STATE OF THE ART AND PROSPECTS FOR BIOENERGY DEVELOPMENT IN UKRAINE

UABio Position Paper N 9

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Introduction

Position Paper N 9 prepared by the Bioenergy Association of Ukraine covers state of the art, existing barriers and prospects for bioenergy development in Ukraine. The Paper shows opportunity, importance and urgency of biomass use as a fuel. Realistic targets for the bioenergy sector development in Ukraine are suggested. To a great extent, Position Paper N 9 uses and compiles results of Position Papers 1-8, and suggests an integral conception of the sector development on their basis.

State of the art of bioenergy in the world

Renewable energy is an energy sector that is dynamically developing in the world. Today, the share of RES in the global primary energy supply is about 13%, including that of biomass **10%** that is over 1300 Mtoe/yr [1].

The European Union is successfully achieving its 2020 targets on renewable energy – 20% energy from RES in the gross final energy consumption. During past 10 years this index has increased from 8% to **14%** (**Fig. 1**). Three countries (Sweden, Bulgaria and Estonia) have already achieved their national targets of 2020 (**Table 1**).

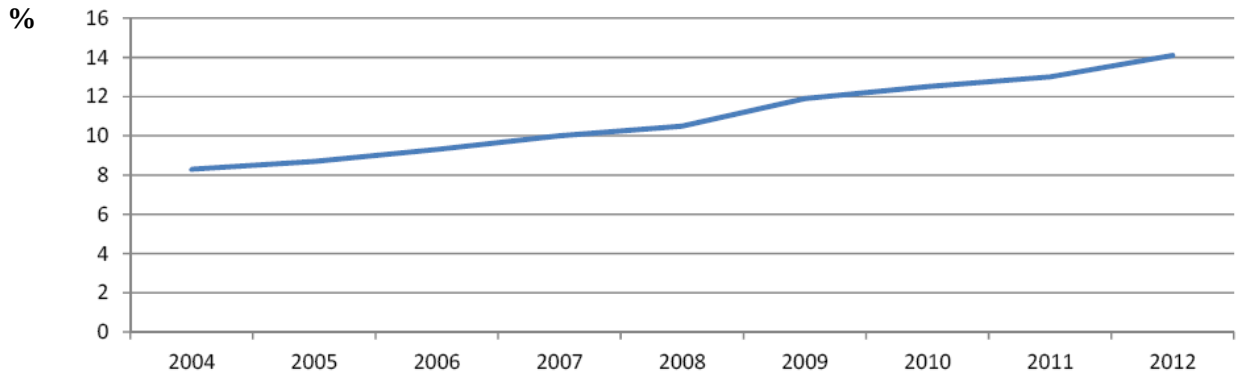


Fig. 1. Growth dynamics of RES share in the EU-28 gross final energy consumption [2]

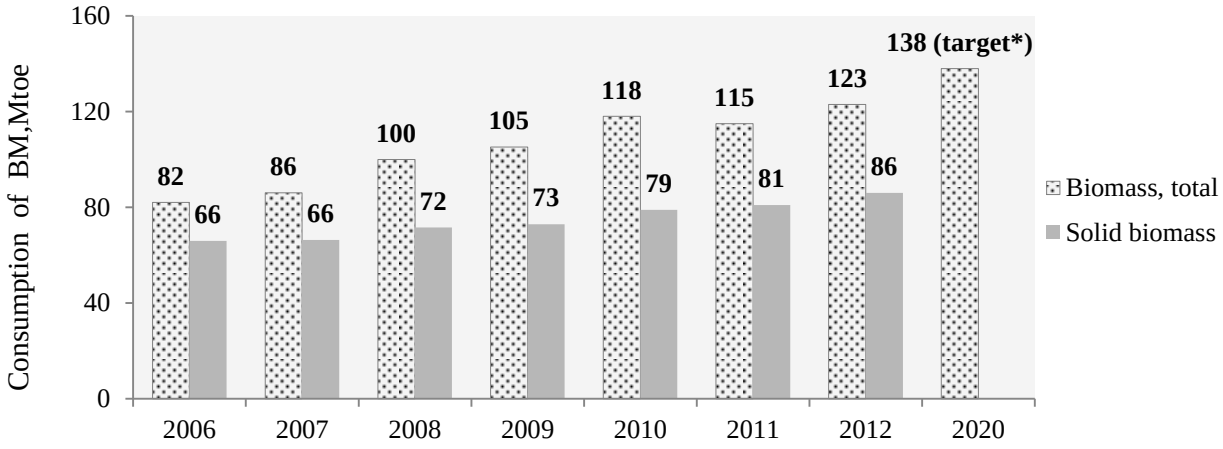
At present the European Union is consuming over 120 Mtoe/yr of biomass for energy production, and the gross final consumption of biomass is to rise up to 138 Mtoe/yr by 2020 (**Fig. 2**). The main type of the biomass used is solid biomass. Its share in the total consumption of biomass is always about 70%.

Contribution of biomass the EU's gross final energy consumption has already exceeded **8%**, and it must increase up to 14% by 2020 (**Table 2**). In some leading countries the level of bioenergy development is much higher than average European level. For instance, in Finland the share of biomass in the final energy consumption is 28%, in Latvia it is over 27%, in Sweden and Estonia it is about 26% (for comparison, in Ukraine the index makes up 1.78%) (**Fig. 3**). By now, Austria and

Estonia have already attained their 2020 targets on biomass contribution to the gross final energy consumption (**Table 3**).

Table 1. Dynamics of achieving by the EU its targets on RES contribution to the gross final energy consumption [18]

EU countries	**2012 (actual data)**	**Indicative trajectory**			**2020 (target)**
		2013-2014	**2015-2016**	**2017-2018**	
EU-28	**14.1%**	n.a.	n.a.	n.a.	**20%**
Belgium	6.8%	5.4%	7.1%	9.2%	13%
Bulgaria	*16.3%*	11.4%	12.4%	13.7%	*16%*
Czech Republic	11.2%	8.2%	9.2%	10.6%	13%
Denmark	26.0%	20.9%	22.9%	25.5%	30%
Germany	12.4%	9.5%	11.3%	13.7%	18%
Estonia	*25.8%*	20.1%	21.2%	22.6%	*25%*
Ireland	7.2%	7.0%	8.9%	11.5%	16%
Greece	13.8%	10.2%	11.9%	14.1%	18%
Spain	14.3%	12.1%	13.8%	16.0%	20%
France	13.4%	14.1%	16.0%	18.6%	23%
Croatia	16.8%	14.8%	15.9%	17.4%	20%
Italy	13.5%	8.7%	10.5%	12.9%	17%
Cyprus	6.8%	5.9%	7.4%	9.5%	13%
Latvia	35.8%	34.8%	35.9%	37.4%	40%
Lithuania	21.7%	17.4%	18.6%	20.2%	23%
Luxembourg	3.1%	3.9%	5.4%	7.5%	11%
Hungary	9.6%	6.9%	8.2%	10.0%	13%
Malta	1.4%	3.0%	4.5%	6.5%	10%
Netherlands	4.5%	5.9%	7.6%	9.9%	14%
Austria	32.1%	26.5%	28.1%	30.3%	34%
Poland	11.0%	9.5%	10.7%	12.3%	15%
Portugal	24.6%	23.7%	25.2%	27.3%	31%
Romania	22.9%	19.7%	20.6%	21.8%	24%
Slivenia	20.2%	18.7%	20.1%	21.9%	25%
Slovakia	10.4%	8.9%	10.0%	11.4%	14%
Finland	34.3%	31.4%	32.8%	34.7%	38%
Sweden	*51.0%*	42.6%	43.9%	45.8%	*49%*
United Kingdom	4.2%	5.4%	7.5%	10.2%	15%



** Target for the gross final consumption of biomass in 2020*

Fig. 2. Dynamics of the total biomass consumption for energy production in the EU [3-6, 18, 19]

Table 2. Actual and forecasted share of RES and biomass in the EU's energy balance [3, 6, 7, 18]

Показатели	Actual data, **%** 2011-2012	Forecast, **%** 2020
Share of RES in the gross final energy consumption	14.1	20
Share of biomass in the gross final energy consumption	8.4	14
Share of RES in the gross heat production	16.5	20
Share of biomass in the gross heat production	15.8	18-19
Share of RES in the gross power production	23.5	34
Share of biomass in the gross power production	4.0	7
Share of RES in motor fuels	5.1	10
Share of biomass in motor fuels	5.0	~10%

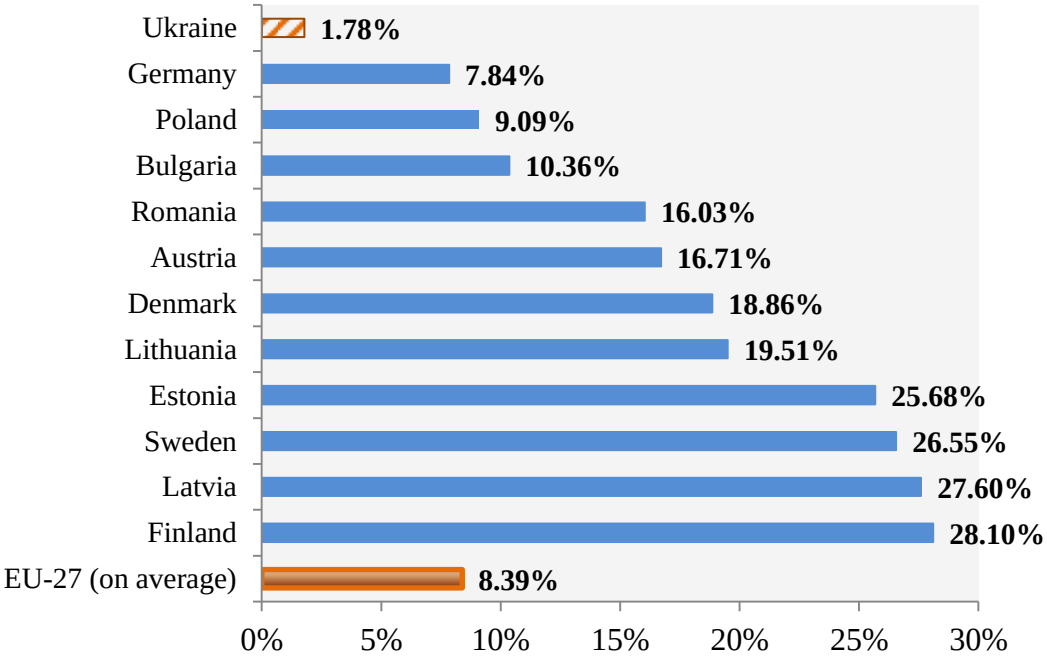


Fig. 3. The share of biomass in the gross final energy consumption of some selected EU countries and Ukraine[1], 2011 [3]

[1] The figure for Ukraine is assessed by the authors of the Position Paper.

