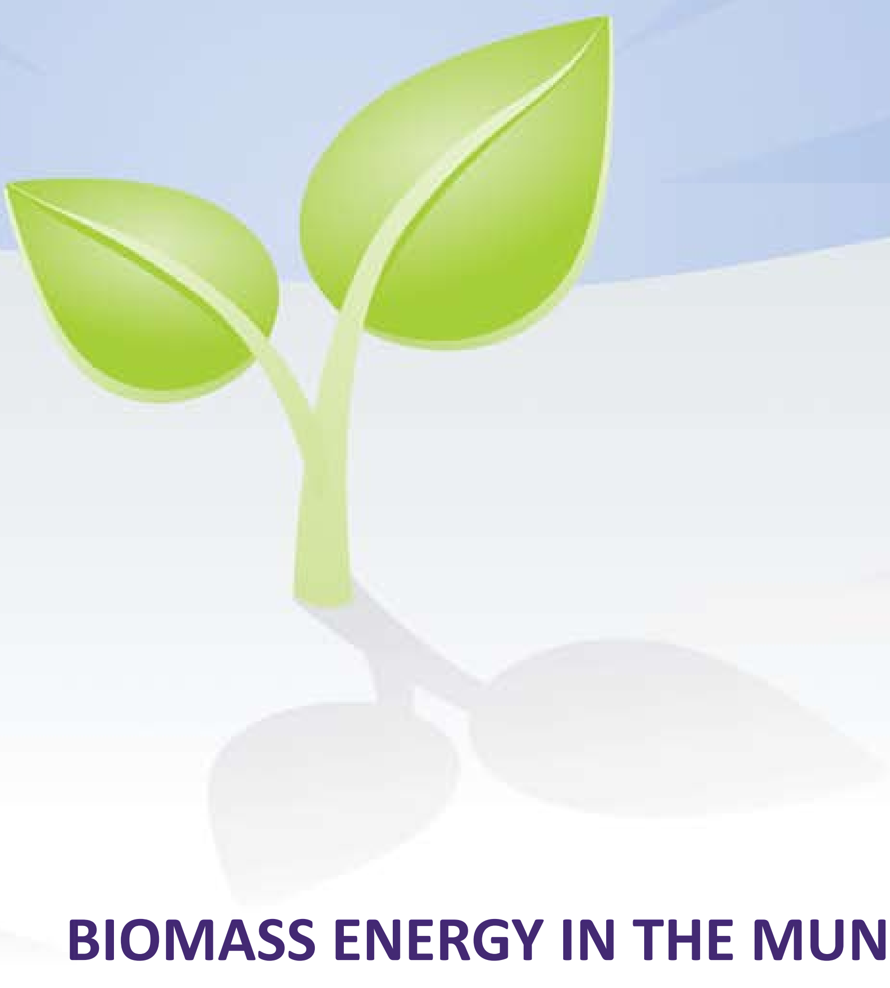

BIOMASS ENERGY IN THE MUNICIPALITIES OF BEROVO, GEVGELIJA AND STRUGA

INITIAL REPORT

UNDP Programme “Local Governance for Sustainable Human and Economic Development”,
Local Development Agencies in Berovo, Gevgelija and Struga

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INITIAL REPORT

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Skopje, Januari 2005

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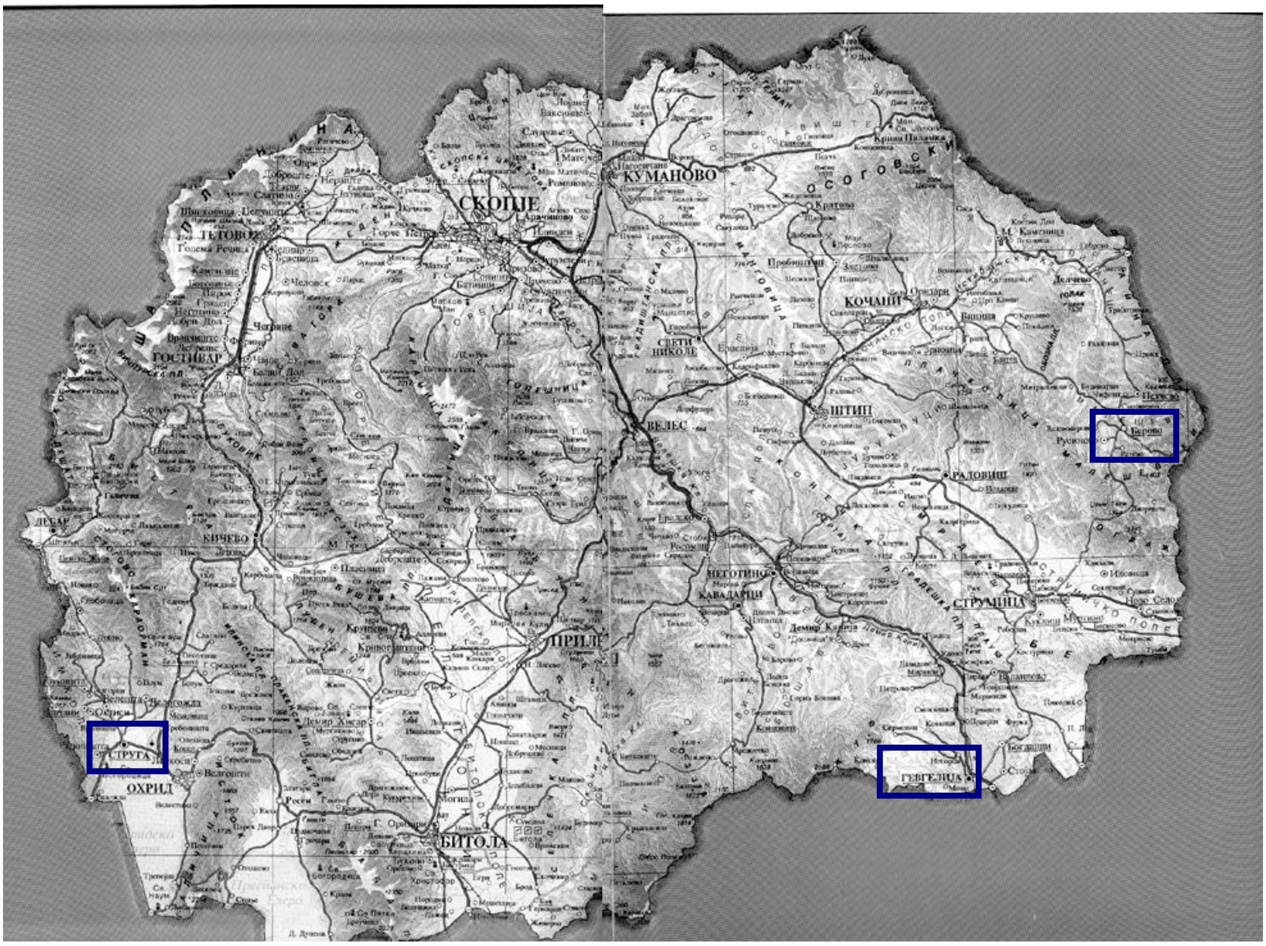


Location of the municipalities of Berovo, Gevgelija and Struga

1. INTRODUCTION

Within the frames of the activities for implementation of the sub-project “Energy and Biomass” that is part of the project “Local Governance for Sustainable Human and Economic Development” this report was prepared in order to give an initial estimation about the quantity of biomass and potential energy value of the biomass from sources in the fields of forestry, agriculture and farms in the municipalities of Berovo, Gevgelija and Struga. This report is a result of analysis and researches carried out during several visits to relevant entities in the mentioned municipalities, by studying literature sources, and using the experience of several countries where similar projects for use of biomass have already been implemented.

The report presents the collected data about the available quantity of waste biomass from certain sources in the three municipalities, it also presents the results from the analysis of the energy potential of biomass, and possible methods for using the energy of biomass. It also emphasizes the probable users of the obtained energy.

1.1. Subject of Interest and Objectives

Subject of interest in this report is the following: studying the available biomass and its energy potential and analyzing the potential opportunities for use of the energy from waste biomass for local purposes – heating energy in the municipalities of Berovo, Gevgelija and Struga.

The main objectives of this reports are the following: collecting data about the quantity of biomass from plant and animal origin, determination of the available waste biomass that can be used for energy purposes and pointing out the possible methods for its use.

1.2. Biomass

Biomass is an organic substance of plant and animal origin that can be used as fuel or raw material for obtaining fuel. Wood, wood waste from cutting and processing of wood, bushes, energy forests (forests specially grown for obtaining wood for fuel), waste from agricultural production, grass, algae, and water plants are considered as biomass of plant origin. Biomass of animal origin is the waste (animal waste) that is obtained from breeding cattle in barns.

The biomass of plant origin is the oldest source of energy that the man had been using since ancient times. From a historic point of view, the wood had been the primary fuel to which, the man owes his survival and development. Even nowadays, in the era of oil, gas, coal, electricity and alike, the wood is still the most important source of energy in the households in the developing countries (for preparing foods, heating), as well as for small businesses (bakeries, brickyards),

In underdeveloped regions, the wood is the basic fuel for the majority of population, particularly for preparation of food and heating. In rural areas, depending on the climate characteristics, the energy for food preparation participates with 50-80% in the total energy spent.

The use of biomass for energy purposes, in addition to the quantity, type and content, depends on its spreading on the terrain, the season, form and content of humidity.

The waste wood in forests, orchards, vineyards and fields spreads in large areas and has a small volume density. Its collection and transportation for the purpose of organized use influences the price of energy obtained from burning and determine the economic justification of the use.

