87
Per 1 ha (m ³)	average	229	231	232	235*	237	239	241	244
	conifer	264	268	269	272*	274	276	278	281
	Broad-leaf	204	206	207	210*	212	215	217	221

Source: Compendium of Slovak Forestry Statistic, NFC-IFRI Zvolen, 2013

Table 6. Carbon stock in forest

Year	Carbon stock in forest				
	Carbon in biomass		Carbon in dead biomass		Carbon in soil
	Aboveground	Belowground	Deadwood	Humus	
	mil. ton				
2012	180,6	39,0	16,5	22,4	270,5
2011	178,3	38,5	16,3	22,4	270,5
2010	173,6	37,6	15,3	22,4	270,5
2005	166,3	36,1	15,3	20,4	270,5
2000	156,1	33,7	14,5	19,5	270,5
1990	133,9	28,8	12,5	16,7	270,5

Source: Moravčík, M. et al. 2010: National Report on Quantitative Indicators for SLOVAKIA. Enquiry on State of Forests and Sustainable Forest Management in Europe 2011; National Data on PAN-EUROPEAN Indicators for Sustainable Forest Management (roky 1990 – 2010), own resources NFC – FRIS Zvolen (roky 2011 a 2012)

2.4 Forest ownership structure

The structure of ownership and forest tenure is given in Table 5. According to table, state subject managed last year 54,6 % of the total forest area, but held property rights only to 40,5 % of the area. There are still and estimated 12,8 % of forest with unidentified ownership. Table also shows that the process of restoration of original forest ownership rights has yet to be fully completed.

Table 7. Ownership and tenure in forest

	State	Non state	Community	Church	Agri cooperatives	Municipal	Σ Non state	Unknown
	Timber land (%) ownership / tenure							
2012	40,5	11,3	23,1	2,7	0,3	9,3	46,7	12,8
	54,6	7,0	28,0	1,4	0,4	8,6	45,4	-
2011	40,8	11,3	24,5	2,9	0,3	9,4	48,3	10,9
	55,1	6,5	27,9	1,3	0,3	8,9	44,9	-
2010	40,9	12,3	25,0	2,9	0,3	9,4	49,9	9,2
	55,4	6,4	27,4	1,4	0,3	9,1	45,6	-
2009	40,9	13,4	26	3	0,3	9,7	52,4	6,7
	54,8	6,9	27,4	1,6	0,3	9	45,2	-
2008	40,2	13	25,6	3	0,2	9,7	51,5	8,2
	55,1	7,2	26,9	1,7	0,3	8,8	44,9	-
2007	41,4	14,3	25,5	3,2	0,2	9,8	53,0	5,6
	55,5	7,2	26	2,1	0,3	8,9	44,5	-
2006	41,1	15	25,3	3,1	0,2	9,8	53,4	5,5
	56,1	7,2	25,5	2	0,3	8,9	43,9	-
2005	41,8	14,2	24,9	3,4	0,1	9,7	52,3	5,9
	58,5	6,3	23,8	2,5	0,2	8,7	41,5	-
2004	42,1	14,6	24,4	3,4	0,2	9,9	52,5	5,4
	59,4	6,2	23	2,5	0,2	8,7	40,6	-
2003	42,2	12	24,3	3,2	0,1	9,7	49,3	8,5
	61,5	5,9	21,6	2,1	0,2	8,7	38,5	-
2002	42,8	12,9	24	3,2	0,1	9,7	49,9	7,3
	62,3	6,1	20,6	2,1	0,2	8,7	37,7	-

State forest

At present, forest in state ownership are managed by the Forest of the Slovak Republic, s.e., Banská Bystrica (Forest SR), Forest – agricultural Estate Ulič, s.e. (FAE), and State Forest (SF TANAP). All of the abovementioned subjects fall under the MA SR authority. The Military Forests and Estates, s.e., Pliešovce (MFE SR) are administered by the Slovak Ministry of Defence. These subjects also manage forests unreclaimed by their original owners and forests leased from non-state subjects.

Table 8. Basic indicators for state forests

Indicator	Subject					Total
	Forest SR	SF Tanap	FAE Ulič	MFE SR	FC, TU	
Forest crop land, ha	923 357	38 855	21 252	63 731	12 102	1 059 297
Growing stock, thous. m ³	227 725	6 084	4 771	13 725	3 393	255 697
Area of mature stand, ha	179 450	3 570	3 127	13 027	2 667	201 841
Growing stock of mature stands, thous. m ³	73 727	1 316	1 340	4 269	1 363	82 015
Total current increment, thous. m ³	5 813	136	148	417	86	6 600
TCI ha/m ³	6,34	4,53	6,96	6,62	7,15	6,33

Source: Compendium of Slovak Forestry Statistic, NFC-IFRI Zvolen, 2013

Non state forest

There are following main categories of ownership in non-state forests: private, community, church, agro-cooperatives, and municipal.

Table 9. Basic indicators for non-state forests

Indicator	Ownership					Total
	Private	Community	Church	Agri	Municipal	
Forest crop land, ha	136 586	543 456	26 557	6 978	167 426	881 003
Growing stock, thous. m ³	35 486	130 143	6 747	1 528	42 582	216 486
Area of mature stand, ha	34 379	107 543	5 289	1 626	32 762	181 599
Growing stock of mature stands, thous. m ³	14 650	42 828	2 129	582	14 418	74 607
Total current increment, thous. m ³	892	3 385	161	42	1 046	5 525
TCI ha/m ³	6,58	6,35	6,10	6,11	6,30	6,37

Source: Compendium of Slovak Forestry Statistic, NFC-IFRI Zvolen, 2013

Table 10. Outsourced operation

Subjects	Artificial regeneration		Forest protection		Cleaning		Felling		Skidding		Timber haulage	
	ha	%	ha	%	ha	%	tis.m ³	%	tis. m ³	%	tis. m ³	%
Subjects under MA SR	4 871	95	37 656	96	18 442	90	3 716	95	3 394	92	1 577	48
Subjects under other ministries	680	98	1 935	90	1 750	99	395	92	389	96	260	72
Σ State subjects	5 551	95	39 591	95	20 192	91	4 111	95	3 783	92	1 837	50
Non-state subjects	5 840	95	36 733	97	8 334	79	3 787	97	3 652	97	3 194	86
Total	11 391	95	76 324	96	28 526	87	7 898	96	7 435	94	5 031	69

Source: Statistical record Les, MP SR, 2013

2.5 Forest owner cooperation (FOCs)

The biggest owner and managing subject of the forests in state ownership are the Forests of the Slovak Republic, s.e. , Banská Bystrica (Forests SR), whom the volume of timber felling reaches values between 3 800 000 and 4 200 000 m³. The other state enterprises are the Military Forests and Estates, s.e., (MFE SR), the State Forests TANAP (SF TANAP) and the Forest-agricultural Estate Ulič, s. e. (FAE), which reach the total volume of timber felling from 800 000 to 1 200 000 m³. All of these state enterprises trade with the manufacturers of wood independently on the base of long-term contracts. They are the main suppliers for the domestic market and ensure its stability.