Table 3. Actual and forecasted contribution of biomass to the gross final energy consumption in the EU countries [3]

EU countries	GFC*, 2011	Contribution of BM to GFC, 2011		Contribution of BM to GFC, 2020 (target)	
	ktoe	ktoe	% GFC	ktoe**	% GFC***
EU-28	**1103260**	**92599**	**8.39**	**138312**	**12.54**
Belgium	38886	1639	4.21	3772	9.70
Bulgaria	9287	962	10.36	1344	14.47
Czech Republic	24634	2193	8.90	3671	14.90
Denmark	14679	2769	18.86	3665	24.97
Germany	207093	16240	7.84	20908	10.10
Estonia	*2843*	*730*	*25.68*	*726*	25.54
Ireland	10800	321	2.97	1054	9.76
Greece	18835	1163	6.17	1947	10.34
Spain	86532	5898	6.82	9311	10.76
France	148065	12043	8.13	21431	14.47
Croatia	6181	445	7.20	н.д.	н.д.
Italy	122312	6838	5.59	9765	7.98
Cyprus	1896	41	2.16	80	4.22
Latvia	3982	1099	27.60	1543	38.75
Lithuania	4696	916	19.51	1295	27.58
Luxembourg	4276	93	2.17	328	7.67
Hungary	16276	1332	8.18	2069	12.71
Malta	446	1	0.22	14	3.14
Netherlands	50663	1581	3.12	3143	6.20
Austria	*27328*	*4566*	*16.71*	*4540*	16.61
Poland	64689	5883	9.09	8214	12.70
Portugal	17350	2706	15.60	3101	17.87
Romania	22576	3620	16.03	4365	19.33
Slovenia	4951	558	11.27	776	15.67
Slovakia	10795	774	7.17	1022	9.47
Finland	25179	7076	28.10	8280	32.88
Sweden	32168	8539	26.55	11583	36.01
United Kingdom	132023	3021	2.29	10368	7.85

** GFC – gross final energy consumption.*

*** Estimation based on the National Renewable Energy Action Plans of the EU countries [3].*

**** Estimation by the authors of the Position Paper based on data of [3] and assumption on the constant level of the gross final energy consumption in the EU countries.*

The biggest progress has been made in the heat energy sector – biomass covers almost **16%** of the total generation that answers the third place after natural gas (43%) and coal (28.5%) (**Fig. 4**). At that, biomass covers over 95% of the total renewable heat energy. In a number of countries, the share of biomass in heat production is much higher than the average European figure: Sweden – 60%, Austria – 31%, Finland – 27%, Denmark – 25%.

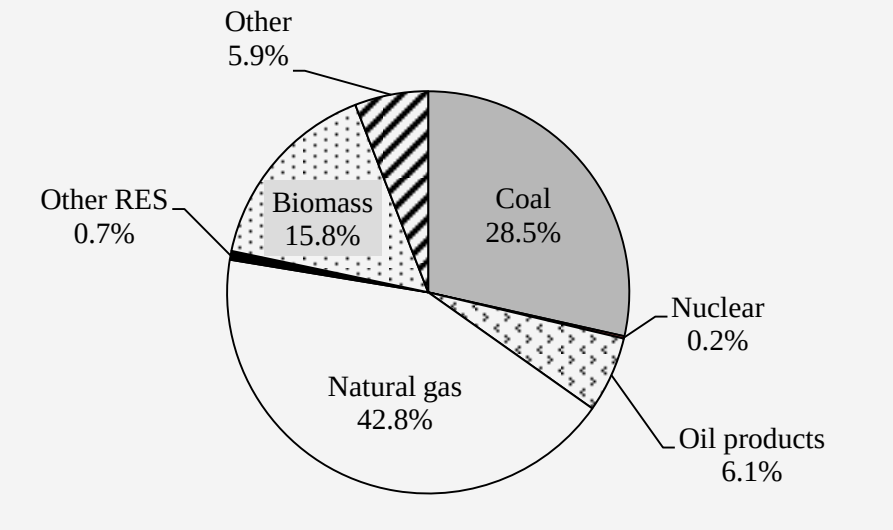


Fig. 4. Structure of heat production in the EU, 2011[6]

During past 20 years, the structure of heat production in the EU has had two stable trends: the increase of RES share and decrease of coal share. Consumption of natural gas, after the period of priority rise (1990-2005) has remained nearly the same recently (**Fig. 5**).

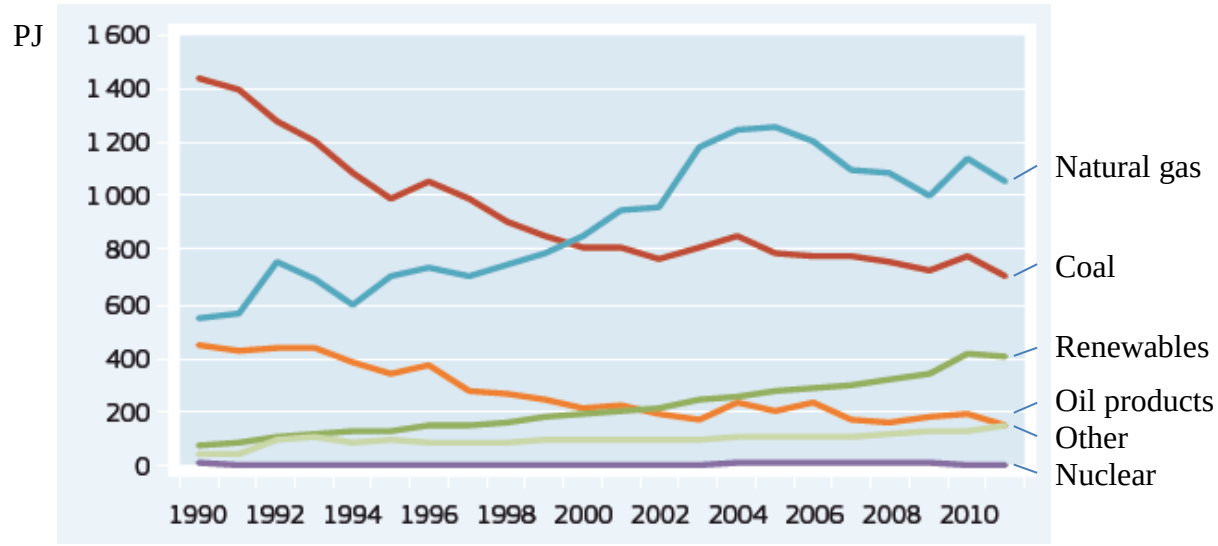


Fig. 5. Dynamics of the structure of heat production in the EU [6]

Analysis of dynamics of the power production structure in the EU shows that the share of renewable power has been stably rising – from about 300 TWh (12.5%) in 1990 to over 700 TWh (**23.5%**) in 2012 (**Fig. 6**). At that power generation from oil products has been decreasing,

generation from natural gas has been increasing with some stabilizing lately, and the use of coal and nuclear energy has remained roughly unchanged.

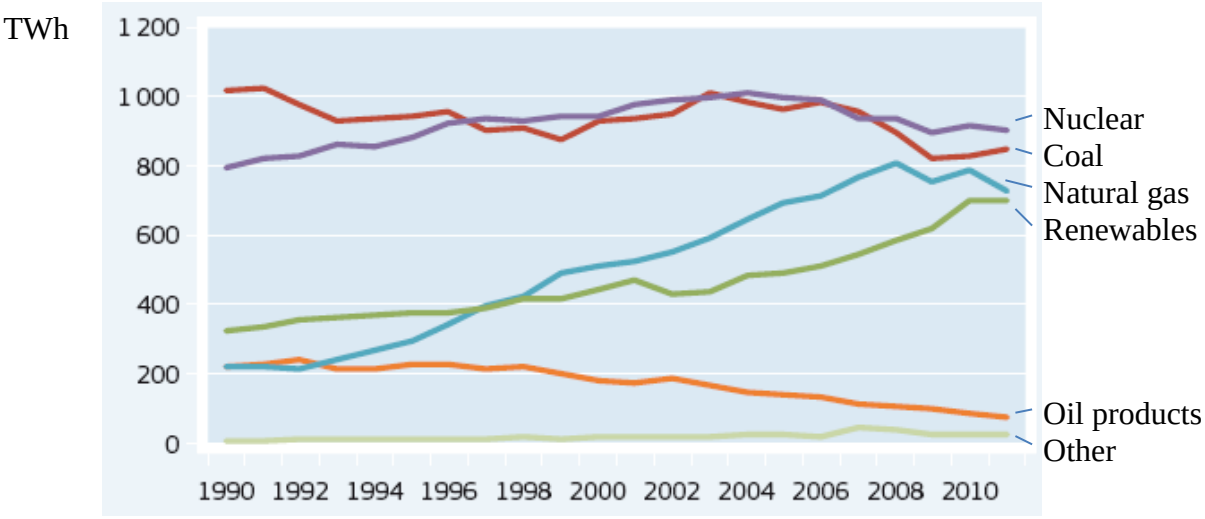


Fig. 6. Dynamics of the structure of power production in the EU [6]

Contribution of biomass to the EU power sector is comparatively modest – **4%** of the total generation and **19%** of all renewables (**Fig. 7**). In some countries the contribution is much higher: in Finland biomass covers 15.3% of the total power generation, in Denmark 12.4%, in Sweden 7.7%, in Austria 6.9%.