The season is a negative characteristic of biomass, except for industrial processing of wood. In order to ensure regular use in the course of the year, the same should be stored in adequately prepared storage. Certain types of biomass are not suitable of storing and they can be used only for satisfying the seasonal energy needs – e.g., for drying agricultural products. The form of waste biomass and high level of humidity impede its collection, transportation, and burning.

The table 1.1 presents the possible border values of certain energetic and physical characteristics of different types of biomass.

Table 1.1. Border values of certain energetic and physical characteristics of biomass. [8]

Characteristics	**Border value**
Heating power	5000 ÷ 20000 kJ/kg, depending on the content of humidity
Density	400 ÷ 900 kg/m^3
Forced density	40 ÷ 600 kg/m^3
Content of humidity	8 ÷ 50 %
Content of ash	1 ÷ 10 %
Content of evaporating burning substances	50 ÷ 70 %
Temperature of sintering of ash	800 ÷ 1100^oC

The wide limits of energetic and physical characteristics of various types of biomass require application of various burning cycles and technologies for their use.

Biomass as a notion has wider meaning and covers not only substances of plant, but also substances of animal origin. Relatively modest, but permanent energy potential is hidden in organic waste of animal origin. Biomass of animal origin – animal waste represents a useful energy source only in case of breeding cattle and pigs in barns. In such conditions of breeding, when a larger number of cattle and pigs are concentrated in one unit of space, the quantity of waste from a unit of space is significant and costs for its collection and transportation are relatively low. The quantity of waste obtained from different kinds of animals, as well as its content, depend on the daily intake of forage they eat and the duration of staying in the closed area – the barn, table 1.2

Table 1.2. Quantity and content of ingredients of the waste obtained form various kinds of animals [12]

Animal	Mass of animal [kg]	Volume of waste [m^3/24 h]	Humidity in the waste [kg/24 h]	Contents [%]				
				Humidity	Evaporating components	N	P	K
Cattle for meat	500	0,028÷0,037	27,7÷36,6	85	9,33	0,47÷0,70	0,09÷0,25	0,14÷0,28
Cattle for milk	500	0,031÷0,036	30,2÷35,0	85	7,98	0,38÷0,53	0,06÷0,1	0,13÷0,3
Horses	500	0,025	28,0	60	14,3	0,86	0,13	-
Pigs	100	0,0056÷ 0,0078	5,4÷7,6	80	7,02	0,59÷0,83	0,2÷0,6	0,24
Sheep	50	0,002÷ 0,003	1,9÷3,0	70	21,5	1,0÷1,9	0,3	0,78
Poultry	2,5	0,00014÷ 0,00017	0,14÷0,17	82	16,8	0,86	0,13	0,43

The relatively high content of humidity in the waste (60-80%) limits the technological opportunities for obtaining energy from it. The average heating power of waste is 17450 kJ/kg dry mass [12]. Relatively high quality liquid and gas fuels can be obtained by adequate processing.

1.3. Energy potential of biomass

Compared to the fossil fuels (coal, oil and natural gas) for the creation of which a very long time-period is needed (more than 300 million years), the biomass is a renewable source of energy, since the flora is renewable and grows every year. Energy of biomass can be viewed as a form of solar energy taking into consideration that through the process of photosynthesis, the solar energy is indirectly used for growing of the flora, which on the other hand serves as food for the fauna.

Among the renewable sources of energy: the solar energy, wind energy and geo-thermal energy, the energy potential of biomass is the most significant.

In global frames, participation of the biomass in the world primary energy potential is around 13%, while the participation of the wind energy is bellow 1%, and the same is with the solar energy, the participation of which is also bellow 1% [8].

Among the various kinds of biomass of plant and animal origin, the wood is the most common one, used particularly for heating. Basic substances that constitute the wood are the following: cellulose, lignin and chemi-cellulose. Differences between certain types of wood come from the difference in the content of cellulose and lignin, the heating power of which is approximately 17100kJ/kg, i.e. 25000kJ/kg. Dry coniferous wood contains 53-54% cellulose and 26-29% lignin, while in foliar wood the contents of cellulose is between 43-45% and lignin 19-26%. Cellulose, lignin and chemi-cellulose participate in semi-dry wood with 80%, and the remaining is water (17%), around 2% extractive substance and 1% ash.

The heating power of wood mass depends on the type of wood, part of the trunk, percentage of humidity, volume mass (density) and other factors. Approximate values of heating power of absolutely dry wood and semi-dry wood from foliar and conifer forests are presented in table 1.3. (according to Nikolic, in [8]).

Table 1.3. Approximate values of heating power of absolutely dry and semi-dry wood.

Type of forest	Heating power [kJ/kg]	
	Absolutely dry	Semi-dry wood
Foliar	18000	14150
Conifer	19500	15750

One of the significant characteristics of the trunk wood mass is the non-variability of the contents of burning mass, table 1.4 [2].

Table 1.4. Basic characteristics of burning mass of trunk wood [2]

Type of wood	Elementary content of burning mass [%]				Evaporating substances of a unit of burning mass [%]	Heating power of burning mass [kJ/kg]
	C	H	O	N		
Conifer	51,0	6,15	42,25	0,6	85	19079
Foliar	50,5	6,10	42,80	0,6	85	18660
Mixture	51,0	6,10	42,30	0,6	85	18870

For practical thermal calculations, without making a significant mistake, the following elementary contents of burning mass of trunk wood can be adopted:: C=51 %, H=6,1 %, O=42,3 % and N=0,6 %.

Table 1.5 Presents the values of volume mass and heating power of different kinds of wood.

Table 1.5. Volume mass and heating power of different kinds of wood

Type of wood	Volume mass of wood [kg/m³]						Heating power [kJ/kg]		Heating power in [MJ/m³] of semi-dry wood (W=15 %)	
	Raw		Semi-dry (W=15 %)		Absolutely dry		Absolutely dry	Semi-dry (W=15 %)		
	Borders	Average	Borders	Average	Borders	Average			Borders	Average
Beech	820-1270	1070	540-910	720	490-880	690	18815	14812	8015-13506	10686
Oak	650-1160	1010	430-960	690	390-930	650	18380	14445	6211-13867	9967
Acacia	750-1000	870	580-900	770	540-870	730	18954	14968	8681-13471	11525
Hornbeam	660-1200	970	540-860	830	500-820	790	17007	13314	7190-11450	11051
Juniper	900-1040	960	330-680	470	300-640	430	19661	15596	5147-10605	7330
Pine	380-1030	700	330-890	520	300-860	490	21210	16957	5266-14207	8298
Fir	770-1230	1000	350-750	450	320-710	410	19485	15449	5407-11587	6952

On the base of data from the State Statistical Office of the Republic of Macedonia, the review of quantity of wood that is used in Macedonia on an annual level in the period between 1996 and 2003 is presented in table 1.6. [3].

Table 1.6. Quantity of wood mass used in the Republic of Macedonia on annual level (in 1000 m³)

	1996	1997	1998	1999	2000	2001	2002	2003
Forests owned by the state	1012	908	785	789	923	644	657	764
Private forests	106	92	112	164	225	148	153	166
Technical wood	166	159	168	124	171	116	133	142
Heating wood	844	745	647	742	875	610	602	709
Waste	108	96	82	87	102	66	75	79
Total gross m ass	1118	1000	897	953	1148	792	810	930

The use of plant biomass for energy purposes is important from the environmental aspect, as well. The wood mass practically does not contain any sulfur and have high reaction capability, i.e. high content of evaporating flammable substances and small content of mineral substances. Taking into account the aforementioned, the evaporating gases from the device in which the wood mass burns do not contain any sulfur oxides. This ensures relatively low temperature of evaporating gases (110-120°C) and increased degree of usefulness of the device. By using rational construction solutions of premises where the burning processes take place and the gas channels, the content of carbon monoxide (CO) as a by-product of incomplete burning and content of particles in evaporating gases can be brought to minimum. At the same time, the produced CO_2 in the course of the burning of biomass can be considered as a segment of the natural cycle of carbon dioxide. Also, the presence of carbon and nitrogen in the wood mass is slightly lower than in fossil fuels.

Thus, from a point of view of air pollution, the evaporating gases from the burning processes of wood mass are clearer compared to evaporating gases from burning of fossil fuels.

For efficient transformation of biomass into heating energy in the course of burning, a different kind of technology than the one developed for burning of coal and liquid fossil fuels is needed. This is mostly due to the specific characteristics of the biomass as a fuel, that are manifested through the following:

1) Physical and chemical characteristics of the biomass of plant origin are very specific. In principle, it has a lower forced and energetic density compared to liquid fuels, and certain types of coal.

2) The irregularity of production of biomass is its most specific characteristic creates problems for storage and eventual use in combination with other types of fuels.

3) Collection, seasonal storage, drying, packing into bales and briquettes, transportation and preparations prior the burning process to a great extent increase the costs for using the biomass for energy purposes. The previous preparation and transportation of biomass should be reduced to the necessary minimum, and the storage should preserve its quality in order to use it for obtaining heating energy.

4) Due to the presence of sticky resins in the biomass of plant origin and due to its celluloid and fibrous structure, different kinds of systems of transportation from the place of storing and dosing in the burning device should be applied.

3) The plant biomass contains a big percentage of fast evaporating substances, often exceeding 80%, and the ash from the biomass has a relatively low point of melting, generally 800^{o}C, which limits or completely prevent the use of classical burning technologies

Taking into account the aforementioned, the preparation of the biomass of plant origin as a fuel can significantly increase the price of the obtained energy or even to make it uncompetitive (economically non-viable) compared to the energy from fossil fuels. In addition to this, the limiting factor for using the biomass for energy purposes is the non-existence of an organized burning cycle.

