Bioenergy Association of Ukraine

BIOMASS

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Development of Biogas Technologies in Ukraine and Germany:

Regulatory and Legal Framework, Status and Prospects

FNR

GFA Consulting Group

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**Scientific Engineering Center "Biomass", Ukraine and
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CONTENT

Abbreviations

AIC – Agro-industrial complex;
BAU – Bioenergy Association of Ukraine (UABio);
CHP – Combined heat and power plant;
CMU – Cabinet of Ministers of Ukraine;
EBRD – European Bank on Reconstruction and Development;
ERU – Emission reduction unit;
EU – European Union;
GDP – Gross domestic product;
GHG – Greenhouse gas;
GTS – Gas transportation system;
LFG – Landfill gas;
MSW – Municipal solid waste;
NAAS – National Academy of Agrarian Sciences;
NASU – National Academy of Science of Ukraine;
NBU – National Bank of Ukraine;
NERC – National Energy Regulatory Commission of Ukraine;
NG – Natural gas;
RES – Renewable energy sources;
SAEE – State Agency on Energy Efficiency and Energy Saving of Ukraine;
TS – Total solids;
VAT – Value added tax;
WTO – World trade organization;

Energy Measurement Units

Conversion table of energy units

	GJ	tce	toe	Gcal	MWh
GJ	1	0,0341	0,0239	0,239	0,278
tce	29,31	1	0,700	7,0	8,130
toe	41,87	1,429	1	10,0	11,63
Gcal	4,19	0,143	0,100	1	1,163
MWh	3,60	0,123	0,0861	0,861	1

Designation of the energy units

J – Joule;
tce – tones of coal equivalent;
toe – tones of oil equivalent;
cal – calorie;
Wh – Watt·hour.

The value of decimal prefixes to the energy units

Kilo	(k)	10^3
Mega	(M)	10^6
Giga	(G)	10^9
Tera	(T)	10^{12}
Peta	(P)	10^{15}

INTRODUCTION

This booklet has been prepared by Scientific Engineering Centre "Biomass" and Bioenergy Association of Ukraine in cooperation with the Center for Economic Studies of the Institute of Economic Research and Policy Consulting and the Special Agency for Renewable Resources (Fachagentur Nachwachsende Rohstoffe eV / FNR) on the initiative of FNR and with the financial support of Federal Ministry of Food, Agriculture and Consumer Protection of Germany.

The purpose of this booklet is:

- To describe and analyze the status and development strategy of biogas technologies in Germany and Ukraine, focusing on the existing regulatory and legal framework;
- To compare the framework conditions for the biogas plants development in Germany and the Ukraine;
- To analyze the barriers to biogas technologies development in Ukraine;
- To assess the prospects for biogas technologies development in Ukraine for the period up to 2030;
- To develop the recommendations to improve the framework conditions for biogas plants development in Ukraine.

The target audience includes representatives of agro-industrial enterprises of Ukraine interested in commercial biogas plants construction, representatives of municipal, regional, provincial authorities considering the construction of landfill gas collection systems at landfills and biogas plants in the municipal sewage treatment stations, public members supporting renewable energy development, environmental improvement and agricultural resources efficiency increasing, representatives of executive and legislative power in Ukraine, having an influence on the framework conditions creation for biogas technologies development, as well as all readers interested in the development of renewable energy sources, and in particular the biogas technologies in our country.

Authors of the booklet will consider this mission to be accomplished in case, if the publication appearance and dissemination of the information presented will encourage representatives of legislative and executive authorities of Ukraine to create favorable framework conditions for the development of biogas technologies in Ukraine, as well as, if after reading this booklet, some representatives of the local government, agriculture and other businesses would think about the biogas projects development.

The booklet has been prepared as part of MOE 08-01 project “Promoting the use of renewable resources in the Ukraine with a focus on biomass for energy”.

MOE 08-01 project implementation started 01.01.2009, a project is funded by the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV). The overall project objective is to contribute to the sustainable energy implementation using the bioenergy potential of Ukraine through the regional and national programs and approaches development in the field of energy efficiency with a focus on bioenergy. The project is intended to serve as an initiator and catalyst for future action on the certain projects in bioenergy and synergy field in the partner country. The focus of activities in Ukraine is the implementation of bioenergy projects and activities to create the framework conditions for their development.

Also, the project is to promote renewable energy sources cultivation and use through the advisory services implementation in Ukraine. In particular, the project coordinates the activities at the sectoral and national level to create the framework conditions in the bioenergy area. The regular consultations at the ministerial level are expected to lead to increased project efficiency and to the multiplier effect. Work on providing various consulting services in the field of bio-energy in Ukraine is carried out since 2009.

In particular, Ukraine has successfully conducted a large number of specialized conferences, seminars and discussions on bioenergy. The project maintained and distributed materials on the subject of bio-energy and biogas, on Internet sites and using other features of the Internet. Support for the implementation activities of bioenergy projects in Ukraine continues.

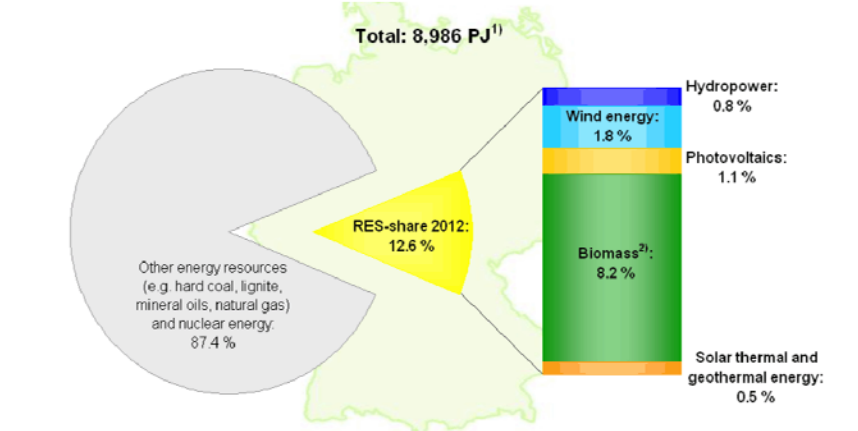
1 DEVELOPMENT OF BIOENERGY AT GERMANY

1.1.1. RES and Biomass

Germany is a federal republic comprising 16 federal states (Länder), over 30 percent of the country is covered by forests and woodland. Biomass is one of the most important and most diverse renewable energy sources in Germany. Biomass is used in solid, liquid and gaseous form to produce electricity and heat and to manufacture biofuels. In 2012 8.2 percent of total final energy consumption and 65 percent of total final energy consumption from renewable sources were covered by the different types of biomass (Fig. 1.1).

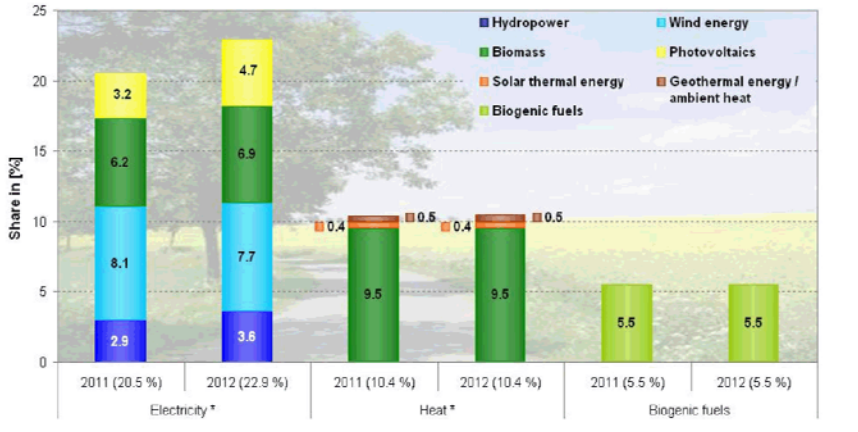
In Germany, bioenergy (in terms of final energy consumption) accounted for 6.9 percent of total electricity consumption, 9.5 percent of total heat consumption and 5.5 percent of total fuel consumption (Fig. 1.2.).

Figure 1.3. shows that in 2012 already 50.2 % of the biomass-based electricity supply in Germany where produced in biogas plants.



1) Source: Working Group on Energy Balances e.V. (AGEB); 2) Solid and liquid biomass, biogas, sewage and landfill gas, biogenic share of waste, biofuels;
Source: BMU - EI 1 based on Working Group on Renewable Energy-Statistics (AGEE-Stat) and Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW), according to AGEB;
RES: Renewable Energy Sources; deviations in the totals are due to rounding; 1 PJ = 10^{15} Joule; as at: February 2013; all figures provisional

Fig. 1.1. RES shares in TPEC in Germany, 2012.
Source: German Federal Ministry for the Environment, AGEE-Stat (2013a)



* Biomass: solid and liquid biomass, biogas, sewage and landfill gas, biogenic fraction of waste; electricity from geothermal energy not presented due to negligible quantities produced; deviations in totals are due to rounding; Source: BMU - EI 1 according to Working Group on Renewable Energy-Statistics (AGEE-Stat); image: BMU / Dieter Böhme; as at: February 2013; all figures provisional

Fig. 1.2. RES shares of energy consumption in the electricity, heat and fuel sector in Germany, 2011 – 2012.
Source: German Federal Ministry for the Environment, AGEE-Stat (2013a)

In early 2012 the Federal Government published the first progress report in accordance with Article 22 of the Renewable Energy Directive. In this report the Government concludes that between 2005 and 2010 the consumption of renewable energy has increased from 635 PJ to 1,052 PJ which equals an increase of 65%.

The electricity sector showed the highest growth rates (on average 11.7% annually). The average annual growth rates in the heating/cooling sector were 10.1% and in transport 9.8%. In the electricity sector the share in 2010 reached 18.4 % and was 1 percent point above the estimate contained in the NREAP. Photovoltaic installations and biogas installations achieved the highest growth rates.

In the heating/cooling sector the share of renewable energy consumption in 2010 was 521 PJ and hence considerably higher than the estimated trajectory in the NREAP (420 PJ). The main reason for this is the increased use of solid biomass and biogas.

In the transport sector the use of RES remained below the expected trajectory of the NREAP (134 PJ compared to 157 PJ). This is mainly related to the lower than expected consumption of biodiesel (94 PJ compared to 117 PJ). The use of bioethanol was higher than expected (31 PJ compared to 27 PJ).

By far, the most important source of bioenergy in Germany is wood. One third of the national territory is covered by forests. Domestic consumption of wood resources has increased continuously over the past two decades and currently amounts to 126.7 million cubic meters per year (FNR 2010). Wood resources include raw wood, waste wood (recovered wood), and woody biomass from landscape management, but also industrial wood residues which are already included in the raw wood fraction. A total of 72 million cubic meters are used in industry and 54.7 million cubic

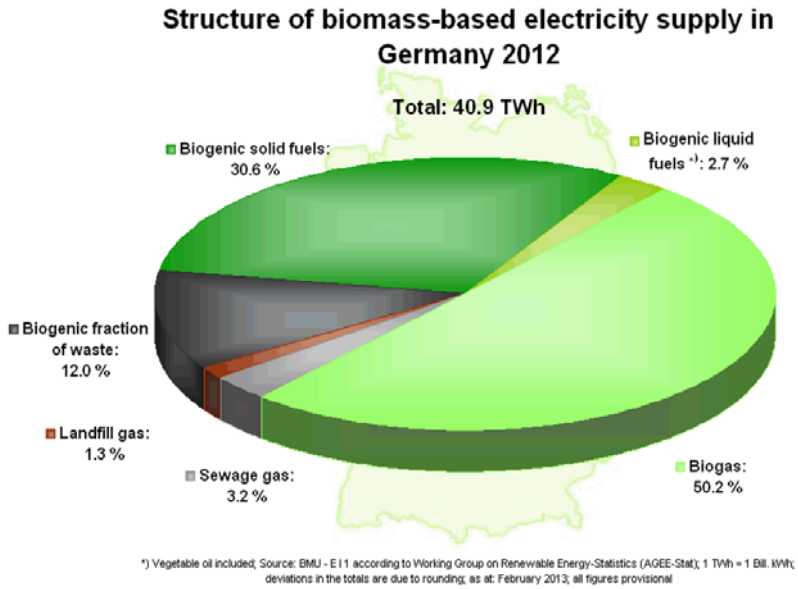


Fig. 1.3. Structure of biomass-based electricity supply in Germany, 2012.

Source: German Federal Ministry for the Environment, AGEE-Stat (2013a)

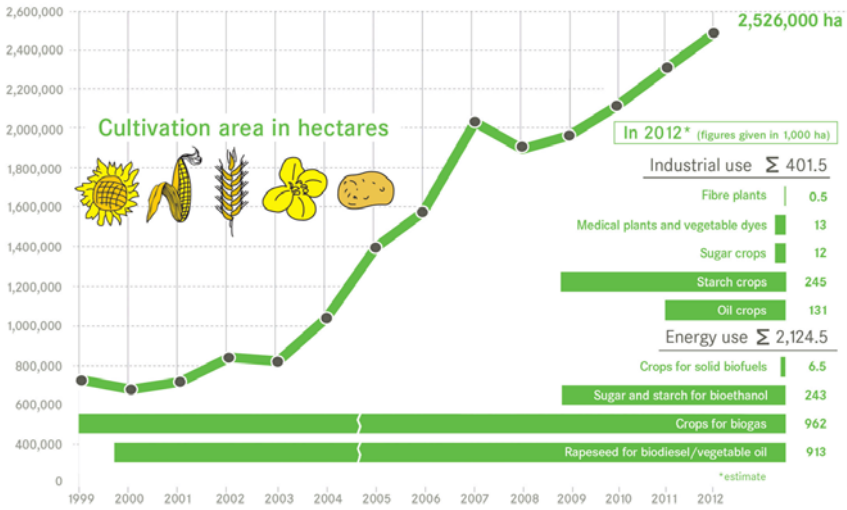


Fig. 1.4. Cultivation of energy crops in Germany, 1999 – 2012.

Source: FNR, 2013

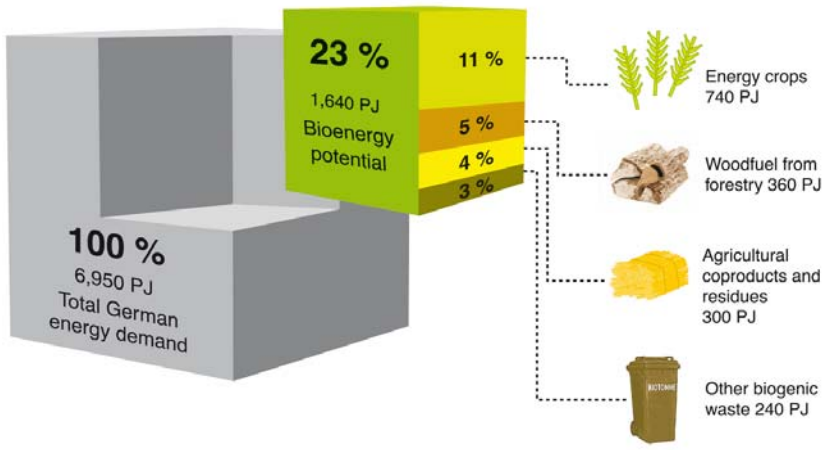


Fig. 1.5. Bioenergy potential in Germany by 2050.

Source: FNR, 2013

meters for energy generation (FNR 2010).

Germany has the largest wood reserves in Europe and the annual timber growth exceeds annual cuttings. The reserves for use of energy production (mostly deciduous wood and forest residues) are estimated to be in the range of 12 to 19 million m3/a equivalent to 65 to 116 PJ. Model calculations assume that an expansion of wood utilization would be possible without jeopardizing sustainability of forest management. The gross energy potential from forestry is estimated at 200 to 250 PJ.

In addition to forestry, agriculture also plays an important role in producing biomass for energy generation. In 2012 the acreage used to grow energy crops already amounted to 2.5 million ha which is almost 20 per cent of arable land in Germany (Fig. 1.4). Most prominent are rape seed as a crop for biodiesel production (913,000 ha), crops for biogas production (962,000 ha) and sugar and starch for bioethanol production (243,000 ha). An additional 400,000 ha are cultivated by plants and crops to provide renewable raw materials for industrial use (FNR 2013). There is also a certain potential for the expansion of agricultural biomass production. The results of various studies show that from 2020 onwards it will be possible to use 2.5 to 4 million hectares of agricultural land for the cultivation of energy crops (BMU 2009).

In 2012, renewable resources have been grown already on almost 2.5 million ha, among which plants for use in industry grew on 400,000 ha, and plants for energy production on 2.12 million ha (FNR 2013). Short rotation coppice is presently

cultivated on an area of 4,000 ha (FNR/INVEKOS/Länder 2011). Furthermore, a certain potential for expansion still exists, primarily through augmentation of cropland productivity and structural changes in agriculture policy. In addition, optimised conversion processes will contribute to improved utilization of the existing potential.

In addition to the biomass from forestry and agriculture, residual biogenic substances and biogenic wastes are available for energy production. These include in particular waste wood/recovered wood, biowaste, sewage sludge/sewage gas/landfill gas, slurry/solid manure and straw. The Agency for Renewable Resources (FNR) estimates the energy potential of agricultural co-products and residues and other biogenic waste to 540 (Petajoules) PJ in 2050 (Fig. 1.5). In the future special attention must be given to the exploitation of this still largely unused potential. Energy production from biogenic residues and waste helps to avoid or mitigate potentially conflicting uses between biomass for energy purposes or as production material.