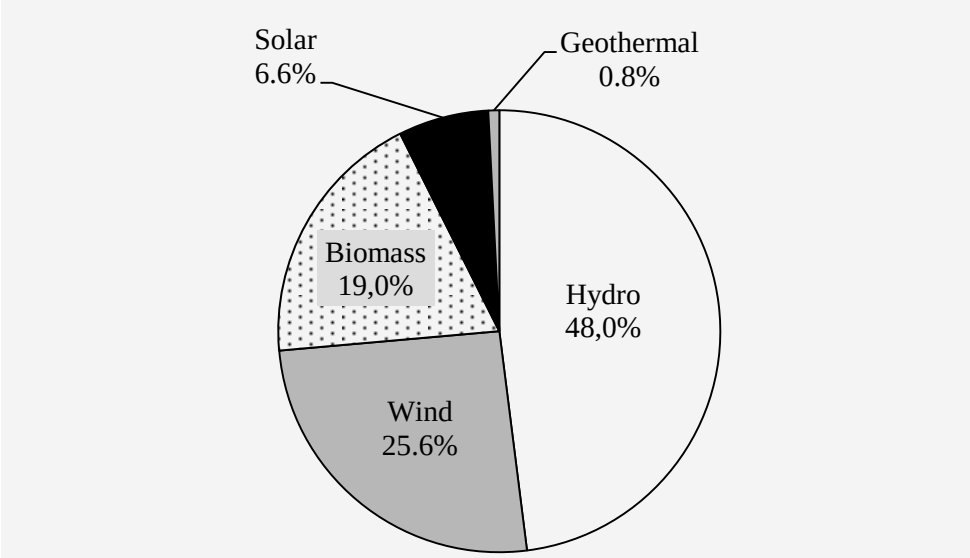


Fig. 7. The structure of renewable power production in the EU, 2011 [6]

Wood is the main type of biomass for power production in the EU. Installed capacity of wood power plants is almost 17 GW_{el} (**Table 4**). Biogas (7191 MBT_{el}) and municipal waste (6158 MBT_{el}) are also actively used for power generation. Power from liquid biofuels is produced only in some countries, for example, in Italy and Germany.

Table 4. Installed capacity of biomass power plants in some selected EU countries and Ukraine, 2011 [6]

EU countries	Installed capacity, MW_{el}			
	wood	municipal waste	biogas	liquid biofuels
EU-27	**16874**	**6158**	**7191**	**1102**
Sweden	3397	571	4	-
Austria	2394	459	607	25
Germany	2148	1486	3233	243
Finland	1910	-	-	-
United Kingdom	1667	401	1189	-
Denmark	920	295	77	-
Netherlands	713	649	217	17
Belgium	701	240	129	81
Spain	563	224	209	-
Portugal	478	76	44	-
Italy	421	742	732	736
Hungary	436	38	45	-
France	324	910	233	-
Ukraine (2014)*	**6**	**-**	**11**	**-**

** The figure for Ukraine is assessed by the authors of the Position Paper*.

Potential of biomass in Ukraine

Ukraine has a big potential of biomass available for energy production, and that is a good precondition for the dynamic development of bioenergy. Theoretical potential of biomass in the country is about **20-25 Mtce/yr**. Main parts of the potential are agricultural waste (straw, corn stalks, sunflower stalks etc.) – over **11** Mtce/yr (2013 data) and energy crops – about **10** Mtce/yr (**Table 5**). At that the agricultural waste is a real part of the biomass potential, and the presented data on energy crops show how much biomass can be obtained by growing energy crops on unused agricultural land in Ukraine. It should be noted that cultivating energy crops has been actively developing lately.

The area of unused agricultural land in Ukraine is **3-4** Mha, according to 2012 data **3.5** Mha (**Table 6**). Several possible scenarios for cultivating energy crops on the land are presented in **Table 7**. The scenarios have different area of land under energy crops – **1** Mha, **2** Mha, and **3** Mha. All the scenarios include 4 most promising crops[2] – willow, miscanthus, poplar, and corn with the following allocation of the total area: willow 25%, miscanthus 15%, poplar 10%, and corn 50%.

[2] The proposed set of energy crops is just one of possible options used for biomass potential assessment. In real conditions, taking into account local circumstances other crops may be also cultivated (for instance, sugar sorghum).

Table 5. Energy potential of biomass in Ukraine, 2013[1)]

Type of biomass	Theoretical potential, Mt	Share available for energy production, %	Economic potential, Mtce
Straw of grain crops	30.6	30	4.54
Straw of rape	4.2	40	0.84
Residues of grain corn production (stalks, cobs)	40.2	40	4.39
Residues of sunflower production (stalks, empty heads)	21.0	40	1.72
Secondary residues of agriculture (husks, bagasse)	6.9	75	1.13
Wood (firewood, felling residues, wood processing residues)	4.2	90	1.77
Biodiesel (from rapeseed)	-	-	0.47
Bioethanol (from corn and sugar beet)	-	-	0.99
Biogas from residues and by-products of agro-industrial complex of Ukraine	1.6 billion m^3 of methane (CH_4)	50	0.97
Landfill gas	0.6 billion m^3 CH_4	34	0.26
Sewage gas (industrial and communal)	1.0 billion m^3 CH_4	23	0.27
Energy crops[3)]: - willow, poplar, miscanthus - corn (for biogas)	 11,5 3.3 billion m^3 CH_4	 90[2)] 90[2)]	 6.28 3.68
Peat	-	-	0.40
Total	-	-	**27.71**

1) Expert estimation by the Position Paper authors. The conservative assessment includes main types of biomass, which have considerable influence on the potential volume. In real conditions, there are much more sources of biomass, for example residues of grain cleaning, beet leaves, biomass of reed and others.

2) Taking into account harvesting loses.

*3) According to scenario II (**Table 7**).*

Table 6. Structure of agricultural land in Ukraine, 2012 [23]

Land class	Area, million ha
Agricultural land, including:	41.5
arable land (I)	*32.5*
hayfields	2.4
pastures	5.5
Sawn area (II), including:	*27.8*
grain and leguminous crops	15.4
industrial crops	7.8
potatoes, vegetables and cucurbitaceous crops	2.0
fodder crops	2.5
Fallow area (III)	*1.2*
Unused arable land (I – II – III)*	**3.5**

** Estimation by the authors of the Position Paper.*

Таблица 7. Possible scenarios for raising energy crops in Ukraine[3]

Indexes	Scenarios		
	I	II	III
Area under energy crops (total), Mha	**1**	**2**	**3**
Structure of the area by crops, Mha:			
- willow	0.25	0.5	0.75
- miscanthus	0.15	0.3	0.45
- poplar	0.1	0.2	0.30
- corn (for biogas)	0.5	1.0	1.5
Economic potential of energy crops (total), Mtce/yr	**4.98**	**9.95**	**14.93**
Structure of the potential by crops, Mtce/yr:			
- willow	1.66	3.32	4.98
- miscanthus	0.94	1.88	2.82
- poplar	0.54	1.08	1.62
- corn (for biogas)	1.84	3.68	5.51
Parameters used in the scenarios			
Allocation of the area under energy crops, %			
- willow	25		
- miscanthus	15		
- poplar	10		
- corn (for biogas)	50		
Yield*, dry t/ha per year:			
- willow	12 [24]		
- miscanthus	12 [25]		
- poplar	9.5 [26]		
- corn for biogas (fresh mass)	30 [20]		
Heating value (dry mass), MJ/kg:			
- willow	18		
- miscanthus	17		
- poplar	18.5		
- corn (for biogas)	CH_4 yield: 100 m^3/t of silage* CH_4 content in biogas: 60%		

**Conservative approach.*

Biomass potential varies from year to year depending chiefly on the yield of main agricultural crops. In 2013, there was the biggest yield of grain and leguminous crops in Ukraine (63 Mt) over past 20 years; therefore the economic potential of biomass also reached its maximum value of

[3] Cultivation of energy crops will be considered in more detail in the next Position Paper of Bioenergy Association of Ukraine

almost 28 Mtce (**Fig. 8**). On the contrary, in 2003 the yield of grain crops was very low (20 Mt), and biomass potential dropped to18.5 Mtce.