On the other hand, series of other facts point out that the use of biomass for energy purposes in numerous cases can be a very good solution:

- Energy potential of the biomass is significant;
- There are significant quantities of waste biomass where heating energy is needed;
- The quality of produced energy is equal to the energy obtained from fossil fuels according to the temperature level, quantity and efficiency in transforming the chemical energy into heating energy;
- There have already been developed and put into practice modern technologies for use of various kinds of biomass as fuel;
- Biomass represents a renewable source of energy, and
- Environmental problems in the course of its use are significantly smaller compared to the hard and liquid fuels.

2. REVIEW OF EXISTING STUDIES AND REPORTS ON THE STATUS IN THE FIELD OF USE OF BIOMASS FOR ENERGY PURPOSES IN MACEDONIA

Researches of available resources of biomass as a possible source of energy in Macedonia and the possibilities for using the same were being carried out in the beginning of the ‘80s. The research paper “Production of Biogas in SRM” [5] reviews and presents of the waste burning substances in several business organizations in Macedonia. It also describes the initial domestic experiences from the production of biogas from farms for cattle breeding. The ingredients of the biogas were analyzed from the first plant and certain more important characteristics of this plant were described.

During the 80s of the past century in former Yugoslavia a research had been carried out titled “Biomas as Fuel – Opportunities and Limitations” under the leadership of the Institute “Boris

Kidric" - Vinka (IBK-ITE-504, Vinka, march 1985), in the course of which the possibilities for complex use of biomass for production of raw materials, food and energy were being analyzed.

The main results from the research in the filed of use of biomass as energy source on the level of Former Yugoslavia are summarized in the publication "Burning of Biomass for Energy Purposes" – N. Nini), S.Oka, Yugoslav Association of Thermal Scientists, Naucna knuga, Belgrade, 1992 [8].

In 1998, a Memorandum of understanding was signed between the governments of Macedonia and Netherlands, for the purpose of initiating the technical and economic cooperation. Preparation of a project in the frames of which, the status of the agricultural sector was to be analyzed, was identified as the priority step. The study "Agricultural Sector Study, Macedonia", Center, PSO98/MA/1/3, Utreht, the Netherlands, 1999 [9] was the result of this activity. Although the main objective of this study was estimation of the conditions in the agricultural sector in Macedonia and giving recommendation for intensifying the cooperation between Macedonia and Netherlands in this sector in general, as well as in certain sub-sectors, certain conclusions regarding the available biomass can be made based in the results of this study.

The Netherlands' company "Haskoning" made a study on the availability of biomass in Macedonia – "Biomass Availability Study for Macedonia" Feasibility Study, Co. HASKONING, the Netherlands, 2000 [14]. The purpose of the study was to estimate what types of biomass are present in Macedonia, in which sectors, in which quantity and for which price. Based on prior experience and other reports and projects, three sectors were being analyzed: forestry, wood processing and agriculture.

According to the results from the study, the total production/use of wood mass for processing and heating in 1999 was 900000 m^3. During the processing, approximately 14% of waste wood mass is produced. This means that annual cutting in 1999 was 1050000 m^3, out of which approximately 150000 m^3 of wood waste was obtained. Taking into account that this year was one of the not so positive years for the forestry sector, the previous estimation can be considered as pessimistic. If we suppose that the average density of wood mass is 650 kg/m^3, the annual quantity of waste biomass from the forestry sector in Macedonia could be 100000 t/year. In future, the introduction of modern techniques of cutting woods can result in reduction of waste to 7%, which means a quantity of 75000 m^3/year or approximately 50000 t/year.

According to estimations made by certain experts, approximately 150000 m^3 of technical wood are processed in Macedonia, of which, large producers produce one third, and smaller companies the rest of it. During the processing by large producers, 35% is waste, meaning 18000 m^3 of waste wood mass per year. The greater part of this quantity is used in the factories' boilers for production of technological steam for the working processes and heating. The total quantity of waste wood mass from the wood processing is estimated at around 70000 m^3/year, which in average density of 650 kg/m^3 gives approximately 45000 t/year.

The winegrowing and fruit growing are the most interesting sectors in the agriculture from the aspect of waste biomass in Macedonia, according to the opinion expressed in this study. The annual production of straw is significant, however, it is much better if it is used for other purposes, which is a common practice.

Main quantitative data from the study are presented in table 2.1 [14].

Table 2.1. Theoretical and practical annual availability of waste biomass in the sectors: forestry, wood processing and agriculture [14]

Sector	Theoretical availability (t/year)		Practical availability (t/year)	
1) Forestry		100000		50000
2) Wood processing		45000		15000
3) Agriculture		436000		55000
- vine sticks	81000		50000	
- straw	334000		0	
- rice husk	4000		500	
- fruit tree branches	17000		4500	
Total		581000		120000

Basic conclusions from this study can be summarized in the following manner:

1) The forestry sector in Macedonia produces large quantities of waste biomass, of which only 1% is used for burning in boilers. Nevertheless, the need for heating energy in this sector is very small. On the other hand, it means that the waste biomass from the forestry sector is available for use in burning installations, but from a logistic point of view it is complicated and expensive because of costs for its collection and transportation.
2) Waste that is produced in the wood-processing sector is mostly used in the boilers of wood processing capacities. There is also a small number of sawmills that produce waste biomass, but it can be used only locally in boiler units with small capacity since the collection from several places is economically not viable.
3) Using the straw from the agricultural sector for other purposes is better than using it for energy purposes. Annual quantities of vine sticks, rice husk and fruit tree branches from larger production capacities are significant, but the collection from individual producers in current conditions of non-existence of a biomass market is practically impossible.
4) Practical availability of 120000 t of waste biomass per year from the analyzed sectors, in conditions of low heating power of the biomass of 10÷15 MJ/kg, points out to an energy potential of 1200000÷1800000 GJ/year. This would mean that in principle, there are conditions for installation of several dozens of boilers with heating capacity of 4 MW.

3. AVAILABLE POTENTIALS OF WASTE BIOMASS AS ENERGY RESOURCE IN BEROVO, GEVGELIJA AND STRUGA

3.1. Municipality of Berovo

Berovo is located in the Malesh valley, which is situated in the eastern part of the Republic of Macedonia, very near to the Bulgarian border, in the basin of the river Bregalnica. The area is characterized by well-developed hill and mountain relief and climate with characteristics from the warm continental to cold continental, with altitude of 1700 m and high mountainous climate in the areas above the 1700 m altitude.

In the municipality of Berovo, as well in the neighboring municipality of Pehchevo there are several entities the activities of which (forest management companies, production, processing, farming) produce significant quantities of waste biomass that can be used for energy purposes.

- AD „Ograzden“ - Berovo;
- P[S „Maleshevo“ – Berovo, Branch office of JP „Makedonski Shumi“;
- Sviwarska farma „Zito Malesh“;
- P[S „Ravna reka“ – Pehchevo, Branch office of JP „Makedonski Shumi“;
- AD „Crn Bor“ – Pehchevo;
- AD „Napredok“ – Pehchevo.

3.1.1. Available biomass from the forestry and wood processing industry in the region of Berovo and Pehchevo

The Malesh area disposes with significant forest reserves. Forests and forest soils in this area are managed by the regional forest management company “Maleshevo” from Berovo and the regional forest management company “Ravna Reka” from Pehchevo that operate as branch offices of the public company “Makedonski Shumi”.

The forests and forest soil in Malesh cover a total area of 40978 ha, of which 36.563 ha or 89,0% is covered by forests, and 4.415 ha is covered by forest soil, or 11,0% (of which 4% are forest cultures). Approximately 77% of the total area covered by forests is in state property (28077 ha), while the remaining 23% (8486 ha) are in private property. [13].

The total wood mass in the arranged forests is estimated at 7096646 m^3, where the high trunk forests participate with 6521792 m^3, low trunk forests with 477457 m^3, and forest cultures with 97397 m^3. Annual cutting and processing of wood from the areas managed by the company “Malesh” is 32000 m^3/year. Additionally, the company provides cutting services for other entities in quantity of 16000÷20000 m^3/year of forest areas in private property. Around 10000 m^3 of the total quantity (32000 m^3/year) is processed as technical wood, from which a lumber is obtained which is usually sold in the surrounding places, and one part of it is exported. The waste from the cutting (around 10%), due to the configuration of the terrain is hard to collect, while the waste from the processing is usually used for heating purposes.

Data on the structure of forest areas and forest soil in the Berovo and Pehchevo region are presented in table 3.1. Review of the status of forest reserves in the Malesh region (municipalities of Berovo and Pehchevo) on different grounds is presented in table 3.2. Data on the stock and sort structure in the Mlaesh region are presented in table 3.3., while data on the cut wooden mass in the municipality of Berovo during the past couple of years (according to the State Statistical Office of the Republic of Macedonia, Statistical Review: Agriculture – Forestry, 1996-2003, State Statistical Office of the Republic of Macedonia, Skopje, 2004 [3] are presented in table 3.4.