Finally, energy from biomass has become an important economic sector in Germany. In 2012 approximately 129,000 persons were employed in the bioenergy related sector. The total turnover for the entire bioenergy sector amounted to 14.4 billion euro in 2012 (FNR 2011).

The National Renewable Energy Action Plan envisages that in 2020 the production of biomass for energy will be approx. 1,000 PJ. The difference of 400 PJ between consumption (1,400 PJ) and production could be covered through imports of biomass, increased yields of energy plants, increased use of forest wood for energy production and landscape conservation material, short rotation plantations and cultivation of energy plants on ecological compensation areas.

1.1.2. Main Players

On the federal level, there are several ministries with responsibilities relevant to bioenergy, including agriculture, energy, environment, rural and economic development, forestry and health.

The Federal Ministry of Economy and Technology (BMWi) has the overall responsibility for the formulation and implementation of energy policy and support export activities for renewable energy technologies. It is responsible for the programmatic orientation of the energy research policy.

The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) holds responsibilities for climate policy including renewable energy policy, nuclear safety and waste management policy. BMU is also responsible for the project-oriented funding of research and development of renewable energy sources including bioenergy.

The Federal Ministry for Food, Agriculture and Consumer Protection (BMELV) holds responsibilities for agricultural policy, forest policy, rural development policy, the use of renewable resources and supports research and development in the field of bioenergy.

The Federal Ministry for Education and Research (BMBF) runs research programs supporting bioenergy related research.

Further responsibilities are shared by the Federal Ministry of Finance (BMF), the Federal Ministry for Transport, Construction and Urban Development (BMVB) and Federal Ministry for Economic Cooperation and Development (BMZ).

There are a number of governmental agencies, public authorities and organizations with responsibilities in the field of bioenergy:

The Agency for Renewable Resources (Fachagentur für Nachwachsende Rohstoffe, FNR), which was founded by the German Federal Ministry for Agriculture, Food and Consumer Protection in 1993, is the central coordinating agency in Germany for the funding of research, development and demonstration projects. However, its tasks also include providing information and advice to a wide range of different target groups as well as supporting the market introduction of products made from renewable resources.

The Federal Agency for Agriculture and Nutrition (Bundesanstalt für Landwirtschaft und Ernährung – BLE) is responsible for the authorization and monitoring of certification schemes and certification bodies with regard to the sustainability requirements for biofuels and bioliquids.

The Bio-economy Council (BioÖkonomieRat) is an independent advisory body to the Federal Government for all matters relating to the bio-economy including bioenergy. The Council consists of experts from university and non-university research institutes, the federal government's own

departmental research, and from research in the private sector. The Council's administrative unit is at the German Academy of Science and Engineering, and it is supported by the **Federal Ministry of Education and Research (BMBF)** and the **Federal Ministry of Food, Agriculture and Consumer Protection (BMELV).**

The German Biomass Research Centre (Deutsches Biomasse Forschungs Zentrum, DBFZ) was founded on 28 February 2008. The Federal Government represented by the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) is the sole shareholder of the DBFZ. Scientific research commenced immediately after the foundation of the DBFZ. DBFZ took over and continued work on third-party funded projects of the Institute for Energy and Environment and new research projects were launched. DBFZ has the task of using applied research to promote effective integration of biomass as a valuable resource for sustainable energy supply while taking account of technological, environmental, economic, social and industry needs along the entire supply chain. DBFZ is also responsible for providing science based decision making tools for policymakers.

1.2. REGULATORY AND LEGAL FRAMEWORK FOR THE DEVELOPMENT OF THE ENERGY SECTOR

The general framework conditions in Germany are suitable for biogas projects and include various support mechanisms, which enable the application of several financing tools.

The main legislative driver for biogas production as renewable energy development in Germany is the Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz, or EEG), promoting the development of renewable energy sources with an electricity feed-in tariff scheme.

The latest version of the EEG with feed-in tariff for biogas applications depending on the size of the biogas plant. It also includes several bonuses for several issues, such as for dedicated energy crops, CHP, technologies, manure use and formaldehyde emissions from CHP. The introduction of the EEG was the main driver for attracting investment and for creating financing opportunities, since it ensures revenues for 20 years. This framework makes biogas projects in Germany calculable.

1.2.1. EU Policies and Objectives for the Development of RES

The electricity generation capacity of renewable resources reached an estimated 1606 gigawatts worldwide in 2012 (BWK, Bd. 65, 2013). Renewable resources, including hydropower capacities represent 25 percent of global power capacity[1]. In Europe, bioenergy remains the major source of renewables accounting for almost 64% of European renewables or 8.16% of the total final energy consumption in EU-27, and showing steady growth patterns across the different market segments (AEBIOM, 2010).

Today, bioenergy is the largest source of renewable energy providing heat, electricity as well as transport fuels. It can be generated from wood, energy crops, and biomass residues and wastes. Biomass fuel sources are readily available in rural and urban areas of all countries and can considerably contribute to the rural development,

1 - U.S. Energy Information Administration, International Energy Outlook 2011

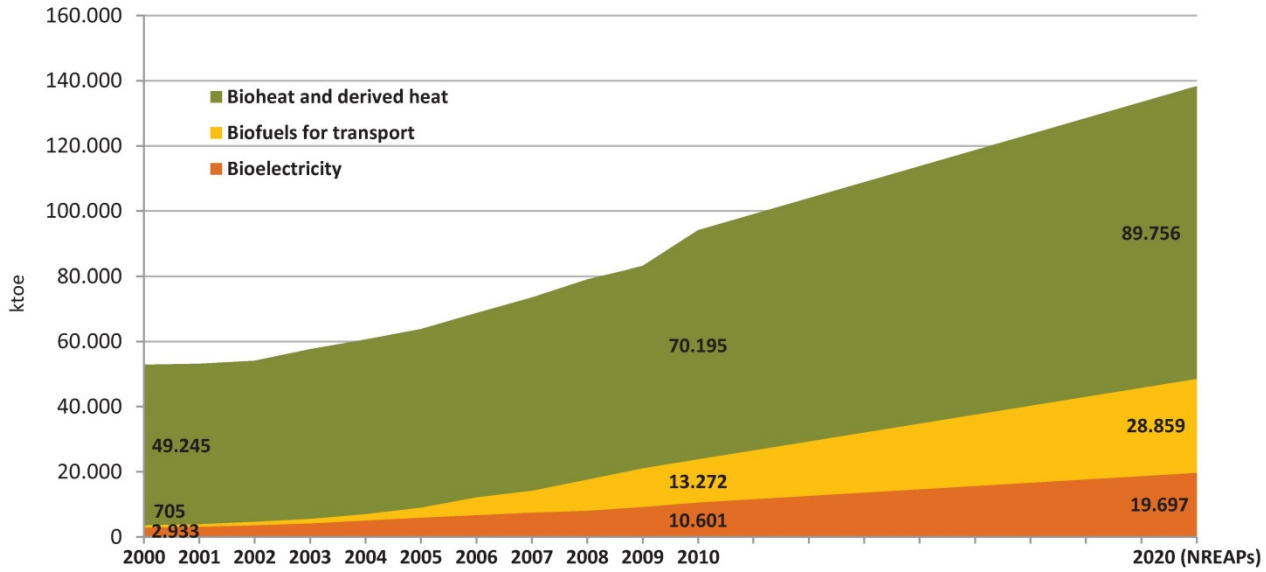


Fig. 1.6. Final energy consumption of bioenergy in 2000-2020 in Europe.
Source: Eurostat, NREAPs, AEBIOM

creating new opportunities for farmers and forest owners. Biomass-based industries can provide CO2-emission reduction and appreciable employment opportunities. The application of sustainable land management practices allows effective avoidance of competition issues with other biomass applications. The negative aspects of traditional biomass utilization in developing countries can be mitigated by promotion of modern waste-to-energy technologies which provide solid, liquid and gaseous fuels as well as electricity. Biomass wastes encompass a wide array of materials derived from agricultural, agro-industrial, and timber residues, as well as municipal and industrial wastes.

In Germany the use of bioenergy is to be further expanded. In the agricultural and forestry sectors, a part of the 17 million hectares of agricultural land (approximately 12 million hectares of arable land and approximately 5 million hectares of grassland) and 11 million hectares of woodland are available. For non-food biomass production and especially energy crops are approximately 3 million hectares disposable.

Bioenergy support at the EU level is closely interrelated and derived from with common European climate and energy policy that committed to combat climate change by reducing greenhouse gas emissions and to increase security of its energy supply by substituting energy import by domestic renewables sources. Bioenergy currently accounts for more than two thirds of total renewable energy in the EU. Biomass is a reliable source of energy as it's amply in most parts of Europe, can be produced constantly and has the technically and economically proven technologies for electricity generation as well as production of heat, liquid fuels and biomethane.

The central piece of EU-wide policy for renewable energy supply is Renewable Energy Directive 2009/28/EC (RED Directive) which sets ambitious target of reaching 20% share of renewable energy by 2020. Each Member State has to contribute to this target by transposing the RED Directive into their national legislation and elaborating National Renewable Energy Action Plans (NREAPs) which should outline the most cost-effective ways of renewable energy development in the country, including bioenergy.

Each Member State has a target calculated according to the share of energy from renewable sources in its gross final consumption for 2020, including the share in transport sector (at least 10% of final energy consumption in the sector by 2020).

According to NREAPs, in 2020 the overall share of renewable will reach 20.7% with total contribution of bioenergy of 138.8 mtoe, covering 56.5% of all renewables (see Fig. 1.6). The biomass in Europe is mainly used for heat (75% of the total final energy consumption in 2010) and according to the projections for 2020 heating will continue being by far the most important sector for bioenergy counting 65% of the total and follow by transport with 21% and electricity 14% (AEBIOM, 2012).

The NREAPs must take into account the effects of other energy efficiency measures on final energy consumption (the higher the reduction in energy

consumption, the less energy from renewable sources will be required to meet the target). These plans will also establish procedures for the reform of planning and pricing schemes and access to electricity networks, promoting energy from renewable sources.

Apart of the binding targets the European Commission developed several recommendations for Member States in regard to biomass sustainability criteria, development of biomass action plans, and permitting procedures for bioenergy installations. According to these recommendations, the Member States are motivated to introduce certification schemes for biomass (voluntary and mandatory) in the agriculture, forestry and energy sectors that cover biomass production (land management, cultivation and harvesting), land use, life cycle greenhouse gas (GHG) performance, and energy conversion efficiency (EC COM/2010/11). In 2005 the EC presented the Biomass Action Plan that identified 32 key activities for boosting the bioenergy market and encourage Member States to establish their national Biomass Action Plans (EC COM (2005) 628). Based on 130 real cases of permitting processes covering biofuel, biogas, biomass combustion and co-firing installations the EC also recommended to the Member States to facilitate identified non-technical barriers for the development of bioenergy projects in the EU[2].

1.2.2. Energy Concept and Energy Sector Transforming

In 2000 was made the decision of the German government to gradually phase out nuclear power in Germany. On 28 September 2010, the government adopted an ambitious Energy Concept (Federal Ministry for the Environment 2011b) which lays down the main strategic targets of Germany's energy and climate policy. Nuclear power was considered a bridging technology and the Energy Concept envisaged an average prolongation of the operation of nuclear power plants of 12 years.

However, as a response to the nuclear accident in Fukushima in March 2011, the same government reassessed the role assigned to nuclear power, and revised its previous decision to extend the lifetime of nuclear power plants. It decided on unique gradual phase-out of nuclear power by 2022. The seven oldest nuclear power plants were already shut down permanently.

On 6 June 2011 the Federal Government adopted the energy package, a package of measures to accelerate the transformation of the German energy system (Energiewende) and a financing plan for its implementation. According to official information, the Energy Concept of September 2010 was not changed, except the passages on nuclear power which were replaced due to a decision taken by the Federal Government on the amendment of the Nuclear Energy Act of 6 June

The overall goals of Germany's energy and climate policy can be summarized as follows:

- Reduction of GHG emissions by 40% by 2020, 55% by 2030, 70% by 2040 and by 80 to 95% by 2050, compared to reference year 1990;
- Reduction of primary energy consumption by 20% by 2020 and by 50% by 2050;
- Increase of energy productivity of 2.1% per year compared to final energy consumption;
- Reduction of electricity consumption by 10% by 2020 and by 25% by 2050, compared to 2008;
- Reduction of heat demand in buildings by 20% by 2020, while primary energy demand is to fall by 80% by 2050 (compared to 2008);
- Renewable energy shall achieve an 18% share of gross final energy consumption by 2020, 30% by 2030, 45% by 2040 and 60% by 2050;
- By 2020 renewable energy shall achieve a share of at least 35% in gross electricity consumption, 50% by 2030, 65% by 2040 and 80% by 2050.

2 – Permitting of bioenergy installations in the EU-27: Practical recommendations based on a study of 130 real cases // http://ec.europa.eu/energy/renewables/bioenergy/doc/installations/2009_ecofys_bioenergie_brochure.pdf

The Energy Concept of 2010 includes also several provisions directly referring to bioenergy summarized below:

- Bioenergy remains the most important renewable energy source in 2050. 30% of total primary energy consumption shall be met by biomass;
- Compared to 2008 levels, the amount of bioenergy has to be increased by the factor of 2.5 (reaching 2,200 PJ);
- By 2050 biomass imports shall reach 20% (given 1,760 PJ domestic biomass use in 2050);
- Domestic biomass supply cannot be secured by simply expanding energy plant production, because an additional need of 760 PJ (on top of the estimates for 2020) would require additional 4.1 million ha energy plant-area (not available);
- Without measures to considerably increase the domestic biomass supply (better plant varieties, optimizing agro and forest cultivation systems to obtain higher energy yields, etc.) and without further biomass imports, the overall objectives will hardly be reached.

The Concept also includes a section addressing "Sustainable and efficient use of bioenergy" with the following key provisions:

- Better utilization of domestic bioenergy avoiding utilization conflicts by increased use of organic residues and wastes, agricultural by-products, landscape conservation material and wood from short rotation coppice;
- Increase of energy and land use efficiency through better management practices, more use of biomass in combined heat and power plants, improvement of electricity production from biomass to promote integration of RES into the energy supply system and further development of integrated biomass utilization concepts;
- Better use of biomethane by improved injection into natural gas grids;
- Meeting bioenergy demand by additional imports of sustainable biomass.

2011. The policy package adopted in summer 2011 supplements the Energy Concept of 2010 and accelerates the implementation of measures contained therein. Those measures give a stronger focus on energy efficiency and an accelerated switch to renewable energies.

The Government will develop a coherent, cross-sector biomass utilization strategy taking into account the lessons from the National Biomass Action Plan (nBAP) and the National Renewable Energy Action Plan (NREAP, see below).

The package of measures adopted in summer 2011 envisages, inter alia, a faster expansion of renewable energies and an integration of renewable energies into the overall energy system. The central component of the energy supply of the future will be the continued and rapid expansion of renewable energy sources. To achieve this, the foundations for electricity market that will be increasingly based on renewable energies shall be laid. This calls for optimized coordination of conventional power plants with electricity generation from RES (market and system integration).

Renewable energy sources (RES) must be increasingly able to provide electricity according to demand and to provide system services to ensure grid and supply security. At the same time, storage facilities and an increasingly flexible fleet of conventional power plants will make fluctuating electricity generated from RES more stable.

The concept of the Government offers the following politic measurements:

1. The Government will ensure that only biomass which is produced and used in a sustainable way is counted for quota obligations and is eligible for tax reductions. This applies both for domestic and imported biomass.
2. The Government will evaluate the implementation of the sustainability requirements for bioliquids and transport biofuels applying from 2011 and then decide about a proposal for further action in the European and national context.
3. The Government will advocate at EU level to extend the sustainability criteria of the RED to cover all bioenergy carriers. This should adequately take into account indirect land use changes in the context of GHG balances.
4. The Government aims at avoiding competition between and food and fodder production, and to ensure sustainable and efficient, environmentally sound agriculture and forestry. In this view, potentials of biogenic residues and bio-waste should be unlocked with proper incentives.
5. Biogas should be utilized stronger than today as a transport biofuel, but also in the

electricity and heat sector. Amendments to the Renewable Heat Act are envisaged.

1.2.3. National Plan for the Development of Renewable Energy (2010)

According to Directive 2009/28/EC (Annex I), the share of energy from renewable sources in gross final energy consumption was 5.8% in 2005. Based on this value, Germany is obliged to increase its share of energy from renewable sources by 2020 to at least 18.0%.

On 4 August, 2010 the Federal Government adopted the National Renewable Energy Action Plan (NREAP). In its NREAP the government lists in detail existing and future measures, instruments and policies for achieving the binding RES targets.

The government plans to reach its national 18% target domestically. It considers the cooperation mechanisms as a promising opportunity for target cooperation in the future and is thus interested in its further development. Germany would in that respect consider transferring the currently estimated excess amount of 1.6% RES production to other member states, making thereby use of the cooperation mechanisms.