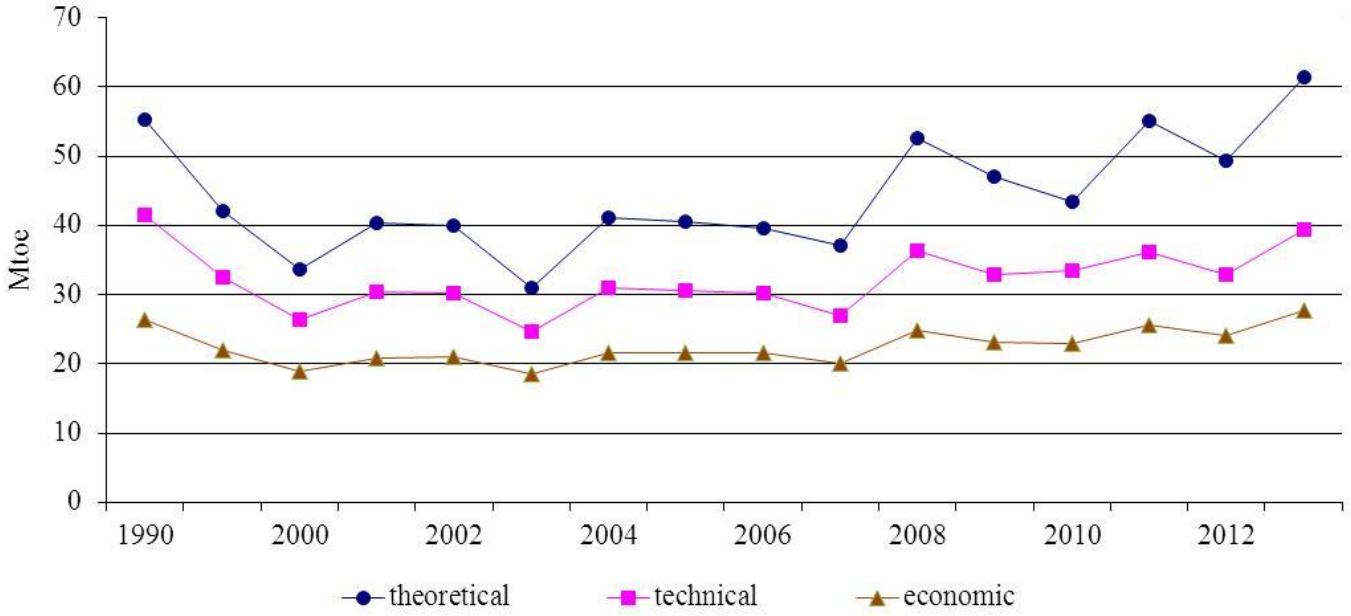


Fig. 8. Dynamics of biomass potential in Ukraine.

When assessing biomass potential, a very important question is what share of agricultural waste and residues may be used for energy production without negative influence on soil fertility. Having researched the matter, experts of Bioenergy Association of Ukraine arrived at a conclusion that for Ukraine, on average, one could suggest the use for energy purposes of up to **30%** of the theoretic potential of grain crops straw and up to **40%** of the theoretical potential of residues from sunflower and grain corn production [9]. At that each agricultural enterprise or farm requires individual approach on the matter taking into account existing non-energy use of straw and other crop residues (for instance, application as organic fertilizer, bedding and fodder for livestock).

Development in Ukraine

In Ukraine, bioenergy is one of the strategic areas of renewable energy development taking into account high dependence of the country on imported energy carriers, first of all natural gas, and a big potential of biomass available for energy production. Unfortunately, in Ukraine bioenergy is developing much slower than in European countries. Current share of biomass in the total primary energy supply of the country is only 1.2% [8], and the share of biomass in the gross final energy consumption is 1.78%[4].

Annually about 2 Mtce of different types of biomass are used for energy production in Ukraine. At that the main contribution is made by wood biomass as its share in the annual consumption of biomass is almost 80% (**Table 8**). The highest percentage of the use of the economic potential (80%) also falls at wood biomass whereas for other types of biomass (apart from sunflower husk)

[4] Estimation of the authors of the Position Paper based on data from [8].

the index is much lower. The lowest share of use (about 1%) is attributed to the energy potential of grain crops straw and rape straw.

Table 8. The use of biomass and biofuels for energy production in Ukraine (2012)*

Type of biomass (biofuel)	Annual consumption**		Share in the annual consumption	Share of the use of the economic potential
	natural units	ktce		
Straw of grain crops and rape	84 kt	43	2.0%	1.0%
Firewood (population)	1.7 million m^3	413	19.0%	80%
Wood biomass (apart from consumption by population)	3.8 Mt	1296	59.6%	
Sunflower husk	627 kt	343	15.8%	42%
Bioethanol	52 kt	48	2.2%	6.7%
Biodiesel	~0	~0	~0	~0
Biogas from agricultural waste	20 million m^3	12	0.6%	3.9%
Landfill gas	26 million m^3	18	0.8%	6.8%
Total		**2173*** **	**100%**	

** Authors' expert estimation.*

*** Consumption for energy production in Ukraine. Export of biomass pellets/briquettes is not taken into account.*

**** The figure agrees with data of the State Statistics Service of Ukraine: 2.17 Mtce in 2012 [8].*

Dynamics of renewable energy development is strongly determined by existing mechanisms of support. Now one of few effective instruments for RES support in Ukraine is Green Tariff[5] on the power produced from renewables including biomass. According to NERC, in Ukraine's bioenergy sector five companies producing power from biomass and five companies generating power from biogas have Green Tariff (as of 1 May 2014) (**Table 9**). For all the producers GT is 12.39 eurocents/kWh that is equivalent to 194.85 kop./kWh (without VAT) as of 01.05.2014 [16].

In addition to biogas plants presented in **Table 9**, there are a number of BGPs in Ukraine that operate without GT or do not produce power at all. The complete list of operating plants, plants under construction and the announced BGPs in the agro-industrial complex of Ukraine is presented in **Table 10**. Information on operating systems for LFG collection and utilization is included in **Table 11**.

[5] GT is Ukrainian analogue of the feed-in tariff.

Table 9. Producers of power from biomass/biogas that obtained Green Tariff (as of 01.05.2014).

№	Company / location	Energy installation	Date of obtaining Green Tariff
	Producers of power from biomass		
1	«Biogasenergo» Ltd (1st unit of TPP) Ivankovo urban village, Kyiv oblast	6 MW_{el} TPP on wood biomass*	01.12.2013
2	«Agro-industrial company Evgroil» Ltd, Mykolaiv city	5 MW_{el} CHPP on sunflower husk (main fuel) and wood chips	01.01.2014
3	Public stock company «Kirovogradoliya», Kirovograd city	1.2 MW_{el} + 33.6 MW_{th} CHPP on sunflower husk	01.01.2010
4	«Enterprise Cargill» Ltd, Donetsk city	2 MW_{el} + 15 MW_{th} CHPP on sunflower husk	01.01.2013
5	«Smelaenergopromtrans» Smela town, Cherkasy oblast	6 MW_{el} + 10 MW_{th} CHPP on wood biomass	01.06.2010
	Producers of power from biogas		
6	«LNK» Ltd Landfill belonged to the Glyboke village council (Boryspil district of Kyiv oblast)	1.06 MW_{el} LFG cogeneration plant	01.04.2012
7	«LNK» Ltd Landfill belonged to the Pidgirtsi village council (Obukhiv district of Kyiv oblast). 2nd unit of Pidgirtsi L-31 facility and Pidgirtsi L-51 facility)	1.9 MW_{el} LFG cogeneration plant	01.11.2013
8	«LNK» Ltd Landfill belonged to the Rozhivka village council (Brovary district of Kyiv oblast).	1.06 MW_{el} LFG cogeneration plant	01.05.2014
9	Private stock company «Orel-Lider» (poultry factory, 1st unit), Elizavetivka village, Dnipropetrovsk oblast	5 MW_{el} biogas plant on poultry manure and silage	01.12.2013
10	«TIS Eco» (landfill) Mariupol town, Donetsk oblast	170 kW_{el} LFG cogeneration plant	01.09.2013

** The plant is to be commissioned in 2014.*

Table 10. Biogas plants in the agro-industrial complex of Ukraine [20].

Company / year of commissioning of a biogas plant	Consumption of feedstock t/day	Digester volume, м^3	Capacity, kW_{el}	Technology
Operating biogas plants				
Pig farm belonged to enterprise «Zaporizhstal», Zaporizhzhia city / 1993	20…22 (pig manure)	595	-	Bigadan, Denmark
Pig farm belonged to corporation «Agro-Oven», Olenivka village, Dnipropetrovsk oblast / 2003	80 (pig manure, fat waste from poultry slaughter)	2×1000	180	BTG, the Netherlands
Agricultural company «Elita», Terezino urban village, Kyiv oblast / 2009	60 (by d.m.: 90% cattle manure + 10% pig manure)	1500	250	LIPP, Germany
Cattle farm «Ukrainian milk company», Velyky Krupil village, Kyiv oblast / 2009	400 (cattle manure)	3×2400 + 1000	625	Zorg, Ukraine/ Germany
Poultry factory «Orel-Lider» (Public corporation «Myronivsky khliboproduct»), Elizavetivka village, Dnipropetrovsk oblast / 2012	140 (poultry manure) + 80 (silage)	10×3500	5000	NVT, the Netherlands
«Danosha» pig farm, Kopanky village, Ivano-Frankivsk oblast / 2013	400 (mainly pig poultry + ~10% agro-waste)	~13000 m^3 of biogas per day	1000	n.d.
Agro-industrial holding «Astarta-Kyiv», Globinsky sugar mill (Poltava oblast) / 2013	120 kt/yr (bagasse)	~14.4 million m^3 of BG/yr	н.д.	n.a.
BGP under construction and announced BGP				
Agro-holding «Ukrlandfarming», poultry factory in Khmelnytsky oblast / 2014 (planned)	poultry manure	n.a.	4000	n.a.
Agro-holding «Ukrlandfarming», poultry factory in Kherson oblast / 2014 (planned)	poultry manure	n.a.	3000	n.a.
Agro-industrial holding «Astarta-Kyiv», Narkevitsky sugar mill (Khmelnytsky oblast) / planned	1200 (bagasse)	n.a.	n.a.	n.a.
Pig farm belonged to «Demis-Agro» Ltd (Podgorodne village, Dnipropetrovsk oblast) / completed construction was announced in 2013	pig manure	n.a.	125	Zorg, Ukraine/Germany
Peresadovka village, Mykolaiv oblast / under construction	cattle manure and corn silage	n.a.	1360	Zorg, Ukraine/Germany
Voznesensk town, Mykolaiv oblast/ planned	silage and vine vinasse	n.a.	125	Zorg, Ukraine/Germany
«Ecoprod», Volnovakha town, Donetsk oblast / planned	n.a.	5.8 million m^3 of BG per year	1200	n.a.

Table 11. Operating systems for LFG collection and utilization [20].