Table 3.1. Structure of the forest areas and forest soils in Malesh [13]

Municipality	Total		Forests [ha]	Forest cultures [ha]	Bare terrains [ha]	Area not covered with forests [ha]
	Forests [ha]	Without vegetation [ha]				
Berovo	29102	3870	27970	1132	1651	2219
Pehchevo	7461	545	7292	170	496	48
Total	**36563**	**4415**	**35262**	**1302**	**2147**	**2267**

Table 3.2. Review of the status of forest reserves in Malesh [13]

Status of forest reserves on different grounds	**Berovo**		**Pehchevo**		**Total**	
	ha	%	ha	%	ha	%

Structure of forest areas according to ownership						
- State						
- Private	20976	72	7101	95	28077	76
- Total	8126	28	360	5	8486	24
	29102		7461		36563	
Structure of forests according to their arrangement						
- Arranged forests	24498	84	6916	96	31417	86
- Non-arranged	4604	16	545	8	5149	14
- Total	29102		7461		36563	
Structure of forests according to the form of growing						
- High trunk forests						
- Low trunk forests	26063	90	6895	92	32958	90
- Total	3039	10	566	8	3605	10
	29102		7461		36563	

Table 3.3. Annual stock and sort structure of stock in Malesh [13]

Municipality	Growth [m^3/year]	Stock [m^3/year]	Sort structure of the stock [m^3/year]					
			Logs		Technical wood in small dimensions (beech)	Round wood (pine)	Wood for heating	Waste
			Beech	Pine				
Berovo	93054	40300	7800	1700	2200	2000	22000	4600
Pehchevo	32488	20000	3000	3000	1000	500	10500	2000
Total	**125542**	**60300**	**10800**	**4700**	**3200**	**2500**	**32500**	**6600**

Table 3.4. Cut wooden mass in the municipality of Berovo [3]

Year	1996	1997	1998	1999	2000	2001	2002	2003
Quantity [m^3]	88082	90087	77169	52070	54134	47740	35999	50971

The company AD „ Ograzden“ – Berovo, whose primary activity is production of furniture from massive wood, during the past several years processes approximately 12000 to 15000 m^3 logs per year, of which the biggest part is used for its own production and 3000÷5000 m^3 are processing services for other entities. Beech participates with 70-80% in the total quantity and the pine participates with around 20%. The waste that is produced in the course of the processing is in quantity of 30% of the initial mass. One part of the waste is used for production of briquettes in its own facilities for briquettes. The total quantity of briquettes produced in AD „Ograzden“ is 800÷1000 t/year. There are no problems regarding the sales, on the contrary, according to the information obtained from the factory, the facility for briquettes cannot satisfy the needs for briquettes in the market. The remaining quantity of waste from the wood processing is directly used for burning in the boiler of the factory, which produces steam for heating and technological purposes (steaming of lumber, drying of sawdust in rotating drying device, etc.).

3.1.3. Waste biomass from animal origin

The pigsty “Zito Malesh” is another interesting business entity, which is important for the analysis. This pigsty operates within the company AD “Zito Vardar” from Veles and it is located several kilometers from Berovo. The number of pigs in the farms is 8000, and in certain periods it reaches even 9000. the water in the farm is used for watering he animals through special automatic devices and also for washing the floors. In the course of the activity of dry cleaning, a quantity of 5-8 liters per one pig per day is enough. Wastewater from the farm contains urine, feces, water from broken watering devices, unused food and other kinds of waste. The daily quantity of waste substances obtained from one pig depends mainly on the weight of the animal, due to which, for comparing purposes, the usual presentation is made with a pig weighing 100 kg. One pig of 100 kg produces per day 2,5 l urine and 4 l of feces, i.e. a total mass of 7 kg waste substances. Taking into consideration that 5-10% dry substance is obtained from the total quantity, this means that we are talking about waste of 0,35 to 0,7 kg dry mass daily from one pig, i.e. 4 t dry mass per day.

Worldwide experiences show that with certain processing in special plants, special fertilizers can be produced from waste substances from pigsties, which are stabilized and can be directly used on agricultural soil without negative consequences for the soil and cultures. Also, biogas is obtained that contains 60% methane (CH_4). No methodology has been defined so far for dimensioning the capacity of certain elements from the plants for production of biogas. Estimations show that approximately 0.15 m_n^3 of biogas are produced from one kg of dry substance per day (0,15 m_n^3/kg SM day), which, taking into account some other technological factors in the process, correspond to approximately m_n^3 of biogas per year from one pig of 100 kg. The typical content of substance in the biogas produced from waste from pigsties with the method of anaerobic fermentation is presented in table 3.5.

Table 3.5. Content and heating power of biogas produced with the method of anaerobic fermentation of waste from a pigsty

Type of process	Voluminous content of the gas [%]					Heating power [kJ/m_n^3]
	CH_4	CO_2	H_2	O_2	H_2S	
Laboratory	55÷75	20÷30	1÷10	0÷2	0,1÷1	23000÷26000
Continual process according to [5]	62,2	16,2	6,2	2,0	0,8	23812

Biogas can be used as a high quality fuel in an adequate device: steam or water heating boiler, furnace and alike, gas motor within an aggregate for obtaining electrical energy, by using at the same time the heat from gases and the water for cooling, etc. Lately, opportunities have been researched for construction of energy plants with devices for burning cells functioning on biogas.

As a result of the work of the farm „Zito Malesh“ – Berovo, liquid waste is produced in quantity of 70÷80 m^3, which is collected in lagoons and one part of it is used for fertilizing agricultural areas. If we analyze the data with smaller number of pigs which is 8000, the daily production of biogas would be

$$8000 \times 0,5 \times 0,15 = 600\ m_n^3/\text{day}$$

With the supposed lower heating power of 23000 kJ/m_n^3, it would bee energetic potential of

$$600\ m_n^3/\text{day} \times 23000\ \text{kJ}/m_n^3 = 13,8\cdot 10^6\ \text{kJ/day} \approx 5037\ \text{GJ/year},$$

i.e. approximately GWh/year, which is equivalent to 125 t of mazut per year.

3.2. Gevgelija

Municipality of Gevgelija is located in the southern part of the Republic of Macedonia, very near to the border with Greece. The combination of continental and Mediterranean climate results in warm days during the entire year. There are 240 sunny days in Gevgelija with relatively high average daily temperatures.

In Gevgelija and its surrounding, there are several business capacities which produce significant quantity of waste biomass as a result of their regular activities. This biomass can be used for energy purposes.

- Forest management company „Kozuf“ (JP „Makedonski Shumi“),
- One bigger and several smaller facilities for wood processing in the surrounding inhabited places

- Waste from the winegrowing, mostly from the vineyards of “Vinojug” and some smaller producers.
- „Rigo-Impeks”, private company for purchasing and processing of grapes
- Orchards.

According to information obtained from relevant institutions and responsible persons in the municipality and from the reports of “Kozuf” – Gevgelija, the status in the field of forestry in the municipality of Gevgelija is the following: Total area under the management of “Kozuf” can be divided in the following categories:

1. Forests	45128,48 ha
2. Areas covered with forest cultures	414,20 ha
3. Bare terrains	5429,10 ha
4. Areas not covered with forests	559,78 ha.

Possible annual stock, i.e. the total possible annual cut of wood is slightly above 50000 m^3. The planned gross annual stock of “Kozuf” – Gevgelija for 2004 was 34282 m^3, of which 23572 m^3 wood for heating, 7670 m^3 technical wood and the anticipated normative waste is 10% of the total cut, i.e. 3040 m^3, however, estimations show that the waste from the cut pf certain forest areas can reach even 20%. Approximately 25 % of the total quantity of technical wood is exported, and the remaining part is processed in domestic facilities. Most of the technical wood consists of beech, less white and black pine, and the least of oak. Depending on the class and the product (lumber, wooden boxes, etc.) approximately 30-60% of waste is produced from the processing of technical wood, or between 2300 and 4000 m^3 on annual level.

If we suppose that volume of such waste is 650 kg/m^3, and the heating power has a value of 14,5 MJ/kg, we talk about energetic potential of

$$(2300 \div 4000)\ m^3/year \times 650\ kg/m^3 \times 14{,}5\ MJ/kg = (21{,}7\cdot 10^6 \div 37{,}7\cdot 10^6)\ MJ/year,$$

or 6028÷ 10470 MWh/year, which is equivalent to 540÷938 t of mazut/year.

According to data from the State Statistical Office of the Republic of Macedonia, the quantity of cut wood mass in the Republic of Macedonia, the quantity of cut wood mass on annual level in the municipality of Gevgelija for the period 996-2003 is presented in table 3.6 [3].

Table 3.6. Cut wood mass in the municipality of Gevgelija [3]

Year	1996	1997	1998	1999	2000	2001	2002	2003
Quantity [m^3]	33459	29934	52380	30072	32668	17393	14790	31012

There are 2240 ha covered with vineyards in the region of Gevgelija. Usually, three tons of vine sticks from one ha per year are obtained during the process of trimming the vineyards. Taking into consideration that part of the vineyards are owned by individual farmers in relatively small areas, it is supposed that realistically approximately 50 –7-% of the waste biomass could be collected from the trimming. So, the total quantity would around

$$2240\ ha \times 3\ t/year \times 0{,}6 = 4032\ t\ \text{waste biomass (vine stick) per year.}$$

If we suppose that the heating power of sticks is 11500 kJ/kg, the total energetic potential contained in them would be:

$$4032\cdot 10^3\ kg/year \times 11500\ kJ/kg = 46{,}4\cdot 10^9\ kJ/year,$$

or approximately 12,9 GWh/year, which according to the energetic value corresponds to 1150 t mazut per year.