In its NREAP the Federal Government expects for 2020 to reach a share of 19.6 percent of renewable energy in final energy consumption, hence slightly exceeding the binding national target of 18%. It envisages a 15.5 percent share for renewable energies in the heat/cooling sector, a share of 38.6 percent in the electricity sector and a share of 13.2 percent in transport. These figures do not constitu-

Tab. 1.1. Overview of key policies and measure contained in the National Renewable Energy Action Plan

Name and reference of the measure	Type of measure	Expected result	Target group	Activity existing/ planned	Starting and closing date of the measure
Renewable Energy Sources Act (EEG)	Legisla-tive	Increased share of renewable energies in electricity	Investors, private households	Existing	Start: April 2000 (as a follow-up regulation to the Electricity Feed Act of 1991); amendments in 2004, 2009 and 2011. The law is not limited in time.
Renewable Energies Heat Act (EEWärmeG)	Legisla-tive	Renewable energies in the heating of buildings (focus on new buildings)	Building owners (private and public)	Existing	Start: Jan 2009; first revision in 2011
Market Incentive Programme (MAP)	Financial	Investments in renewable energy in heating	Private households , investors	Existing	Start: 1999, financed from funds established in the EEWärmeG; until 2012
Combined Heat and Power Act (KWKG)	Legisla-tive	New construction, modernization and operation of CHP plants and district heating networks	Power plant, operators, energy suppliers, investors	Existing	Start: April 2002, amended in January 2009
Biofuels Quota Act (BioKraftQuG)	Legisla-tive (Finan-cial)	Minimum share of biofuels in total fuel put into circulation, and tax incentive for certain biofuels	Companies that bring fuels on the market	Existing	Start: January 2007 Duration: beyond 2020 / tax incentive for certain biofuels until the end of 2015

Sourse: National Renewable Energy Action Plan, p. 20, 21

te new targets, but are current estimates or expectations.

The government had already defined and legally enacted sector targets before the NREAP was drawn up. By 2020, for instance, the share of RES in electricity consumption is to be at least 30 percent, the share in the heat sector 14 percent. These sector targets remain valid.

In its NREAP the Federal Government lists in detail existing and future measures (Table 1), instruments and policies for the promotion of the use of renewable energy. The measures and instruments required for achieving the binding RES goals, e.g. the Renewable Energy Sources Act (EEG), have been basically established, but they will be regularly evaluated and further developed in the future. The NREAP also outlines examples of regional and local measures which contribute to achieving the overall goals.

By 2020 the Government expects a further growth of biomass demand to 1,400 PJ compared to 888 PJ in 2008 which means an increase of approx. 60%, of which 1,000 PJ could be covered by domestic biomass (500 PJ from forest-biomass, 400 PJ from agriculture and 100 PJ from waste). The corresponding difference of approximately 400 PJ (9,500 ktoe) between biomass demand and domestic supply in 2020 might be covered through yield increases of energy crops (e.g. breeding), increased energy use of forest wood and landscape management residues, the cultivation of fast growing tree species on agricultural land, future cultivation of energy crops on compensation areas under nature protection law and by future biomass imports. The Government did not further specify the future demand for imports; however, it conceded that imports of woody biomass will likely be necessary to bridge the supply gap. Also imports of biomethane and other biomass sources could become relevant.

1.2.4. Fixed Tariffs for Electricity Production from Biomass

The main support instrument promoting the production of electricity from RES is a feed-in tariff/feed in premium scheme of the Renewable Energy Sources Act (EEG). All relevant technologies are eligible, except for co-firing in conventional power plants (exclusive use of biomass for energy). The access to the e-grid is guaranteed. The scheme grants fixed feed-in tariffs for a period of 20 years. Tariffs are differentiated by technology and size of installation, and are subject to annual degression. There is no general cap on the support. The scheme is not financed by public budgets, but by the final customers.

The German Act on Granting Priority to Renewable Energy Sources (Renewable Energy Resources Act, EEG) from 2000, which was amended in 2004, 2009 and 2011, includes a target of a minimum 30% share of electricity from renewable sources by 2020, which will steadily continue to be increased afterwards. This target is not defined in terms of technology or year.

So far, the EEG envisaged a basic remuneration and various cumulative bonuses for compliance with certain quality and sustainability criteria. There were e.g. bonus payments for the utilisation of renewable raw materials (“Nawaro” bonus), for the utilisation of surplus heat in CHP plants (CHP bonus), and for the use of innovative technologies, such as Stirling engines, fuel cells, or upgrading biogas to natural gas quality (biomethane). In 2009, an additional bonus for the use of manure and landscape conservation materials was introduced. The remuneration and bonus system was completely amended in 2011.

On 30 June 2011 the German Bundestag adopted the "Act on the amendment of the legal framework for the promotion of electricity generation from renewable energies" (Gesetz zur Neuregelung des Rechtsrahmens für die Förderung der Stromerzeugung aus erneuerbaren Energien), which completely revised the EEG. The revised version entered into force on 1 January 2012.

With the most recent amendments to the Renewable Energy Sources Act of 2011, the Federal Government decided to continue the dynamic expansion of RES, making RES more cost-effective and improving market and system integration.

The main changes include a revision of remuneration rates and stimulation of market integration by direct sales (feed in premium). In the case of biomass the new support scheme includes a basic tariff and an additional raw material tariff, de-

pending of the used input material.

The introduction of an optional market premium and a "flexibility premium" for demand-based electricity generation from biomass provides targeted incentives for market and system integration. For the first time, this gives operators of renewable energy installations the opportunity to market their electricity themselves and to create additional revenues by developing optimized processes for demand-based generation.

The cultivation and use of dedicated energy crops (particularly maize) for biogas production came under severe criticism mainly due to potentially adverse effects for visual landscape, and due to socio-economic and environmental risks (e.g. soil erosion, soil compaction, humus depletion, nitrate leaching, biodiversity losses, increasing transport volumes for transporting input material and fermentation digestate).

The Renewable Energy Sources Act (EEG) was amended in 2009 and in 2011 and some of the amendments envisaged to optimize the feed-in tariff support scheme towards more sustainable production and use of biomass with the aim to increase climate mitigation efficiency, resource efficiency and energy efficiency, particularly of biogas use, and to minimize land use conflicts between energy crop, food and fodder production.

The following amendments of 2009 gave more weight to the use of residues (manure, landscape conservation material) and aimed to support energy efficiency and resource efficiency and avoid land use conflicts:

- The basic remuneration rates for small-scale plants up to 150 kW were raised;
- The CHP bonus was significantly increased and new requirements for the use of heat generated during electricity production have been introduced. A positive list of eligible heat use concepts has been introduced (certification by environmental verifiers);
- For new facilities with capacities > 5 MW_e, the basic remuneration only applied to electricity generated in CHP plants;
- For new facilities with capacities > 5 MW_e, the basic remuneration only applied to electricity generated in CHP plants;
- The use of agricultural waste in biogas facilities has been alleviated in that selected plant-derived secondary products may be used together with agriculturally produced renewable raw materials;
- A technology bonus was paid for fermentation of organic waste in combination with subsequent composting of fermentation waste. Thus, use of organic waste for electricity production can be combined with its use as a raw material.

The 2011 amendments which came into effect in 2012 were aimed to improve transparency, to increase market orientation and to avoid proliferation of bonuses. Furthermore, measures have been taken to restrict the utilization of maize, to reduce competition for land and resources and to better reflect the environmental protect-

Tab. 1.2. Feed-in-tariffs for biomass since 01.01.2012 (in €ct/kWh)

	Electric capacity	2012	2013
Basic tariff (1)/(3)	up to 150 kW	14.3	14.01
	150 kW up to 500 kW	12.3	12.05
	500 kW up to 5 MW (8)	11	10.78
	5 MW up to 20 MW	6	5.88
Special tariff for small plants (2)	up to 75 kW	25.00	24.5
Input material category I	up to 500 kW	6/6 (4)	6/6 (4)
	500 kW up to 750 kW	5/2.5 (4)	5/2.5 (4)
	750 kW up to 5 MW	4/2.5 (4)	4/2.5 (4)
Input material category II	up to 500 kW	8	8
	500 kW up to 5 MW	8/6 (5)	8/6 (5)
Biomethane upgrading (6)	up to 700 Nm^3	3	2.94
	700 Nm^3 up to 1,000 Nm^3	2	1.96
	1,000 Nm^3 up to 1,400 Nm^3	1	0.98
Biowaste fermentation facilities (7)	up to 500 kW	16	15.68
	500 kW up to 20 MW	14	13.72

(1) incl. heat use commitment of 60 %; exceptions: biomethane plants with ≥ 60 % slurry/solid manure input
(2) Small slurry plants with ≥ 80 % slurry input
(3) Maximum 60% maize and grain
(4) Bark and forest residues
(5) For slurry and solid manure 8 ct/kWh up to 500 kWe and 6 ct/kW up to 5 MWel
(6) 700 Nm^3/h (ca. 2.8 MWel). 1000 Nm^3/h (ca. 4.0 MWel). 1400 Nm^3/h (ca. 5.5 MWel)
(7) ≥ 90% Biowaste

tion needs. The 2011 amendments give more weight to the use of organic residues compared to dedicated energy crops. The following changes aim to strengthen support sustainable bioenergy production and use:

- The tariff structure has been simplified and harmonized. There is a basic remuneration for 4 capacity based categories in the range of 6-14.3 €ct/kWh. Additional remuneration is available depending on the type of biomass. There are two input material categories: category I (renewable raw materials like e.g. cereals, fodder beet, sugar beet, grass, maize, forest residues except root stock, leaves, needles, wood from short rotation plantations), Category II (ecologically beneficial material like e.g. blooming strips, buffer strips, wildflower growth, poultry manure, clover as catch crop from arable land, liquid manure, straw, landscape management material). The additional remuneration varies in the range of 2.5-6 €ct/kWh for category I and 6-8 €ct/kWh for category II. The remuneration is paid according the energy content of the used input materials;
- There are special remuneration rates for biowaste fermentation plants (14-16 €ct/kWh) and small scale biogas facilities (up to 75 kW_{el}) which use at least 80 per cent liquid manure (25 €ct/kWh);
- By introducing an optional feed in premium operators of RES installations have a direct incentive to operate their plants in a more market oriented way. Direct marketing of electricity is mandatory for biogas installations >750 kW commissioned after 2013;
- The CHP bonus has been replaced by a general energy efficiency requirement. Biogas plants only qualify for remuneration if they comply with basic requirements: at least 60 per cent of the heat produced is used, or the facility is operated using 60 per cent or more of slurry, or the electricity is sold directly. 25 % of the produced heat is calculated for the fermenter heating. In the first year the share of heat use has to be only 25 %. Accepted heat uses are e.g heating, cooling, warm water, wood drying, district heating, digestate processing and ORC; a negative example, which would not be accepted, would be the heating of non-insulated buildings;
- There is an input restriction for biogas plants: the maximum share of maize and grain amounts to 60 per cent;
- A bonus of EUR Cent 1 to 3/kWh is paid for processing and injection of bio-methane. The initial basic tariff decreases by two percent per year, whereas the fuel-related tariff does not change.

The table 1.2 includes the actual basic tariffs, input material bonuses and special remuneration rates for electricity generation from biomass pursuant to the latest version of the Renewable Energy Sources Act. They apply to installations commissioned from 1 January 2012.

1.3. IMPLEMENTATION OF ACTIVITIES IN THE BIOENERGY FIELD

1.3.1. Activities of the Action Plan for Sustainable Development

Bioenergy potentials are not, however, available in unlimited quantities. Hence, promotion of its use, as set out in this action plan, must be seen in the context of promoting use of all other renewable energy sources. And promotion of renewables must go hand-in-hand with great efforts towards reducing energy consumption and improving energy efficiency. Research and development (R&D) provides the foundations for the innovation needed in this regard. R&D activities are supported by the government's High Technology Strategy, which promotes market entry and use of newly developed technologies and practices. This means focusing on market needs from the outset.

Bioenergy offers great opportunities, but to protect nature and the environment it must be

produced sustainably to the same extent as biomass grown for food and feed. Its global contribution to climate change mitigation and to biodiversity conservation is key criteria. Public debate controvert on the impacts of biomass crops on the environment and competition between biomass use and food security. In Germany, acceptance of bioenergy is threatened by fears concerning negative outcomes of non-sustainable production (such as shortened crop rotation) leading to a loss of organic substances in the soil (humus depletion) and to biodiversity loss. There are thus legitimate calls for negative developments to be avoided in the quest for sustainable development.

The actual Renewable Energy Heat Act (REHA) sets out sustainability requirements for the type of biomass used. For example, palm and soya oil produced under non-sustainable conditions may not be used to comply with the Act's obligations to use renewable energy. The Act refers in this connection to the sustainability rules under the Biofuels Quota Act. The amended Renewable Energy Sources Act (EEG) contains sustainability requirements for biomass and these must be further defined in a separate sustainability ordinance. The German government's draft sustainability standards for biofuels, which will finalise these requirements and govern monitoring activities, are now being reviewed in line with the EU Sustainability Directive.

Growing competition for biomass and land on which biomass can be produced must be countered with the following measures (some of which have already been taken):

a) Increase yield per unit area in agriculture;
b) To achieve a sustainable increase in biomass yields on existing arable land, the German government promotes the development and optimisation of regionally adapted models for energy crop production;
c) The breeding of plants with high energy yields per unit of land but minimal use of fertiliser and pesticides plays an increasingly important role. The government has thus made large amounts of research funding available;
d) Further improvement of agricultural production;
e) Promote wider use of waste products and secondary products that do not compete with food production or other uses of biomass as a raw material;
f) Incentives under the Renewable Energy Sources Act (EEG) should be used to foster greater use of silage and unused organic waste, including landscape maintenance waste.

The Federal Government also supports the activities of the Global Bioenergy Partnership (GBEP), a G8 initiative launched in 2005 which cover the issues of biomass mobilisation and supply from biodegradable fractions of municipal waste, industrial waste, sewage sludge etc.

Country wide separate collection of bio-waste and green waste and corresponding composting and anaerobic digestion capacity of around 12 million tons annually exists. The recently adopted amendments of the Recycling and Waste Management Act (Kreislaufwirtschaftsgesetz) and the introduction of compulsory separate collection will lead to a further increase in recoverable biowaste, which will contribute to energy production, such as for biogas, through the established recycling routes. Amendments to the Renewable Energy Sources Act (EEG) aim to promote the extension of existing composting installations through additional fermentation stages, so as further the exploitation of the energy potential of organic waste.

Germany has realised a national ban on landfilling of untreated and biodegradable waste by June 2007 and surpassed the targets of the EU Landfill Directive already. Around 50 mechanical biological treatment plants with 5.5 million tons of treatment capacity stabilize the organic part of the residual municipal solid waste (after separate collection of bio-waste) so it meets the German acceptance and storage criteria for landfills.

1.3.2. Production of Biomethane and Development of Biogas Technologies

The opportunities to feed prepared biogas (biomethane) into the gas grid must be improved in order to exploit efficient ways of using biogas. Boi-methane can be transported via the gas grid to supply heat or fuel, and can also be used in CHP plants and in the transport sector. For this purpose,

Germany's Gas Grid Access Ordinance (GasNZV), Gas Grid Payment Ordinance (GasNeV) and Incentives Ordinance (AregV) have been amended accordingly. These amendments entered into force on 12 April 2008. The most significant changes involve:

a) The setting of a 6 percent target for 2020 and a 10 percent target for 2030 for Germany's gas demand to be met with biomethane;
b) Optimisation of the gas grid access regulations for biomethane (obligation on the part of gas network operators for priority access and priority grid-feed and priority transport);
c) Greater transparency in the modalities for grid connections;
d) The setting of a lump sum for avoided charges for use of the grid;
e) Breaking down barriers in biomethane grid-feed via special provisions in the Gas Grid Access Ordinance and the Gas Grid Payment Ordinance, and by adapting the Incentives Ordinance (e.g. uniform quality standards, longer balance periods, greater scope for flexibility and special terms);
f) Research in line with the High Technology Strategy;
g) Improve efficiency and reduce costs by means of improved processes;
h) Further development of liquid-to-gas processes to provide for efficient use of ligno-cellulose biomass in medium-sized facilities;
i) Research to develop new, efficient combined heat (refrigeration) and power technologies for biomass use.

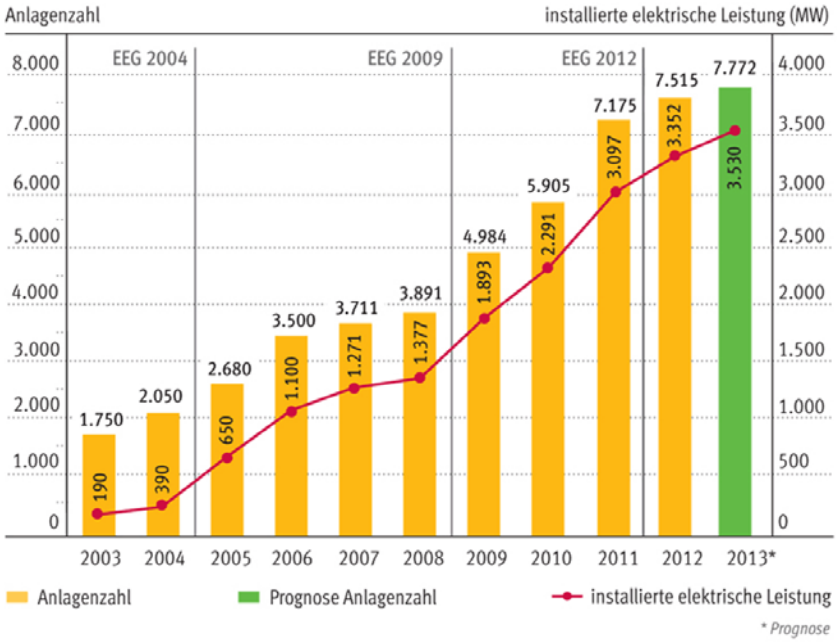


Fig. 1.7. Number of biogas installations and electricity generated from biogas in Germany.
Source: FNR 2013

After the amendments to the Renewable Energy Sources Act taking effect in 2004, dedicated energy crops have been increasingly used for biogas production. In 2011, there were approximately 7,000 biogas plants in operation with an installed electric capacity of 2,728 MW. In 2010, the main input material for biogas plants included energy crops (46% mass related), livestock excrements (45%) industrial and agricultural residues (2%), and biowaste (7%). The dominant energy crop was maize silage (76%), followed by grass silage (11%), whole plant grain silage (7%), cereal grain (4%), sugar beet (1%), and others (1%).