Landfill (location) / period of operation	Accumulated MSW, Mt	Landfill area, ha	Beginning of LFG collection	Technology for LFG utilization
Alushta town/ 1960-p.t.*	1.0	3.2	2008	FU** HOFGAS-Ready 500
Yalta town/ 1973-2010	1.3	5.0	2008	FU HOFGAS-Ready 800
Lviv city/ 1957-p.t.	4.0	26	2009	FU HOFGAS-Ready 2000
Mariupol town/ 1967-2009	2.5	14	2010	FU HOFGAS-Ready 800, ICE*** 170 kW_{el}
Kremenchuk town/ 1965-p.t.	2.8	15	n.a.	FU Haase
Lugansk city / 1979-2010	2.0	11.6	2011	FU Biogas Ltd (Great Britain), 600 m^3/h
Zaporizhzhia city / 1952-p.t.	3.2	11	2011	FU Haase
Vinnytsa town / 1980-p.t.	3.0	10	2012	FU Haase
Kyiv city / 1986-p.t.	10	36	2012	ICE TEDOM 5×177 kW_{el}
Boryspil town / 2003-p.t.	0.9	6	2013	ICE GE Jenbacher 1.06 MW_{el}

** p.t. – present time.*

*** FU – flare unit.*

**** ICE – internal combustion engine.*

Prospects for bioenergy development in Ukraine

Main areas for the use of energy potential of biomass and biogas in Ukraine are production of heat and power. Respective conceptions for the development of energy production from biomass/biogas until 2020 and 2030 have been elaborated by the Bioenergy association of Ukraine [10, 11, 20, 21].

Under current prices of fossil fuels (first of all natural gas), heat energy and biomass, introduction of biomass boilers for heat production is economically feasible and can be recommended for industrial and state-financed sectors. Implementation of such projects in housing-communal sector is now on the verge of profitability. Payback period of wood and straw fired boilers is 2-3 years for industrial and state-financed sectors and 8-10 years for housing-communal sector.

By 2020 biomass can replace about **3.5** billion m^3/yr of natural gas for heat production in Ukraine, and by 2030 **7.5** billion m^3/yr (**Table 12)**. One of the key points of the conception is gradual increase of the share of biomass CHPPs and MSW CHPPs installed capacity. For 2030 we consider the following allocation of thermal capacity to be optimal: biomass CHP plants 25%, MSW CHP plants 10%, boiler installations and domestic boilers 65%.

Table 12. Key points of the conception for heat production from biomass in Ukraine [10]

Indexes	2011	2020	2030
Consumption of primary energy, Mtce	180.7	212.8	238.1
Share of biomass in the total primary energy consumption	1.24%	3%	7%
Mtce	*2.24*	*6.4*	*16.7*
Share of biomass in the gross final energy consumption	1.78%	4.3%	10%
Installed capacity of bioenergy equipment for heat production, MW_{th}	3586	7665	17150
capacity allocation:			
biomass CHP plants	*1%*	*13%*	*25%*
MSW CHP plants	-	*2%*	*10%*
biomass boiler installations, domestic boilers, ovens	*99%*	*85%*	*65%*
Consumption of biomass for heat production, Mtce	2.16	4.29	8.84
share of biomass potential	*6.4%*	*13%*	*26%*
Total heat production, million Gcal	232	250	271
Share of biomass in the total heat production	6%	14%	32%
million Gcal	*13.9*	*35*	*86.7*
Replacement of natural gas for heat production, billion m^3/yr	**1.67**	**3.5**	**7.5**
share of the total consumption of natural gas	*2.9%*	*7%*	*15%*

In the power sector, installed capacity of the biomass plants may come to over **530** MW_{el} by 2020 and over **2100** MW_{el} by 2030 (**Table 13**). It is predicted that biomass CHPPs, biogas cogeneration plants and co-combustion of biomass with coal on the existing coal TPPs will considerably contribute to the structure of electrical installed capacity on biomass.

Table 13. Installed capacity of biomass power plants according to the conception for power production from biomass in Ukraine [11]

Power plants	2010, MW_{el}	Prediction, MW_{el}			
	(actual data)	2015	2020	2025	2030
Biomass CHP plants	4.1	51	216	497	890
Biomass thermal power plants	0.0	31	54	87	110
Reconstructed coal TPPs (co-combustion of biomass with coal)	0.0	0.0	91	230	389
MSW TPPs / CHP plants	0.0	0.0	43	118	257
Biogas cogeneration plants	0.0	21	102	217	446
LFG cogeneration plants	0.2	10	27	32	40
Total, biomass power plants installed capacity, MW_{el}	**4**	**112**	**533**	**1181**	**2133**

According to the suggested conception for heat and power production from biomass in Ukraine, the share of biomass in the total heat production will be **14%** in 2020 and **32%** in 2030; and that in power production will be **1%** and **4%** respectively. The contribution of biomass to the gross final energy consumption of the country may reach **4.3%** in 2020 and **10%** in 2030 (**Table 14**).

Table 14. Biomass share in the production and consumption of energy in Ukraine until 2030 (conception of the Bioenergy association of Ukraine)

Indexes	2011 (actual data)	Prediction			
		2015	2020	2025	2030
Share of biomass in the gross final energy consumption	**1.78%**	**2.2%**	**4.3%**	**7.2%**	**10%**
Share of biomass in heat production	6%	8%	14%	22%	32%
Share of biomass in power generation	0.01%	0.2%	1%	2.2%	4%
Replacement of natural gas, billion m^3/yr	**1.67**	**1.85**	**3.5**	**5.5**	**7.5**

The suggested conception for bioenergy development is quite well harmonized with main provisions of the draft National Renewable Energy Action Plan [17]. The Plan was elaborated by the State Agency on Energy Efficiency and Energy Saving of Ukraine in order to meet Ukraine's commitments within the Energy Community. According to the draft NREAP, the share of renewable energy in the gross final energy consumption of Ukraine in 2020 must be **11% (Table 15)**. Unfortunately, the Plan is not still approved by Ukraine's government.

Table 15. Planned indexes for 2020 and predicted dynamics of RES growth in different sectors and in the gross final energy consumption [17]

Indexes	2009	2013	2014	2015	2016	2017	2018	2019	**2020**
RES – heating, %	3.4	6.0	6.5	7.1	8.0	8.8	9.7	10.8	**12.2**
including biomass, ktoe	*1433*	*2480*	*2550*	*2680 (2430*)*	*2900*	*3100*	*3350*	*3650*	***4000 (4290*)***
RES – power production, %	7.1	7.2	7.6	8.3	8.7	9.4	10.2	10.9	**11.5**
including biomass, MW_{el}	*0*	*n.a.*	*n.a.*	*110 (112*)*	*n.a.*	*n.a.*	*355*	*n.a.*	***530 (533*)***
RES – transport, %	1.5	2.3	4.1	5.0	6.5	7.5	8.2	9.0	**10.0**
including biofuels, ktoe	*0*	*30*	*110*	*150*	*220*	*265*	*300*	*340*	***390***
Share of RES in GFCE**, %	3.8	5.6	6.1	6.8	7.5	8.2	9.0	9.9	**11.0**

** Data of UABio's conception.*

*** GFCE – gross final consumption of energy.*

Another important document containing information on the dynamics of RES development is updated Energy Strategy of Ukraine until 2030 [12] approved in 2013. According to the Strategy, the share of renewables (including large hydro) in power production will be **10.6%** in 2020 and **9.9%** in 2030 (**Table 16**). The target of 2020 agrees with the analogous target of the draft NREAP – **11.5%**.

Table 16 Contribution of renewables to power generation in Ukraine [12]

Indexes[1)]	2012	2015	2020	2025	2030
Installed capacity (total), GW_{el}, including	53.8	51.5	59.4	63.8	66.5
HPPs[2)]	4.5	4.8	5.2	5.8	5.8
RES	0.6	1.9	6.9	7.3	8.4
Share of RES in the installed capacity[3)]	1.1%	3.7%	11.6%	11.4%	12.6%
Power generation (total), TWh, including	198	215	236	259	282
HPPs[2)]	10	12	13	14	14
RES	1	3	12	13	14
Share of RES in power production[3)]	0.5%	1.4%	5.1%	5.0%	5.0%
Share of RES in power production including large HPPs[3)]	**5.6%**	**7.0%** (8.3%[4)])	**10.6%** (11.5%[4)])	**10.4%**	**9.9%**

1) According to base scenario.

2) Without small HPPs (below 10 MW_{el}). Small HPPs are taken into account in RES.

3) Estimation of the authors of the Position Paper based on data of [12].

4) Figure according to the draft NREAP [17].

As for bioenergy, the Energy Strategy comprises just a few figures. It is stated that according to different estimations the potential installed capacity of bioenergy plants may be **10-15** GW_{th} and **1-1.5** GW_{el}. At that there is no specification of the installed capacity by years and types of biomass. Also there is no information on the planned share of biomass in the energy balance of Ukraine that complicates analyzing bioenergy development prospects. The Energy Strategy includes detailed data only for liquid biofuels – bioethanol and biodiesel (**Table 17**). The figures agree with targets of the draft NREAP.

Table 17. Dynamics of production and consumption of motor biofuels in Ukraine in 2010-2030.

Biofuels	2010	2015	2020	2025	2030
Bioethanol, Mt	<0.1	0.3 (0.23*)	0.6 (0.50*)	0.8	1.1
Biodiesel, Mt	~0	~0 (0*)	<0.1 (0.08*)	0.3	0.8
Total, Mt	**<0.1**	**0.3**	**0.6**	**1.1**	**1.9**

** The target according to the draft NREAP [17] (assessment of the authors of the Position Paper based on data of [17]).*

It should be noted that regarding liquid biofuels of the first generation UABio's position is rather critical. From business point of view we consider production and consumption of bioethanol and biodiesel in Ukraine to be rather risky and that it requires creation of corresponding framework conditions. The main risks are described below.