The official representant of the non-state forest sector is Council of the Non-state Forest Owner Associations (CNFOA), which associates:

- Union of Regional Associations of Non-state Forest Owners

- Slovak Association of Municipal Forests
- the Slovak Union of Diocese Forests
- the Union of Owners of Private, Community and Municipal Forests of Banská Bystrica Region

The main aim of these associations is protection of the interests of non-state forests owners in the field of legislation. These associations don't provide independent commercial activities and services concerning the forest management. Non-state owners of forests provide independent commercial activities, but they don't cooperate each other. Small and medium-sized owners (approx. up to 300 ha) sell wood mostly to private business enterprises or to inhabitants. The big owners sell part of its production directly to manufacturers of wood. The disadvantage of the small-sized owners is their fragmentation and lower selling prices of wood because of unregularly timber felling and smaller volume of deliveries.

3. Biomass resources

Due to natural conditions and structure of land use, wood biomass from forestry, non-forest land and wood wastes are main source for solid biofuels in Slovakia. Agricultural non-wood biomass is utilized as well. Share of wood biomass on present total annual consumption of biomass for energy production is 88 %, while agriculture provides 12 % of the biomass for energy use.

3.1 Forest biomass

The total wood stocks in Slovakia amount to 472,2 mil.m³ , which equals 244 m³.ha⁻¹ . 55 % of the stocks are broad-leaved wood, while 45 % are coniferous. The annual increment is 12,1 mil.m³ in total or 6,3 m³.ha⁻¹. About 55 % of stocks in Slovakia are standing in state forest and 45 % in non-state forest.

According to statistics, a total of 9 248 100 m³ of timber was removed from Slovak forests in 2009. This represented a 2.3 % (219 000 m³) decrease from the 2008 figure of 9 467 100 m³. Incidental felling accounted for 60.4 % of the total volume. At 5 547 000 m³ of removed timber, felling in state subjects accounted for 60% of all removals. Of this volume, coniferous and non-coniferous timber accounted for 63 % and 37 %, respectively. The remaining 40% of timber was removed from non-state forests of which 72 % was coniferous and 28% non-coniferous timber. Large volume of incidental felling was the main contributing factor behind abnormally high removals of timber from Slovak forests (118% of the planned volume).

3.2 Short rotation coppice

According to statistic of Slovak Ministry of agriculture and rural development a total area of short rotation coppice on forest land is 520 ha. The main tree species is Robinia pseudoaccacia. Rotation time is 15 – 20 years, expected annual production 10 t dry matter. Potential area for short rotation plantations (Robinia, poplars) on forest land is 15 000 ha. According estimations of NFC theoretical potential for short rotation coppices on agricultural land in Slovakia is 45 000 ha. However currently there are only about 150 ha of short rotation coppices. The main tree species used are willow and

poplar. Rotation time reaches from three to ten years. Expected annual yield is in the range of 12 – 18 t biomass per hectare (6 – 10 t dry matter under good conditions and management).

3.3 Wood residues

Changes in the area of ownership relations after 1990 led to fragmentation and changes of Slovak wood processing industry. Annual amount of processed wood was decreased from 5,5 mill.m³ to 4 mill.m³. Current annual processing of wood is in the range of 6 – 7 mill.m³.

The residues that come as by product in wood working industry provide raw material for energy use for covering energy consumption of wood working factories, bioenergy market supply in form of fuel chips, sawdust, firewood and wood pellets. Part of raw material production is using producers of wood fiber and chip boards.

Potential of wood residues which is available for energy use are used almost to the full extent, but there are many possibilities for improvements of efficiency (costs, energy efficiency, environmental impacts) including diversification of fuel sources and optimization of biomass supply chain.

3.4 Agricultural biomass

Solid or liquid agricultural biomass has currently been used for energy production mainly in biogas stations and for liquid fuels production

By 2020, there is binding objective in the field of biofuels to add only 10 % of biomass components into the conventional fuels transport. This objective should be achieved by the cost-efficient way. A binding character of this objective is appropriate under the condition that production will be sustainable and second-generations biofuels will be available and also the directive on biofuels quality will be amended in order to achieve a higher share of bio-component in the fossil fuels.

Government, it was proposed to adopt measures to promote the use of agricultural biomass for energy purposes. It is necessary to create such conditions to build biogas plant each year with an installed power of 7,5 MW (Ministry of Economy estimates 30 devices with an average power of 250 kW). More significant construction of biogas plants was estimated after the adoption of Act on renewable energy sources and combined production in 2009. According to the lower competitiveness of agriculture in the area of food production, one of the possibilities is to improve the economic situation in the sector and also growth of efficient productions of energy crops is the significant factor of rural development. Growth of this production depends on optimal solutions of using the managed agricultural land, while maintaining the national food security, and on solution to the problems of unused agricultural land and proposals for their use to produce fuel wood biomass in Slovakia.

4. Wood and Biomass use in Slovakia

4.1 Production and demand of biomass in Slovakia

4.1.1 Wood chips

In 2012 total annual production of wood chips was about 1 470 000 tons. Production of wood chips in forestry was 550 000 tons. State forest enterprises produced 160 000 tons, non-state producers produced 390 000 tons. Production of wood chips on non-state forest land (non used agriculture land, river banks trees, etc.) was 580 000 tons.

Production of wood chips in wood processing industry for Slovak biofuels market was 340 000 tons. No specific date regarding the quality of the produced wood chips is available. Quality of wood chips is object of contract conditions between and user and supplier. Maximal moisture of chips is limited usually.

4.1.2 Fire wood

In 2012 total annual production of firewood was 1 060 000 tons. Production of firewood in forestry was 780 000 tons. State forest enterprises produced 250 000 tons, non-state producers produced 530 000 tons. Production of piece wastes used as firewood in wood processing industry for Slovak biofuels market was 280 000 tons. Quality of firewood is characterized in Slovak technical norm of wood assortments, but that is recommendation for producers and user.

4.1.3 Pellets and other biofuels

Slovak pellets market was established in the end of 90s and still is relatively small. Annual domestic consumption in 2012 was approximately 50 thousand tons. Slow development of Slovak pellets market is impacted relatively high prices of heating devices (boilers), and by low competitive ability of pellets with comparison of natural gas and firewood. Pellets supply chain is still very low development.

The pellet consumption market is confined to the residential sector and small or mid communal houses (i.e. school). Device for pellets being automatically stocked pellet boilers with a heat output up to 100 kW.