The good framework for implementing biogas projects has contributed to the installation of about 7800 agricultural biogas plants and of many industrial biogas plants (including wastewater treatment plants and landfill sites) with an electrical capacity of about 3000 MW (3 GW) (Fig.1.7).

In 2010, energy maize for biogas was grown on an area of about 530,000 hectares, in 2011 on an area of 700,000 hectares corresponding to 28% of the total area cultivated with maize. There are huge regional differences: in several rural districts of Lower Saxony, the share of maize in total arable land surpasses 60-70%.

Maize offers the highest energy yield and depending on the regional situation maize can contribute to a more balanced crop rotation and biodiversity. The area under maize cultivation rapidly increased in Germany.

Maize offers the highest energy yield and depending on the regional situation maize can contribute to a more balanced crop rotation and biodiversity. The area under maize cultivation rapidly increased in Germany:

- Development of policies for biogas project development including the introduction of feed-in electricity tariffs;
- Availability of a sound biogas industry with mature technical concepts and technologies (including turn-key plants) creating confidence by banks and investors;
- Calculability of the financial risk of biogas

projects due to stable policies, legislation, and due to the accumulated knowledge about biogas in Germany.

In Germany, typical investors in biogas plants are single farmers or farmer societies, several farmers jointly investing in one biogas plant, municipalities, energy utilities, waste companies and industry. The size of the biogas project and the feedstock type influences the capital costs which usually ranges from 2,500 to 6,000 €/kW. The average electrical size of biogas plants in Germany is about 400–500 kW, but the trend of the last years shows a line towards 1 MW. Thus, capital costs are usually too high for financing with equity capital only, and thus, financing concepts usually include a large percentage of debt capital.

2 PRECONDITIONS FOR DEVELOPMENT OF BIOENERGY IN UKRAINE

2.1. GENERAL INFORMATION

The territory of Ukraine is 603,549 km^2. A distinctive feature of the country is the dominance of agricultural land – 70.9% of the territory. About 17.6% is covered by forests, 4.0% - by water, 4.2% by settlements[3]. As for February 1, 2012 the population of Ukraine was 45.6 million people[4] with an average population density 75,6 inhabitants per 1 km^2.

Administrative-territorial structure consists of 24 regions and Autonomous Republic of Crimea and two cities of republican subordination - Kiev and Sevastopol.

The climate in the country is temperate continental with some differences in the Carpathians and the Crimean Mountains being subtropical on the southern coast of Crimea. The average monthly temperature in January is from minus 8 °C in the north-east of Ukraine and the Carpathian highlands to +4° C in the southern coast of Crimea, in July from +17° C in the north-west and +9°C in the highlands of the Carpathians to +23 °C in the south. Precipitation is unevenly distributed, its annual amount decreases in the west and north-west to the south and south-east from 650-600 to 300 mm. Maximum precipitation occurs in the Crimean mountains (1000-1200 mm) and the Ukrainian Carpathians (1500 mm). To the south in the steppe zone the lack of moisture in certain years invokes the droughts.

There are three agricultural zones in Ukraine: forest (Polissya, 6 regions/oblast), forest-steppe (10 oblasts), steppe (9 oblasts), and mountain Carpathian and Crimean regions.

Polissya occupies 19 % of the agricultural land of the country, the leading sector of agriculture is the meat and dairy cattle (more than 25% meat and 20% of milk production in Ukraine). It provides more than 15 % of sugar beet, more than 6% of grain, 7% of the vegetables.

The steppe zone covers more than 40 % of the territory of Ukraine. Animal husbandry (dairy and meat cattle in the north, meat and dairy cattle in the south), swine, sheep and poultry breeding provide about 60% of commercial output produced in Ukraine. Large areas are taken for growing of winter wheat, maize, spring and winter barley, sunflower, millet, peas and rice. Steppe zone produces about 55 % of Ukraine's grain.

In the forest-steppe zone three quarters of sugar beets cultivation lands are concentrated, the production of sunflowers, potatoes, vegetables, wheat, maize grain is developed as well.

Production decline took place in Ukraine since 1992 especially in high-tech manufacturing and engineering industries. By 1999, the gross domestic product (GDP) was less than half of the 1991 level. In the period from 2000 to 2008 recovery of GDP had been observed. Dynamics of Ukraine's GDP development over the last 25 years according to the World Bank is shown in Fig. 2.1.

Fig. 2.1. Development of the Gross Domestic Product of Ukraine.

3 – According to the State Agency of Land Resources of Ukraine. Statistical Yearbook of Ukraine for 2010. State Statistics Committee of Ukraine

4 – State Statistics Committee of Ukraine: http://www.ukrstat.gov.ua/

5 – Source: http://web.worldbank.org/

2.1.1. Energy Complex Structure

Ukraine is a country with a deficit of its own fossil fuels. The demand for natural gas in the country is met through its own reserves for only 35%, whereas 65% of the required amount is imported, mainly from Russia. The share of own resources to meet the oil demand is 10-12%.

The generalized data of 2010 on primary energy consumption in Ukraine, European Union (EU), United States and the worldwide are presented in Table 2.1. Analysis of these data demonstrated that the share of natural gas consumption in Ukraine is unreasonably high - about 43%, which is almost twice higher than, for example, in the EU. Meanwhile the contribution of renewable energy sources (RES) in Ukraine is unreasonably small - about 2.0% which is 5 times lower than in the EU. Mentioned 2.0% from renewable energy sources is mainly provided by biomass (1.24%) and large hydropower plants (0.76%).

Despite the low current level of renewable energy development and energy strategy disadvantages, Ukraine has good preconditions for the future development of renewable energy sources and, in particular, bioenergy. The country possesses a large potential of biomass available for energy production. The main components of this potential are waste from agriculture and public utilities, waste wood, and in prospect also energy crops, growing of which has been actively developing lately.

According to the SEC Biomass data of 2011, an economically expedient energy potential of the existing biomass waste was 24.5 million tons of coal equivalent (718 PJ), and the energy potential of biomass that can be planted on currently unused agricultural land of more than 4 million hectares is about 13.7 million tons of coal equivalent (402 PJ, tab. 2.2). At the expense of biomass waste and energy crops potential it is possible to cover up to 38.2 million tons of coal equivalent which makes up 18% of the total primary energy consumption in Ukraine.

The value of biomass energy potential varies by years and depends mainly on the land use structure and major crops yields (wheat, maize, sunflower, etc.). Over the last 10 years, the economic potential ranged from 25 to 38 Mtce/yr. (Fig. 2.2).

Tab. 2.1. Structure of primary energy sources consumption (%)[6]

Energy source	2010				2030	
	Worldwide	Ukraine*	EU	USA	Ukraine**	EU
Natural gas	20,9	42,4	25,1	25,2	28	24
Oil	32,9	10,0	35,1	36,1	14,5	33
Coal	27,1	27,8	15,9	23,0	30	7
Uranium	5,8	17,8	13,5	9,8	22,5	11
RES	13,1	2,0	9,8	5,6	5,7	25

**According to the energy balance of Ukraine for 2010, compiled by the State Statistics Committee of Ukraine.*

***In contrast to the world practice, the energy balance of Ukraine in 2030 besides the five listed energy carriers includes also rather big share of "other" sources of unknown origin (25.8 Mtce in the basic scenario, or 10.8% of the total energy consumption). The energy balance also includes "heat energy of the environment" (8 Mtce) but its calculation is non-transparent. Therefore, the shares of individual energy sources have been calculated as the ratio of their contribution to the total energy consumption (238.1 Mtce in the basic scenario) after deduction of 25.8 Mtce of "other" energy sources and 8 Mtce of "heat energy of the environment", so that their sum is 100%. The share of large hydro is included in the renewables*

6 – UABIO position paper №1: http://www.uabio.org/ru/activity/uabio-analytics

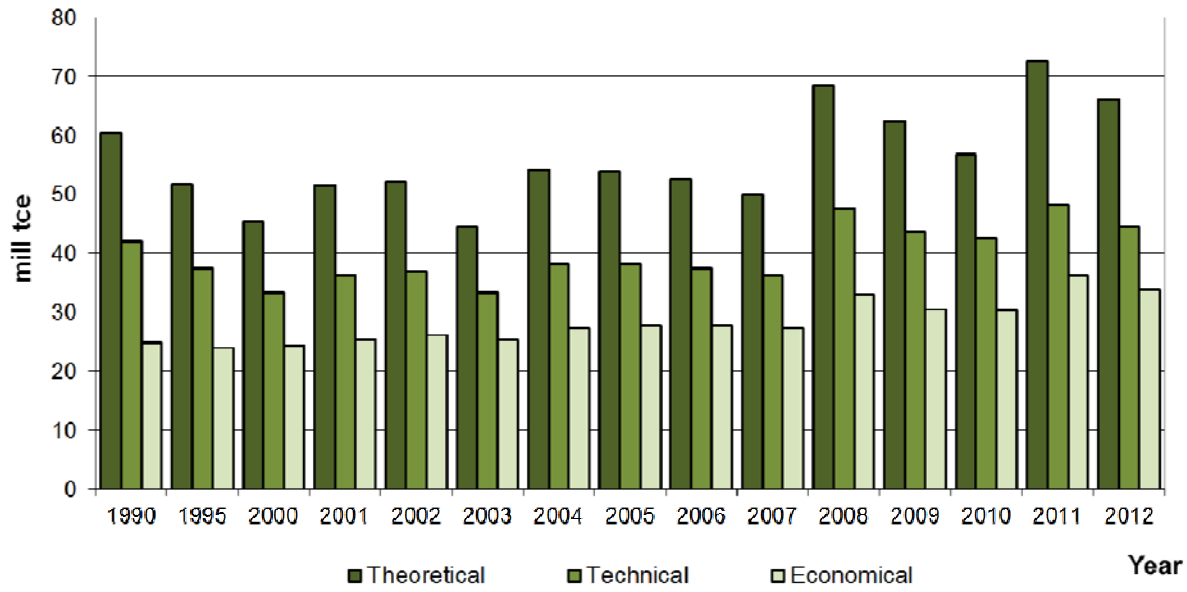


Fig. 2.2. The energy potential of biomass in Ukraine, 1990-2012.

Tab. 2.2. Biomass energy potential of Ukraine for 2011 [7,8]

Biomass type	Total generation, mill t	% of the total amount	Economic potential, Million tce
Strew of cereal crops	32	20	3,17
Straw of rapeseeds	2,9	70	0,96
Residues from the production of maize for grain	34	52	8,59
Residues from the production of sunflower	17	67	5,55
Agricultural by-products (husk, cake)	9,7	77*	0,99
Wood biomass	3,9	89*	1,87
Biodiesel	-	-	0,35
Bioethanol	-	-	2,36
Biogas from manure	-	-	0,35
Landfill gas	-	-	0,26
Sewage biogas	-	-	0,09
Energy crops:			
- poplar, miscanthus, willow, etc.	20	85	10,30
- rape (straw)	3,2	70	1,13
- rape (biodiesel)	-	-	0,77
- maize silage (biogas)	-	-	1,10**
Peat (renewable part)	-	-	0,4
Total	-	-	38,24

**Average*

***Maize silage for biogas production is assumed to be grown at 8% of unused arable land*

7 – G.Geletukha, T.Zhelezna, M.Zhovmir, Y.Matveev, O.Drozdova. Assessment of the energy potential of biomass in Ukraine. Part 2. Energy crops, liquid biofuels, biogas / / Industrial Heat Engineering– 2011, т. 33, № 1, с.57-64. (in Rus): http://biomass.kiev.ua/images/library/articles/potential_2010_1.pdf

8 – G.Geletukha, T.Zhelezna, M.Zhovmir, Y.Matveev, O.Drozdova. Assessment of the energy potential of biomass in Ukraine. Part 1. Agricultural waste and woody biomass / / Industrial Heat Engineering— 2010, т. 32, № 6, с.58-65. (in Rus): http://biomass.kiev.ua/images/library/articles/potential-2010-2.pdf

2.1.2. Agro-Industrial Complex

Prior to January 1998 there were accounted nearly 36 million of small-scale private farms and 8 thousand of large collective farms in Ukraine. The large collective farms were canceled in 2000, the collective ownership was divided into land shares among employees of the former collective farms. In the 2000s there appeared a number of large farms that have started to rent the vacant land from the population.

Reduction of governmental subsidies had a negative impact on the agriculture conditions. It affected reduction of the livestock breeding to a greater degree, and crop cultivation to the smaller degree (Fig. 2.3). At present, agricultural production in Ukraine is gradually increasing. It provides 16-22% of the national income.

In the agricultural land use structure arable land of individual farms and agricultural enterprises holds the domination (Fig. 2.4).

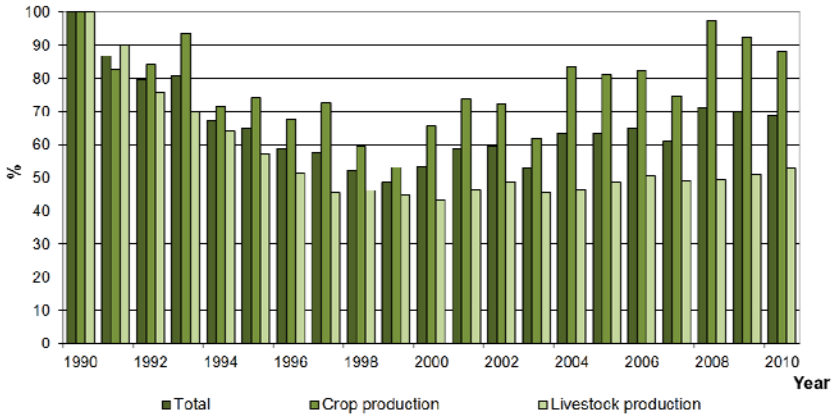


Fig. 2.3. Agricultural production dynamic in Ukraine.
Sourse: State Statistics Committee of Ukraine http://www.ukrstat.gov.ua/

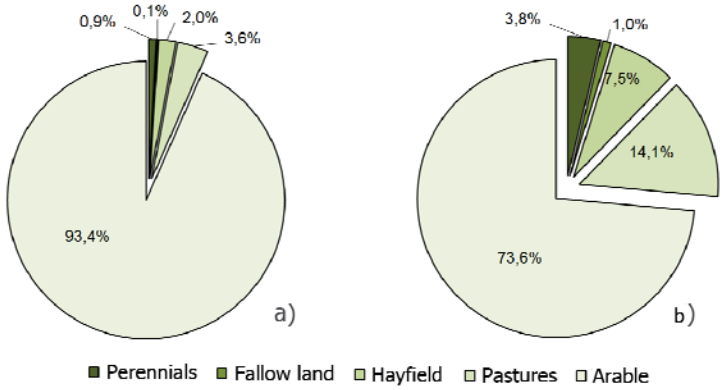


Fig. 2.4. Structure of agricultural land use for agricultural enterprises (a) and individual households (b).

Favorable climate and soil conditions of Ukraine can provide high yields of various crops including grain crops. In the north, there are suitable conditions for growing maize and soybeans. Ukraine is the leader in Europe for sugar beet, buckwheat and carrot production, the country is second on the cultivation of wheat (after Russia) and tomato (after Poland).

Over the past 20 years, the structure of arable land has changed significantly. In particular, the share of land under fodder crops decreased from 37% in 1990 to 9% in 2011, while, as part of the land under industrial crops increased from 11.6% in 1990 to 26.9% in 2011 (Fig. 2.5)

Thus, in the structure of sown areas in 2011 grain crops dominated, followed by industrial crops. Both of these categories showed a tendency to growth, mainly due to increasing of sunflower and rapeseed cultivation.

Decrease in the proportion of forage crops is apparently caused by the low level in Ukrainian livestock production. Over the last twenty years the number of cattle and pigs in Ukraine has consistently decreased. Today, cattle population at the farms of all types equals 5 million heads, at pig farms population correspondingly accounts about 7,000,000 heads. The exception is a rapidly growing poultry population (230 million head).

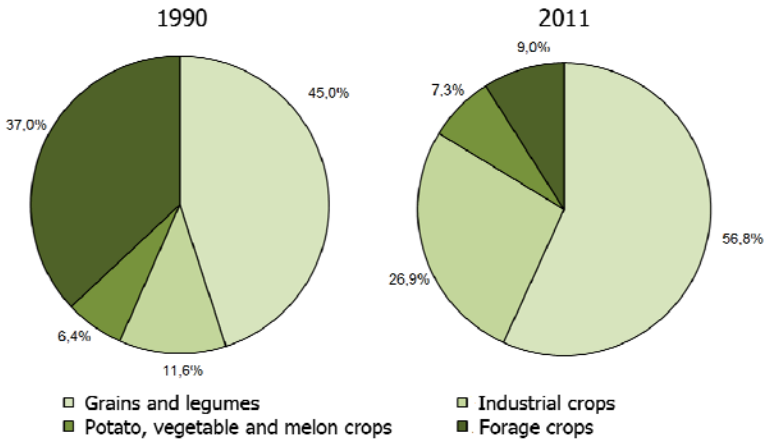


Fig. 2.5. The change in the structure of areas under major crops.