Economic risks. Most experts suppose that an energy unit of bioethanol/biodiesel is more expensive than that of petrol/diesel and therefore increasing share of biofuels in motor fuels will make the latter more expensive. At that there are no subsidies for consumers of blended motor fuel in Ukraine. Therefore the consumers will prefer purchasing oil fuels without admixtures. In the EU the

matter is settled by a high excise tax on oil products and zero tax on biofuels. As a result, blended motor fuels are much cheaper for consumers than pure oil fuels. In Ukraine, the excise tax on oil products is much lower than in the EU and is not a sufficient economic instrument for the promotion of first generation biofuels in the market.

Energy risks. Production of bioethanol and biodiesel has rather low ratio of output energy (energy that is contained in the products) to input energy (energy required for preparation of feedstock and implementation of the production process)[6]. The index is as usual about 1.5 whereas for biomass combustion it is 8-10, and for biogas technologies it is 2-6. In other words, technologies for the production of liquid biofuels are not sufficiently attractive from energy point of view; in many countries they represent a hidden mechanism for agriculture support. One can assume that positive energy result may be achieved only in some cases under certain conditions, for example, when using feedstock in the form of residues awaiting utilization.

Environmental risks. In the EU, development of liquid biofuels market is regulated by Directive 2009/28/EC. According to the Directive, by 2020 each EU country must cover 10% of fuel needs in transport sector by RES including biodiesel, bioethanol, other bio-liquids, biogas and renewable power for electric transport. Liquid biofuels are taken into account for the target achievement only on condition that they provide GHG reduction minimum 35% until 1.01.2017, 50% from 1.01.2017 and 60% from 1.01.2018 (for biofuels plants put into operation after 1.01.2017). This causes the problem of bioethanol and biodiesel as fuel. Typical reduction of GHG emission when using most kinds of bioethanol/biodiesel is below 50%, so production of these biofuels must be ceased from 1.01.2017 or from 1.01.2018 as they do not meet the requirements of Directive 2009/28/EC. It is important to note that provisions of the Directive are obligatory for Ukraine from 1.01.2014 in accordance with Ukraine's commitments within the Energy Community.

Organizational risks. It is necessary to create rather complex infrastructure so that to provide production, blending and sale of the blended fuels through filling stations.

Technical risks. Most part of Ukraine's vehicle fleet has no technical means to use blended motor fuels (especially when the share of biofuels is > 5%).

Production and use of **biogas** seems to be much more promising area for Ukraine. In case of co-digestion of waste with corn silage the potential of biogas plants in Ukraine's agro-industrial complex (cattle farms, pig farms, poultry factories, sugar mills, alcohol plants and brew houses) is estimated at about 1600 units with mini-CHP plants of > 100 kW_{el}. Total installed capacity of biogas plants may come to 820 MW_{el} and 1100 MW_{th}. At that it is assumed that 2/3 of the capacity will run on biogas from corn silage and 1/3 of the capacity will run on biogas from waste. Also it is assumed that during a short-term period (until 2020) and medium-term period (until 2030) it is rational to develop about 10% and 50% of economically reasonable market of BGPs respectively.

[6] The matter is considered in more detail in UABio's Position paper N 8 [22].

Under the total investments of 15 billion UAH into more than 800 biogas plants until 2030 the volume of the obtained biogas may be about 1.0 billion m^3 CH_4/yr. The matter is considered in more detail in UABio's Position Paper N 4 [21] and the booklet «Development of biogas technologies in Ukraine and Germany» [20].

To increase the potential and implementation of commercial biogas projects it is important to support production of biogas not only from organic waste but also from energy crops like corn. When using 3% of Ukraine's arable land (1 Mha) to obtain corn silage with the conservative yield of 30 t/ha and methane yield of 100 m^3 per ton of silage one can obtain 3.3 billion m^3 CH_4/yr (3.68 Mtce/yr). Under the higher yield of 40 t/ha and methane yield of 115 m^3/t, one can obtain 5.1 billion m^3 CH_4/yr (6.2 Mtce/yr).

Existing barriers to bioenergy development in Ukraine

Detailed analysis of the barriers to bioenergy development in Ukraine is given in [13, 14]. We can note briefly the following.

The Law of Ukraine "On Power Industry" contains incorrect ("narrow") definition of "biomass", according to which only biomass waste from agriculture, forestry and technology-related industries are considered and products are not. Such definition of biomass doesn't include the most common in practice its types, particularly, firewood, pellets, briquettes, wood chips, and energy willow as fuel for biomass CHPPs/TPPs, and also corn silage as a feedstock for biogas plants. All these biomass types cannot be classified as "waste".

Furthermore, the requirement for the "domestic component" of the projects eligible to receive "green" tariff is unreasonably high, and the coefficients of GT for electricity produced from biomass and biogas are insufficient for a dynamic development of the industry.

In 2013, an additional barrier to the development of bioenergy technologies in Ukraine appeared. In September 2013 bioenergy facilities (biomass boilers and CHPPs, biogas plants) were referred to the 5th category of complexity along with objects of nuclear energy and chemical industry. This, in turn, leads to a significant complication and appreciation of procedures for design and construction, to a raise in requirements for the location of the corresponding objects, to a necessity of carrying out design and construction only by organizations which have the appropriate licenses. It should be noted that due to the active position of UABio on this issue Ministry of Regional Development, Construction and Housing of Ukraine has developed a draft of the State Construction Norms, in which bioenergy objects are referred to a lower (mostly 3rd) category of complexity.

A separate serious problem is the state subsidizing of prices for gas and heat for the population and housing sector. In 2013, heat energy for the population in housing sector was produced from Russian gas, purchased at the price of more than $ **400**/1000 m^3, and sold to municipal utilities at **1309** UAH/1000 m^3. Price of gas itself in the selling price amounts to **770** UAH/1000 m^3 that is

more than **4.5** times cheaper than the purchase price of gas. In order to compensate this difference, the State budget subsidized NJSC "Naftogaz of Ukraine" at the level of 25-30 billion m^3 per year.

Average tariff for heat, produced from gas in the housing-communal sector, for sale to the population was **229.5** UAH/Gcal without VAT (data of NCSPURC[7]). If this heat energy was produced from gas at market (unsubsidized) price, its average tariff would have been as **778.6** UAH./Gcal without VAT. Accordingly, the State budget of Ukraine subsidizes 778.6 – 229.5 = **549.1** UAH without VAT in each Gcal sold to population. Subsidizing is performed by two mechanisms: 1 – through subsidizing gas prices for public utilities and 2 – through subvention to local budgets to cover the difference between the heat tariff to the population and its cost.

Average tariff for heat, produced from biomass, was according to NERC[8] data **546.1** UAH/Gcal without VAT (with an overall range of tariffs 276…799 UAH/Gcal without VAT – **Fig. 9**). Accordingly, when heat tariff for sale to the population is **229.5** UAH/Gcal without VAT, such projects cannot be profitable without subsidies from the state. But, at the same time the required subsidy is 546.1 – 229.5 = **316.6** UAH/Gcal without VAT, i.e. **43%** less than for the subsidized heat from natural gas.

So, to replace gas with biomass in the housing sector UABio considers it necessary to establish a mechanism of subsidies redistribution from heat, produced from natural gas, for heat, produced from biomass. In this case the Budget of Ukraine will save in funds, allocated for this, in the amount of **43%**, and investing in such projects will become profitable for investors.

With the expected increase of heat tariffs for population in the housing sector by **40%** from 01.07.2014 situation won't be fundamentally changed. Heat tariff for population will rise to 229.5 × 1.4 = 321.3 UAH/Gcal without VAT. Accordingly, the heat from biomass will require less redistributed subsidy: 546.1 – 321.3 = **224.8** UAH/Gcal without VAT.

After the second rise in heat tariff for population in the housing sector by another **40%** since 01.07.2015, the tariff will rise to 321.3×1.4=449.8 UAH/Gcal without VAT. Accordingly, heat, produced from biomass, requires less amount of redistributed subsidy: 546.1 – 449.8 = **96.3** UAH/Gcal without VAT.

After the third rise in the heat tariff for population in the housing sector by another **20%** since 01.07.2016, the tariff will rise to 449.8×1.2=539.7 UAH/Gcal without VAT. Accordingly, heat from biomass will hardly require redistributed subsidy: 546.1 – 539.7 = **6.4** UAH/Gcal without VAT. Thus, we can predict that mechanism of subsidies redistribution will degenerate since 1.07.2016 at planned rates of heat tariffs increase. Before this the proposed mechanism of

[7]The National Commission of the State Public Utilities Regulation http://www.nkp.gov.ua/
[8]National Energy Regulation Commission http://www.nerc.gov.ua/

compensation is critical to ensure the profitability of heat production from biomass in the housing sector.

