Bioenergy Association of Ukraine

PROSPECTS FOR HEAT PRODUCTION FROM BIOMASS IN UKRAINE

UABio Position Paper N6

Georgiy Geletukha, Tetiana Zheliezna, Eugen Oliynyk

31 May 2013

Discussion within UABio: from 18.05.2013 to 31.05.2013
Approval by the Board of UABio and publication at www.uabio.org: 31.05.2013
The publication is available at: www.uabio.org/activity/uabio-analytics
Responses and comments: geletukha@uabio.org

Table of contents

Introduction

UABio's Position Paper N6 is a regular document of the planned series of publications on the key issues of bioenergy development in Ukraine. The Paper considers state of the art and prospects for the development of heat production from biomass in the EU countries and the world. We have analyzed prerequisites and barriers existing in Ukraine for the development of this sector and suggested conception for introduction of bioenergy equipment for heat production from biomass in Ukraine until 2030.

General description of the biomass heat sector in the world

Today biomass as fuel ranks fourth in the world in terms of energy production and consumption. Its share in the total primary energy supply reaches 10% that amounts to 1272 Mtoe/yr [1]. In the heat energy sector, biomass also takes fourth place after coal, natural gas and oil.

The European Union has achieved significant progress in the development of bioenergy. The share of biomass in the EU's total energy consumption increased from 3% in 1995 to almost 7% at present. Moreover, in some countries this figure is much higher than the European average. For example in Latvia, the share of biomass in gross domestic energy consumption is about 28% (the leader in the EU), in Sweden 22%, in Finland 21%, in Denmark 17%, in Austria 16%, in Germany 8%. For comparison, the contribution of biomass to the total energy consumption is 3.9% in the USA and 1.24% in Ukraine [2-4].

Biomass plays the most important role in the heat energy sector: its current contribution to the total heat production in the EU is about 15% (**Fig. 1**). Almost all heat energy generated from renewables (99%) is obtained at the expense of biomass and organic waste.

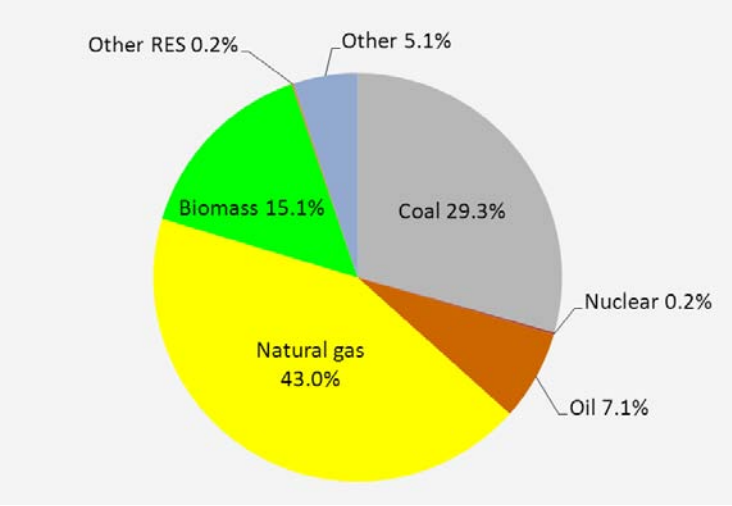


Fig. 1. Structure of the EU heat production, 2010 (the total production is 2652 PJ) [3].

In some countries, the volume of heat production from biomass is much bigger than the European average: in Sweden it is 61% (the EU leader), in Austria 37%, in Denmark 35%, in Finland 32% [3, 5].

Solid biomass is the main type of biomass that is used for heat production in most EU countries, for example in Finland 94%, in Poland 93%, in Austria 89%, in Sweden 78% (**Table 1**).

Table 1. Structure of heat production by different types of biomass in some EU countries, 2009 [5]

EU countries	Type of biomass/biofuel				Total, TJ/yr
	solid biomass	MSW	biogas	liquid biofuels	
Sweden	78%	17%	1%	5%	113405
Finland	94%	4%	2%	-	51595
Denmark	62%	36%	3%	-	41252
Germany	37%	58%	3%	1%	37758
Austria	89%	8%	2%	1%	24471
Poland	93%	-	7%	-	11270
France	-	100%	-	-	10613
Netherlands	24%	73%	3%	-	6869
Italy	37%	34%	12%	17%	6861
Czech Republic	56%	39%	5%	-	3703
Hungary	68%	31%	1%	-	1696

Table 2 presents the structure of heat production from biomass by different technologies. The data show that situation in the presented countries is quite different. For example Finland, Austria, and Sweden produce main part of heat by biomass CHP plants while the CHPPs running on MSW generate much smaller volume. In contrast, the CHPPs running on biomass and MSW produce almost equal amount of heat in Denmark and the Netherlands. In Italy, all the heat is produced by CHP plants.

Table 2. Structure of heat production from biomass by different technologies in some EU countries, 2009 [5]

EU countries	Type of technology/installation			Total, TJ/yr
	Biomass CHP	MSW CHP	boiler installations and domestic boilers	
Sweden	52%	13%	36%	113405
Finland	77%	3%	20%	51595
Denmark	30%	32%	38%	41252
Germany	24%	39%	37%	37758
Austria	52%	6%	42%	24471
Poland	85%	-	15%	11270
France	-	77%	23%	10613
Netherlands	27%	23%	50%	6869
Italy	66%	34%	-	6861
Czech Republic	38%	11%	51%	3703
Hungary	61%	31%	8%	1696

For comparison in the USA, the share of biomass in the total heat production is 7.4%. At that the main part of heat is produced from solid biomass (80%); MSW and biogas contribute with 17% and 3% respectively. All the heat is produced by biomass CHP plants (83%) and by MSW CHP plants (17%) [2, 5].

According to forecast given by the European Commission in the Renewable Energy Road Map [6], the EU will produce 120 Mtoe of renewable heat in 2020 that is about 18% of the total production. Of this, about 75% is supposed to be from biomass and the rest from geothermal energy (using heat pumps) and solar energy (using thermal collectors) in approximately equal parts (**Fig. 2**).