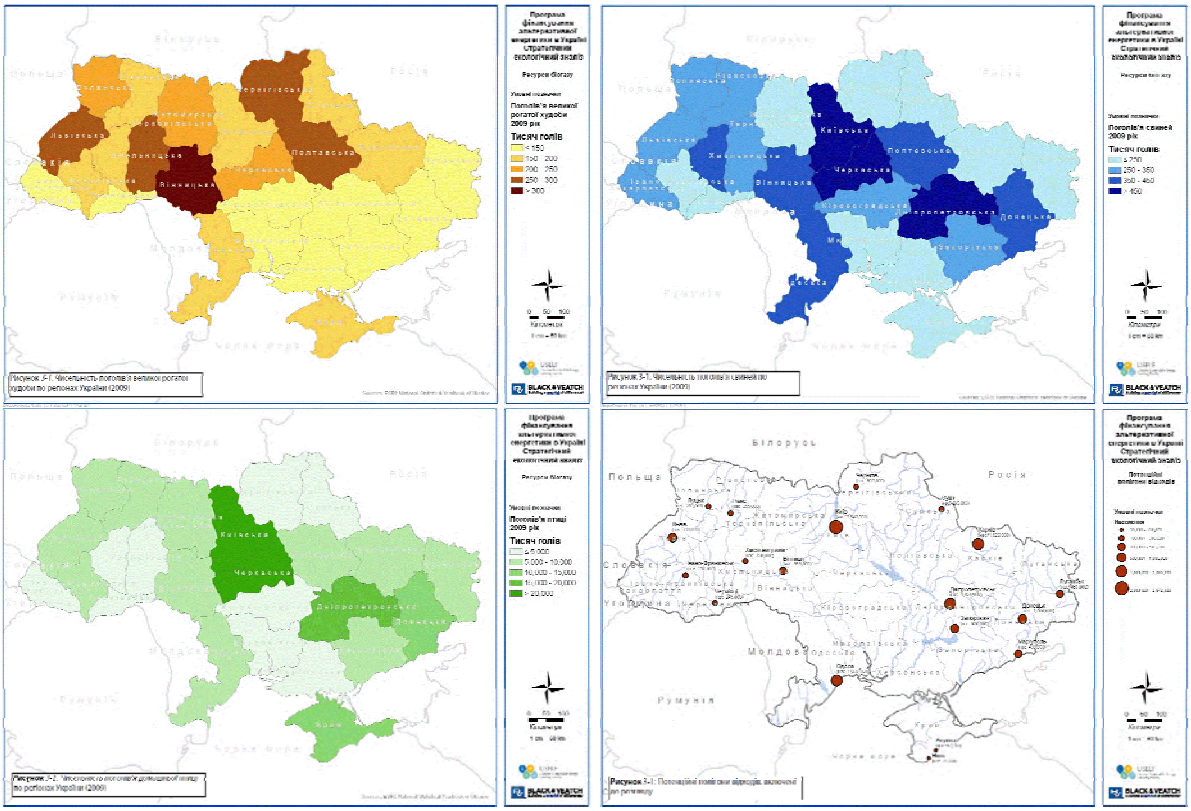


Fig. 2.6. Cattle, pigs, poultry population, and MSW landfills in regions of Ukraine.
Source: USELF

2.1.3. Municipal Services

Every year in Ukraine 10 to 12 million tons of municipal solid waste (MSW) is produced. Most of these waste, mainly from the urban population is delivered for further storage in the landfills and dumps, approximately 2% of MSW is incinerated at two waste incineration plants (WIP) and less than 1% is taken for reuse in existing waste separation plants. At the landfills waste are disposed at partially anaerobic conditions, and as a consequence, generate biogas which can be collected and used for energy purposes. Worth mentioning, that only 75% of Ukraine's population, mostly urban, is covered by a solid waste collection and disposal system. This leads to the formation of a large number of rural small-scale unauthorized dumps. Waste management in Ukraine is poor and needs improving.

As a result of municipal wastewater treatment a significant amount of sludge is produced, the dominant practice of those handling is removal to the sludge fields for drying. Long term storage in the sludge fields creates conditions for generation of methane and other gases released into the atmosphere.

Centralized wastewater systems in Ukraine in 2011 covered 446 cities of 459 ones (97.2 %), 512 of the 885 small towns (61.2 %), and only 727 of the 28,471 rural settlements (2.6%)[9]. The level of the population coverage with centralized sewerage systems was 46.5% in urban areas and 64.8% in urban settlements and 45.6 % in rural areas. In 2011 centralized systems processed 2.2 billion m^3 of wastewater, about 80% of those passed through the full biological treatment[10].

Anaerobic treatment of sewage sludge with controlled methane generation and utilization takes place only at municipal wastewater treatment plant in Kiev (Bortnychi WWTP). Digestion tanks were built in 60-70s of the last century, half of them are no longer functioning.

In general, condition of cities sewerage is characterized by equipment worn-out and technologies obsolescence; it requires a reconstruction, which has to include sludge handling system with equipment for biogas production and utilization.

9 – Centralized sewage system of Ukraine/Ministry of Regional Development, Construction and Municipal service, 2011 (in Ukr): http://www.minregionbud.gov.ua

10 – National report on drinking water quality and drinking water supply sttatus in Ukraine in 2010 / Ministry of Regional Development, Construction and Municipal service 2011. (in Ukr)

2.2. POTENTIAL OF BIOGAS PRODUCTION IN UKRAINE

Biogas potential realization is possible with the use of the three main raw materials groups:

- waste and agricultural by-products – agriculture and food processing industries;
- waste of the municipal services – the organic fraction of solid waste, waste water and sludge;
- specially grown energy crops (such as maize silage).

2.2.1. Potential of Biogas Production from Waste and Agricultural Residuals

In Ukraine, the waste management sphere is regulated by the Law of Ukraine "On Waste"[11] and a number of other laws and legal acts. According to the Law, waste includes any substances and materials formed during the production or consumption, as well as goods (products) that have completely or partially lost their consumer properties and have no further use on the place of formation or detection, and which owner gets rid of or has an intention to get rid of by recycling or disposal.

In energy use potential assessment more extensive approach is applied, where waste means all collected and separated from the target raw materials and products of organic origin, as well as part of the target materials and products unsuitable for consumption.

Agricultural waste can be divided into two main streams: primary and secondary waste. The primary waste include by-products of the target raw material cultivation, excrement generated while animals breeding, as well as off-grade part from the target material; the secondary waste include by-products generated as a result of the target material conversion process as well as off-grade products processing.

Waste total volume can be determined on the basis of agricultural enterprises production volume and products of the food processing industry and also specific waste generation indicators. Only the waste amount that may be collected in the existing technical conditions is estimated. Harvesting and production on the small households is usually not taken into account.

Tab. 2.3. Weight of the main waste categories in 2010 in Ukraine, million tons

Waste category	Total amount	Total solid content	Available amount
Cereal straw	19,4	16,5	7,3
Maize silage and cobs	15,9	8,3	4,5
Sunflower straw	11,2	7,3	3,2
Sunflower seed cake	2,4	2,2	2,2*
Cattle manure	15,4	2,0	2,0
Chicken litter	4,7	1,4	1,4
Sunflower husk	1,4	1,2	0,5
Substandard harvest	2,2	1,1	1,1
Sugar beet tops	5,6	0,8	0,8
Defecate	0,9	0,7	0,7*
Fresh pulp	10,2	0,7	0,5
Pigs manure	5,7	0,6	0,6
Shot	0,6	0,5	0,5*
Other	15,9	5,7	5,7*
TOTAL	111,5	49,1	**31,1**

**Without consumption*

In 2010 the total volume of the primary agricultural waste generation was 111.5 million tons, or 49.1 million tons, based on the dry matter[12]. The main contribution to the agricultural waste formation in Ukraine is made by crops, livestock, sugar and fat and oil industry (see Fig. 2.7).

11 – The Law of Ukraine "On Waste". Bulletin of the Verhovna Rada of Ukraine (VVR), 1998, № 36-37: http://zakon1.rada.gov.ua/laws/show/187/98-%D0%B2%D1%80

12 – SEC Biomass estimation (IFC project – Recovery of Agricultural Waste in Ukraine: Assessment of Potential. Project ID 1055136b, 2012)

By the type of waste categories the most important are cereal straw, maize silage and cobs, sunflower straw and seeds, sunflower seed oil cake, cattle manure, poultry litter, sunflower husk, sugar beet tops (Fig. 2.8).

Part of waste and by-products are used in bioenergy projects (manure, sunflower husks), part is left on field (cereal straw), which is considered in the assessment of the available waste amount (see Tab. 2.3).

The most important agricultural waste types for biogas production include livestock manure, sugar beet cake and tops, molasses, brewery stillage, distillery dreg, substandard harvest of grain and vegetable crops.

AIC of Ukraine has available technical resources of organic waste and by-products for the biogas production in the amount of 2.6 billion m^3 CH_4/year (93 PJ)[13]. Therefore, recycling the most significant waste and by-products in terms of biogas production (livestock, breweries, distilleries and sugar industry) allows to produce about 2 billion m^3 CH_4/year[14] (72 PJ).

Recently, there are investigated the possibilities of ligno-cellulosic materials recycling (straw, dry plant mass) into biogas, using methods for pre-enzymatic and/ or physico-chemical treatment. These technologies are not yet widespread in practice, although their perspective use can expand the raw material base for the biogas production.

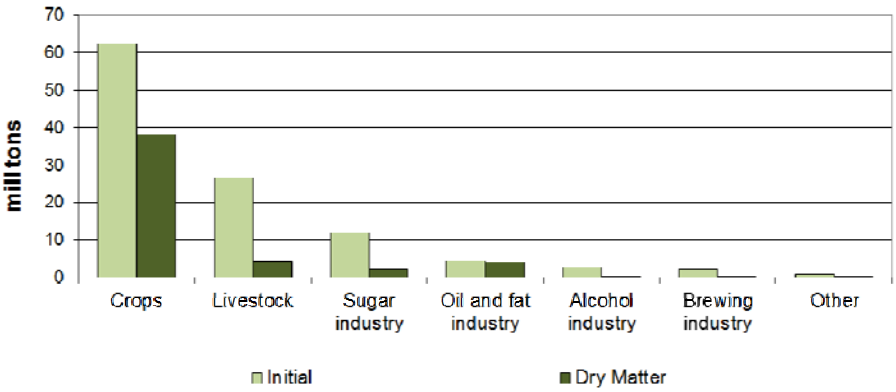


Fig. 2.7. Estimated waste generation at the main sectors of agro-industrial complex of Ukraine.

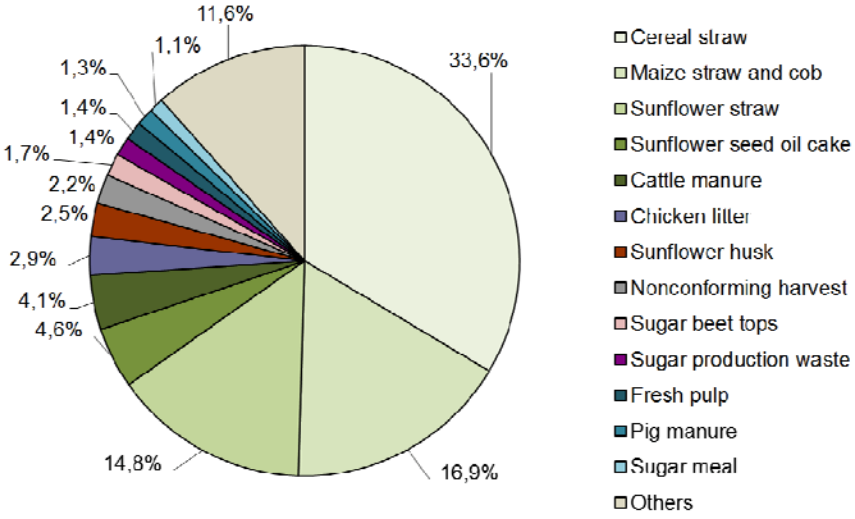


Fig. 2.8. Share of the main waste categories in the total weight (by TS content).

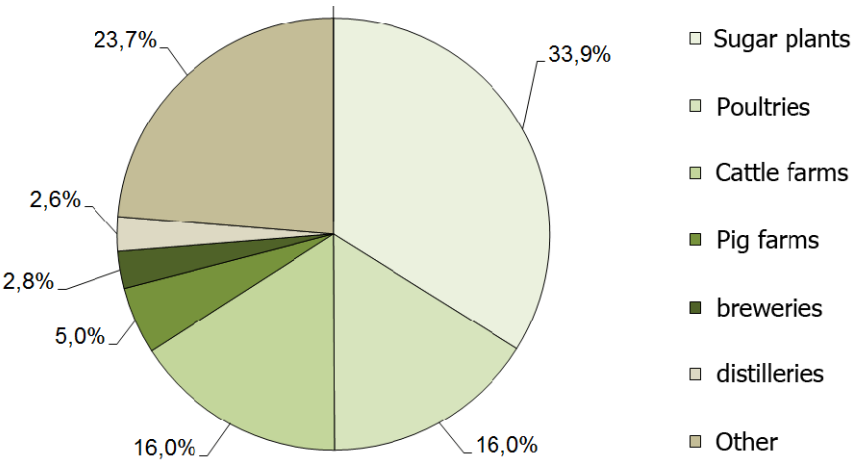


Fig. 2.9. Biogas production potential from agricultural waste in Ukraine.

13 – G.Geletukha, P.Kucheruk, T.Khodakivska, Y.Matveev.Biogas production perspectives in Ukraine. "Renewable energetics", №3, 2011, p.73-77: http://biomass.kiev.ua/images /library/articles/biogas_prospects_re_2011_03.pdf

14 – Source: SEC biomass estimation

2.2.2. Potential of Biogas Production from Energy Crops

To increase biogas energy projects potential and commercial implementation it is important to stimulate the electricity production from biogas obtained not only from biomass waste, but also with the use of specially-grown plants. There are different types of plants that are appropriate for biogas production – maize silage, sweet sorghum, artichoke, clover, switchgrass, and others. Maize grown for the green silage, due to the higher yield of total solid from 1 hectare (up to 30 t TS/ha) by far is the most commonly used substrate in the biogas projects. The temperate climate allows maize cultivation for energy production in Ukraine. Thus, using 6% of arable land for maize cultivation with a conservative value of biogas yield 30 t/ha and methane yield 100 m^3/t, can provide with 5.4 billion m^3 CH_4/year; and while increased yield of 40 t/ha and methane output 115 m^3/t – 8.3 billion m^3 CH_4/year (Tab. 2.4).

Tab. 2.4. Scenarios of arable land use for growing maize aiming to biogas production

Items	Unit	Baseline scenario 2011	Scenario #1	Scenario #2
The total area of arable land	thousand ha	32 499	32 499	32 499
The area under agricultural crops	thousand ha	27 670	27 670	27 670
Free arable land	thousand ha	3 618	1 733	1 733
Fallow area	thousand ha	1 211	1 287	1 287
Area planted for maize silage	thousand ha	0	1 809	1 809
	% of the total area of arable land	0%	6%	6%
	% of the free area of arable land	0%	50%	50%
Maize yield on fresh weight	t/ha	-	30	40
Estimated specific yield of biomethane	m^3 CH_4/t	-	100	115
Total potential of biomethane production	billion m^3 CH_4/year	-	5,4	8,3
The energy potential of biomethane	million tce	-	6,6	10,2

2.2.3. Possibilities to Increase the Capacity of Biogas Production in Agriculture

The possibility of increasing biogas production in agriculture is associated with increased efficiency of agricultural land use and the overall development of agribusiness. The growth of main goods production and the associated growth of waste generation and agricultural by-products suitable for biogas production will extend the base for biogas plants construction.

Achieving the maximum for the last years in Ukraine grain yield of 37 kg/ha under the lack of financing agricultural activities and a peak grain harvest in 2011, were obtained by use of 69 kg of fertilizer per ha, whereas in 1990 the grain was harvested with 141 kg of fertilizer per 1 hectare[15]. Over the years, cereal yields in agriculture of Ukraine ranged from 25-40 t / ha, while the yield of

15 – M.D.Bezuglyi, M.V. Prysiazhnyuk. The current reform status of agro-industrial complex of Ukraine. - K.: Agrar. science 2012. — p. 48. (in Ukr) http://btf-pdatu.at.ua/Tvar-Xm/stan2012.pdf

Tab. 2.5. Grain yield forecast in 2015 and 2017

Crops	2015			2017		
	Cultivation area, thousand ha	Crop yield, c/ha	Gross harvest, million tons	Cultivation area, thousand ha	Crop yield, c/ha	Gross harvest, million tons
Cereals, total	16209	43,8	71,0	16209	49,4	80,0
Including: winter wheat	6000	45,2	27,1	6000	51,6	30,9
Winter rye	300	39,8	1,2	300	44,6	1,3
Winter barley	1200	40,8	4,9	1200	42,8	5,1
Maize	4000	54,7	21,9	4000	60,7	30,4

grain in Germany was more than twice as high (Fig. 2.10). A similar situation is observed in growing other crops, such as maize silage.

National Academy of Agrarian Sciences (NAAS) in collaboration with the Ministry of Agrarian Policy and Food of Ukraine has developed a number of state programs[15]. Prior to 2015 and for the further period, they planned to increase the production of grains, oilseeds and other crops, deeper processing of oilseeds, sugar beets, fruits, berries, vegetables and potatoes. In the basis of the production volume increase there is a yield growth through better land use, tillage, fertilizing improvement, plant protection, development of selection and market infrastructure.

For example, according to the author's opinion, program implementation would contribute to a grain gross yield in 2015 at the amount of 71 million tons (Tab. 2.5). This production will fully satisfy the state's need for food and forage grains, as well as raw materials for industrial processing. Vast majority of the grain yield can be used for export. In 2017 grain production may increase to 80 million tons. This result is anticipated be achieved using 16.2 million hectares, i.e. without an increase of planted area. The implementation of these programs could provide 15 million tons oilseed, 10 million tons of vegetables, 2.5 million tons of fruits and berries and 3.33 million tons of sugar production.