Pellets production is unstable and much dependent on situation on international market (demand, prices). In 2012 Slovak pellets producers produced 80 000 tons and export (i.e. Italy, Netherland, etc.) was 30 thousand tons. Pellets production is based on dry sawdust from wood processing industry and import of technologies for production of pellets and its combustion.

For energy purposes in Slovakia are used black liquor in the pulp-paper industry (450 000 tons annually) and other wood wastes from processing of wood (i.e. sawdust 470 000 tons annually).

4.2 Energetic use of Biomass

Total annual self-consumption of forest enterprises in 2012 was 20 000 tons of woodchips and 30 000 tons of firewood, mainly for space heating and HSW preparing. Total annual selfconsumption

of wood processing industry including pulp and paper industry was 1 280 000 tons of solid and liquid residues. Annual consumption of black liquor was 148 000 tons of solid and liquid residues. Annual consumption of black liquor was 480 000 tons and 830 000 tons of solid residues in form of chips and sawdust. Biomass is used mainly for technological heat and electricity production.

About 230 000 Slovak household (30 %) mainly in the rural area are directly heated by firewood. Only approximately 1 000 household is heated by pellets. Total annual consumption of woody biomass of household in 2012 was 1 064 000 tons. Currently 237 district heating systems exist in Slovakia for space heating and HSW distribution, nine of its are supplied from heating or power plants of wood processing and paper industry, next seven district heating systems are distributing heat from regional power plants which are using coal, natural gas and woody biomass (co firing or separate boilers). Total annual of district heating systems based on woody use is 104.

Structure of thermal power capacity of this system:

- Capacity up to 500 kW : 9
- Capacity from 501 up to 2 000 kW: 16
- Capacity from 2 001 up to 5 000 kW: 24
- Capacity from 5 001 up to 15 000 kW: 36
- Capacity over 15 000 kW: 19

10 CHP (combined heat and electricity production) using woody biomass in Slovakia. Total annual consumption of woody biomass in heating or power plants which are producing heat for district heating system in 2012 is 1 360 000 tons (excluding suppliers from wood processing and pulp industry). Total annual consumption of woody biomass in other industrial branches (machinery, agriculture, food industry, etc.) was 136 000 tons.

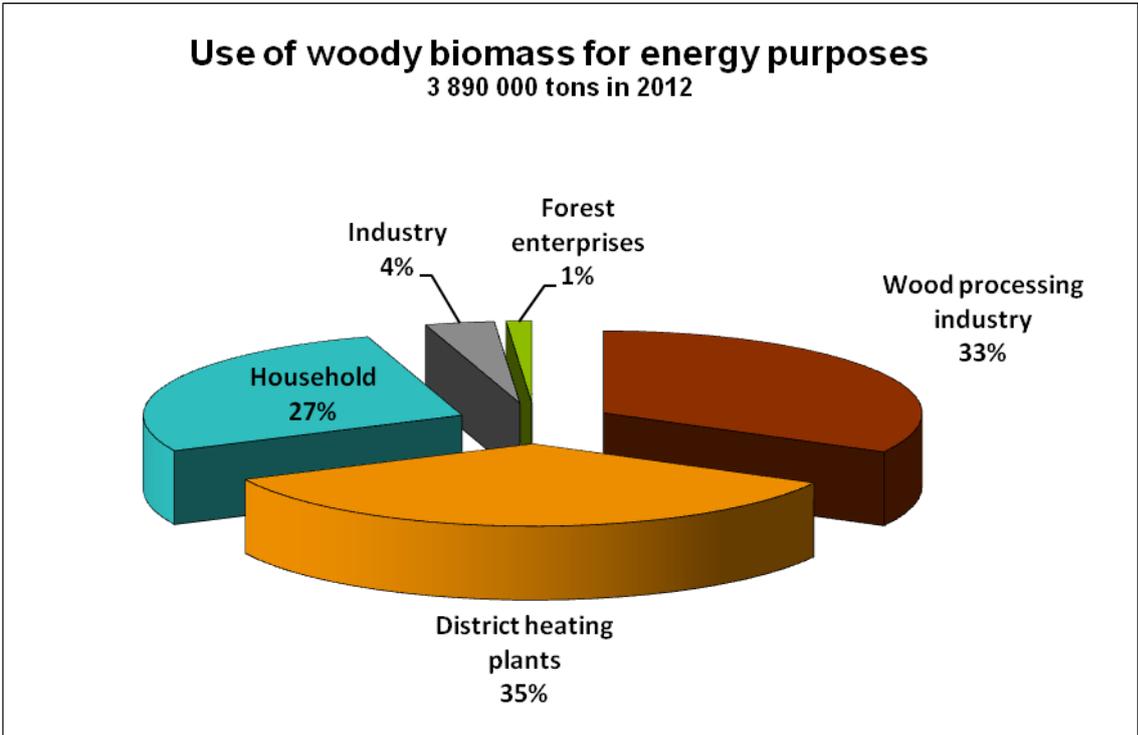


Figure 2: Energetic use of biomass in Slovakia in 2012

4.3 Costs of solid biofuels

4.3.1 Price for woodchips

Prices of wood chips depend of different factors, such as water content, share of additives (soil, minerals, leafs, bark), regional conditions (level of fuel prices) and originality of wood chips (forest, non-forest, wood processing).

Wood chips are traded mostly by weight (in tons) and water content is limited according contract conditions (technical parameters of boilers). Therefore prices are different between different traders or producers. Slovak biofuels market for wood chips, firewood and wood wastes is know for its regional and informal character and trade is based on direct contracts between producers, traders and end user.

Price level of wood chips and firewood is influenced by prices of pulp wood and fossil fuels (especially natural gas and coal) also by prices of electricity produced from RES (Renewable energy sources). There is a competition between pulp industry and energy sector. Due to relatively low prices of pulp wood (36 – 40 Eur.m⁻³) private forest owners often selling pulpwood for energy use to traders, chips producers and end users (for chips production on storage) or as firewood for household.

Prices of fossil fuels since 2002 were increased almost triple that increased competition ability of woody biomass.

Price of wood chips depends also on production costs. Production costs of forest chips are usually higher than chips produced on non forest land and wood processing industry (logging and transport costs). End users prefer lower prices therefore forest sources of wood biomass potential are used on the level about 30 %.

On the opposite side sources of woody biomass on non forest land (i.e. unused agricultural land) are used on the level 60 – 80 %.

Prices of raw material in spring 2013 in Slovakia:

Wood chips: 43 – 55 €·t⁻¹ (wet tonne)

Fire wood: 40 – 55 €·t⁻¹ (wet tonne)

Raw material for chipping

from wood processing industry: 32 – 37 €·t⁻¹ (wet tonne)

Pulpwood for chipping: 35 – 40 €·t⁻¹ (wet tonne)

Required maximal water content (relative moisture) is mostly 30 – 40 %.