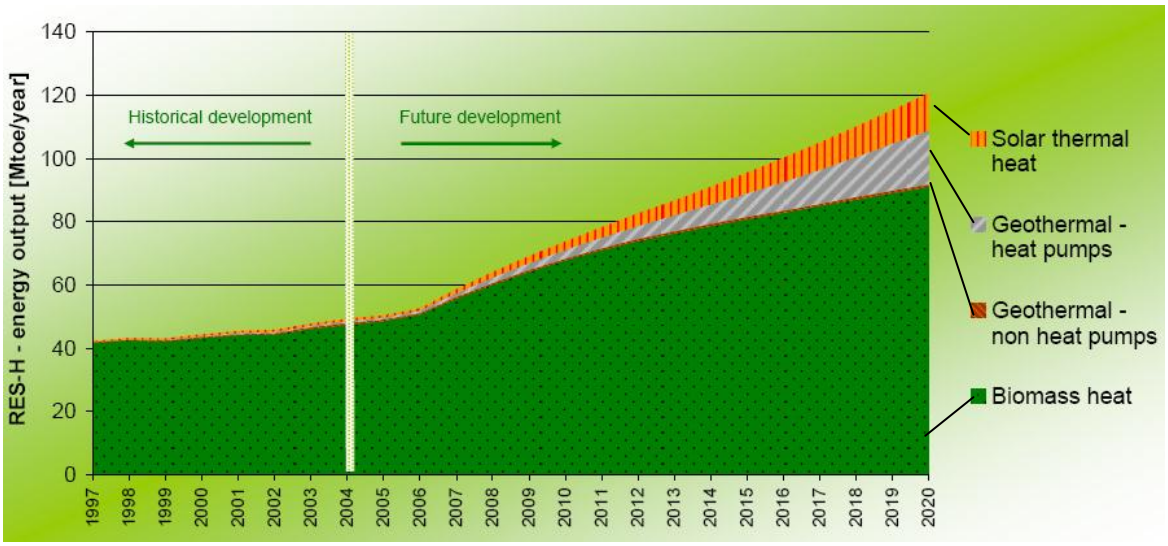
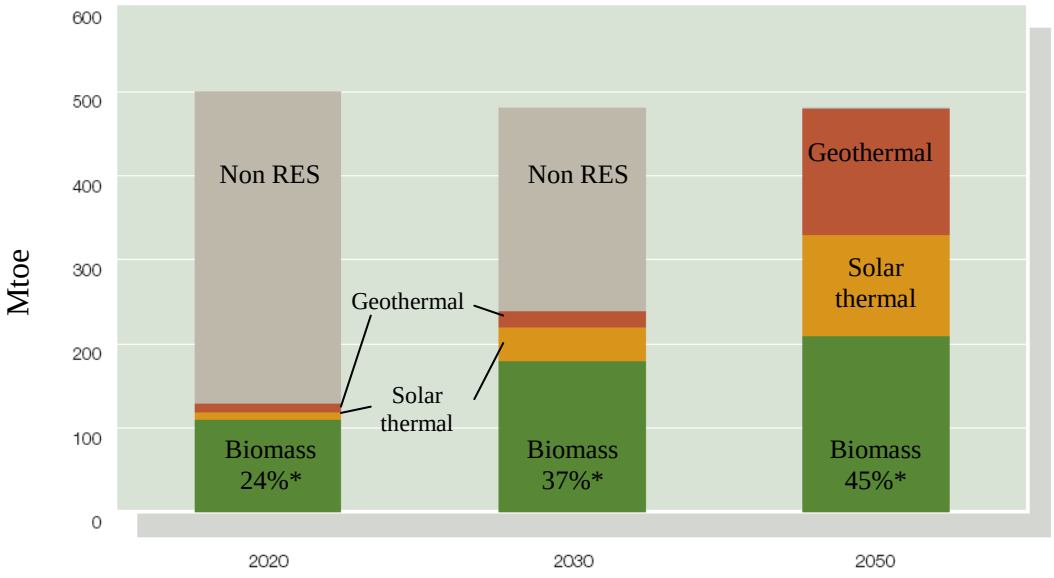


Fig. 2. Renewable growth: Heating and cooling projections by 2020 [6]

A more distant forecast for the period until 2050 was made by the European Renewable Energy Council (EREC) [7]. According to this forecast, by 2030 renewable energy sources will produce about 50% of the total heat (247 Mtoe) in the EU, including 175 Mtoe from biomass (71% of all RES). By 2050, according to EREC's expert estimation, the share of renewables in heat production may reach 100% with 45% (214.5 Mtoe) contribution of biomass. The nearest forecast for 2020 is that biomass will cover 24% of the total heat consumption (**Fig. 3**).



* % of the total heat consumption

Fig. 3. Contribution of renewable heating and cooling technologies to heat consumption in the EU [7]

Incentives for heat production from biomass in the EU countries

Heat production from biomass is successfully developing in the European Union owing to systematic application of the effective supporting instruments [8-12]. These instruments can be divided into the following groups:

- investment grants and subsidies;
- tax exemptions;
- fiscal incentives, financial incentives;
- legal support.

Investment grants and subsidies are used in almost all EU countries. A state fully or partially covers the capital cost of introducing certain types of bioenergy equipment. For example, in Austria the fund that is managed by the Federal Ministry of Agriculture and Forestry, Environment and Water Management covers 30…40% of the construction or modernization cost for district heating boilers and biomass CHP plants.

Tax exemptions for biomass installations are applied in Sweden, Finland, Austria, France, Belgium, Denmark, Greece, Italy, Lithuania, the Netherlands, and Great Britain. An example is the CO_2 tax that must be paid by producers of energy from fossil fuels. The tax is not applied to bioenergy. Another example is reduced VAT on biofuels. For instance in Austria, VAT on fossil fuels is 20% and VAT on biofuels is 10%.

Heat production from biomass is also encouraged by relevant laws, action plans, target programs and funds. For example there were adopted the Heat Supply Act (1990) and State-Subsidized Promotion of Decentralized CHP and Utilization of Biomass Fuels Act (1992) in Denmark, the Energy Taxation Act (2006) and the Renewable Energy Heat Act (2009) in Germany. In Austria, the Green Electricity Act (2002 with amendments of 2006) introduced a feed-in tariff not only for renewable power but also for heat that is produced in combination with power.

Sweden is a country with highly developed heat production from biomass, mostly wood. Among the EU countries, it produces the biggest volume of heat from solid biomass – 87996 TJ/yr. Sweden has a highly developed centralized heat supply system. Practically all the cities and towns are connected to it. The share of biomass among the fuels which are used in the centralized heat supply system is up to 70%. At present, 170 biomass CHP plants operate in Sweden and about 40 plants are under construction.

Swedish Bioenergy Association (Svebio) considers the CO_2 tax for fossil fuels to be the main reason for successful development of bioenergy. The tax was set in 1990. It is a differential tax with basic value of 115 EUR/t CO_2 (the highest value among the EU countries). For example, heat producers which supply heat to the grid pay 7% of the tax basic value if the heat is produced by a CHP plant and 94% if by a boiler. Householders who use fossil fuels for heating must pay the full

tax. Due to this, most householders switched over to biomass as far back as in 2008. Besides, the Local Investment Program and Climate Investment Program are in force in Sweden. The programs support projects on switching houses over to the centralized heat supply based on renewables.