One of the companies that was analyzed in the course of preparing this report is the private company Rigo-Impeks – Gevgelija, which main activity is purchasing and processing of grapes and production of wine. The company currently has a capacity for processing of $15\cdot10^6$ kg grapes per year. Approximately 15-20%, or $2,6\cdot10^6$ kg of waste is obtained from the processed grapes in the form of grape skin. 50% of the total waste ($2,6\cdot10^6$ kg) are seeds or $1,3\cdot10^6$ kg/year and 50 % are skin and seedcases. Taking into account that in this case we are talking about a large quantity of waste of specific kind, additional analysis is necessary relating to the methods of it use.

3.3. Struga

There are several business facilities the operate in the Struga region, which in the course of their activities (forest management, water processing and cleaning, wood processing, agriculture, etc.) produce significant quantity of waste biomass that can be used for energetic purposes:

- PSS „Jablanica“ – Struga, Branch office of JP „Makedonski Shumi“,
- Individual agricultural production,
- Cleansing station near village Vranishta within the frames of Collector System for cleansing and protection of the Ohrid Lake, JP “Proakva” – Struga.

3.3.1. Availability of biomass from forestry

There are large forest reserves in the Struga region. The public company „Makedonski Shumi“ PSS „Jablanica“ – Struga manages with total area of 23787 ha, of which 21511 ha or 90,5 % are in state property while 2276 ha or are in private property. Regarding the quality. Around 30,4 % of forest managed by PSS ”Jablanica” – Struga are high trunk forests, and 69,9 % of the total area is covered by low trunk forests. According to their purpose. 100% of the forests have economic value.

The total wood mass in forests in the municipality of Struga is estimated at 1962160 m^3, with total annual growth of 38947 m^3. Detailed review of forest areas managed by PSS ”Jablanica” – Struga, branch office of JP “Makedonski Shumi”, is presented in table 3.7.

Annual cut in PSS ”Jablanica” – Struga is 33000÷34000 m^3/year, of which 27000 m^3/year are used for heating: 20000 m^3/year beech and 7000 m^3/year oak, and 2600÷3000 m^3/year technical wood (logs of I, II and III category). Around 10% of the total quantity or 3300÷3400 m^3/year is the so called normative waste: branches, tree-stumps) which is also used for heating by the local population. The waste from processing of technical wood, which is exclusively beech is in the form of sawdust and participates with 50%. The same is partially used in the boilers for own purposes and needs like heating and technological steam.

A by-product of the processing is a small quantity of sawdust that is not used for their own needs in quantity, which does not exceed 300 m^3/per year.

Tab. 3.7. List of forest areas per unit managed by PSS ”Jablanica” – Struga

Description	SSE „Karaorman”	SSE „Jablanica - Kafasan”	SSE „Jablanica”	SSE „Globocica”	Total
Total area [ha]	5159,40	7656,90	5292,90	5677,80	23787
- state property	4665,40	6923,90	4786,90	5134,80	21511
- private woods	494,00	733,00	506,00	543,00	2276
Total area [ha]	3541,00	7069,60	4737,20	4156,00	19503,80
- high trunk forests	1054,00	2943,00	1931,90	—	5928,90
- low trunk forests	2487,00	4126,60	2805,30	4156,00	13574,90
Wood mass [m^3]	492765	749202	495873	224320	1962160

- high trunk forests	258705	443355	328277	—	1030337
- low trunk forests	234060	305847	167596	224320	931823
Annual new growth	10818	15187	8841	4101	38947
- high trunk forests	5653	8423	3481	—	17557
- low trunk forests	5165	6764	5360	4101	21390

According to the data of the State Statistical Office of the Republic of Macedonia, the quantity of cut wood mass on annual level in the municipality of Struga in the period between 1996 and 2003 is presented in tab. 3.8 [3].

Tab. 3.8. Cut wood mass in the municipality of Struga

Year	1996	1997	1998	1999	2000	2001	2002	2003
Quantity [m^3]	46043	37683	29999	43520	47427	47621	31970	29519

In the surroundings of the city, in the villages Frangovo, Velesta, Vranista and other, several mills of a relatively small capacity are operating, that use the waste produced in the process of wood processing to satisfy their own need for heat.

3.3.2. Waste biomass from agricultural production

The total agricultural land in the municipality of Struga amounts to approximately 7000 ha. The largest portion of this land, around 4000 ha, are under cereals. After the harvest, around 1,5 t/ha of straw is produced in average and is completely used.

On the agricultural land in the municipality of Struga the corn is present with approximately 1500 ha, of which the most prominent are the hybrid varieties. Projections and assessments show that in 2005 corn will be seeded on 1500÷2000 ha. Waste from corn amounts to around 10 t/ha of green mass or around 2 t/ha of dry mass, which amounts to a total of approximately 3000 t of dry mass per year. The use of the stalks as feed is not possible because of their wooden structure.

Under the assumption that the heating power of the dry mass is around 16,5 MJ/kg, it represents an energy potential of

$$3000 \cdot 10^3 \text{ kg/per year x } 16{,}5 \text{ MJ/kg} = 49{,}5 \cdot 10^6 \text{ MJ/ per year,}$$

that is 13,75 GWh/per year, which according to the energy value is equivalent to around 1230 t crude oil per year.

According to the data of the Regional Unit of the Ministry of Agriculture, Forestry and Water Economy, the areas under vineyards in the region of Struga are estimated to approximately 64 ha in state ownership and approximately 30 ha in private ownership. The assessed average density of 2500 vine plants per hectare and an average quantity of waste (vine sticks) of 1÷1,5 kg/per stalk, indicate that the annual quantity of waste biomass from vineyards is 235÷350 t/per year. Hence, taken that it is real to harvest 60 % of the total quantity and that the average heating power is around 11,5 MJ/kg, an energy potential is achieved of:

$$(235 \div 350) \cdot 10^3 \text{ kg/per year x } 11{,}5 \text{ MJ/kg x } 0{,}6 = (1{,}62 \div 2{,}42) \cdot 10^6 \text{ MJ/per year} = 450 \div 672 \text{ MWh/per year}$$

However, the collecting of the vine sticks is a major problem for the potential use for energy purposes due to the fact that the land is scattered.

In the region of Struga orchards cover approximately 13 ha of state land and approximately 20 ha of private land. Due to the manner of trimming of the fruit trees applied in the recent years (two trimmings: one in the vegetation period and one when ripe) wood waste is insignificant, and thus the energy potential in this segment is also insignificant.

Regarding the company „Proakva”, which is responsible for the management of the collecting system for treatment of wastewater from the Ohrid and Struga region, data were not available for the quantity and composition of the waste substances.

4. TECHNOLOGIES FOR USE OF BIOMASS SUITABLE IN LOCAL CONDITIONS

Biomass is organic substance, which can efficiently be used as a local energy source. At the same time, it is a renewable energy source. The processes and technologies for transformation of energy contained in biomass into energy of higher temperature level, into fuels (hard, liquid and gas), and into row materials for the chemical industry, may be classified in the following three groups:

- thermochemical (combustion, gasification, pyrolysis and production of methanol);
- biochemical (anaerobic fermentation for obtaining biogas and aerobic fermentation for obtaining ethanol) and
- chemical (production of biodiesel and oiling oil).

The principal technologies and processes for transformation of biomass into heat or various types of burning substances are presented in tab. 4.1.

Tab. 4.1. Technologies for conversion of biomass into burning substances

Origin of biomass	Conversion process	Technology	Final product
Wood, agricultural waste, hard communal waste	Thermochemical	Direct combustion	Heat, water/steam, electrical energy
Wood, agricultural waste, hard communal waste	Thermochemical	Gasification	Gas with relatively law and medium heating power
Wood, agricultural waste, hard communal waste	Thermochemical	Purolysis	Synthetic liquid fuel, tar
Wood, agricultural waste, hard communal waste	Thermochemical	Production of methanol	Methanol
Stable dung, agricultural waste, damps, wastewater	Biochemical – anaerobic	Anaerobic fermentation	Gas with medium heating power (methane)
Plantations for production of sugar and starch, waste wood, mush waste, mowed grass	Biochemical – aerobic	Production of ethanol	Ethanol
Beet seeds, waste from seedcase plants, waste vegetable oil, animal fat	Chemical	Production of biodiesel	Biodiesel

4.1. Combustion of biomass from plant origin

The oldest and still the most frequently used process for use of biomass of plant origin for energy purposes is its direct combustion.

The biomass from plant origin is a natural hard fuel with high contents of evaporating substances, which is the reason for its easy flammability. The various types of biomass have very similar composition, but also various range, humidity and heating power, which has an influence on the concentration and the efficiency of the devices in which it is supposed to be combusted. During the combustion of plant biomass several thermophisical and chemical process are carried out in subsequence or with a certain degree of overlapping, including: drying (on temperature of 60÷100^{o}C), separation of evaporating substances (devoltilization) (mainly on 300÷400^{o}C), burning of evaporating substances, burning of coke residue (400÷600°C) and combustion of the coke residue (700÷1500°C).

Characteristic of the various types of waste fuels, including the wood waste, is that the dynamics of their creation in most cases does not overlap with the needs for heating energy. In addition, due to the small volume density a larger space is needed for storage, and the peril of fire is always eminent. Notwithstanding the above, the biomass represents fuel, which can efficiently substitute, in particular in the agricultural industry, a significant quantity of liquid fuel.

For the combustion of biomass, depending on its form, type and humidity classical combustion technologies are used such as combustion on a grid (static, movable, slant and sloping) or flight combustion (space), and the modern technology of fluidized layer combustion.

In respect of the manner of fuel injection, devices for biomass combustion may be classified in two groups: combustion devices with a discontinued fuel injection and devices with automatic continuous fuel injection. The first group includes small fireboxes, which are used to satisfy the needs for heating energy of individual households. The second group includes firebox with larger capacity that serves to satisfy the needs for heating energy of the industrial consumers.