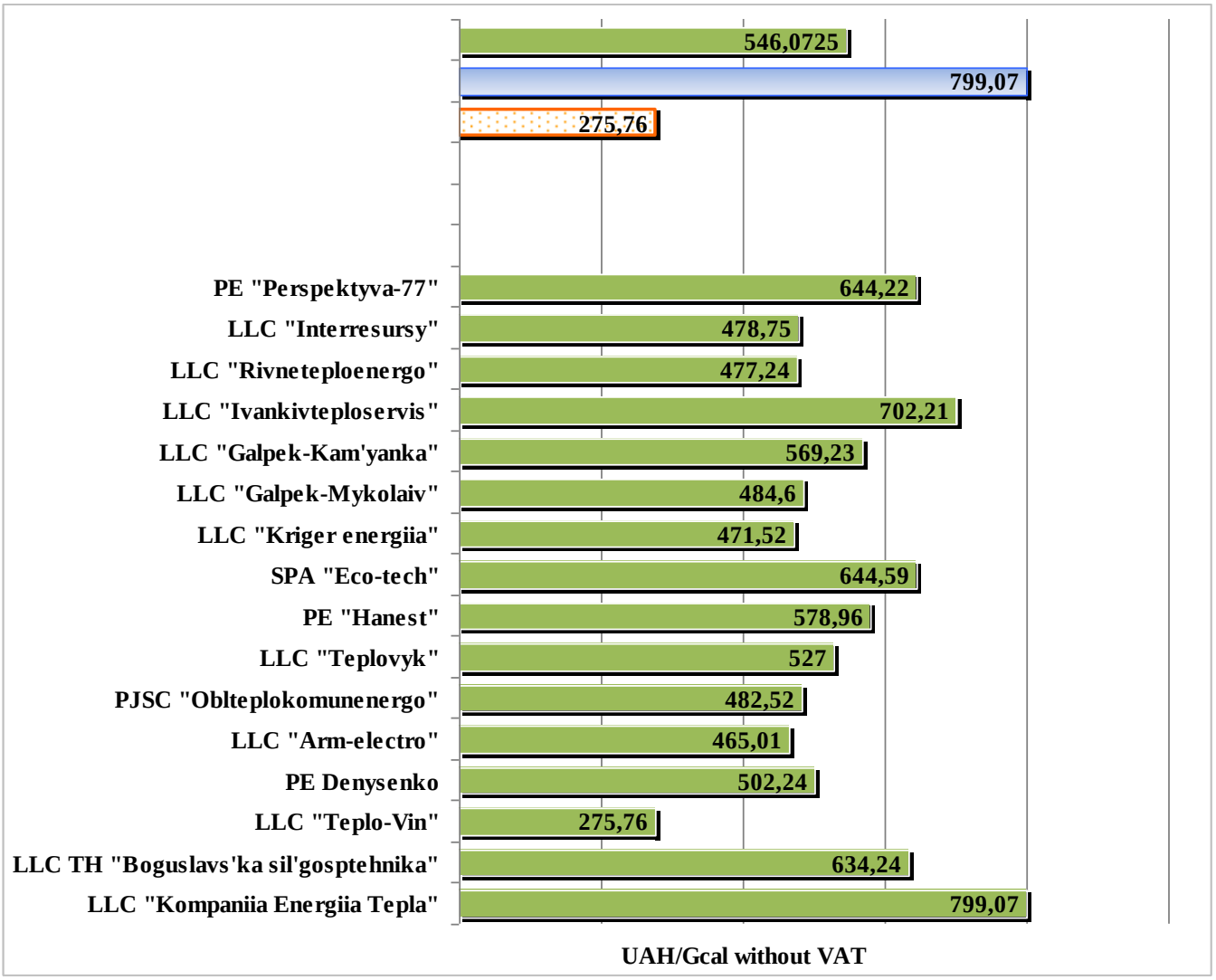


Fig. 9. Tariffs for heat, produced from RES (data of NERC).

UABio's suggestions on how to overcome the barriers to bioenergy development in Ukraine

Bioenergy Association of Ukraine has developed a set of measures aimed at overcoming existing barriers and active attracting of biomass into the energy balance of the country. A list of these measures is presented below.

1. To make the following amendments to the legislation on the "green" tariff (i.e., to adopt the amendments to the Law of Ukraine "On Power Industry" [15]):

1.1. To correct the definition of "biomass" according to the European Directive 2009/28/EC:

"Biomass is a non-fossil biologically renewable substance of organic origin, which is subject to biodegradation, in the form of **products**, **wastes** and **residues** of forestry and agriculture (livestock and crop sectors), wastes of fishery and technologically related industries, as well as the part of industrial or municipal waste".

1.2. To abolish the domestic content requirement for power generation objects which use energy of biomass and biogas.

Arguments:

- This equipment isn't produced in Ukraine. Even no plans have been stated for its production.
- Breaches non-discrimination principle of the World Trade Organization. WTO made a similar conclusion regarding the program on the "green" tariff of Ontario (Canada).
- Contradicts the rules of competition established by the European Union and the Energy Community. There are repeated statements about this of EU Trade Commissioner Mr. De Gucht and of Director of the Energy Community Secretariat Mr. Kovacs. Acknowledgement of this is in the conclusion of Chief Scientific Expert Department of the Verkhovna Rada (the Parliament) of Ukraine to the Draft Law №2946[9].
- Contradicts to the policy of Ukrainian Government on the deregulation of economy.
- The requirement for 30% for domestic content still will not stimulate the release of local equipment: the required 30% will be obtained by construction works (fixed share - 40% for biomass facilities and 30% for biogas plants).
- High risk of monopolization of equipment on market by 1-2 producers.
- In the sector of solar and wind energy local manufacturers of relevant equipment defend the conservation of the domestic content requirement. There are no such manufacturers in bioenergy sector.

1.3. To raise from 01.01.2015 the "green" tariff coefficient for power generation objects operating on biomass and biogas:

up to 2.7 – for biomass plants,

up to 3.0 – for plants on biogas from agriculture,

up to 2.7 – for plants on biogas of other types (MSW landfills, waste water treatment systems, waste from the food and other industries).

Arguments:

- Bioenergy sector doesn't practically develop in Ukraine compared to other RES. Installed power capacities for today are the following: solar – about 750 MW, wind – about 570 MW, small hydro – about 75 MW, bioenergy – about 24 MW. It can be explained by low "green" tariff for bioenergy development.
- Of all the renewable energy objects, only bioenergy ones operate mainly in cogeneration mode with power and heat generation and thus can replace natural gas. For biogas and biomass CHPPs it is realistic to achieve substitution of natural gas consumption up to **2.5 billion m^3/year**. This is especially true in today's gas prices and political circumstances. Only in this sector of renewable energy we can replace natural gas. Therefore, bioenergy sector is in need of immediate stimulus.
- Power generation from biomass and biogas is stable and doesn't require compensating capacities in the energy system.

[9] Draft Law on Amending some laws of Ukraine on the promotion of electricity generation from alternative energy sources (N 2946 from 26.04.2013)http://w1.c1.rada.gov.ua/pls/zweb2/webproc4_1?id=&pf3511=46816

- Even with increased coefficient "green" tariff for power from biomass and biogas in Ukraine will be at the average level of similar indicators of European countries:

№	Country	GT for electricity from **biomass** (max), eurocents/kWh
1	Italy	28
2	Germany	22.67
3	Czech Republic	19
4	Spain	17.16
5	Austria	14.98
	Ukraine (2.7)	**14.54**
6	Bulgaria	13.04
7	**Ukraine (2.3)**	**12.39**
8	France	11.9

№	Country	GT for electricity from **biogas** (max), eurocents/kWh
1	Germany	28.67
2	Italy	28
3	Bulgaria	22.14
4	Austria	18.5
5	Czech Republic	17
	Ukraine (3.0)	**16.16**
	Ukraine (2.7)	**14.54**
6	Spain	14.11
7	**Ukraine (2.3)**	**12.39**
8	Great Britain	10.36

2. To improve the mechanism of tariff formation, which should provide reduction of compensation of difference in tariffs for heat, produced from natural gas, in favor of increasing of such compensation for cost of heat, produced from alternative fuel types.

3. Ot the state level to establish adequate targets for bioenergy development:

Indicators	2011 (fact)	Forecast			
		2015	2020	2025	2030
Biomass share in the gross final energy demand	1.78%	2.2%	4.3%	7.2%	10%
Biomass share in heat production	6%	8%	14%	22%	32%
Biomass share in electricity production	0.01%	0.2%	1%	2.2%	4%
Substitution of natural gas, billion m^3/yr	1.67	1.85	3.5	5.5	7.5

4. To simplify the procedure of land allocation for bioenergy plants.

5. To simplify the procedure for comprehensive expertise of projects for the construction of biomass boiler houses and CHPPs, biogas plants and other bioenergy facilities.

6. To simplify the procedure for obtaining tax exemptions for the importation of energy-efficient equipment to Ukraine (Decree of CMU № 444 from 14.05.2008).

7. To approve the amended DSTU-N (State Standard) to prevent the reference of bioenergy objects, which combust biofuel and pellets, to the V category of complexity.

8. To introduce state reimbursement of interest on commercial credits that were issued for purchasing energy saving equipment including thermal bioenergy equipment on pellets, wood chips and other biofuels. To provide respective financing from the state budget of Ukraine in 2015-2017.

9. To ban designing and construction of new gas boiler plants and reconstruction of existing gas boiler plants in the state-financed sector and communal-housing sector if there are enough resources of biofuels and other alternative local fuels in the respective region.

10. To amend some normative legal documents so that to ensure that when converting boiler plants of the state-financed sector from gas to biofuels, respective local budgets during 5 years will have costs to cover these expenses in the amount that was before the replacement of natural gas by biofuels.

11. To amend some normative legal documents so that to ensure that when calculating production cost and tariff for thermal energy from biofuels all the components are taken into account:

- accelerated depreciation of equipment;
- expenses on reimbursement of interest on commercial credits;
- profitability without a target bonus at the level of 20% and more;
- the target bonus taking into consideration (among others) expenses on reconstruction and maintenance of heat networks.

12. To organize dissemination of information on successful experience of companies from Ukraine's regions on stimulating production and consumption of biofuels including pellets and wood chips via:

- conducting information campaigns through mass media about advantages of energy efficient technologies and priority of renewable energy, first of all bioenergy as it contributes to replacing imported natural gas;
- holding seminars and trainings for the representatives of regional state administrations, interested executive authorities and businessmen on implementing mechanisms for stimulating production and consumption of biofuels including pellets and wood chips.

13. To stimulate cultivating energy crops in Ukraine. A possible stimulation mechanism can be state subsidy to the cultivators per hectare of the area under energy crops. Another mechanism may be state reimbursement of interest on credit for the companies growing energy crops.

14. To simplify procedure for transferring communal boiler plants to private investor concession, including the use of state-private partnership mechanism.

15. To finalize and approve the draft National Renewable Energy Action Plan. The finalization should lie in increasing the planned amount of biofuels including pellets, wood chips and biogas intended for heat and power production.

16. To finalize and submit to the CMU the draft Procedure for issuing loans against state security in 2014-2017 with the purpose of implementation of certain projects. These are the projects aimed at social and economic development in Ukraine's housing and communal sector and stimulating natural gas consumption reduction. Of these projects, the ones on heat and power production from biomass/biogas must be of first-priority.