A law promoting heat production from renewables (EEWärmeG) has been in effect in Germany since 2009. According to the law, owners of new houses must partially use RES for heating. For biomass (firewood, pellets, chips and other) the binding share is 50%. At that, the biofuels may be used only in highly effective boilers that meet the national emission standards. The Market Incentive Program was launched along with the law. The program gives credits on favorable terms to householders who intend to introduce a heating system based on renewables.

Situation in Ukraine's biomass heat sector

In Ukraine, the bioenergy sector has been developing very slowly up to now. According to Ukraine's energy balance for 2011 [4], the share of biomass in the total primary energy supply is only 1.24% (1.56 Mtoe) (**Fig. 4**).

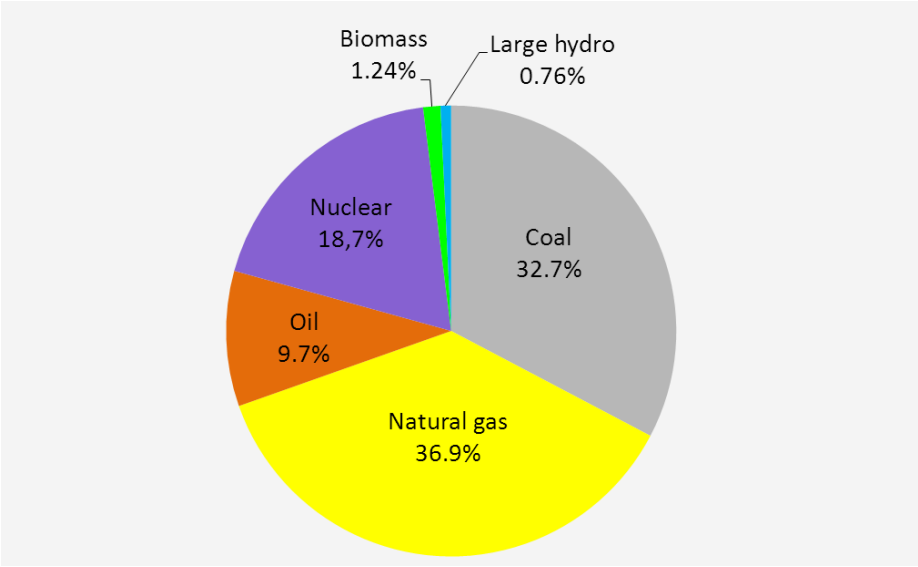


Fig. 4. Structure of Ukraine's primary energy supply, 2011 (total supply is 126 Mtoe) [4]

Natural gas remains the main energy carrier in the country (36.9% of TPES). Coal ranks second (32.7%) though the latest trend is increase in coal consumption and decrease in natural gas use. According to Ukraine's energy balance for 2010, the share of gas in TPES was 42% and coal 28.2%.

The structure of natural gas consumption in 2010 is presented in **Figure 5**. It can be seen that now about a third of gas volume, 31% (18 bn m^3), is consumed by the population, 19% (11 bn m^3) is used for heat supply by communal-housing enterprises, and industry consumes 37% (22 bn m^3). It is planned to reduce natural gas consumption by 14%, from 57 to 49 bn m^3/yr, by 2030 [13].

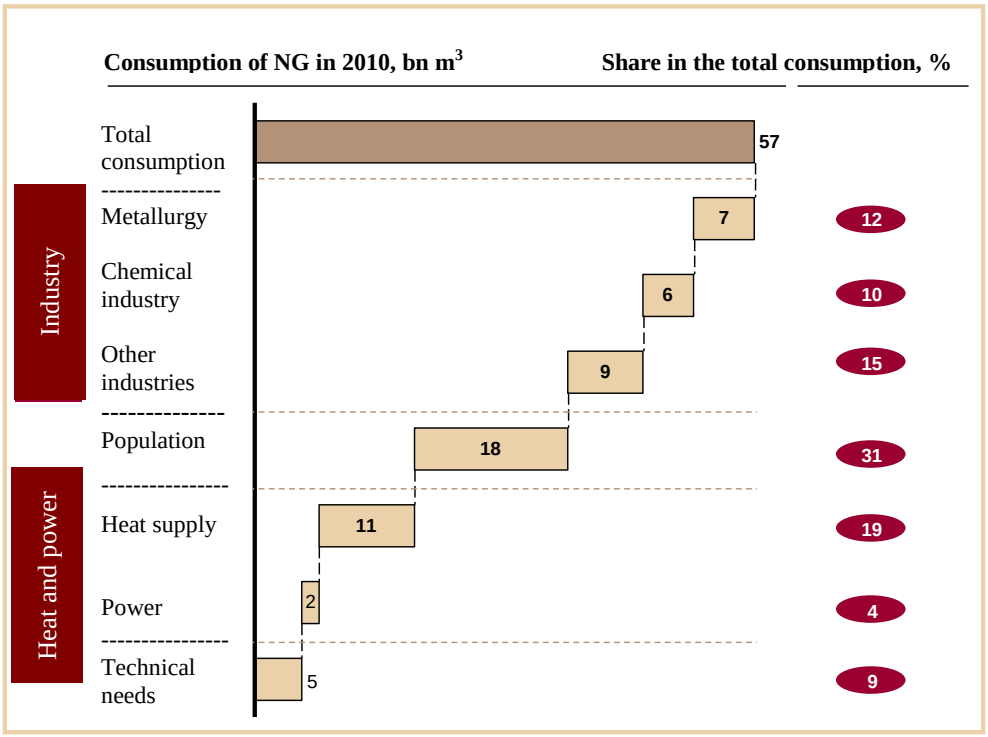


Fig. 5. Structure of natural gas consumption in Ukraine in 2010 [13]

At present, Ukraine annually consumes about 970 PJ (230 Pcal) of heat. Of them, the biggest share (67%) is for population and housing-communal services, 20% is for industry and 13% is for other sectors (**Table 3**). According to Ukraine's draft Energy Strategy until 2030, heat consumption may increase up to 1135 PJ (271 Pcal) by 2030. At that the biggest rise is expected to be in the commercial and state-financed sectors – their share will grow to 20%.

Table 3. Trends and structure of heat consumption in Ukraine in 2005-2010, Pcal [13]

Consumption sectors	2005	2006	2007	2008	2009	2010 (% of the total amount)	2030* (% of the total amount)
Industry	71	66	58	56	38	47 (20%)	57 (21%)
Population and housing and communal services	160	164	149	147	146	156 (67%)	161 (59%)
Commercial and state-financed sectors	27	27	27	27	28	29 (13%)	53 (20%)
Total	**259**	**256**	**234**	**231**	**212**	**232**	**271**

* forecast according to the basic scenario

Heat for Ukraine's economy and population is supplied through the DH systems and individual heating systems. About 11 million apartments, mostly in cities, towns and urban settlements, are connected to the DH systems; that makes up about 60% of all heat consumers.