Modern fireboxes for combustion of plant biomass should satisfy the following criteria:

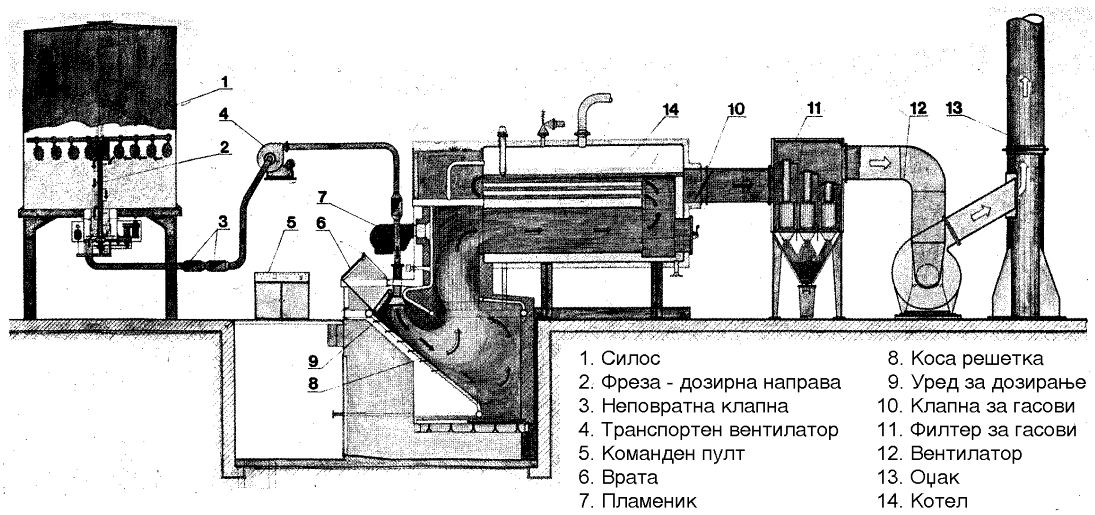
- the construction of the firebox should be adjusted to the combustion of a certain type of biomass;
- the volume of the fire place should be sufficient to allow complete combustion of the evaporating substances by way of intensive whirling and injection of secondary air;
- the level of utilization of the firebox, that is the quality of combustion must be independent from the burden, from the type of biomass and from the interrelation of the various biomasses when their combustion is simultaneous.

Follows a brief presentation of some possibilities and technical solutions for use of biomass from plant and animal origin for energy needs, so as to make a contribution in making correct decisions for optimal use of biomass.

However, it has to be emphasized that certain experiences already exist in the Republic of Macedonia for use of specific types of biomass for energy purposes by way of combustion in the boiler rooms of several industrial plants: wood and wood waste, rice husks ("Zito-oriz" - Kocani) and vine sticks ("Lozar" – Veles).

Combustion of biomass in steaming/hot-water boiler with static layer (on grid)

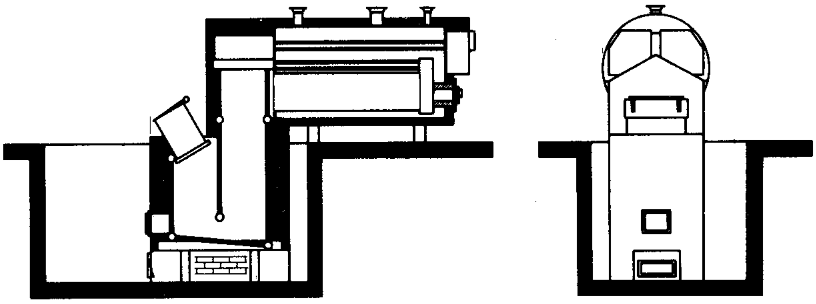
Picture 4.1 gives the scheme of a complete standard plant for combustion of wood waste, including the main elements: silo for storing biomass and accompanying equipment, boiler with slant grid combustion and the refiner of gases, produced by EMO, Celje [15].



Pic. 4.1. Plant for combustion of wood waste [15]

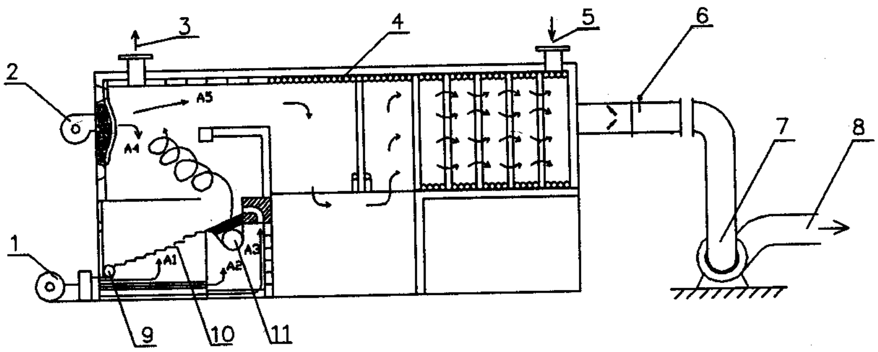
1. Silo 2. Dosing device 3. Irreversible cover 4. Transporting ventilator 5. Control panel 6. Door 7. Torch 8. Slant grid 9. Dosing device 10. Cover for gases 11. Filter for gases 12. Ventilator 13. Chimney 14. Boiler

Picture 4.2 gives the scheme of a boiler of Slovenian production, specially construed for combustion of biomass including pre-firebox and frontal fuel injection [15].



Pic. 4.2. Scheme of the boiler for combustion of biomass with pre-firebox of Slovenian production (EMO, Celje) [15]

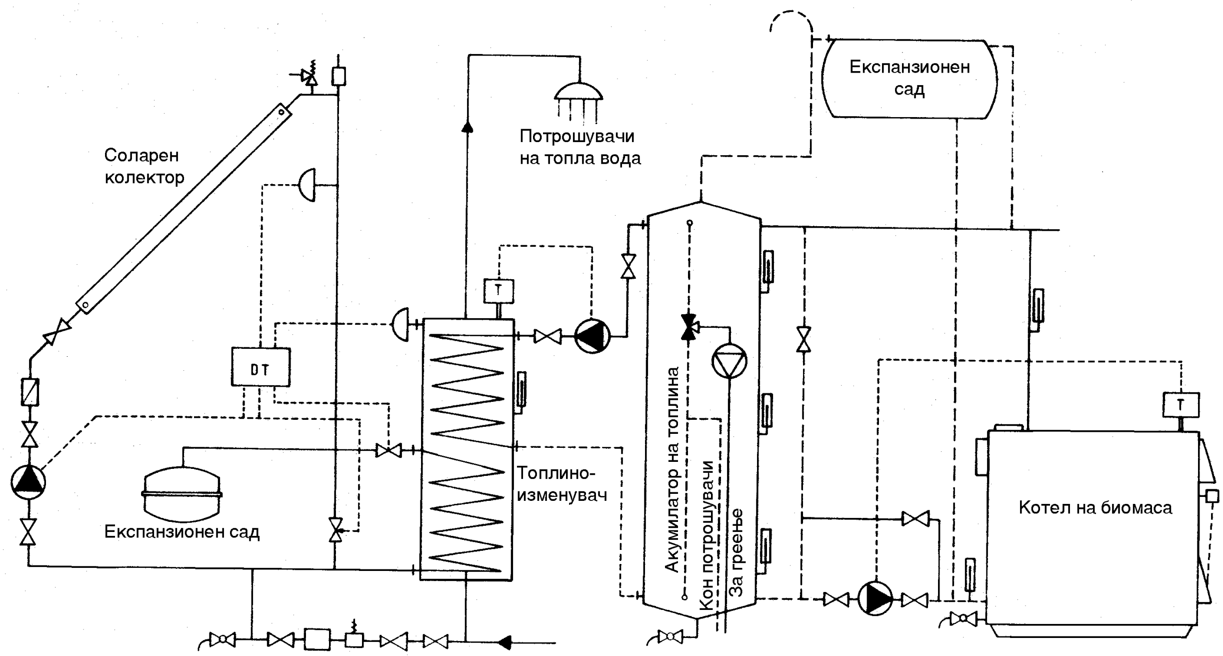
Picture 4.3 gives a scheme of modern concept of a hot-water boiler of Italian production for efficient combustion of wood waste with side fuel injection [15]. This type of boilers are produces with a heating capacity in the range of several hundreds kW to several MW.



Sl. 4.3. Scheme of the boiler of biomass BI-COMB 5000 (Ferolli)
1 – primary air; 2 – secondary air; 3 – outlet for hot water; 4 – heat-modifying surfaces; 5 – inlet of power-creating water; 6 – measuring probe; 7 – ventilator for outgoing gasses; 8 – channel for outgoing gasses; 9 – snail transporter for ashes; 10 – fuel grid (biomass);
11 – snail transporter for fuel (biomass)

Use of biomass in hot-water boiler combined with solar collectors

Picture 4.4 presents a principal electrical scheme of a system for use of energy from waste biomass combined with a system of solar collectors. The system has a built-in heat accumulator, which allows flexibility in supplying consumers with energy for heating and sanitary needs. Such a combined system may be quite suitable for the regions in Macedonia where there are many sunny days during the year.