NAAS jointly with the Ministry of Agrarian Policy and Food of Ukraine also developed a national project "Revival of cattle breeding." The project is expected to increase milk production to 15.4 million tons, beef production in live weight - up to 1.02 million tons (in slaughter weight - up to 0.6 million tons), to increase the cattle population on farms by 100 thousand heads (from 2.63 to 2.72 million heads), to bring the percentage of cows on farms with 1,000 heads or more from 11.2 to 16.8 and the amount of milk produced by agricultural enterprises from 2.2 to 4.8 million tons.

In the case of increasing agricultural production in Ukraine, biogas production potential will grow proportionally. The potential feasibility of ambitious NAAS plants and plans of the Ministry of Agrarian Policy and Food of Ukraine to increase production of basic agricultural products is confirmed by independent studies on Ukrainian agricultural land use efficiency.

In particular, the Dutch researchers[16] showed that in case of the intensive agricultural development scenario, similar to developed countries, domestic demand for agricultural products in Ukraine can be met by using half of the agricultural land already in 2030. Free land can be used for agricultural production for export, or to produce biofuels (biogas from maize silage, biodiesel and bio-ethanol from energy crops).

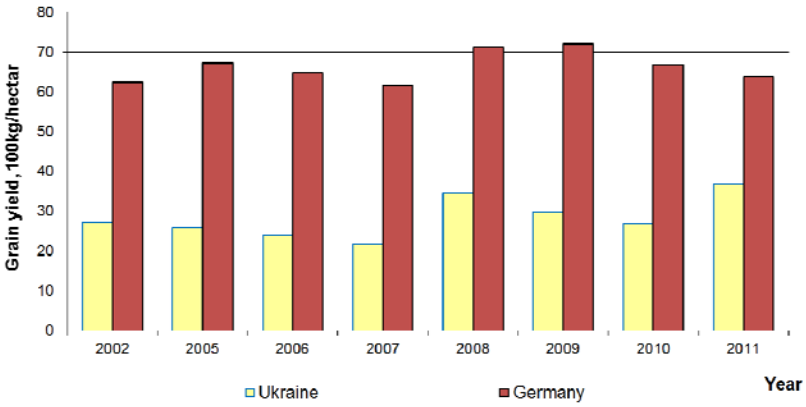


Fig. 2.10. Dynamics of grain yield in Ukraine and Germany, c/ha

Similar conclusions were done by German experts in project framework "European strategy

16 – Floor van der Hilst. Shades of Green. Spatial and temporal variability of potentials, costs and environmental impacts of bioenergy production, 2012

for sustainable use of bio-methane"[17]. According to the authors, the potential use of agricultural land consists of the fallow land use resumption and increasing productivity. The yield increase potential is equivalent to the area extension by 7 million hectares, and the total yield increase and fallow land use by 20 million hectares. This potential use is equivalent to getting 40 billion m^3 CH_4/year (1440 PJ).

Thus, the existing potential of agricultural land in Ukraine allows combine the production of food and forage, including for export, with energy crops production and the subsequent generation of electrical and/or thermal energy, and bio-methane - a direct substitute for natural gas. Fast-growing plantations can be used for energy crops, such as willow, poplar or miscanthus to produce solid biofuels, sunflower or rape for biodiesel production, and maize, soybean, various herbs for production of biogas.

In the case of Ukraine, the energy use of the lands is not an alternative to food production, but the additional opportunity of agriculture intensification and its profitability increase. Thus, the priority for biogas production should remain the use of agricultural waste generated, including waste from food production.

Land resources usage, including for energy needs, requires an understanding of the current situation with soils fertility, and potential ways to increase it. Ministry of Ecology and Natural Resources of Ukraine notes the trend toward soil quality deterioration: decreasing reserves of humus, nutrient content; and increasing acidification, salinization, soil de-structuring[18]. Due to the excessive plowing, inadequate organic fertilizers application, Ukrainian soils are degrading. According to the State Statistics Committee, the use of organic fertilizers is carried out at 2% of cultivated area; up to 20% of the land is not fertilized[19].

During 1986-2010 humus content in the soil decreased by 0.5%. Considering that about 10 years will be required for its content increase by 0.04 %, these losses will have to be compensated for decades. One of the main reasons for this is a significant reduction in organic fertilizers intrusion.

Over the past 20 years, the organic matter intrusion decreased from 8.6 tons per 1 ha of arable land in 1990 to 0.5 tons per 1 ha in 2011.

All this points to the urgent need for increase the share of organic fertilizers application. In this regard, widespread biogas technologies implementation will be an important and effective mechanism, as recycled by anaerobic methods organic waste is high-quality organic fertilizer, devoid of pathogenic organisms, weed seeds, unpleasant odor.

Agronomic advantage of energy crops cultivation for biogas production is the fact that actually all of the nutrients mass (nitrogen, phosphorus, potassium, trace element) taken from the field while harvesting may be returned into agro technological cycle with fermented mass in plant-available mineralized form. As a result, soil fertile properties are conserved. Herewith it is important to maintain the optimum crop rotation to avoid the agro-ecological problems associated with long-term cultivation of monoculture in a limited area.

2.2.4. Biogas Potential in Residential Sector (Municipal Solid Waste and Sewage)

SEC Biomass estimated theoretically possible biogas emissions potential, which is determined by the municipal solid waste amount disposed at the landfills and share of municipal solid waste, decomposing under anaerobic conditions to produce biogas in 2010, was equal to 470 thousand tce (14 PJ).

Technically accessible potential of landfill gas collection is determined by the gas collection efficiency at the sites of various sizes. Estimation for

17 – Schierhorn F., Müller D., Hahlbrock K., Balmann A. Agrarflächenpotentiale in der Ukraine, presentation held at Nachhaltige europäische Biomethanstrategie: Konferenz Ukraine, Kiew/Ukraine, 21.06.2011 - 22.06.2011

18 – National Report on the State of Environment in Ukraine in 2011. -Kiev: Ministry of Ecology and Natural Resources of Ukraine LAT & K. – 2012. – 258 c. (in Ukr)

19 – Mineral and organic fertilizing for crops yield in 2012 / Statistical Bulletin / State Statistics Committee of Ukraine. - Kyiv, 2013 (in Ukr)

2010 is 316 thousand tons of coal equivalents (9.3 PJ). Economically feasible energy potential of biogas is determined by viability of biogas use at landfills serving a population of no less than 100 thousand inhabitants, for 2010 it is 266 thousand tce (7.8 PJ). Thus, about 57% of the total biogas produced at Ukrainian landfills and dumps is appropriate for economically feasible use.

To increase biogas generation and energy utilization potential at the landfills, landfill operation practice should be improved and LFG collection at the early stages of the landfill operation is to be ensured. The strategic direction should comprise the reduction of landfills total number by building large regional landfills that would reduce the costs of their operation, as well as increase LFG collection volume and its energy utilization.

The increase in generating capacity and energy utilization of biogas from MSW may be associated to mechanical-biological treatment methods of solid waste in digesters that prevent untreated waste landfilling. Currently, these technologies are not applied in Ukraine, but they are expected to develop in future due to the expected limitation of unprocessed waste disposal at the landfills.

In the waste water biological treatment process, sludge with water content 96...99% is evolved. The traditional practice of handling this sludge is drying on the open fields with a possible subsequent removal beyond the treatment station. For long term storage on the sludge drying fields the natural processes of organic contaminants anaerobic decomposition with methane release into the atmosphere take place.

Anaerobic treatment of sewage sludge in controlled bioreactors can produce up to 6 m^3 of biogas from 1 m^3 of sludge. Biogas production potential from the sludge of wastewater entering the centralized sewerage system and extending full biological treatment in wastewater treatment plants is 85 million tce (2.5 PJ).

2.2.5. Biogas as an Energy Source, and Not Only

It would be wrong to limit the biogas production only for obtaining an additional renewable energy source. The development of biogas technology creates a combined positive effect, including both the energy and the environmental and social aspects, as well as contributes to the fertile land revival.

The energy aspect of the benefits of biogas technology is connected to the stability of the electricity production from biogas during the year, which allows covering grid peak loads including the case of unstable renewable energy sources use such as solar and wind power. The methods of biogas energy utilization are almost universal. Biogas can be used for electrical and/or thermal energy generation at the location of its generation, and at any facility connected to the natural gas network (in the case of feeding the purified biogas to the NG network) and also as a motor fuel.

Biogas production from plant substrates results in more efficient energy use of arable land compared to the production of liquid fuels (bioethanol and biodiesel). It is proved[20] that in case of biogas production from maize silage, net energy production by 1 hectare of arable land is from 2… 4 times higher compared to the bioethanol or biodiesel production. The environmental effect of biogas technology consists in prevention of harmful substances discharge into the atmosphere, soils and groundwater. Formation, accumulation and storage of agricultural waste, as well as storage of solid and liquid wastes from public sector lead to an increase in environmental pollution and increased risk to human health. This is primarily due to emissions of methane, which is produced by waste biodegradation and is a harmful greenhouse gas. Along with methane emissions, a danger to the environment is related with other harmful substances (ammonia, hydrogen sulfide, etc.) emissions, which cause contamination of large areas around the waste accumulation sites while releasing into the air, soil and groundwater. Biogas technologies application, where anaerobic digestion process is controlled, as well as biogas collection systems at landfills, significantly reduce greenhouse gas emissions and hazardous substances discharge into air, soils and groundwater.

One should mention the problems associated with the odors spread and methane burning at the landfills and dumps with the formation of dioxins and furans. To the date, one of the most appropriate methods of organic waste recycling

20 – State Institute of Agricultural Engineering and Bioenergy, Universitat Hohenhaim. Germany, 2009

remains an application of biogas technology, where controlled process of anaerobic digestion is implemented. In the issue of biogas technology application in agricultural sector, it is possible to obtain useful fermentation products - organic fertilizer. Agronomy effect of the fermented mass use in agricultural fields results in the improved soil structure, regeneration and increase fertility by application the nutrients of organic origin.

Digestate separation into the solid and liquid fraction facilitates its use. The solid fraction can be transported over long distances; the liquid fraction is applied on the nearby field in a favorable time of year, for example, after the harvesting. The development of organic fertilizer market in the long term perspective will contribute to the development of organic farming and market of environmentally friendly agricultural production and, as a consequence, increase competitiveness with similar markets in the EU.

Biogas technologies development leads to the jobs creation through the formation of a market chain from biomass suppliers to energy facilities operating personnel. In Germany, the bioenergy sector outperforms all other sectors of the renewable energy sources in the number of jobs created 122 thousand jobs, as of 3/2011)[21].

2.3. MAIN PLAYERS

The following relevant ministries, agencies and organizations are related to the bioenergy development in Ukraine:

Ministry of Economic Development and Trade of Ukraine (*http://www.me.gov.ua/*) creates and implements the state policy in the field of economy and trade. The Ministry is responsible for the implementation of regulatory policy, government policy on business development and pricing policy regulation.

Ministry of Energy and Coal Industry of Ukraine (*http://mpe.kmu.gov.ua/*) deals with energy policy issues of Ukraine and the implementation of the program of economic reforms in the country's energy sector.

Ministry of Agrarian Policy and Food of Ukraine (*http://minagro.gov.ua/*) ensures the implementation of the agrarian policy.

Ministry of Ecology and Natural Resources of Ukraine (*http://www.menr.gov.ua/*) is the main governmental body in state policy formation and realization in the sphere of environmental protection, waste management, sustainable use, reproduction and conservation of natural resources.

Ministry of Regional Development, Construction and Municipal Services of Ukraine (*http://minregion.gov.ua/*) is responsible for the forming and implementing a state housing policy and policy in the field of construction, architecture, urban planning and housing and communal services.

Ministry of Industrial Policy of Ukraine (*http://industry.kmu.gov.ua/*) is responsible for the concept development of the state industrial policy and ensuring its implementation, as well as for the development of high-tech products and services on the basis of innovation, increase the level of scientific support for the industries development.

Ministry of Education and Science of Ukraine (*http://www.mon.gov.ua/*) ensures the implementation of the state policy in the field of education, research, science, technology, innovation and intellectual property.

The purpose of the **National Academy of Science of Ukraine (NASU)** (*http://www.nas.gov.ua/*) activity is to obtain new and summarization of current knowledge, the establishment of scientific, technical, socio-economic and cultural development of the country, the training of highly qualified scientific personnel. National Academy of Sciences organizes and carries out fundamental and applied research, and coordinates research in academic institutions and organizations of Ukraine. To the renewable energy problems at the National Academy of Sciences there are involved Institute of Engineering Thermophysics, Institute of Gas, Renewable Energy Institute, the Institute of Economics and Forecasting.

21 – Production and use of biogas in Ukraine / Biogas issues council Biogasrat e.V., May 2012 (in Ukr)
http://ua-energy.org/upload/files/Biogas_ukr.pdf

The main task of **National Academy of Agrarian Sciences** (*http://www.uaan.gov.ua/*) is scientific support of agricultural development in Ukraine: fundamental research, the development of innovative products based on new knowledge for the scientific development of agricultural sector.

The activity of the **State Agency on Energy Efficiency and Energy Saving of Ukraine** (*http://saee.gov.ua/*) is aimed at improving energy efficiency and energy conservation. The main Agency objective is creation of the state monitoring system of energy production, consumption, exports and imports.

The State Agency of Ukraine for Investment and Development *(http://in.ukrproject.gov.ua/*) takes part in the state policy formation and realization in the sphere of investment and innovation; promotes investment, enhancing local capacity for the export of products manufactured by enterprises.

National Energy Regulation Policy, (*http://www.nerc.gov.ua/)* performs state regulation of activities in the fields of power and heat supply, including using non-traditional or renewable energy sources; ensures the price and tariff policy in the energy sector and oil and gas sector.

Public Union "Bioenergy Association of Ukraine" (*http://www.uabio.org/*) has been established to create a common platform for cooperation on bioenergy market in Ukraine in order to ensure the most favorable business environment, accelerated and sustainable development of bioenergy sector. Association was officially registered on April 8th, 2013.

2.4. REGULATORY AND LEGAL FRAMEWORK FOR THE BIOGAS PRODUCTION AND ENERGY GENERATION

2.4.1. Support and Stimulation of the Biogas Production

In different countries to stimulate energy production using RES and biogas in particular, the following economic and administrative mechanisms are applied:

- Market price and often even "super-market" (that is overcharged at the expense of extra taxes) price of fossil fuels (natural gas, oil products, and coal);
- Special-purpose increased tariffs for power produced from renewable energy sources – so called Green Tariffs (the EU's term is "feed-in tariff"), or an alternative mechanism – Green Certificates;
- Subsidy (reimbursement) to a final user for purchasing energy-saving or RE equipment. Subsidizing the final consumer, and not the equipment manufacturer does not violate the market competition principle among the equipment manufacturers and does not hinder the equipment improvement;
- State investment grants and subsidies when the government fully or partially covers the capital cost of implementing certain types of bioenergy equipment;
- Tax benefits. One example of this support tool is a CO_2 emissions tax, compulsory to pay by producers of energy from fossil fuels; meanwhile this tax does not apply for biomass and biofuels. Another example is reduced VAT on biofuels sale and use;
- Financing on favorable terms through a special program funds;
- Working state programs with enough ambitious targets for the development and careful planning of energy efficiency and renewable energy sector development. This is reflected in the adoption of government programs, "action plans", energy strategies with clear mandatory objectives, and the development of appropriate mechanisms for their implementation and financing.

In Ukraine, only a few of these incentive mechanisms are in use; those can be conditionally divided into the following categories:

- "green" tariff for electricity produced from renewable energy sources;
- tax benefits.

Green tariff presents the economic and political framework designed to encourage investment in renewable energy technologies. This mechanism is based on three main factors:

- fixed, usually high, electricity cost;
- guaranteed network connection;
- long-term contract on the purchase of all renewable energy produced.

According to the Law of Ukraine "On Electricity" #575/97-BP from 16.10.1997"[22] "green" tariff is a special rate at which electricity produced with the use of alternative energy sources purchased. The wholesale electricity market of Ukraine represented by the state enterprise "Energy market" is obliged to buy electricity on the "green" tariff. In 2012, of the Law of Ukraine "On Amendments to the Law of Ukraine "On Electricity" concerning stimulation of power generation from alternative energy sources" (№ 5485-VI of 20.11.2012). For electricity produced from biogas, green tariff guaranteed by law comes into force on since April 2013, and its value is 0.1239 Euro/kWh without VAT (with a coefficient of 2.3).

The procedure for green tariff obtaining is quite complicated[23]. It involves the development of feasibility study, the registration of a legal entity, obtaining a deed of ownership (usage) to the land plot, drafting project documentation, equipment selection according to the feasibility study, the conclusion of agreement on a grid connection, Certificate issued by State Architectural and Construction Inspectorate or a Registered Declaration on Readiness for Exploitation (RDRE), obtaining license and award of green tariff by NERC, Gaining Membership in Wholesale Energy Market (WEM) and, finally, the conclusion of contracts for electricity sale on "green tariff".

Unfortunately, the existing Law "On Electricity" has been holding back the development of bioenergy in Ukraine. The proposed green tariff for power generated from biogas with coefficient 2.3 (for the plants which are put into operation from 01.04.2013 to 31.12.2014) is absolutely insufficient for the development of biogas technologies. At that ratio, payback period is more than 10 years, making biogas projects unsuitable for investment.

The Law introduces the incorrect definition of term "biomass", which does not apply to products of forestry and agriculture, as well as unjustified requirement concerning 50% domestic share of the equipment used. The last requirement will apply to:

- biomass power plants, construction of which was started after 01.01.2012 and which will be commissioned after 01.07.2014;
- biogas power plants, construction of which was started after 01.01.2012 and which will be commissioned after 01.01.2015.