At the present time, heat is produced by about 35 large CHPPs (their share in the total heat supply is 18%), by 200 industrial installations (21%), by over 100,000 boiler plants (up to 60%), and also by individual heat-generators and installations running on secondary and renewable energy sources. Equipment of most CHPPs is outdated and does not meet the existing environmental norms; it requires reconstruction and modernization. Most boiler installations are small industrial or stand-alone heating plants. Their equipment is also obsolete and requires reconstruction or even complete replacement. The main fuel for the boiler plants is natural gas with the share of 52-58%. The share of fuel oil is 12-15% and coal 27-36%. Quite a big amount of heat is also produced by individual heat-generators (boilers running on natural gas or liquid fuels or solid fuels, ovens etc), by heat-recovery plants and other installations.

According to information from the Ministry of Regional Development, Construction and Housing-Communal Services of Ukraine, total number of heating plants by the end of 2012 was 35424 units. Of them, the number of heating plants of up to 3 Gcal/hr capacity was 31106, 3-20 Gcal/hr – 3508, 20-100 Gcal/hr – 619, ≥ 100 Gcal/hr – 191. Of these plants, 9791 run on solid fuel, 333 run on liquid fuel, 24564 run on gaseous fuel. Total capacity of the boiler plants by the end of 2012 was 117783.4 Gcal/yr. Of this, capacity of the boiler plants of up to 3 Gcal/hr capacity was 21455.5 Gcal/hr (18.2% of the total capacity), 3-20 Gcal/hr – 25664.8 Gcal/hr (21.8%), 20-100 Gcal/hr – 23357.3 Gcal/hr (19.8%), ≥ 100 Gcal/hr – 47305.8 Gcal/hr (40.2%). The number of boilers (energy units) by the end of 2012 was 80070, of them 15871 units had been in operation over 20 years. Total heat production at Ukraine's enterprises in 2012 was 104074.5 Tcal, of which 1.2% was produced from alternative fuels.

Ukraine has good preconditions for much wider use of biomass for energy production, first of all heat energy. One of the preconditions is a big potential of biomass available for energy production. The largest constituent parts of the potential are agricultural residues and energy crops. Depending on the yield of main agricultural crops, the economic potential varies within 25-35 Mtce/yr that is 13-18% of Ukraine's energy consumption. The biomass energy potential is considered in detail in UABIO's Position Paper N 1 [14].

Of the available potential, wood biomass and sunflower husk is most actively used for energy generation in Ukraine now. It can be seen from **Table 4** that utilization of wood biomass comes to 80% of its potential and sunflower husk to 59%. As for the potential of such important and available type of biomass as straw, only 1% of it is utilized now.

Table 4. The use of biomass for energy production in Ukraine (2011/2012)*

Type of biomass	Annual consumption**		Share of the total annual consumption of biomass	Share of the economic potential
	natural units	ktce		
Straw of cereal crops and rape	77 kt	37	1,6%	1%
Firewood (population)	2 million m^3	478	21,4%	80%
Wood biomass (except population)	3 Mt	1330	59,5%	
Sunflower husk	665 kt	318	14,2%	59%
Bioethanol	180 kt	48	2,1%	4%
Bioduesel	100 kt	~0	~0	~0
Biogas from agro-residues	10 million m^3	7	0,3%	2%
Landfill gas	26 million m^3	18	0,8%	7%
TOTAL		**2236*** **	**100%**	

* Authors' expert estimation.

** For energy production in Ukraine. The export of biomass pellets is not taken into account.

*** It conforms with the data of Ukraine's State Statistics Service (2.24 Mtce in 2011).

At the present time, biomass is used in Ukraine mostly for heat production. The main areas of biomass utilization are:

- Population in rural areas burns firewood in traditional stoves (about 74% of the total amount of the firewood). The rest is used by enterprises.
- About 2000 modern boilers run on wood biomass (chips, pellets) and a CHP plant runs on wood in Smila town (Cherkasy region). According to information from Ukraine's State Forest Resources Agency, 1387 biomass boilers of 246 MW total installed capacity are in operation at the enterprises of the sector Among the domestic manufacturers of wood fired boilers one can mention «Kriger» plant (Zhytomir town), «Volyn-Kalvis» Ltd. (Kovel town, Volyn region), «Royek-Lviv» (Lviv) and some others.
- Over 1000 boilers converted from coal / fuel oil to wood biomass are in operation at forestry enterprises.
- About 40 boilers and 40 heat-generators run on baled straw. Almost all the boilers are of UTEM (Kyiv) manufacture (UTEM manufactures straw fired boilers under the exclusive license of Passat Energy A/S, Denmark). The boilers operate at rural schools, agricultural enterprises and some other objects. The heat-generators operate within grain dryers in 20 regions of Ukraine. They are manufactured by «Brig» public corporation (Pervomaysk, Mykolaiv region).
- Over 70 sunflower husk fired boilers operate at oil-extraction plants and fat-and-oil plants. Some of the boilers were designed by «Energomashproject» design office (Kyiv); the others are of foreign make, particularly of Vyncke (Belgium), Rafako (Poland), Babcock. Two installations are CHP plants located at «Kirovogradoliya» public corporation (Kirovograd) and «Cargill Complex» Ltd. (Donetsk).

Another important area of the biomass potential use is production of pellets and briquettes. According to data of Ukraine's Association of producers of alternative fuels and energy, 810 kt of solid biofuels were produced in Ukraine in 2012. The lion share of the produced biofuels is exported, mainly to European countries. However, the latest trend is the decrease of the exports. As far back as 4-5 years ago, 90-95% of the produced solid biofuels was exported; by 2012 the exports decreased to 70%.

Barriers existing in Ukraine

Barriers to bioenergy development in Ukraine are analyzed in detail in UABIO's Position Paper N 3 [15]. This Position Paper briefly covers the barriers directly connected with heat production from biomass.

Barrier 1: Subsidizing internal prices of natural gas for population and housing-communal sector makes biomass uncompetitive in these sectors

UABIO's suggestion for overcoming the barrier:

In our opinion, it is necessary to gradually put an end to subsidizing household and communal consumers of natural gas. As a result the tariffs for gas for population and housing-communal sector are to increase to the economically sound level. This will improve economic preconditions for the replacement of natural gas by biomass in these sectors.