17. To recommend the Council of Ministers of AR Crimea and local administrations to give a top-priority status to the investment projects on the production of heat and power from alternative fuels including pellets and wood chips.

Conclusions

Renewable energy is an energy sector that is dynamically developing in the world. Today, the share of RES in the global primary energy supply is about **13%**, including that of biomass **10%** that is over 1300 Mtoe/yr.

The European Union is successfully achieving its 2020 targets on renewable energy – 20% energy from RES in the gross final energy consumption. During past 10 years this index has increased from 8% to **14%**. Contribution of biomass into the EU's gross final energy consumption has already exceeded **8%**, and it must increase up to 14% by 2020. The biggest progress has been made in the heat energy sector – biomass covers almost **16%**of the total generation that answers the third place after natural gas and coal. Contribution of biomass to the EU power sector is comparatively modest – **4%** of the total generation and **19%** of all renewables.

Ukraine has a big potential of biomass available for energy production, and that is a good precondition for the dynamic development of bioenergy. Theoretical potential of biomass in the country is about **20-25 Mtce/yr**. Main parts of the potential are agricultural waste (straw, corn stalks, sunflower stalks etc.) – over 11 Mtce/yr (2013 data) and energy crops – about 10 Mtce/yr.

In Ukraine, bioenergy is one of the strategic areas of renewable energy development taking into account high dependence of the country on imported energy carriers, first of all natural gas, and a

big potential of biomass available for energy production. Unfortunately, in Ukraine bioenergy is developing much slower than in European countries. Current share of biomass in the total primary energy supply of the country is only 1.2%, and the share of biomass in the gross final energy consumption is 1.78%.

Dynamics of renewable energy development is strongly determined by existing mechanisms of support. Now one of few effective instruments for RES support in Ukraine is Green Tariff on the power produced from renewables including biomass. According to NERC, in Ukraine's bioenergy sector five companies producing power from biomass and five companies generating power from biogas have Green Tariff (as of 1 May 2014). For all the producers GT is 12.39 eurocents/kWh that is equivalent to 194.85 kop./kWh (without VAT) as of 01.05.2014.

Main areas for the use of energy potential of biomass and biogas in Ukraine are production of heat and power. Respective conceptions for the development of energy production from biomass/biogas until 2020 and 2030 have been elaborated by the Bioenergy association of Ukraine. By 2020 biomass can replace about **3.5** billion m^3/yr of natural gas for heat production in Ukraine, and by 2030 **7.5** billion m^3/yr. In the power sector, installed capacity of the biomass plants may come to over **530** MW_{el} by 2020 and over **2100** MW_{el} by 2030. According to the suggested conception of UABio, the share of biomass in the total heat production will be **14%** in 2020 and **32%** in 2030; and that in power production will be **1%** and **4%** respectively. The contribution of biomass to the gross final energy consumption of the country may reach **4.3%** in 2020 and **10%** in 2030.

In Ukraine, there are a number of barriers to the successful development of the bioenergy sector. They include imperfection of the existing legislation on the "green" tariff, the insufficient attention of current Energy Strategy to the opportunities of the sector, the lack of effective mechanisms for renewable energy stimulating and others. Bioenergy Association of Ukraine has developed a set of measures aimed at overcoming these barriers and active involvement of biomass into the energy balance of the country. We believe that the implementation of these measures will make a significant contribution to strengthening of Ukraine's energy independence.

REFERENCES

1. *Key World Energy Statistics*. Publication of the International Energy Agency, 2013 http://www.iea.org/publications/freepublications/publication/KeyWorld2013.pdf
2. *Renewable energy in the EU28.* Eurostat news release 37/2014 – 10 March 2014 http://europa.eu/rapid/press-release_STAT-14-37_en.htm
3. *European Bioenergy Outlook*. AEBIOM, 2013 http://www.aebiom.org/blog/aebiom-statistical-report-2013/
4. *Solid Biomass Barometer*. EurObserv'ER, December 2013. http://www.energies-renouvelables.org/observ-er/stat_baro/observ/baro219_en.pdf
5. *Solid Biomass Barometer*. EurObserv'ER, December 2012. http://www.eurobserv-er.org/pdf/baro212biomass.pdf
6. *EU Energy in Figures*. Publication of European Commission, 2013

http://ec.europa.eu/energy/publications/doc/2013_pocketbook.pdf

7. *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
8. *Energy Balance* of Ukraine for 2012. Express-release by the State Statistics Service of Ukraine № 08/4-16/240 от 20.12.2013.
9. *Geletukha G.G., Zheliezna T.A*. Prospects for the use of agricultural residues for energy production in Ukraine. UABio's Position Paper N 7, 2014 http://www.uabio.org/img/files/docs/Position-paper-UABIO-7-EN.pdf
10. *Geletukha G.G., Zheliezna T.A., Oliinyk Ye.M.* Prospects for the use of heat energy from biomass in Ukraine // Industrial Heat Engineering. – 2013, v. 35, N 5. – P. 48-57. (Rus.)
11. *Geletukha G.G., Zheliezna T.A., Oliinyk Ye.M., Geletukha G.I.* Prospects for the use of electric energy from biomass in Ukraine // Industrial Heat Engineering. – 2013, v. 35, N 6. – P. 67-75. (Rus.)
12. *Energy Strategy* of Ukraine until 2030. Approved by Resolution of CMU N 1071 of 24.07.2013. (Ukr.) http://mpe.kmu.gov.ua/fuel/control/uk/doccatalog/list?currDir=50358
13. *Geletukha G.G., Zheliezna T.A*. Barriers to bioenergy development in Ukraine. Part 1 // Industrial Heat Engineering. – 2013, v. 35, N 4. – P. 63-71. (Rus.)
14. *Geletukha G.G., Zheliezna T.A*. Barriers to bioenergy development in Ukraine. Part 2 // Industrial Heat Engineering. – 2013, v. 35, N 5. – P. 43-47. (Rus.)
15. *Law of Ukraine* «On Power Industry» (№ 575/97-BP of 16.10.1997 with amendments). (Ukr.) http://zakon2.rada.gov.ua/laws/show/575/97-%D0%B2%D1%80
16. *NERC Resolution* «On setting Green Tariffs on power» (N 567 of 30.04.2014) (Ukr.) http://www.nerc.gov.ua/?id=10756
17. National Renewable Energy Action Plan until 2020 (draft) (Ukr.) http://saee.gov.ua/documents/NpdVE.pdf
18. *EUROSTAT* statistics http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/other_documents
19. *Annual Statistical Report* on the contribution of biomass to the energy system in the EU 27, AEBIOM, 2011. http://ru.scribd.com/doc/73012151/2011-AEBIOM-Annual-Statistical-Report
20. *Georgiy Geletukha, Petro Kucheruk, Yuri Matveev, Dmytro Naumenko, Andrej Stanev, Lesya Matiyuk.* Development of biogas technologies in Ukraine and Germany: regulatory and legal framework, status and prospects. Kyiv-Gülzow 2013. http://www.uabio.org/img/files/news/pdf/development-of-biogas.pdf
21. *Geletukha G.G., Kucheruk P.P., Matveev Yu.B.* Prospects of biogas production and use in Ukraine. UABio's Position Paper N 4, 2013 http://www.uabio.org/img/files/docs/position-paper-uabio-4-en.pdf
22. *Geletukha G.G., Zheliezna T.A., Drozdova O.I.* Energy and environmental analysis of bioenergy technologies. UABio's Position Paper N 8, 2014

http://www.uabio.org/img/files/docs/position-paper-uabio-8-en.pdf
23. *Statistical Yearbook* of Ukraine for 2012. Publication by the State Statistics Service of Ukraine, 2013. (Ukr.)
24. *Svitlana Trybush.* Willow for Energy: Myths and Reality. Proc. of 8th International Conference on Biomass for Energy, 25-26 September 2012, Kyiv, Ukraine.
25. *Blium Ya.B., Geletukha G.G., Grygoriuk I.P.* at al. Modern technologies for bioenergy conversion. – K: «Agrar Media Group», 2010. – 326 p.
26. *Ya.D. Fuchylo, M.V. Sbytna, O.Ya. Fuchylo, V.M. Litvin.* Experience and prospects for growing poplar (*POPULUS SP.L.*) in southern steppe of Ukraine // Proceedings of the Forest Academy of Sciences of Ukraine. – 2009. Issue 7, c. 66-69.

Abbreviation

BG – biogas;
BM – biomass;
BGP – biogas plant;
CHP – combined heat and power;
CHPP – combined heat and power plant;
CMU – the Cabinet of Ministers of Ukraine;
HPP – hydro power plant;
GHG – greenhouse gas;
GT – Green Tariff;
LFG – landfill gas;
NERC – National Energy Regulation Commission;
NCSPURC – The National Commission of the State Public Utilities Regulation;
NREAP – National Renewable Energy Action Plan;
RES – renewable energy sources;
TPP – thermal power plant;
UABio – Bioenergy Association of Ukraine;
Mha – million hectares;
Mtce – million tons of coal equivalent;
ktce – thousand tons of coal equivalent;
d.m. – dry matter;
n.a. – data are not available.

Previous publications by UABIO

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

1. *Position Paper N 1* "Position of bioenergy in the draft updated energy strategy of Ukraine till 2030".
2. *Position Paper N 2* "Analysis of the Law of Ukraine "On amending the Law of Ukraine «On Electricity" No5485-VI of 20.11.2012".
3. *Position Paper N 3* "Barriers to the development of bioenergy in Ukraine".

4. *Position Paper N 4* “Prospects of biogas production and use in Ukraine”.
5. *Position Paper N 5* “Prospects for the electricity generation from biomass in Ukraine”
6. *Position Paper N 6* “Prospects for heat production from biomass in Ukraine”
7. *Position Paper N 7* “Prospects for the use of agricultural residues for energy production in Ukraine”.
8. *Position Paper N 8* “Energy and environmental analysis of bioenergy technologies”

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.

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