Another mechanism to stimulate biogas projects implementation is legislatively provided tax benefits.

Thus, according to the Tax Code of Ukraine[24]:

- temporarily, for a period of 10 years starting from January 1, 2011 income derived from operations of electric utilities (class 40.11 of Chapter 40 of Ukrainian Industry Classification System 009:2005), which produce electricity exclusively from renewable energy sources will be exempt from taxation;
- temporarily, until January 1, 2020 income received by enterprises from the activity for combined electrical and thermal energy production and/or thermal energy production from biofuels will be exempt from taxation;
- electricity produced from RES is exempt from the fee payment in form of target premium to the current tariff for power and thermal energy;
- land tax provided for placing units that produce electricity from RES, will be charged at the rate of 25% from set value.

Also, temporarily, until January 1, 2019 the following operations are exempt from value added tax (subsection 2 of section XX of Tax Code) and on payment of a custom duty (Chapter XXI of the Customs Code of Ukraine[25]):

- the supply of machinery, equipment, devices specified in Article 7 of the Law of Ukraine "On Alternative Fuels", on the territory of Ukraine;
- imports by commodity classification codes

22 – The Law of Ukraine "On Electric Power Industry" (№ 575/97-BP from 16.10.1997) (in Ukr) http://zakon4.rada.gov.ua/laws/show/575/97-%D0%B2%D1%80

23 – Source: http://saee.gov.ua/wp-content/uploads/2012/05/RUS_GT_final.pdf

24 – Tax code of Ukraine. Law #2755-VI from 02.12.2010 (in Ukr) http://zakon1. rada.gov.ua /laws/show/2755-17

25 – Custom code of Ukraine. Law # 4495-VI from 13.03.2012. (in Ukr) http://zakon4.rada.gov.ua /laws/show/4495-17

of Ukrainian Foreign Economic Affairs defined by Article 7 of the Law of Ukraine "On Alternative Fuels", technology, equipment used for the reconstruction of existing and construction of new plants for the production of biofuels, if such goods are not produced in Ukraine. In particular, these types of equipment include steam boilers, boilers for central heating systems and auxiliary equipment, gas generators, internal combustion engines, burners, etc.

The order of import these types of machinery, equipment, technics and vehicles is defined by the Cabinet of Ministers of Ukraine[26].

Tax-exempt import to the customs territory of Ukraine covers the following categories:

- equipment operating on renewable energy, energy-efficient equipment and materials, equipment and materials for the alternative fuels production or energy generation from renewables;
- materials, equipment, components used to manufacture equipment that runs on renewable energy, raw materials, equipment and components to be used in alternative fuels production and energy generation from renewables;
- energy-efficient equipment and materials, products which operation provides savings and rational use of energy resources.

The tax benefit can be obtained if these products are used by taxpayers for their own production, and if the same goods with the same quality characteristics are not produced in Ukraine. The list of such products with the commodity classification codes indication is established by the Cabinet of Ministers of Ukraine[27].

80% of corporate profits earned from the sale of own-produced commodities in Ukraine according to list established by the Cabinet of Ministers of Ukraine are tax-exempt[28]:

- equipment operating on renewable energy;
- materials, raw products, equipment and components to be used in of energy generation from renewables;
- energy-efficient equipment and materials, products which operation provides savings and rational use of energy resources;
- equipment for the production of alternative fuels.

Among other items, the list of these commodities include solid biomass boilers with an efficiency of 80 % and above, biomass gasifiers with an efficiency of 85 % or higher, heat-generator on alternative fuels (which includes biofuels) with a capacity of 3 kW_{th} and more and efficiency from 80%, cogeneration plants on biogas from waste and other types of equipment. The tax benefit is valid for 5 years since the first profit earning from productive energy efficiency improvement.

50% of the profits from the implementation of energy efficiency measures and the realization of energy efficiency projects of the companies included to the State Register of enterprises, institutions and organizations that carry out the development, implementation and use of energy efficiency measures and energy efficiency projects, are exempt from taxation. The register is kept in the SAEE[29]. The tax benefit is valid for 5 years from the date of the first profit earning from productive energy efficiency improvement.

There exist the laws that indirectly affect the prospects for biogas production. For example, on 2 October 2012, the Law № 5400 -VI and 5402 –VI was adopted regulating activities in the field of waste removal and disposal and prohibiting untreated waste dumping from January 1, 2018[30]. Requirement to waste processing before disposal at the landfills will encourage different methods of solid waste recycling including anaerobic ones with biogas production.

July 8, 2010 Law of Ukraine "On functioning principles of the natural gas market" was adopted

26 – CMU Decree "On Approval of the Procedure for import into the customs territory of Ukraine appliances, equipment, technics and vehicles used for the development of production and consumption of biofuels» № 581 from 18.05.2011 (in Ukr) http://zakon2.rada.gov.ua/laws/show/581-2011-%D0%BF.

27 – CMU Decree "Issue on energy-saving materials, equipment and components import into the customs territory of Ukraine» № 444 dated 14.05.2008. (in Ukr) http://zakon2.rada. gov.ua/laws/show/444-2008-%D0%BF

28 – CMU Decree "On approval of the list of own produced goods, which 80 percent of the profits from the sale at the customs territory of Ukraine shall be exempt from taxation» № 1005 from 28.09.2011. (in Ukr) http://zakon0.rada.gov.ua/laws/show/1005-2011-%D0%BF.

29 – SAEE Decree "On approval of the inclusion into the State Register of enterprises, institutions and organizations involved in the development, implementation and application of energy-saving measures and energy efficiency» (№ 49 from 01.04.2008) (in Ukr) http://zakon4.rada.gov.ua /laws/show/z0318-08

30 – Source: http://www.rbc.ua/ukr/news/rubric/v-ukraine-opublikovan-zakon-o-zaprete-zahoroneniya-nepererabotannyh-05112012114400

In accordance with Article 7 of this law, all subjects of natural gas market have equal rights of access to the unified gas transportation system (GTS) of Ukraine". The Act does not mention biogas; thus, in practice, the potential Ukrainian producers of upgraded biogas (biomethane) are devoid of access to the Ukrainian gas transportation system. The issue has also not been resolved by the Decree "On Approval of the Procedure for access to the gas transportation system of Ukraine".

Biogas trade is a subject of licensing. This is fixed in the Law of Ukraine "On licensing certain types of activities". Thereby, the license conditions for the implementation of economic activity on biogas sale are not developed, as well as the requirements for the biogas quality and the method of its determination to introduce mandatory standards and norms.

2.4.2. Strategy of Bioenergy and Biogas Production Technologies Development

The basic policy document that defines the trends of Ukraine's energy sector development till 2030 is a draft of the updated Energy Strategy to 2030. The analysis shows that the directions of Ukraine's energy sectors development, proposed in the draft updated Energy Strategy are opposite to the trends in the EU's energy. Thus, Ukraine is going to enlarge consumption of coal and use of nuclear energy. In addition, Ukraine actually plans stagnation of RE sector. According to data of 2010, the share of renewable energy in Ukraine's total energy balance is 5 times less than in the EU. By 2030 the situation will remain almost the same.

The goals for power production from biomass set in the updated Strategy are significantly underestimated. Thus, in 2030, the share of biomass in the total primary energy resources consumption will be only 1.4% (Tab. 2.6). For comparison, in the EU in 2030, the share of biomass in the final gross power consumption is expected to be 19%. At present Ukraine is behind the EU as for the biomass share in the final gross power consumption by 5,4 times, and in 2030 the lag may reach 15,3 times.

Thus, the document suggests a negligible bioenergy contribution into the energy balance of the country in 2030, the possibility of the bioenergy sector in general and biogas technologies in particular have been virtually ignored.

In Ukraine, there is practically no coherent national policy for the development of renewable energy in general and bioenergy in particular. Defined goals for RES are significantly different in various state programs. The most ambitious of those - 30% renewables in energy balance to 2030, contained in the draft concept of the State target scientific and technical program on renewable energy development until 2030, the least ambitious - 10% of the total renewable energy installed capacity of electricity generation in 2030 was in the draft updated Energy Strategy of Ukraine till 2030. Goals for biogas in the latter document are absent.

Tab. 2.6. Targets on biomass contribution to the total energy consumption in Ukraine and the EU[31]

Indexes	2011	2015	2020	2025	2030
BM share in the total primary energy consumption of Ukraine (Energy Strategy of Ukraine, 2006)	1.3%	-	2.6%	-	3.0%
BM share in the total primary energy consumption of Ukraine (draft updated Energy Strategy of Ukraine, 2013)	1,24%	1,24%	1,24%	1,24%	1,24%
BM share in the total primary energy consumption of Ukraine (the view of the UABio)	1,24%	1,5%	3%	5%	7%
BM share in the gross final energy consumption of Ukraine (the view of the UABio)	1,78%	2,2%	4,3%	7,2%	10%
BM share in the gross final energy consumption of the EU	6.7%	10%	14%	16%	19%

31 – G.Geletukha , T. Zheleznaya. Place of bioenergy in the draft updated Energy Strategy of Ukraine till 2030 // Industrial Heat Engineering. – 2013, t. 35, № 2, p.64-70. (in Rus)

It should be noted that virtually all of the approved state programs on RES development are not implemented in practice due to the lack of financial mechanisms for their realization. Another questionable example of the developed project is the National Project "Energy from Biogas", submitted by the State Agency for Investment and National Projects Management of Ukraine[32].

Project foresee the implementation of biogas plants and mini-cogeneration plants using biogas with total capacity of 1700 MW heat + 1,500 MW of power; production of up to 5 billion m^3 bio-methane per year and its supply into NG pipelines. The strategic objectives of the project is to promote energy independence and environmental security of Ukraine, biomethane production as a substitute for natural gas, increasing the profitability of agriculture in Ukraine, raising and stabilizing soil fertility, contribute to the implementation of "organic farming".

National project economic feasibility is defined by the substitution of imported natural gas with biogas and biomethane, the possibility of covering peak loads in electricity consumption, infrastructure development of the local economy, investment climate improvement, organic fertilizers production, diversification of agricultural production. Unfortunately, the project is not yet well developed. Project development activation would provide the necessary impulse for the biogas technologies development in Ukraine and attract investment into the biogas industry.

Becoming a competent member of the Energy Community, Ukraine undertook an obligation to initiate a number of European directives and regulations which lead to harmonize legislation in the energy sector with the European regulatory base. Ukraine committed to reach 11% share of renewable energy in its overall energy consumption in 2020[33]. Given the current contribution of RES at the range of 2% (according to the energy balance of Ukraine in 2011), it means more than a fivefold increase in the energy production from RES in a relatively short period of time. To meet the obligations it is necessary to introduce additional incentives for the development of RES sector in Ukraine.

In addition, these same commitments of Ukraine to the European Energy Community provide for the harmonization of Ukrainian legislation in RE field with the laws and regulations of the European Union (Directive 2009/28/EC), to be undertaken in 2013. These problems are also mentioned in the "Plan of priority measures for the integration of Ukraine into the EU in 2013", approved by the Cabinet of Ministers of Ukraine № 73-p dated 13.02.2013.

National Action Plan for renewable energy up to 2020 and the Action Plan on the implementation of European Parliament and Council Directive #2009/28/EC from 23.04.2009, which are currently in the development process, suggest that the electricity production from biogas in Ukraine in 2020 will come to 560 GWh per year, meanwhile the total installed capacity of different biogas plants types is to reach 130 MW_e.

2.4.3. Trends in the Development of the Regulatory Framework at Bioenergy Sector

During the last years, there were a number of both positive and negative trends for bioenergy development in Ukraine. Among the positive trends one can mention the following:

- Operation of Green Tariff for electricity generated from solid biomass (minimum 134.46 kop./kWh without VAT or 12.39 eurocents/kWh);
- Continued growth in the price of natural gas on Ukraine's border. The average price of NG in 2012 was the highest in the country's history – 425 $/1000 m^3. Despite the overall negative impact on the development of the Ukrainian economy, the rise of natural gas prices makes biomass and biogas more attractive alternative;
- At the end of 2012, within the Energy Community obligation, Ukraine committed to a binding share of renewable energy in its overall energy consumption – 11% in 2020; .

32 – National project "Energy from Biogas" objectives and strategy implementation (in Ukr) http://www.uabio.org/img/files/news/pdf/maraykin.pdf

33 – Decision on the Implementation of Directive 2009/28/EC and amending Article 20 of the Energy Community Treaty/ D/2012/04/MC-EnC: http://www.energy-community.org/pls/portal/docs/1766219.PDF

- Registration and elaboration of the projects "Energy of Biomass" and "Energy of Biogas" within the National project "Energy of Nature".

Along with the positive trends there was unfortunately a great deal of negative events for bioenergy. Passing by the Verkhovna Rada and signing by the President Ukraine the Law of Ukraine "On Amending the Law of Ukraine "On Power Industry" regarding promotion of power production from alternative energy sources" (N 5485-VI of 20.11.2012) sets an unacceptably low Green Coefficient for power produced from biogas K=2.3 with its further gradual decrease. Thereby the biogas sector once more did not get a sufficient stimulus for its successful growth. Also, the new Law introduces an unjustified and unreasonable domestic content requirement for power plants that have a claim on Green Tariff. The incorrect definition of "biomass" and a number of terminology mistakes also occur in the Law.

Continued practice of subsidizing domestic prices of natural gas for the population and housing-communal sector makes the production of energy from biomass in these sectors unprofitable.

Some negative information on bioenergy that can be regularly heard from officials at various levels also causes concern. The potential of bioenergy is ignored or depicted in an unfavourable manner. The draft updated Energy Strategy of Ukraine until 2030 mentions that: “Wind power generation will be the basis for the RES development in Ukraine in the forecast period”, while evidence is in favour of wind selection is absent despite that globally biomass and biogas is one of the most promising types of RES in the coming decades.

2.5. ECONOMIC PARAMETERS AND FINANCIAL CONDITIONS FOR BIOGAS PRODUCTION

2.5.1. Factors Determining the Economic Attractiveness of Biogas Projects

The most important factors determining the economic attractiveness of biogas project are specific investments, technological efficiency, operating costs and revenues.

1. Specific investment

Specific investment into biogas plant construction, usually defined by 1 kW_e of CHP installed capacity, depend on the project scale, the type of substrates used (and, as a consequence, technical and technological solutions for their efficient processing), the requirements for end products (biogas, biomethane, digestate), environmental requirements for biogas plant performance, tax and customs preferences for the imported equipment and materials, project financing conditions. There is a great diversity of implementation condition for biogas projects construction and operation, so the specific investments can vary in a wide range.

Most demonstrative is experience of Germany. Table 2.7 shows the basic parameters for the biogas projects investment in Germany.

Information on the investment volume and its structure for biogas projects operating in Ukraine is limited. It can be assumed that specific investments for the biogas plants capacity of 0.5…-2.0 MW_e are within 3...4 thousand Euro for 1 kW_e installed capacity. Reservoirs construction and site arrangement forms an average 40...45% of the costs, and energy and technological equipment (including cogeneration plant) - 55...60%.

Investment into the project of biomethane production from biogas, followed by injection into the natural gas distribution network, is commensurate with an investment into the project of power generation from biogas. The estimated

Tab. 2.7. Basic parameters for the biogas projects investment in Germany[34]

Indicator	Unit	Value		
		average	min	max
Specific investment on 1 kW_e installed capacity of biogas plants	EUR/kW_e	3096	1529	6140
Specific investment on 1 m^3 working digester volume	EUR/m^3	647	209	2922

cost of the biogas enrichment complex within the water scrubber is 2 million Euro for 1100 Nm^3/h biomethane performance (similar to 4 MW_e).

2. Technological efficiency of biogas plant operation

The main indicator of the biogas plant effectiveness is the specific biogas (methane) yield per unit of bioreactor volume per day. By increasing this indicator, investment costs can be reduced which consequently improves the project economy.

For biogas plants in Germany biogas specific yield varies from 0.3 to 3.2 with average value of 1.1 Nm^3 CH_4/m^3/day. High values of biogas specific yield are ensured by using materials with a high content of organic substances (fatty residues, energy crops, cereals, etc.), as well as by the optimal technical solutions for digestion of certain feedstock mixtures.

3. Annual costs

The annual cost of biogas projects include the direct costs of maintaining the operational status of biogas plant and purchased raw materials, as well as indirect costs associated with the payment of the loan interest, amortization, and staff salary. Total annual cost could range from 20 to 50% of the invested assets. Price and amount of purchased raw materials plays significant part in total expenses. Table 2.8 shows the annual cost structure for some of biogas projects in Germany.

In case of the raw material transportation, an average delivery distance affects the operating costs considerably. In this case, the spatial distribution of the raw materials availability is crucial.

In Ukraine, the cost of maize silage varies from 13 Euro/t (cost of cultivation on the own fields) to 20 Euro/t (purchase price). With an increasing demand for silage as an additional substrate for biogas production there are risks of its price rising what is need to be taking into account while preparing a feasibility study for the project.