Barrier 2: No subsidies for the purchasers of bioenergy equipment

UABIO's suggestion for overcoming the barrier:

We consider that it is necessary to introduce a state subsidy for the purchasers of bioenergy equipment in the amount of 20…30% of its cost (depending on the equipment type).

Barrier 3: No working state program for bioenergy development

UABIO's suggestion for overcoming the barrier:

We consider it is necessary to develop and approve on the governmental level a bioenergy action plan which would be elaborated according to the methodology of the European Commission (such plans were developed and adopted in most EU countries).

Barrier 4: Potential of bioenergy was almost disregarded when elaborating the draft updated Energy Strategy of Ukraine until 2030

UABIO's suggestion for overcoming the barrier:

It is necessary to set reasonable targets for bioenergy development on the state level, in particular, in the updated Energy Strategy of Ukraine until 2030. We recommend the targets for the contribution of biomass to energy consumption that is shown in **Table 5**.

Table 5. Targets for the contribution of biomass to energy consumption in Ukraine and the EU

Indicator	2011	2015	2020	2025	2030
The share of biomass in the total primary energy consumption in **Ukraine** (Energy Strategy of Ukraine, 2006) [16]	1.3%	-	2.6%	-	3.0%
The share of biomass in the total primary energy consumption in **Ukraine** (draft Energy Strategy of Ukraine, 2012)*	1.24%	1.24%	1.24%	1.24%	1.24%
The share of biomass in the total primary energy consumption in **Ukraine** (UABIO's suggestions)	**1.24%****	**1.5%**	**3%**	**5%**	**7%**
The share of biomass in the gross final consumption in of energy in **Ukraine***** (UABIO's suggestions)	**1.78%**	**2.2%**	**4.3%**	**7.2%**	**10%**
The share of biomass in the total primary energy consumption in the EU [3, 7]	6.7%	10%	14%	16%	19%

* Recalculation by the authors

** According to Ukraine's energy balance for 2011 [4]

*** Gross final consumption of energy means the energy commodities delivered for energy purposes to industry, transport, households, services including public services, agriculture, forestry and fisheries, including the consumption of electricity and heat by the energy branch for electricity and heat production and including losses of electricity and heat in distribution and transmission (Directive 2009/28/EC, Article 2 (f) [20]). This term is introduced as Ukraine has obligation within the Treaty establishing the Energy Community to reach 11% RES in the gross final consumption of energy in 2020. According to Ukraine's energy balance for 2011, final consumption of energy was 75.8 Mtoe [4].

Barrier 5: Underdeveloped market of biomass as fuel

UABIO's suggestion for overcoming the barrier:

The problems may be solved by way of development of civilized market of biomass as fuel, in particular, by way of creating a sufficient number of companies, core business of which is biomass supply and which can guarantee biomass supply to a final user. Besides, it is necessary to elaborate and approve national standards on different types of solid biofuels and also programs to stimulate investments into infrastructure for storage and supply of biomass.

Barrier 6: Steep ecology demands for biomass boilers

UABIO's suggestion for overcoming the barrier:

UABIO's recommendation as for the maximum permissible levels of solid particles emission depending on biomass boiler capacity is presented in **Table 7**.

Table 7. Maximum permissible levels of solid particles emission for biomass boilers according to UABIO's suggestion (at 6% of O_2 content in flue gas)

Capacity, MW	Maximum permissible levels of solid particles emission, mg/nm^3
0.1…1.0	300
1.0…10	150
>10	50

Barrier 7: The existing mechanism of setting tariffs does not encourage heat producers to use biofuels and, on the contrary, encourages them to use the imported natural gas.

Cost-effectiveness of any new technical system at the initial stage of its life cycle generally is lower than that of the systems that are in the early stage of their aging. We can see this by example of bioenergy formation: its introduction requires replacement or considerable renovation of boilers running on gas, fuel oil and solid fuel; it requires creation of a system for harvesting, transportation and supply of biofuels. These actions require considerable financial costs and lead to the increase (albeit temporarily) of heat production cost of.

Over 75% of boiler plants in Ukraine, producing 83% of heat, are operating on natural gas. Natural gas has an **artificial advantage** over other fuels. Such advantage is foreseen by the CMU Decree "On Approval of the Procedure and Conditions for Provision of Subsidy from the State Budget to Local Budgets for Repayment of Debt in 2013" (№ 167 from 20.03.2013) that provides a mechanism for subsidies **only for consumed natural gas** for repayment of debts of the enterprises generating, transporting, and supplying heat to population.

The above is contrary to Article 20 of the Law of Ukraine "On Heat Supply» (№ 2633-IV from 02.06.2005) and prevents a fair competition on the Ukrainian heat generation market.

Today, the actual cost of thermal energy generated from renewable sources, including wood chips, pellets, wood, straw, agricultural residues, exceeds the existing tariffs for the population, which are approved and/or agreed by the state or local authorities. <u>At that, the main consumer of heat provided by heat supply companies is population.</u>

The above mentioned problem hinders local governments and businesses to introduce installations generating thermal energy from RES such as wood chips, pellets, wood, straw and other agricultural waste.

We consider that this unsettled legal problem:

- suppresses the development of alternative energy sources market in Ukraine;
- suppresses the use of internal energy sources for heat production, including wood chips, pellets, wood, straw and other agricultural residues;
- encourages consumption of the imported NG, the price of which is subsidized by the state (NG price limit for the communal heat supply companies including expenses of NSC[1] «Naftogas Ukrainy» without VAT and target premium is 770 UAH[2]/1000 m^3);
- leads to losses of NSC «Naftogas Ukrainy» running into millions. The losses are caused by the difference between NG price for the communal heat supply companies and NG price on the border (430 USD/1000 m^3),

[1] National Stock Company
[2] 1 USD = 8 UAH

- suppresses the development of domestic agro-industrial sector,
- leads to reduction of the currency reserve due to payments for the imported natural gas.

UABIO's suggestion for overcoming the barrier:

We suggest initiating appropriate amendments to Ukrainian legislation that would:

- provide the preferential categories of consumers with a compensation mechanism for the established tariffs for generation and supply of heat from alternative energy sources (including biofuels);
- establish binding share of biofuels for heat production by communal utilities;
- ensure equal in rights use of different types of fuels for heat generation.

In April 2013, the above problem of tariffs setting in the heat energy sector was described in the letter from UABIO to Ukraine's parliamentary deputy Mr. Sergiy Tigipko. We asked him to apply to the Cabinet of Ministers of Ukraine, to NERC and other relevant ministers and agencies and inform them about the problem. In reply we obtained a letter from the National Commission for State Regulation in Communal Services signed by its Head – Mr. Valeriy Saratov. The Commission informed UABIO that they elaborated and negotiated with the relevant state structures a draft Order of CMU. The Order determines procedure for reimbursement of the difference between the market tariffs for heat/water supply to population and the existing tariffs. This procedure is valid for all kinds of fuel including biomass. We expect the procedure to be approved by the Cabinet of Ministers of Ukraine.