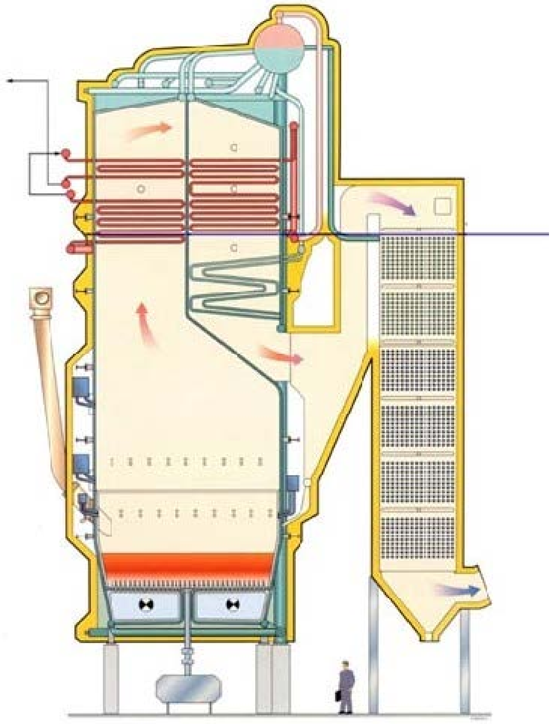


Pic. 4.4. Principal scheme of a system with a hot-water boiler for biomass with heat accumulator and solar collectors

#Solar collector #Expansion bowl #Hot water consumers #Heat modifier #Heat accumulator #to consumers #for heating #Expansion bowl #Biomass boiler

Combustion of biomass in steaming or hot-water boiler with fluidized layer

One of the efficient ways of using the potentials of the biomass, both in terms of energy and environment, is combustion in a fluidized layer. This is a relatively new technology which satisfies the stringent regulations concerning emission of harmful components in the gases, that is ensures low concentrations of nitrogen and sulfide oxides in the outgoing gasses, while at the same time allows for efficient transformation of chemical energy contained in the fuel (biomass) into heat. Picture 4.5 presents the scheme of a boiler with bubble fluidized layer.



Sl. 4.5. Boiler with a relatively large capacity for combustion of biomass in a bubble fluidized layer

4.2. Briquetting and palletizing

The production of pellets and briquettes from wood processing waste (sawdust), as well as from certain types of agricultural production such as for example corn stalks, may be of interest in terms of energy and environment in some regions of Macedonia.

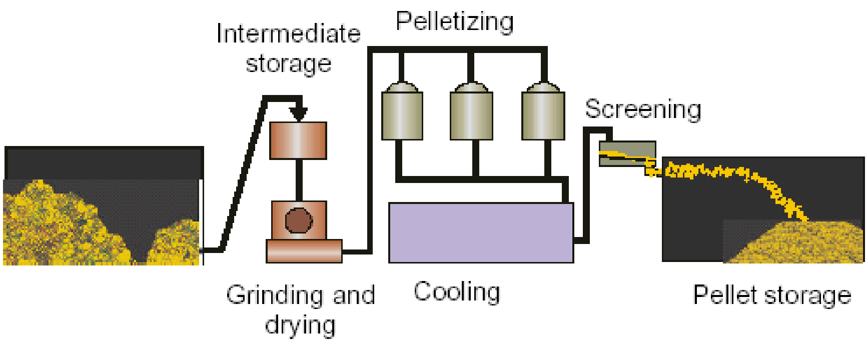
The processes of bracketing and palletizing actually mean compressing of biomass under high pressure, when particles and pieces of biomass are compressed in molds so as to produce briquettes or pellets. These products have significantly smaller volume that the original form of the biomass and, accordingly, have much more concentrated energy potential (more content of energy per volume unit), which makes them more compact sources of energy. At the same time, this facilitates transportation and storing as opposed to the biomass natural condition, and allows for their efficient combustion.

A typical example of pellets of a German manufacturer (Holz-Energie-Zentrum), produced from wood processing waste, is presented in tab. 4.2 [15]. For purposes of comparison, the norms for quality of pallets to be satisfied according to DIN standards are given in different columns.

In addition, the illustration in picture 4.6 presents a scheme of the process of production of pallets from wood waste. Picture 4.7 shows a plant for production of pallets with its constituent parts [15], while picture 4.8 presents a torch that can also be built-in into a boiler of classical construction.

Tab. 4.2. Typical characteristics of pallets produced from wood processing waste

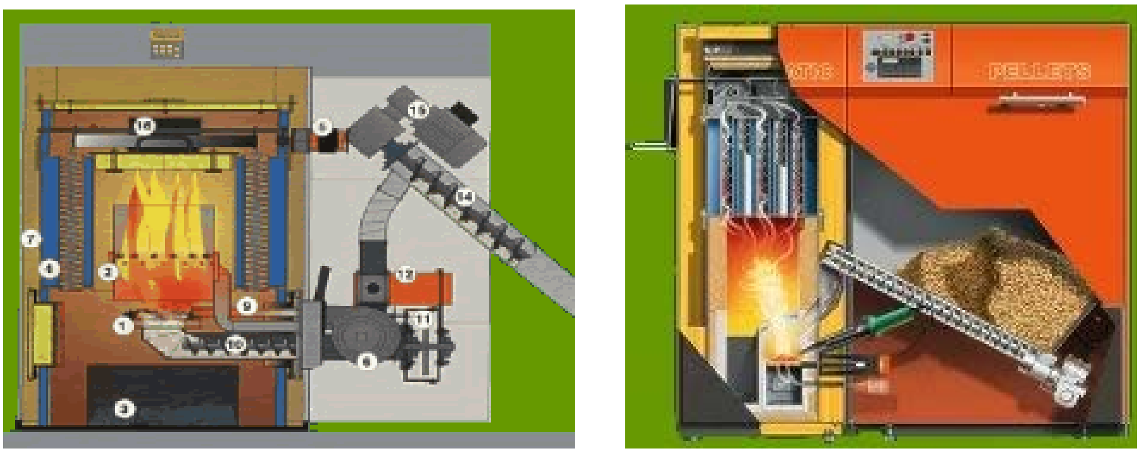
Norms for quality of pallets from wood waste		Norm M 7135	DIN 51731	DIN plus
Diameter (D)	mm	4 to 10 mm	4 to 10 mm	
Length	mm	5 x D[1]	< 50	5 x D[1]
Density	kg/dm³	> 1,12	1,0 - 1,4	> 1,12
Humidity	%	< 10	< 12	< 10
Ashes	%	< 0,50	< 1,50	< 0,50
Heating power	MJ/kg	> 18	17,5 - 19,5	> 18
Sulfur	%	< 0,04	< 0,08	< 0,04
Nitrogen	%	< 0,3	< 0,3	< 0,3
Chlorine	%	< 0,02	< 0,03	< 0,02
1	Not more than 20% of the pellets may be longer than 7.5 x D			



Pic. 4.6. Scheme of the pellet production process (system: Turenki, Finland) [15]

Sl. 4.7. Plant for pellet production (Holz-Energie-Zentrum) [15]
1. Entry of row material (wood waste); 2. Pressing cylinder;
3. Electric power engine; 4. Contact surface for sawdust; 5. Uncut pellets;
6. Transmission elements; 8. Pressing out mold; 9. Cutting device

Sl. 4.8. Torch for pallets from wood waste (HT Enerco Oy, Finland) [15]



Sl. 4.9. Scheme of small capacity boilers for combustion of pallets
1. Grid; 2. Combustion space; 3. Ashes space; 4. Heat-modifying surface; 6. Ventilator; 7. Insulation; 8. Controlling device; 9. Electrical device for kindling; 10. Spiral pellet transporter; 11. Motor and transmission;
12. Safety device

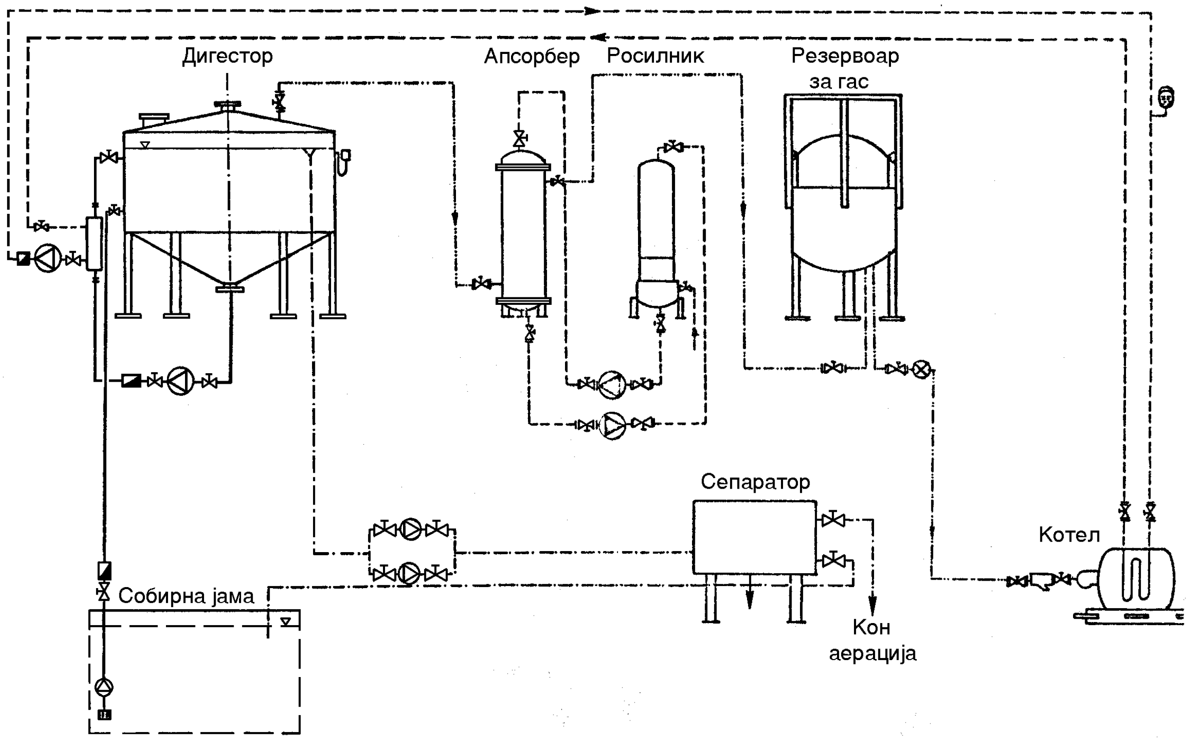
Considering the large number of factors that influence the economic justification of use of energy from various sources, it is very difficult to give exact assessment as to which energy source is most favourable in given conditions. Tab. 4.3 makes comparison of the economic justification for use of various heat sources for heating a living surface of 140 m2, in German weather and economy circumstances.