4.3.2 Price for wood pellets

The pellet market in Slovakia is very low developed because of low demand (about 1000 household) and about 100 small or mid end users with annual consumption up to 3000 tons. Most of pellets producers is depended on export possibilities. In the year 2010 – 2012 annual production dropped from 120 000 tons to 80 000 tons and many producers stopped their production.

Pellets market is based on regional and local level.

Pellets are standardized product which consist solely of sawmill dry residues from coniferous (mainly spruce) and broadleaves (mainly oak and beech) and is traded in tons only.

Domestic prices of pellets depend on export possibilities and seasonality and regional conditions. Present price level (spring 2013) of pellets in Slovakia is 170 – 210 €·t⁻¹.

4.4 Technical standards for solid biofuels

The most important standard in the European context regarding the characteristic of solid biofuels is EN 149 61 “Solid biofuels – Fuel specifications and classes” which consists from six parts. The standard specifies the characteristic of wood pellets, wood briquettes, wood chips, firewood and non-woody pellets.

4.4.1 Standard for wood chips

Relevant standard for wood chips in Slovakia are STN 480058 “Assortment of wood, sawdust and offcuts of hardwood” and STN 480057 “Assortment of wood, chips and sawdust of softwood”. The most important product parameters of wood chips specified in these standards are grain size, type of raw material, moisture, bark content, ash content and net calorific value. As well methodology of moisture, quality, grain size and bulk density testing and assessment are specified.

These standards included terms and definitions of raw material based on standard STN 480056, STN 490002 and STN EN 844-3.

The chips are divided according to the grain size in the following way:

- Fine grain size chips from 5 to 50 mm
- Thick grain size chips from 5 to 120 mm

The chips are divided according to the moisture content and calorific value to the 4 categories:

V₁- moisture up to 20 %, calorific value over 14,1 GJ.t⁻¹

V₂ - moisture from 21 to 35 %, calorific value 10,5 – 14,1 GJ.t⁻¹

V₃ – moisture from 36 to 45 %, calorific value 8,3 – 14,0 GJ.t⁻¹

V₄ – moisture over 45 %, calorific value under 8,3 GJ.t⁻¹

Bark content is limited by 30 % of total weight.

4.4.2 Standard of wood pellets

There are no own specific standard for wood pellets in Slovakia. Therefore foreign standard are accepted. Especially countries with exported Slovakia wood chips are considered, i.e. Italy, Austria, Germany, Netherland, etc.

4.4.3 Conversion factors

There are no special national standard for factors conversion between different parameters of biofuel assortments. The standard STN 480057 and 480058 provide conversion factors between moisture content and calorific value of wood chips. The standard STN 480055 “Assortment of hardwood” and STN 480056 “Assortment of softwood” provide conversion factors from solid to bulk cubic meters especially for firewood.

Solid biofuels business is based on woody biomass weight almost only in Slovakia (wood chips, pellets). Weight of woody biomass is measured on end user storage. Conversion factors are included sometime in contracts of biomass supply.

5. Forest infrastructure and logistics

5.1 Forest road infrastructure

Slovakia has insufficient forest road networks with 21m.ha⁻¹ in average. Lack of forest roads density is especially in the mountains terrains of Slovak forest between 4 – 8 m.ha⁻¹, which complicated availability of forest biomass due to technological barriers and high production costs. Total length of the forest roads network amounts to 40 000 km. The most common forest roads widths are 2 – 3 m (85 %) and 3 – 5 m (15 %). Approximately 50 % of forest roads are asphalted or paved with gravel or broken stone (20 000 km). Additionally for woody biomass transport is available 3100 km of public roads. Establishment of new forest roads is not finished in Slovakia due to lack of financial investment sources of forest owners.

5.2 Biomass supply chain

Three different supply chains have been analyzed for Slovak woody biomass supply chain.

SCORPs determination

3 SCORPs have been indicated on the basis of the structure and quantity of potential wood biomass sources and present status quo of their utilization for energy purposes:

1. Forest biomass as fuel chips produced within the state forests for the needs of the boiler houses and power plants.
2. Forest biomass as fuel chips produced within non-state forests and tree biomass from the non-forest lands for the needs of end users.
3. Waste wood biomass after the mechanical processing in wood-processing industry as sawdust particles, chips and pellets for the needs of end users.

Intervention area determination

Increased demand for wood biomass appeared in Slovakia last decade, due to intensive construction of new heating plants as well as wood biomass power plants. Especially medium and larger heating and power plants are supplied from several sources, represented by the combination of the forest biomass of state and non-state forests, tree biomass from non-forest lands and wood-processing industry waste. Annual fuel consumption for the energy producers is within 10 – 150 thousand tons. Following cases were selected for the needs of analytical scheme determination, aimed at the analysis generalized on the national level:

- 1) Supplies of forest fuel chips from state enterprise State forests SR to the heating plant Martinská teplárenská in Martin.
- 2) Supplies of fuel chips from non-state forests and non-forest lands ensured by private company to the heating plant Zvolenská teplárenská in Zvolen.

- 3) Supplies of energy wood in the form of sawdust, chips and pellets from the wood-processing industry in Lučenec to several consumers.
- 4) Woody fuel several sources supplies to power plant of Bučina enterprise in Zvolen.

Particular types of supply chains (SCH) mentioned are generalized for other cases of SCH in Slovakia, aimed at their improvement.

Brief description of 3 supply chains

Supplies of state forests forest fuel chips to the power plant stock

State Forests SR Banská Bystrica manage the forests of 900 thousands hectares with annual wood felling of 4 – 5 mil. m³. Organizational structure of the enterprise covers nowadays 20 forest enterprises managing the forests, special enterprise for the forest fuel chips (BIOMASA) and forest technology enterprise. Wood logging and transport are ensured by own enterprise capacities within 4 % of annual volume, 96 % is carried out by private companies supplies.

Fuel chips enterprise owns 8 mobile chippers. Annual chips production is within 130 - 180 thousand tons. Enterprise activities are managed by Directorate General.

Fuel chips are produced from the crown parts of the trees of principal and intermediate cutting, whole trees from the thinning and wood waste occurred during the assortment production in forest stocks.

Forest enterprise BIOMASA Management communicates directly with the fuel chips end users, represented in Slovakia by Slovak heating plants and power plants. Approximately 5 thousand tons of chips are exported abroad (Czech Republic). Chips supplies contracts are concluded usually for next calendar year. In the case of unexpected changes (consumption failure), the chips are provided flexibly to other customers on the basis of short-term contracts. Contracts with the customers are concluded by Enterprise Directorate General. The contract subjects are chips quantity, supplies time schedule and quality determined by permissible moisture and impurities proportions and price.