Conception for the development of heat production from biomass in Ukraine

Based on results of the techno-economic assessment of biomass heat technologies, we can suggest the following conception for the introduction of bioenergy equipment in Ukraine.

Under the current prices of fossil fuels (first of all natural gas), heat energy and biomass, the introduction of biomass boilers for heat production is feasible and therefore can be recommended for industry and state-financed sector (payback period is 2-3 years). Implementation of such projects in the housing-communal sector is now practically unfeasible (payback period is >7-10 years).

Comparatively low prices of natural gas for population and the housing-communal sector are the main barrier to the wide use of biomass as fuel in these sectors. Taking into account the general trend of rising gas price in Ukraine, one may expect that gas price for the housing-communal sector will come to the market level in the near future. Any rise in NG price in the sector will be a considerable stimulus for the introduction of biomass boilers. As for population, the state is keeping the gas price even father from the market level than for housing-communal sector. That is why one can expect the introduction of bioenergy equipment in the domestic sector only in a long-run prospect.

In our opinion, first of all Ukraine should introduce equipment for heat production and for combined heat and power production from biomass. The equipment includes domestic and industrial boilers, heating boiler plants and CHPPs. Technical issues of biomass combustion are described in [17, 18].

We consider that mass transition from NG to biomass use will require rather big extension of DH systems that means that a part of individual consumers will have to connect to (moderate) DH systems. That is necessary to ensure effective use of solid fuels including biomass.

Another important assumption used for the development of UABIO's Conception on heat production from biomass in Ukraine is the structure of heat production by technologies. Based on the analysis of EU's experience (see **Table 2**), UABIO's Conceptions for the development of other bioenergy sectors and some technical and nontechnical constraints, we suggested the following structure of heat production: biomass CHPPs – 25%, MSW CHPPs – 10%, boiler plants and domestic boilers – 65%. The structure was implemented for 2030. For 2020 the structure of heat production from biomass is different taking into account current situation in Ukraine (few CHPPs on solid biomass, no CHPPs on MSW) and rather short period of time till 2020 (**Table 7**).

Comparison of the investments required for the concept implementation and the money that may be saved by substitution of biomass for natural gas is presented below.

Cost of the replaced natural gas:

425 \$/1000 m^3 × 3.47 bn m^3/yr × 8 UAH/\$ = 11.79 bn UAH/yr,
where 425 \$/1000 m^3 is the average price of NG on Ukraine-Russia border in 2012;
8 UAH/\$ is the UAH/\$ exchange rate.

Approximate cost of biomass for the suggested park of boilers and CHP plants:

300 UAH/t × 4.29 Mtce/yr × 29.3/12 = 3.14 bn UAH/yr,
where 300 UAH/t is the average biomass cost for the calculation, 29.3 MJ/kg is heating value of equivalent fuel, 12 MJ/kg is the average biomass heating value for the calculation.

Money saving due to replacement of NG by biomass:

11.79 – 3.14 = 8.65 bn UAH/yr.

It is obvious that under the current NG price, the investments required for the implementation of the suggested conception (16 bn UAH) can be repaid at the expense of replacement of NG by biomass (9 bn UAH/yr) during about **2 years** (15.79/8.65=1.83). It is important that the money saving will be annual.

UABIO's conception for **2020** is presented in **Table 8**. Implementation of the conception would result in the annual saving of about 3.5 bn m^3 (4.3 Mtce) of natural gas and reduction of GHG emission by almost 7 Mt CO_2/yr. The creation of new jobs is assessed at about 10000.

Table 7. Predicted trends of growth of bioenergy equipment capacity for heat production in Ukraine

Indexes	2011	2020	2030
Consumption of primary energy, Mtce	180.7[1)]	212.8[2)]	238.1[2)]
Biomass share in the total primary energy consumption	1.24%[1)]	3%[7)]	7%[7)]
Mtce	*2.24*	*6.4*	*16.7*
Biomass share in the gross final consumption of energy[3)]	1.78%	4.3%	10%
Installed capacity of bioenergy equipment for heat production[4)], MW_{th}	3586	7665	17150
structure of the equipment capacity:			
Biomass CHPPs	*1%*	*13%*	*25%*
MSW CHPPs	-	*2%*	*10%*
biomass boiler plants, domestic boilers and stoves	*99%*	*85%*	*65%*
Biomass for heat production, Mtce	2,16[4)]	4.29[5)]	8.84[5)]
the share of biomass potential	*6,4%*	*13%*	*26%*
Total production of heat, Pcal	232[2)]	250[4)]	271[2)]
Biomass share in the total production of heat[4)]	6%	14%	32%
Pcal	*13.9*	*35*	*86,7*
Replacement of NG for heat production, bn m^3/yr[4)]	1.67	3.5	7.5
the share of the total NG consumption[6)]	*2.9%*	*7%*	*15%*

1) According to Ukraine's Energy Balance for 2011 [4].
2) According to [13].
3) UABIO's suggestions assumed as a basis for the Conception development.
4) UABIO's expert estimation.
5) UABIO's expert estimation. It is calculated by subtraction from the total biomass consumption the amount of biomass for power production and the volume of liquid biofuels (biodiesel and bioethanol).
6) Total consumption of NG: 57.4 bn m^3 in 2011 [19], 51 bn m^3 in 2020 [13], 49 bn m^3 in 2030 [13].
7) Authors' calculation:
a) For the calculation for 2011 we used data from Ukraine's energy balance for 2011. Amount of biomass in the final consumption of energy was determined as biomass/waste that was directly consumed by economy sectors (1040 ktoe) + biomass/waste consumed by energy sector taking into account the efficiency and the network losses (523 ktoe×0,6=314 ktoe). Total: 1040 + 314 = 1354 ktoe.
b) The share of biomass in the final consumption of energy: 1354/75836=1.78%.
c) Ratio of biomass share in the final consumption of energy to biomass share in the total consumption of energy: 1.78/1.24=1.43.
d) The calculated ratio (1.43) was also assumed for 2020 and 2030 on the basis of the following forecast. In the future, efficiency of boiler plants and CHPPs will increase, heat network losses will decrease and the amount of biomass used by thermal plants will rise. On average, these trends will level the summary impact on the ratio, and as a rough approximation we may use the same value for 2020 and 2030.

A similar conception for bioenergy equipment introduction until **2030** is presented in **Table 9**. Investments required for the implementation of the conception can be repaid during about **3 years**.