Tab. 4.3. Comparison of the economic justification of various heating modes in Germany

Living surface 140 m²				
Special requirement of heat (energy-saving house) 70 kWh/m²/year				
Yearly requirement of heat plus hot water 12 500 kWh/year				
	Oil-fired heating	Gas heating	Electrical heating	Pellets heating
Capital expenditure				
Tank / connecting charge	1.800 €	1.200 €	-	1.300 €
Chimney / exhaust installation	1.600 €	600 €	-	1.600 €
Bunker plus accessories	3.400 €	3.000 €	-	6.700 €
Hot-water tank	800 €	800 €	800 €	800 €
Electrical installation plus control	250 €	250 €	1.100 €	250 €
Distribution of heat	3.300 €	3.300 €	4.900 €	3.300 €
Development programme by the Government*	-	-	-	**-1.500 €**
Capital expenditure total	**11.150 €**	**9.150 €**	**6.800 €**	**12.450 €**
Degree of effectiveness	0,89 €	0,89 €	1,00 €	0,89 €
Actual consumption in kWh	14,045 €	14,045 €	12.500 €	14.045 €
Low tariff 70%	-	-	8.750 €	-
High tariff 30%	-	-	3.750 €	-
Consumption costs / year				
Energy price € / kWh	0,03 €	0,04 €	0,07HT/0,045NT	0,03 €
Energy price € / l, € / m3, € / t	0,31 €	0,4 €	-	164 €
Basic charge / price for reading the meter	-	120 €	70 €	-
Auxiliary drives	50 €	50 €	-	50 €
Consumption costs total	**494 €**	**732 €**	**851 €**	**499 €**
Running costs / year				
Chimney-sweep	50 €	30 €	-	50 €
Maintenance / cleaning	70 €	50 €	-	70 €
Spare parts / repairs	50 €	50 €	0 €	50 €
Insurance	50 €	0 €	-	0 €
Running costs total	**220 €**	**130 €**	**0 €**	**170 €**
Yearly costs (without capital expenditure)	**714 €**	**862 €**	**851 €**	**669 €**
*Additionally there are subsidies from federal programmes				

4.3. Production and use of biogas from animal farms

One of the ways to use biomass from animal origin is the production of biogas by way of anaerobic fermentation or organic farm waste. A scheme of the plant for production of biogas from animal waste from a pig farm is presented in picture 4.10.



Sl. 4.10. Plant for processing waste from pig farms to produce biogas by way of anaerobic fermentation #Digester #Collecting pit #Absorber #Drizzler #Gas reservoir #Boiler #Separator #to aeration

5. POSSIBLE CONSUMERS OF ENERGY PRODUCED FROM BIOMASS

The analysis of the established available quantities and types of waste biomass in the concerned municipalities indicates the possible consumers of energy obtained by its combustion.

Berovo

Based on the made analysis, it can be concluded that there are not many possibilities for additional use of waste wood. The quantity of waste that is obtained when cutting woods is difficult to approach for organized collecting, and the waste from the processing of wood in AD „Ograzden" are almost completely used production of briquettes or through direct combustion in the mill's boiler room for the purpose of satisfying their own needs for heating energy.

A predominant potential possibility for use of waste biomass in the municipality of Berovo is the use id biogas that would be used by way of anaerobic fermentation of organic waste from the pig farm "Zito Males". Additional benefit in such a case is the fact that the produced heat would be used in the working premises for satisfying part of the needs for heating the workrooms and the administration building. Under the present circumstances, heating of 2 out of 4 workrooms by inhaling hot air. The farm has a total of 12 workrooms, each with surface of approximately 1500 m^3. The old boiler room has 2 boilers on liquid fuel, each with heating capacity of 650000 kcal/h, that is 2x756 kW, but are not operational for a longer period of time.

Based on the experiences of other similar facilities, it may be concluded that heating the farm workrooms would result in significant positive production outcome: smaller mortality of young animals, increased weight of the animals, etc.

Gevgelia

Possible location of the plant for use if chemical energy of biomass for production of heating energy, that is possible heat consumers may be the following:

- the compound of buildings and future hotels on the border terminal towards the R. Greece;
- the mental hospital in the village of Negorci;
- the greenhouses for early fruits and vegetables, by using a combined system for using heat from biomass and geothermal energy.

Struga

According to the analysis made while working on this report, it is assessed that the most eminent possibilities for use of waste biomass for energy needs are from agricultural production in the Struga region, more precisely from corn stalks, which can be found on relatively large surfaces. In a certain period of the year individual producers, mostly, dispose of a significant quantity of stalks. Their use for energy purposes is also a solution for one real environmental problem. Namely, to present they have mostly been destroyed by direct burning on the fields, thus irreversibly loosing the heating energy contained in them.

Heat consumption is subject to discussion due to the fact that the potential consumers are dispersed. A possible option is to additionally analyze the cost effectiveness of the production of briquettes or pellets.

6. EXPECTED FINANCIAL RESULTS AMD NON-FINANCIAL BENEFITS

6.1. Financial effects

In order to make a general assessment of possible financial costs and effects of certain options for using biomass it is necessary to make detailed comparable analysis of the optimal technical solutions and the heat consumption.

Projections of investment return in different cases of plants installed in certain European countries (Italy, Lithuania, Finland, Denmark and other) for production and use of biogas from pig or cattle farms indicate an average period of 4 to 8 years. When using waste plant biomass for energy purposes this period is somewhat shorter, although the total investment for building a power plant that uses biomass for an installed kW are relatively higher compared to the classical fossil fuel.

6.2. Environmental effects

Among the indirect non-financial and other long-term benefits, emphases should primarily be put on environmental effects from use of biomass as energy source. This means that the use of biomass for energy needs cuts down on the use of fossil fuels.

When using waste biomass of plant origin for direct combustion, in addition to saving fossil fuel, positive effects are also achieved in relation to the protection of the environment. For example, reproduced CO_2 may during biomass combustion be considered a segment of the natural cycle of CO_2, which means that the total emission of CO_2, considered one of the main direct greenhouse gases (gases causing the "greenhouse" effect), is reduced.

In the case of using waste from pigsties for producing fertilizer and biogas some benefits for the environment are also concurrently achieved:

- the emission of methane is reduced by capturing this gas in a digester, thus reducing the potential for global heating (CH_4 is one of the gases causing the "greenhouse" effect, having more than 20 times larger influence on the global heating compared to CO_2);
- a certain quantity of high quality organic fertilizer is produced, which reduced the risks for polluting the soil;
- the appropriate type of energy is produced (heat), which helps improve the efficiency of production (less illnesses and mortality with the animals) and the quality of the product.

Concerning the use of waste from corn production (stalks) for production of pellets achieved are certain effects relevant for the protection of the environment, by virtue of the fact that they would not be burned in the fields.

7. EXPECTED IMPEDIMENTS AND LIMITING FACTORS

The assessment of the barriers, the expected impediments and the limiting factors for effective application of waste biomass as energy source represents a possible important step in general toward intensifying the use of biomass.

The following may be listed as major barriers and expected troubleshooting when using systems of small capacity for use of biomass energy potential:

- relatively higher investment costs compared to other heating systems;
- undeveloped market for biomass as fuel at local level, except in the case of firewood;
- problems emerging when collecting certain types of biomass from smaller producers;
- relatively high costs for collecting and transportation of certain types of biomass;
- costs for preparations and storage;
- inconsistencies in the legislation for stimulating and supporting the use of alternative energy sources, including biomass;
- lack of information to the public on the benefits from using biomass as energy source;
- bad financial situation of the company and the population.

Pursuant to the forgoing analysis, a main priority for more efficient use of the biomass for energy purposes is the need to establish an efficient chain of biomass, meaning efficient collecting, preparation for transport, transport, preparation of bracketing or the procedures of final use, storage, combustion, etc.

Additional stimulation for use of alternative sources of energy should be provided for in the new legislation of the Republic of Macedonia, in particular in the field of energy.

8. CONCLUSIONS AND RECOMMENDATIONS FOR DEVELOPMENT OF SMALL PROJECTS ADJUSTED TO THE LOCAL CIRCUMSTANCES

Comparable initial analyses and research demonstrate that there are real potential possibilities for effective use of energy from waste biomass in the municipalities of Berovo, Gevgelia and Struga.

Based on the findings of available quantity, type and characteristics of biomass in the said municipalities, the described solutions in part 4 of this report are presented as possible solution for utilizing the energy contained in it. For each particular case a technical and economical analysis is needed that would answer the uncertainties about the technical details as well as the economic justification of the use of biomass under the given circumstances.

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