Annual production capacity of chips is determined by the chippers capacity and disponsible forest biomass quantity, possible for the chips production utilization within state forests during the year. Forest enterprise Biomasa management negotiate disponsible quantities with other forest enterprises managing the forests, focusing on the satisfactory forest biomass quantity, possible for the next period chips supplies on the contracts basis. Disponsible quantity of the biomass after the negotiations process is involved into the state enterprise production plan, coordinated by the Enterprise Directorate General. Quantity, time schedule, production locality and the biomass price are subject of planning.

Biomass logging and biomass storage to the forest stocks are carried out following the agreements among the enterprise organizational components and fuel chips supplies contracts. The production is ensured by private companies suppliers way on the basis of the contracts among the enterprise and suppliers. In necessary cases the harvestors, kits and cables of the enterprise ownership are utilized for these activities. Chips production is ensured by own special plants chippers. For special needs there are mowers of private companies on the basis of the contracts between the enterprise and suppliers. Chips are transported directly to the heating plant storage or to the intermediate storages and consequently to the heating plant storage according to the time schedule. Chips transport is

ensured by the private transport companies on the contracts concluded between Enterprise Directorate General and transport companies.

ICT are utilized only for intra-enterprise communication, planning and production processes organization. Relations between the chips customers and services suppliers are organized by direct negotiations.

Supplies of forest fuel chips from non-forest lands and tree biomass from non-forest lands to the end customer storage

Forest area of non-state ownership is 1,1 mil. hectares in Slovakia and annual felling is in average 4,5 mil. m³. Logging activities altogether with the wood transport are carried out by the private companies on the contracts basis, concluded with the forests owners or wood customers. Fuel chips are produced by the private companies on the basis of the contracts with the chips customers and forest owners. Source of the fuel chips is represented by the crown parts of the trees, whole trees from the thinning and fire wood of lower quality.

Private companies trading with the fuel chips usually don't own chippers, transport means and logging mechanisms. Chips production and their transport is carried out by the following ways:

- 1) Private company is buying the raw material from the forest owners, chipping that in the forest stock, production, transport and storage are carried out by own mechanisms, or these activities are done by subcontracts with the private owners of these machines.
- 2) Private company perform the wood logging and stocking on the contract basis, concluded with the forests owner, and consequently the company produce, storage and transport the chips to the end customer storage. All production activities are done by the combination of own mechanisms and services of other private companies, owning necessary machines.

Approximately 400 thousand tons of the chips were produced in 2012 from the raw material of non-state forests. Private companies producing the fuel chips within non-state forests are negotiating directly with the end customers regarding the chips supplies within the first phase, concluding the contracts, involving the price, quantity, supplies time schedule and quality determined by the chips moisture. Within the second phase the companies are negotiating with the biomass owners, concluding the contracts with them, involving the quantity, price and biomass localization. Third phase is devoted to the contracts conclusions with the machines owners necessary for the production and the transport of fuel chips.

Regarding the fuel chips production within non-forest lands there are unused agriculture lands covered by the forest wood species, coast stands, line plantings and biomass of intrasettlements. Chips suppliers perform the whole chain of the production activities, including the logging by the same way as it is in the case of the biomass utilization from non-state forests. Annually 600 thousand tons of the chips are produced from these sources.

Nowadays in Slovakia ICT are not applied, there is only direct communication among the raw material owners, chips suppliers and end customers.

Supplies of waste wood biomass from the wood-processing industry to the storage of end customers

Enterprises of wood-processing industry use the rests after the mechanical wood processing to cover their energy needs, while over-production is sold directly to the end users or private companies, supplying the fuel to the end users. Annually there is in the market 700 thousand tons of fuel biomass.

Direct fuel supplies to the end users are carried out especially by the medium and larger wood-processing enterprises in following way:

- Direct supplies of the fuel chips produced by own chipper to the energies producer storage,
- Direct supplies of sawdust to the energies producer storage,
- Direct supplies of unit waste to the energies producer storage, if they are owners of the chippers and crushers,
- Direct supplies of the pellets to the energies producers storage, if the wood processors are the pellets producers.

Transport of the fuel biomass is ensured by the private companies on the contracts basis with the producers or end users.

Small and medium wood-processing enterprises are selling the biomass to the private companies dealing with the fuels supplies to the end customers by following ways:

- Sale of the units waste to the suppliers producing the fuel chips for the needs of end customers,
- Sale of the sawdust to the suppliers of the fuel for the needs of end customers – energies producers,
- Sale of the sawdust to the pellets producers, supplying the pellets to domestic end customers or commercial companies abroad,
- Sale of the pellets of own production to the commercial companies abroad.

Private companies supplying the wood fuel to the domestic end customers perform the waste processing from wood-processing industry in the same way as in the case of the forest biomass utilization from non-state forests and non-forest lands.

ICT are applied only within the pellets export abroad. There are international portals and database related to the production, distribution and pellets utilization.

Direct communication among the producers, fuels suppliers, end customers and services providers is carried out within the domestic market, for the contracts conclusions and productive activities flows organization, biomass distribution and consumption.

6. Stakeholders

The following stakeholders play an important role in the production, distribution and promotion of renewable energies, especially wood biomass in Slovakia

6.1 State Forest Enterprise

The company manages more than 900 000 ha of forest properties with the volume of timber felling 3 800 000 - 4 500 000 m³ at present. The company employes 3600 workers and creates other 6000 jobs in the field of services, especially in felling production operations and timber transportation.

State Forest Enterprise is the main contractor in Slovakia for the wood-processing and pulp and paper industries. In 2011, the enterprise started as the first company in Slovakia with the production of chip woods and this production expanded up to the present volume from 150 000 to 220 000 tonnes per year.

In view of the company manages more than half of forests in Slovak Republic, it has the greatest potential possibilities for the expansion of production in the future. The potential sources, which are not used at present, are biomass from the intermediate and regeneration felling and great possibilities of intensification production are in the existing forest stands of fast growing tree species (poplar and black locust).

6.2 Ministry of Agriculture and Rural Development of the Slovak Republic

Ministry of Agriculture and Rural Development of the Slovak Republic is responsible for creation of legislation, strategies and politics in the field of forestry, agriculture and wood processing industry. As national authority has impact on production and using of wood biomass in Slovakia via financial and legislative tools. In 2008, the ministry elaborated and approved the Action Plan of Biomass Utilization produced in the agriculture sector. It manages activities of the state forestry organizations (State Forest Enterprise, National Forest Centre etc.).

6.3 National Forest Centre and other non-state professional organizations

The National Forest Centre (NFC) processes proposals of politics and strategies in the field of wood biomass production and its using for the needs of Ministry of Agriculture and Rural Development of the Slovak Republic and other government ministries. NFC with other organizations work together on activities in applied research, innovation and transfer of knowledge. NFC cooperates with other companies in the realisation of innovations and gives them professional assistance.