At this stage of development of the conception for 2020 and 2030 we have not included heat from biogas plants in it. We believe that in the future the consumption of heat produced by biogas plants will increase and it will be taken into account in future versions of the conception.

Table 8. Conception for the introduction of bioenergy equipment for heat production in Ukraine until 2020

Type of equipment	Ukraine's market capacity, units*	Installed capacity, MW_{th} (+ MW_e)***	NG replacement, bn m^3/yr	Heat production, TCal/yr	Reduction of CO_2 emission**, Mt/yr	Investment, million UAH	New jobs
Population:							
Traditional firewood stoves	50000	500	0.20	1718	0.40	150	---
Domestic firewood and wood pellets boilers of 10...50 kW_{th}	80000	2400	0.97	8248	1.90	1920	480
Transition of population from individual to moderate DH: Boilers on straw and crop stalks of 1...10 MW_{th}	85	170	0.07	584	0.13	170	425
Sub-total	*130085*	*3070*	*1.24*	*10551*	*2.43*	*2240*	*905*
HC sector and state-financed sector:							
Wood fired boilers of 0.5...10 MW_{th}	2500	1250	0.51	4296	0.99	1250	3125
Boilers on straw and crop stalks of 1...10 MW_{th}	500	1000	0.40	3437	0.79	3500	2500
Wood CHPPs	8	240 (+48)	0.10	1650	0.19	1440	180
CHPPs on straw and crop stalks	5	150 (+30)	0.06	1031	0.12	900	113
MSW CHPPs	5	150 (+30)	0.06	1031	0.12	900	113
CHPPs on energy crops	5	150 (+30)	0.06	1031	0.12	900	113
Sub-total	*3023*	*2940 (+138)*	*1.19*	*12475*	*2.33*	*8890*	*6143*
Industrial and commercial consumers:							
Wood fired boilers of 0.1...5 MW_{th}	400	400	0.31	2749	0.60	400	1000
Boilers on straw and crop stalks of 0.1...1 MW_{th}	350	175	0.13	1203	0.26	175	438
Boilers on sunflower husk	60	480	0.37	3299	0.72	480	1200
Wood CHPPs	5	150 (+30)	0.06	1031	0.11	900	113
CHPPs on sunflower husk	15	450 (+90)	0.17	3093	0.34	2700	338
Sub-total	*830*	*1655 (+120)*	*1.04*	*11376*	*2.03*	*4655*	*3088*
TOTAL	**133938**	**7665 (+258)**	**3.47**	**34402**	**6.80**	**15785**	**10135**

* The number of units on the basis of typical capacity of a certain equipment type.

** In comparison with NG combustion.

*** 1 Gcal/hr =1.163 MW_{th}

Table 9. Conception for the introduction of bioenergy equipment for heat production in Ukraine until 2030

Type of equipment	Ukraine's market capacity, units*	Installed capacity, MW_{th} (+ MW_e)***	NG replacement, bn m^3/yr	Heat production, TCal/yr	Reduction of CO_2 emission**, Mt/yr	Investment, million UAH	New jobs
Population:							
Traditional firewood stoves	50000	500	0.20	1718	0.40	150	---
Domestic firewood and wood pellets boilers of 10...50 kW_{th}	80000	2400	0.97	8248	1.90	1920	480
Transition of population from individual to moderate DH: Boilers on straw and crop stalks of 1...10 MW_{th}	1100	2200	0.89	7561	1.74	2200	5500
Sub-total	*131100*	*5100*	*2.06*	*17527*	*4.04*	*4270*	*5980*
HC sector and state-financed sector:							
Wood fired boilers of 0.5...10 MW_{th}	2500	1250	0.51	4296	0.99	1250	3125
Boilers on straw and crop stalks of 1...10 MW_{th}	1400	2800	1.13	9623	2.22	9800	7000
Wood CHPPs	10	300 (+60)	0.12	2062	0.24	1800	225
CHPPs on straw and crop stalks	50	1770 (+300)	0.72	12166	1.40	9000	1125
MSW CHPPs	50	1770 (+300)	0.72	12166	1.40	9000	1125
CHPPs on energy crops	50	1770 (+300)	0.72	12166	1.40	9000	1125
Sub-total	*4060*	*9660 (+960)*	*3.91*	*52479*	*7.66*	*39850*	*13725*
Industrial and commercial consumers:							
Wood fired boilers of 0.1...5 MW_{th}	400	400	0.31	2749	0.60	400	1000
Boilers on straw and crop stalks of 0.1...1 MW_{th}	1300	650	0.50	4468	0.97	650	1625
Boilers on sunflower husk	55	440	0.34	3024	0.66	440	1100
Wood CHPPs	10	300 (+60)	0.11	2062	0.22	1800	225
CHPPs on sunflower husk	20	600 (+120)	0.23	4124	0.45	3600	450
Sub-total	*1785*	*2390 (+180)*	*1.48*	*16428*	*2.91*	*6890*	*4400*
TOTAL	**136945**	**17150 (+1140)**	**7.45**	**86434**	**14.61**	**51010**	**24105**

* The number of units on the basis of typical capacity of a certain equipment type.

** In comparison with NG combustion.

*** 1 Gcal/hr =1.163 MW_{th}

Introduction of bioenergy technologies has a positive local social and economic impact. First, when using biomass as fuel, the money previously paid for the imported energy carriers does not go abroad any longer and remains in the regions thus supporting local economy. Second, bioenergy development contributes to the creation of new jobs for the production, pre-treatment and transportation of biomass and biofuels, for operation and maintenance of bioenergy equipment. This is especially important for rural areas as leads to job growth.

Conclusion

EU experience shows that of all bioenergy sectors, the fastest growth has been in biomass heat generation. In Ukraine the situation is similar – of the total amount of biomass/biofuels which is used for energy production, the lion's share falls to heat generation. However, the share of thermal energy from biomass in the energy balance of the country is still rather low (about 6%), and its growth is prevented by a number of barriers. The existing policy for encouraging bioenergy sector, including heat from biomass, requires a radical and immediate improvement by the state.

Under the current prices of fossil fuels (first of all natural gas), heat energy and biomass, the introduction of biomass boilers for heat production is feasible and therefore can be recommended for industry and state-financed sector (payback period is 2-3 years). Implementation of such projects in the housing-communal sector is now practically unfeasible (payback period is >7-10 years).

According to UABIO's Conception, the contribution of biomass to heat production in Ukraine may reach 14% in 2020 and 32% in 2030 (**Table 10**).

Table 10. Key figures of UABIO's Conception for heat production from biomass in Ukraine

Indexes	2011	2020	2030
Consumption of primary energy, Mtce	180.7	212.8	238.1
Biomass share in the total primary energy consumption	1.24%	3%	7%
Mtce	*2.24*	*6.4*	*16.7*
Biomass share in the gross final consumption of energy	1.78%	4.3%	10%
Installed capacity of bioenergy equipment for heat production, MW_{th}	3586	7665	17150
structure of the equipment capacity:			
Biomass CHPPs	*1%*	*13%*	*25%*
MSW CHPPs	-	*2%*	*10%*
biomass boiler plants, domestic boilers and stoves	*99%*	*85%*	*65%*
Biomass for heat production, Mtce	2,16	4.29	8.84
the share of biomass potential	*6,4%*	*13%*	*26%*
Total production of heat, Pcal	232	250	271
Biomass share in the total production of heat	6%	14%	32%
Pcal	*13.9*	*35*	*86,7*
Replacement of NG for heat production, bn m^3/yr	1.67	3.5	7.5
the share of the total NG consumption	*2.9%*	*7%*	*15%*

UABIO estimates that in 2020 Ukraine can have bioenergy equipment of 7665 MW_{th} + 258 MW_e total installed capacity. The use of biomass by this equipment will reduce natural gas consumption by 3.5 billion m^3/year and decrease CO_2 emissions by almost 7 million tons/year. Under current natural gas prices, total investment required for the implementation of the proposed conception (16 billion UAH) can be repaid during **2 years** at the expense of savings from natural gas replacement by biomass (9 billion UAH). It is important that the savings will be repeated each year. By 2030, the capacity of bioenergy equipment may increase to 17150 MW_{th} + 1140 MW_e. Natural gas savings will amount to 7.5 billion m^3 per year and CO_2 emission will decrease by about 15 million tons per year. Investments for the implementation of this equipment (51 billion UAH) can be repaid during less than **3 years** at the expense of savings on the consumption of natural gas (19 billion UAH).

REFERENCES

1. Key World Energy Statistics. Publication of International Energy Agency, 2011 http://www.iea.org/publications/freepublications/publication/name,31287,en.html

2. International Energy Agency statistics http://www.iea.org/stats/index.asp

3. EU Energy in Figures. Statistical Pocketbook 2012. Publication of European Commission, 2012 http://ec.europa.eu/energy/observatory/statistics/statistics_en.htm

4. Ukraine's Energy Balance for 2011. Express-release № 08/4-16/290 from 20.12.2012. Publication of the State Statistics Service of Ukraine www.ukrstat.gov.ua

5. Renewables Information. Publication of International Energy Agency, 2011. http://www.planbleu.org/portail_doc/renewables_information2011.pdf

6. Renewable Energy Road Map. Renewable energies in the 21st century: building a more sustainable future. COM(2006) 848 final, Brussels, 10.01.2007 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0848:FIN:EN:PDF

7. RE-Thinking 2050. A 100% Renewable Energy Vision for the European Union. Publication of European Renewable Energy Council, 2010 http://www.rethinking2050.eu/fileadmin/documents/ReThinking2050_full_version_final.pdf

8. Solid Biomass Barometer, N 188, 2008 http://www.eurobserv-er.org/pdf/baro188.pdf

9. Solid Biomass Barometer, N 194, 2009 http://www.eurobserv-er.org/pdf/baro194.pdf

10. Solid Biomass Barometer, N 206, 2011 http://www.eurobserv-er.org/pdf/biomasse_2011.pdf

11. Solid Biomass Barometer, N 212, 2012 http://www.eurobserv-er.org/pdf/baro212biomass.pdf

12. Renewable Energy: Progressing towards the 2020 target. COM(2011) 31 final, Brussels, 31.01.2011 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0031:FIN:EN:PDF

13. Draft Energy Strategy of Ukraine until 2030 (draft of 2013).

14. UABIO's Position Paper N 1 «Position of bioenergy in the draft updated energy strategy of Ukraine until 2030» www.uabio.org/activity/uabio-analytics

15. UABIO's Position Paper N 3 "Barriers to the development of bioenergy in Ukraine" www.uabio.org/activity/uabio-analytics

16. Energy Strategy of Ukraine until 2030 [in Ukrainian]. Approved by Resolution of the Cabinet of Ministers of Ukraine N 145-p from 15.03.2006 http://zakon1.rada.gov.ua/signal/kr06145a.doc

17. Geletukha G.G., Zheliezna T.A. Review of modern technologies for wood combustion for heat and power production. Part 1 [in Russian] // Eco-technologies and Resource Saving. - 1999. - N 5, p.3-12 http://biomass.kiev.ua/images/library/articles/wood1.pdf

18. Geletukha G.G., Zheliezna T.A. Review of modern technologies for wood combustion for heat and power production. Part 2 [in Russian] // Eco-technologies and Resource Saving. - 1999. - N 6, c.3-13 http://biomass.kiev.ua/images/library/articles/wood2.pdf

19. Ukraine's Statistical Yearbook for 2011. Publication of the State Statistics Service of Ukraine www.ukrstat.gov.ua

20. Directive 2009/28/EC on the promotion of the use of energy from renewable sources http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=Oj:L:2009:140:0016:0062:en:PDF

Abbreviation

BM – biomass;
CHP – combined heat and power;
CHPP – combined heat and power plant;
CMU – Cabinet of Ministers of Ukraine;
DH – district heating;
HC – housing and communal;
GHG – greenhouse gas;
LFG – landfill gas;
MSW – municipal solid waste;
NG – natural gas;
RES – renewable energy sources;
TPES – total primary energy supply;
bn – billion (a thousand millions);
cal – calorie (1 calorie = 4.19 J);
tce – ton of coal equivalent (calorific value of 1 tce is 29.3 GJ).

Previous UABIO's publications

http://www.uabio.org/activity/uabio-analytics

1. Position Paper N 1 «Position of bioenergy in the draft updated energy strategy of Ukraine until 2030»
2. Position Paper N 2 "Analysis of the Law of Ukraine «On amending the Law of Ukraine «On Power Industry» №5485-VI of 20.11.2012"
3. Position Paper N 3 "Barriers to the development of bioenergy in Ukraine"
4. Position Paper N 4 "Prospects for the development of production and use of biogas in Ukraine".
5. Position Paper N 5 "Prospects for power production from biomass in Ukraine"

Civic union "Bioenergy Association of Ukraine" (UABio) was established to create a common platform for cooperation on bioenergy market in Ukraine, as well as to provide the most favorable business environment, accelerated and sustainable development of bioenergy. General constituent assembly of UABio was held on September, 25, 2012 in Kyiv. The Association was officially registered on 8 April 2013. Among UABio members there are over 10 leading companies and over 20 recognized experts working in the field of bioenergy.

http://uabio.org

Bioenergy Association of Ukraine