6.4 Regional heating plants in state ownership

Regional heating plants in Zvolen and Martin reach the annual consumption 150 000 tonnes of chip woods and they influence production and consumption of wood biomass in their regions significantly.

6.5 Non-state producers of heating energy to distribution networks of cities

The multinational companies (e.g. DTEFE and DALKIA) and some slovak companies (e.g. INTECH SLOVAKIA) own heating plants for wood biomass combustion in several cities and they are active in biomass production and supply chain. Their total annual consumption of wood biomass is about 100 000 tonnes.

6.6 Mondi SCP Ružomberok

Mondi SCP Ružomberok is the greatest pulp and paper player and the biggest wood contractor in Slovakia with the volume of annual consumption of wood up to 2 500 000 tonnes. The company has an ambition to become one of the important suppliers of wood biomass for other regional heating

energy producers and delivers about 250 000 tonnes of wood chips per year at present. Along with it is this company the biggest producer energies from wood, solid and liquid residues arising from paper and pulp production in the annual volume more than 1 000 000 tonnes.

7. Future biomass demand

Assumptions of the production development and the energy utilization of biomass are stated in „Long-term strategy of utilization of agricultural and non-agricultural crops for industry purposes“, which was adopted by Resolution of Government of the Slovak republic No. 108, 4 February 2009.

Implementation of forest biomass

Area of the forest land will be increased from the present 2,006 mil. ha to 2,045 mil. ha in 2025 and 2,091 ha in 2050. Stands area will be increased from the present 1,932 mil. ha to 1,939 mil. ha in 2025 and 1,951 mil. ha in 2050.

Total wood stock will be increased from the present 439 mil.m³ to 446 mil. m³ in 2025. In 2050 however it will be decreased to 418 mil.m³. Wood stock per 1 ha will be increased from the present 227 m³ to 230 m³ in 2025. In 2050 it will be however only 214 m³.ha⁻¹.

Consecutive synchronize of the size and the structure of the wood processing industry capacities with the assortment wood structure felled in SR is assumed within the predicted period. Progressive wood export elimination is taken into consideration. Considerable decrease of the compatible assortments share (log, pulpwood, fuel wood).

Usable potential of the forest fuel wood biomass consist of the raw material not meeting the quality criteria for the industrial processing as for the parameters (dimensions, shape, damage)

Fuel forest wood biomass components:

- fuel wood,
- smallwood and not used trees crowns thick wood,
- waste after the mechanical wood processing in forest institutions and the manipulating waste,
- cleaning mass ,
- stumps and the roots.

Fuel wood biomass potential utilization measure except the size and assortment wood structure is influenced by the fuels and energy prices development binding to the wood prices and state policy in these fields. Especially fuel and energy prices increase since 2002 has been revealed within up to now development.

As for the future the forest fuel wood biomass will be realized in the form of the fuel wood and fuel chips. Due to the technologies development regarding the wood biomass energy utilization there is fuel wood consumption stagnancy assumed altogether with the chips production increase.

Developments of the annual consumption of the fuel wood biomass produced at the forest land after 1990, within the predicted period 2010 – 2025 and vision for 2050 are given in the table 5.

Table 11. Annual quantities of used fuel wood biomass from forest land

Year	present	prognosis			vision
	2010	2015	2020	2025	2050
Indicator	(thousand tons)				
Fuel wood	720	735	742	750	700
Fuel chips	450	903	1551	2002	2250
Totally	1170	1638	2293	2752	2950

Sources of the fuel wood biomass within the non-forest land in the framework of agriculture are so called white areas and line planting. Perspective sources are intensive stands of the fast growing wood species within the agriculture land.

Fuel biomass potential utilization measure within the predicted period was determined on the basis of the same assumptions as for the stands of the forest land, trees crowns chipping and fuel wood production from not quality stem parts were not taken into consideration.

Development of the annual fuel wood biomass consumption development from the white areas within the predicted period 2010 – 2025 and vision for 2050 are given in the table 6.

Table 12. Annual quantities of the utilized fuel wood biomass from white areas

Year	present	prognosis			vision
	2010	2015	2020	2025	2050
Indicator	(thousand tons)				
Fuel wood	18	59	87	118	125
Fuel chips	32	106	191	228	249
Totally	50	165	278	346	374

Source of the fuel wood biomass from non-forest land are line plantings, i.e. shore stands, plantings along the communications and shelterbelts. Considerable share represent fast growing wood species. Share of the fuel wood biomass from the whole stock of approximately 800 000 m³ is estimated to 23 %.

In the case of the reconstruction and suitable maintenance of the line planting stressing main function there is possibility to increase their production potential. Proper maintenance of 3 800 km line plantings of total 912 000 m³ tree biomass stock is assumed in 2025 and in 2050 it will be 4 500 km of the total 1,1 mil.m³ stock.

Perspective source of the fuel wood biomass are intensive stands of the fast growing wood species based on the agriculture land. From among the wood species there are poplar, aspen, willow and partly acacia. Felling period is considered from 5 to 20 years and annual wood production is from 8 to 15 t. ha⁻¹, in average 10 t.ha⁻¹.

Nowadays there are no energy stands at the agriculture lands suitable for logging in Slovakia. Legislative and support mechanisms for the maintenance of these stands are not specified. In the case of necessary conditions creation till 2010 there is 100 000 ha assumption of wood biomass production till 2025 and 130 000 ha in 2050 regarding the agriculture land. Prognosis is based on the assumption that total wood biomass production will be used for the energy purposed. Fuel chips will be produced.

As for the wood processing industry there is assumption of the gradual synchronize of the size and structure of the capacities with the assortment structure of the felled wood in Slovakia.

Annual log supplies within the predicted period of 2010 – 2025 will be in the extent from 4,387 to 4,745 mil. m³ with growth tendency. Supply of 5,272 mil. m³ log is assumed in 2050.

Annual supplies of the pulpwood within the period 2010 – 2025 will be in the extent of 2,904 - 3,244 mil. m³ with a growth tendency. Supply of 3,599 mil. m³ pulpwood is expected in 2050.

Table 13. Usable potential and wood biomass consumption in DSP

Indicator	present state		prognosis			vision
	2006	2010	2015	2020	2025	2050
	thousand ton					
Waste after the mechanical processing	1 300	1 365	1 415	1 490	1 540	1 710
Liquid waste	450	470	485	505	520	560
Totally	1 750	1 835	1 900	1 995	2 060	2 260

Fuel wood biomass produced in agriculture branch at the forest and non forest land, wood processing industry and other branches will be utilized especially for the heat and electricity production. There is assumption of the considerable increase of the wood biomass used for the combined heat and electricity production. Liquid fuels production as for the economic advantages is realistic for chemical wood processing in wood-pulp industry.

Table 14. Energy value of the predicted annual consumption of the wood biomass in SR

Year	Present state		prognosis			vision
	2005 (2007)	2010	2015	2020	2025	2050
Indicator	(PJ)					
Forest land	7,3	11,1	14,6	21,7	26,2	28,1
Non forest land – white areas and line plantings	0	0,5	1,8	2,7	3,5	3,7
Intensive stands at the agriculture land	0	0	0,2	1,4	4,3	12,4
Totally agriculture branch	7,3	11,6	16,6	25,8	34,0	44,2
Totally DSP	21,0	22,0	22,8	23,9	24,7	27,1
Totally	28,3	33,6	39,4	49,7	58,7	71,3

Share of the fuel wood biomass produced at the forest and non-forest land represent nowadays cca 1 % of the total consumption of the primary energy sources (PES) in Slovakia. For predicted consumption increase this share will reach in 2015 value 2,3 %, in 2025 4,7 % and in 2050 it will be increased to 6,1 %.

Total share of the fuel wood biomass including the wood processing industry in the total PES consumption can increase within the predicted period 2010 – 2025 from 2,5 % to 9,1 %.

8. Annex

Annex 1 Result of the swots analyses

1. Supplies of forest fuel chips from state enterprise State forest SR to the heating plants Martinská teplárenská in Martin.
1p (producer), 1s (supplier), 1eu (end user)
2. Supplies of forest fuel chips from non-state forest and non-forest lands ensured by private company to the heating plant Zvolenská teplárenská in Zvolen.
2p (producer), 2s (supplier), 2eu (end user)
3. Woody fuel several sources supplies to power plant of Bučina enterprise in Zvolen.
3s (supplier), 3eu (end user)

Internal strengths

- S1. High potential sources of wood biomass in state and private forests (1P, 2P)
- S2. Sufficient amount of wood chippers with the necessary power capacity (1s, 2s, 3s)
- S3. Great biomass potential for energy use and industrial utilisation (3s)
- S4. Effectiveness of boilers to combust biomass of variable quality (1EU, 2EU, 3EU)
- S5. Sufficient storage capacity of end users and their technological equipment (1EU, 2EU, 3EU)
- S6. Ability to ensure year-round supply of fuel to the needs of end users (1EU, 2EU, 3EU, 3s)
- S7. Good expert knowledge of biomass producers and suppliers (1p, 2p, 1s, 2s, 3s)
- S8. Increasing sales of fuel biomass (1s, 1p, 2p, 2s)
- S9. Support of the electricity production from biomass (2eu, 3EU)
- S.10 Sufficient offer of fuel biomass (1EU, 2EU, 3EU)
- S.11 Acceptable current prices of chips (1EU, 2EU, 3EU)

Internal weaknesses

- W1. Insufficient economic availability of forest biomass (1p, 2p, 1s, 2s)
- W2. Gaps in legislation of biomass production and acquisition on non-forest land (2s, 3s, 1EU)
- W3. Complicated situation in the wood processing industry (2s, 3s, 1 eu)
- W4. Lack of suitable transport machinery – trucks, lorries (1s, 2s, 3s)
- W5. Poor communication with state biomass producers (2s, 3s)
- W6. Low transparency of biomass quality assessment in its supply by end users with a negative impact on the biomass price (1s, 2s)

- W7. Strong economic pressure of end users to suppliers (1s, 2s, 1p, 2p).
- W8. Low cooperation between suppliers of biomass (1s, 2s, 3s, 3 eu)
- W9. Seasonal consumption of biomass and climate impacts (all)
- W10. Unbalanced biomass quality and quantity of additives – rocks, metals (3s, 1EU, 2EU, 3EU)
- W11. Permanent changes of economic conditions (all)
- W12. Long payback period - payment discipline (1p, 2p, 1s, 2s)
- W13. Undue localization of biomass production and consumption sites (all)
- W14. Insufficient quality of services for suppliers (all).
- W15. Different support for biomass producers, suppliers and end users from public sources – end users supporting only (1p, 2p, 1s, 2s)
- W16. Lack of informations and their transparency - pricing (all)
- W17. Lack of strategy of the biomass production and its use (all)

External opportunities

- O1. Creating union of biomass fuel suppliers (1s, 2s, 3s)
- O2. Improving cooperation between suppliers of biomass and improvement of their position towards end users (1p, 2p, 1s, 2s)
- O3. Improving the economic availability of forest biomass (1p, 2p, 1s, 2s)
- O4. Improving biomass production options on non-forest land (1p, 2p, 1s, 2s)
- O5. Updating and implementation strategies of production and energy use of biomass (all)
- O6. Improving economic environment and relations transparency (1s, 1p, 2p, 2s, 3s, 1EU)
- O7. Improving of biomass producers and suppliers technological equipment and services (1s, 1p, 2p, 2s, 3s)
- O8. Standardization of biomass quality referring to prices (1s, 1p, 2p, 2s)
- O9. Optimization of transport and storage of biomass in order to increase the supply security (all)
- O10. Increase of added value in the production of wood and its processing including energy production (1s, 1p, 2p, 2s, 3EU)
- O11. More objective distribution of public financial support between producers, suppliers and end users of biomass (1s, 1p, 2p, 2s)

External threats

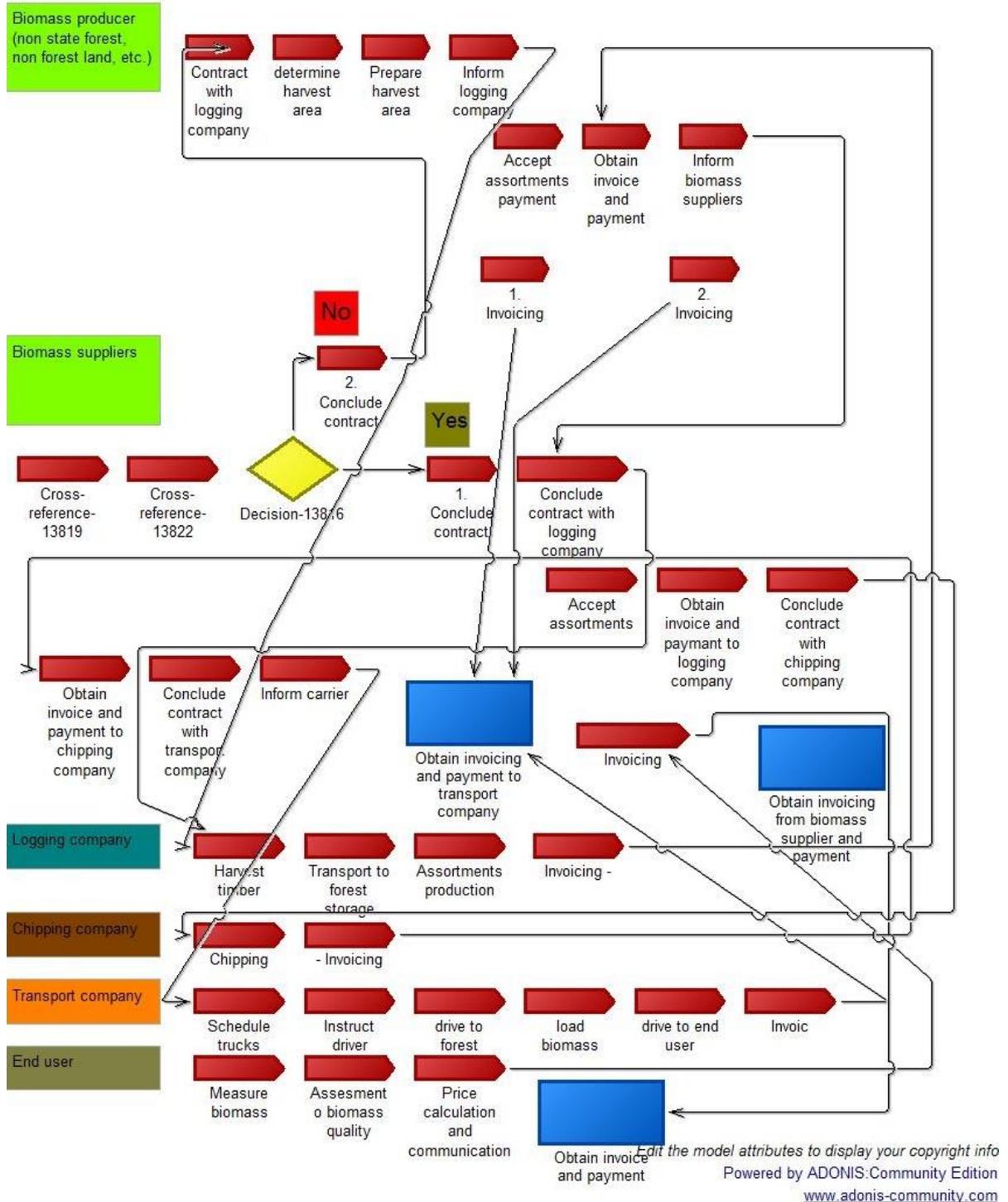
T1. Delaying of biomass production and energy use strategy elaboration and its implementation which threatens the sustainability of production (all).

T2. Permanent current economic instability and low transparency of relations (all)

T3. The deterioration of the business environment of the biomass production and supply (1p, 2p, 1s, 2s)

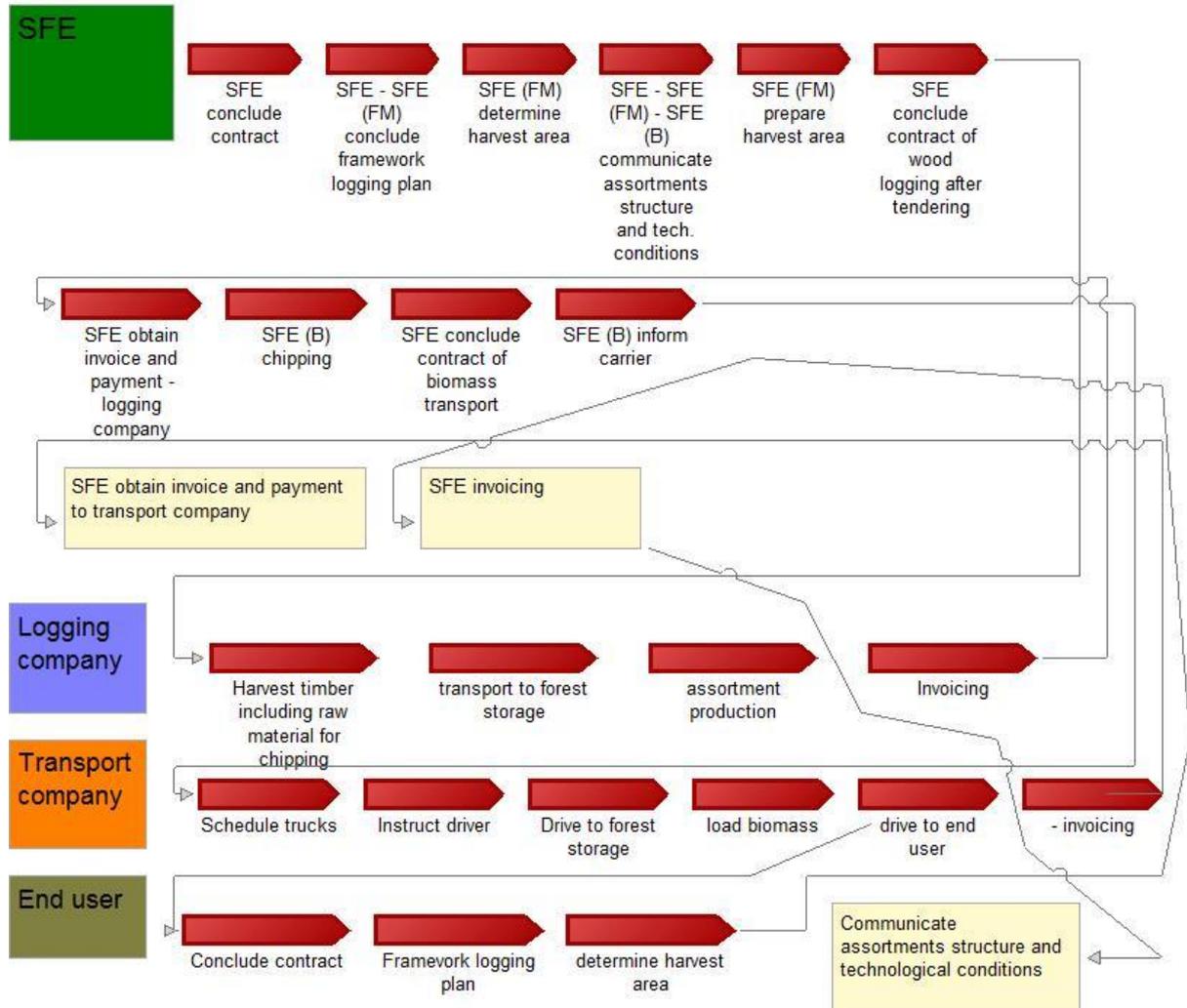
8.2 Annex 2 Process models

Supplies of forest fuel chips from non-state forest and non-forest lands ensured by private company to the heating plant Zvolenská Teplárenská in Zvolen



Supplies of forest chips from state enterprise State forest SR to the heating plants Martinská teplárenská in Martin

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Woody fuel several sources supplies to power plant of Bučina enterprise in Zvolen – evaluating organizational design in supply chain