4. Income

The main parts of biogas project income, depending on its orientation, might be the following:

- income from the sale of generated electricity and/or heat or saving on its purchase;
- income from the sale of biomethane with NG network injection or in the case of use as a motor fuel;
- income from the sale of fermented mass as organic fertilizer or saving from fertilizers purchase;

Tab. 2.8. The annual cost structure for a number of biogas projects in Germany[34]

Indicator		Average value	Min – Max
Specific annual cost for 1kW_e installed capacity of mini CHP, EUR/kW_e		1082	544 – 2015
% of the total costs	Depreciation	22,3	14,2 – 30,8
	Loan interest	4,9	1,0 – 10,7
	Salary	5,9	0,8 – 29,3
	Purchase raw material	42,1	24,1 – 63,2
	Operation costs	15,0	3,7 – 36,1
	Other direct costs	8,3	2,6 – 18,5
	Maintenance contract	2,0	0,0 – 13,8
Production cost of 1 kWh electricity, EUR/kWh		0,16	0,10 – 0,31

34 – Biogas-Messprogramm II. 61 Biogasanlagen im Vergleich, FNR. 2009

- income from ERUs sale under Kyoto Protocol mechanisms;
- saving on environmental charges and fines.

Additional items of biogas project income could be the following:

- income from the stable power supply provision in case of emergency shut-off of power, gas, heat, etc., leading to violations in technical and production cycle, such as milking, feeding, heating, etc;
- income from the damage prevention;
- income from the reduction of number of tillage field works.

The total annual income of biogas project can vary within the range of 25...60% the amount invested, depending on the volume and value of products realization. Table 2.9 shows the actual values of income/savings in Ukraine market, taking into account recent legislative initiatives and the near future expectations.

Tab. 2.9. Tariffs on the valuable products of biogas plant in Ukraine

Indicator	Unit	Value		Note
		As of August 2013	Expected	
Electricity tariff (for industrial enterprises)[35]	UAH/kWh	1,0324	Possible growth +5…10% per year	Without VAT, for 2-nd voltage class consumers
	EUR/kWh	0,0974	-	At the rate of 1059,9 UAH/100€ (NBU rate at 29/07/2013)
Heat tariff (at basic thermal power plants)	UAH/Gcal	900…1000 (average), 1250 – max., 720 – min.	Same level	Tariff for businesses in 2013, with VAT
	EUR/Gcal	84,9…94,4	-	At the rate of 1059,8718 UAH/100 EUR (NBU rate at 29.07.2013)
Green tariff on electricity from biogas	EUR/kWh	0,1239 0,1115 - from 01.01.15 0,0991 – from 01.01.20 0,0867 – from 01.01.25	0,1616 (for biogas from agricultural raw material) 0,1454 (for another biogas types)	Without VAT, for all biogas types
Tariff on biomethane supplied to gas network	EUR/ 1000 m^3	Not established, 460 – NG for industrial enterprises (with VAT, with delivery)	Up to 600 – possible biomethane purchase price from NG network by EU countries	No legislative initiatives at the moment
Tariff on biomethane as motor fuel	EUR/liter	Not established, 0,6-0,7 – methane, propane – butane	n/a	No legal and regulatory framework at the moment
Organic fertilizer	EUR/t	6…7	n/a	Based on nutrient content and mineral fertilizer prices
ERU price	EUR/tCO_{2eq}	< 1	Undefined market prospects	

35 – NERC Decree from 23.07.2013 (in Ukr): http://www.nerc.gov.ua/?id=7441

2.5.2. Economic Performance of Biogas Projects

Biogas production projects can be divided into projects, which primary purpose is waste neutralization (biogas is a co-product of anaerobic waste treatment), and energy projects where biogas is a target product.

Own waste processing can be costly undertaking, necessary from an environmental point of view. In this case, biogas generation helps covering the part of waste treatment cost. In the case of the outside waste processing, the main source of covering project costs may be a gate fee for its tretment.

In the second case, the main income source is the payment for energy produced from biogas. Both in the first and in the second case, under appropriate conditions, there are possible additional income sources, including through the sale/savings of fertilizers.

An example of a typical power biogas project with CHP installed capacity of 2.1 MW_e, working only on pig manure without other raw materials is described below. The specific investment was assumed to be 3.5 million Euro/kW_e, annual operating costs - 6% of total investment, the project owner is the owner of the pig farm, so manure conditionally has "zero" value. On the basis of the Law № 5485-VI from 20.11.2012 the project can count on the generated electricity sale by green tariff 0.1239 Euro/kWh. In case of heat is not used and the digested mass is not considered as a commercial fertilizer, simple payback period is 11 years. For smaller-scale projects, payback period will be even longer. Given the instability of the Ukrainian market payback period is not acceptable for most investors.

Table 2.10 shows the hypothetical scenario of 2.1 MW_e biogas project implementation on pig manure depending to green tariff rate, the share of the heat realization, the percentage of loan assets, the cost of fertilizer and the value of operating costs and investments.

One can notice that the project could have an acceptable payback period of 7 years under the current green tariff on biogas energy (0.1239 Euro/kWh) in case of specific investments not exceeding 2800 Euro/kW_e, or in the case of net profit from the sale/savings the total volume of fertilizer at a price not lower than 1-1.5 Euro/t, or sale of at least 25% waste heat from the plant. At the same time, this payback period can be achieved under the "green" tariff for biogas electricity at the range of 0.1616 Euro/ kWh (3.0 coefficient).

In the case of maize silage use as an additional substrate in biogas energy projects, the economic performance of the project under the tariff 0.1239 Euro/kWh is even less attractive. Table 2.11 shows the results of the economic analysis for the biogas plant with an average power capacity 526 kW_e. The specific project investment was assumed to be 3,800 Euro/kW_e.

One can see that project payback period using green tariff for biogas (0.1239 Euro/kWh), which is valid until 01/01/2015, is more than 15 years, and after the planned tariff reduction in January 2015, is equal to almost 20 years if heat is not used and maize silage price is 20 Euro/t.

Achieve acceptable project payback period at this rate is only possible through a substantial reduction of specific investments - up to 2 thousands Euro per 1 kW_e installed capacity, which nevertheless is hardly possible, at least without reducing the biogas plant effectiveness and reliability. Use of 75% excess heat during the year is only possible with CHP connecting to year-round

Tab. 2.10. Project economy for biogas plant with capacity of 2128 kW_e (pig farm for 160 thousand heads)

Scenarios		till 01.01.2015	after 01.01.2015	1	2	3	4
Specific investment	€/kW_e	3500	3500	2800	3500	3500	3500
Coefficient of "green" tariff	-	2,3	2,07	2,3	3	2,3	2,3
The share of the excess heat used from the CHP	%	0	0	0	0	25	0
Net savings / income from fertilizers	€/t	0	0	0	0	0	1,5
Discounted payback period	years	**11,0**	**13,4**	**7,2**	**6,6**	**7,1**	**7,2**

Tab. 2.11. Project economy for biogas plant with capacity of 526 kW_e (pig farm for 6000 heads + 25 t/day maize silage)

Scenarios		till 01.01.2015	after 01.01.2015	1	2	3	4
Specific investment	€/kW_e	3800	3800	1900	3800	3800	3800
Coefficient of "green" tariff	-	2,3	2,07	2,3	3,0	2,3	2,3
Maize silage price	€/t	20	20	20	20	0	20
The share of the excess heat realized from the CHP	%	0	0	0	0	0	75
Discounted payback period	years	**15,3**	**19,7**	**6,7**	**8,2**	**7,5**	**7,0**

heat consumer, such as domestic hot water system or the heat consumer for technological needs. By increasing project scale economic parameters are improved (Table 2.12) by reducing the value of specific investments, equal to 3000 Euro/kW_e for the project with power capacity of 2128 kW_e.

Thus, the green tariff with coefficient of 2.07 ... 2.3 is not sufficient enough for the development of commercial biogas-to-energy projects neither with mono-digestion of manure waste nor co-fermentation with maize silage. In both cases, the use of "green" tariff for electricity produced from biogas at the range of 0.1616 Euro/kWh (green tariff coefficient 3.0) would achieve acceptable payback period of 6 ... 8 years.

Worth mention that the commercial attractiveness of co-digestion depends on the cost of maize silage. Creating demand on maize silage as a feedstock for biogas production can lead to its market price increase. In the other hand, cultivation efficiency increase can reduce purchase prices. Combination of growing silage and biogas production by one company is reasonable from an economic point of view.

In case of biomethane production for injection into the natural gas distribution network (project of 25 million m^3 biomethane per year, 52 million EUR investment), using maize silage as the basic raw material at the market price of 20 EUR/t, its cost may reach 550 EUR/t. In case of biomethane supply to the EU countries, such as Germany, the Netherlands, at a rate of 600 EUR/1000 m^3 such projects will payback at least for 14-15 years.

At the moment, both in Germany and in Ukraine biomethane production can be economically feasible only with the State support.

Biogas collection and utilization projects at the landfills also have unacceptable payback under the current tariff of 0.1239 Euro/kWh. The minimum tariff rate for such projects shouldn't be less than 0.1454 (coefficient 2.7). The relevant calculations are made for biogas collection and utilization project at the landfill site for the city with a population of 100 thousand people (Tab. 2.13).

Tab. 2.12. Project economy for biogas plant with capacity of 2128 kW_e (pig farm for 24 thousand heads + 100 t/day maize silage)

Scenarios		till 01.01.2015	after 01.01.2015	1	2	3	4
Specific investment	€/$kW_{e.}$	3000	3000	2000	3000	3000	3000
Coefficient of "green" tariff	-	2,3	2,07	2,3	3,0	2,3	2,3
Maize silage price	€/t	20	20	20	20	10	20
The share of the excess heat realized from the CHP	%	0	0	0	0	0	40
Discounted payback period	years	**11,2**	**14,2**	**6,9**	**6,0**	**7,4**	**6,8**

Tab. 2.13. Project economy of construction LFG collection and utilization system for the city with a population of 100 thousand inhabitants (CHP capacity 380 kW_e, specific investment ~ 3200 Euro / kW_e)

Scenarios	I	II	III	IV	V
Coefficient of "green" tariff	2,5	2,7	2,7	3,0	3,5
Excess heat used , %	50	40	20	10	0
Loan share at total investment, %	50	50	0	0	50
Discounted payback period	8,3	8,4	9,4	7,7	8,6

2.5.3. Financing of Biogas Projects

The Ukraine Sustainable Energy Lending Facility USELF

Given the increased interest in alternative energy projects, EBRD launched the "The Ukraine Sustainable Energy Lending Facility" USELF. Its purpose is to promote renewable energy market development by providing loan financing and technical assistance to the Government of Ukraine for the legislation development in this field and the knowledge transfer to local companies. USELF is an investment facility of up to €50 million which provides debt finance as well as development support to projects that meet commercial, technical and environmental eligibility criteria. Another 20 million EUR is financed by Clean Technology Fund (CTF). USELF focused on projects of up to 10 million EUR for the electricity generation from renewable energy sources (solar, water, wind, and biomass). Money is available for up to 10 years, the interest rate depends on the project risks and is determined individually.

As of May 2013 there have been received about 100 applications, a third of the projects were feasible, the rest was unacceptable for a bank or required significant improvement. Seventeen applications were related to the biogas technologies implementation projects, the six projects were approved, five are at the preparatory stage. In the allocated credits list there is a biogas plant in Volnovaha, Donetsk region, which is to be constructed and operated by the company "Ecoprod." Design capacity is 5.8 million m^3 of biogas per year, installed power capacity - 1.2 MW. EBRD funding includes a seven-year loan in the amount of 3.1 million EUR from EBRD and the 15 year loan in the amount of 1.1 million Euros from the Clean Technology Fund, the World Bank (CTF) https://www.climateinvestmentfunds.org/.

More information about the program USELF refer to: http://www.uself.com.ua/.

NEFCO financing

The Nordic Environment Finance Corporation (NEFCO) is an international finance institution established in 1990 by the five Nordic countries: Denmark, Finland, Iceland, Norway and Sweden. NEFCO provides loans and makes capital investments in order to generate positive environmental effects of interest to the Nordic region.

To date, NEFCO has financed a wide range of environmental projects in Central and Eastern European countries, including Russia, Belarus and Ukraine. NEFCO's activities are focused on projects that achieve cost-effective environmental benefits across the region. NEFCO prioritizes projects that reduce releases of climate gases, improve the ecological status of the Baltic Sea or mitigate release of toxic pollutants. NEFCO's portfolio currently comprises nearly 400 small and medium-sized projects spread across different sectors.

One of NEFCO financial mechanisms is an Investment Fund. With the capital of EUR 113.4 million, Investment Fund provides a loan and advances to equity participation and guarantees the implementation of cost-effective environmental projects. NEFCO gives priority to small and medium-sized projects that have positive environmental effects not only for the project country but also for the Nordic region, emphasizing mainly on projects that reduce harmful discharges into waterways and seas as well as reduce cross border airborne emissions.

As a condition of receiving funding is the long-

term cooperation with the partner countries of North, for example, the implementation of various forms of direct investment from the private or public sector. Funding from the Investment Facility is also open to institutions in the Nordic countries, the scope of municipal projects.

NEFCO requires that the projects financed by the Investment Fund should meet reasonable profitability criteria, but as long as this can be achieved, the primary focus is, however, on the positive environmental impacts. NEFCO always carefully examines the technical feasibility and financial profitability of all projects. The Investment Fund provides capital investments or loans at market rates. Generally, the maximum investment loan per project is EUR 4-5 million. In capital investments, NEFCO's financing portion does not generally exceed 50 per cent of the total investment. Regarding share capital, the financing portion is usually around 30 per cent.

One of the successful projects financed by NEFCO is the construction of a biogas plant in an agricultural enterprise " Danosha " (Kalush district, Ivano-Frankivsk region). For this project, in 2012 the company " Danosha " attracted NEFCO to provide a credit line of 1.8 million Euros.

Details of the NEFCO: http://www.nefco.org/.

Ukraine Energy Efficiency Program (UKEEP)

UKEEP is a credit facility developed by the European Bank for Reconstruction and Development (EBRD), targeting Ukrainian private companies in all sectors looking to invest in energy efficiency or renewable energy projects – investments that will decrease energy consumption, increase own energy production or make energy usage more efficient. UKEEP provides free technical assistance by international energy efficiency experts for companies with project ideas that are eligible for UKEEP financing. If a project idea is found feasible, UKEEP can provide debt financing for the project.

Since the launch of the program UKEEP in 2007 for its implementation EBRD has committed about 220 million U.S. dollars. UKEEP credit line services are provided through intermediary banks, which, in fact, provide loans to Ukrainian private companies that applied for funding. As of June 2013 the role of intermediary banks were performed by Ukreksimbank and Megabank.

The standard loan size is 2.5...3 million U.S. dollars. For larger investments, companies can combine several sources of financing, such as UKEEP program funds and own funds or another commercial loans.

For more information about UKEEP please refer the link : http://ukeep.org/.

UBRD Business Advisory Services Program

For today in Ukraine there exists EBRD Business Advisory Services Program. Aim of the program is to provide business advisory assistance to small and medium-sized private enterprises by partial covering of their cost for consulting, promotion of the consulting services market in Ukraine and upraising competitiveness of local consulting companies.

Business Advisory Services Program offers assistance in identifying business needs of the enterprises; cooperation in selection of the most effective local consultants to solve specific business problems of enterprises; compensation of up to 50% of the costs for consulting services companies involvement, but not exceeding 10000 Euro (without taxes).

For more information of EBRD Business Advisory Services Program refer the link: http://www.ebrd.com/apply/tambas/.

IFC financing

If the company already has a business plan or feasibility study, it is advisable to apply for financial support from the International Finance Corporation (IFC) to obtain a loan on favorable terms for the project implementation. IFC supports private sector development through investment and the provision of technical support and advice, which are necessary for the development of enterprises.

IFC can offer financing structure tailored to the needs of a specific project. The bulk of funding and the primary responsibility for decision making and project management is laid on private owners.

For more information of IFC refer the link: http://www.ifc.org/.

3 DEVELOPMENT OF BIOGAS TECHNOLOGIES IN UKRAINE

3.1.1. Biogas and Energy Production between 2009-2012

In Ukraine, for energy production is used about 2.2 million tce (65 PJ) of biomass, which is 1.24% of the total primary energy consumption in Ukraine. Basically, biomass is sunflower husk, wood waste and firewood for the population. Evaluation of individual components inputs published in position paper #6 of Bioenergy Association of Ukraine is shown in Table 3.1.

Thus, even in the structure of slowly developing bioenergy sector, share of biogas remains low (1%), the potential utilization is less than 2% in agriculture and 7% in MSW landfills and dump sites.

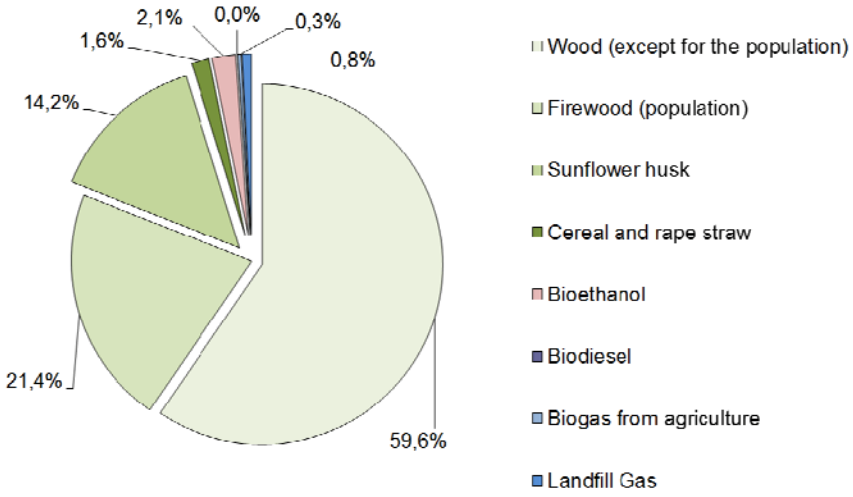


Fig. 3.1. Biomass for energy production use in Ukraine (2011/2012)

Tab. 3.1. Biomass use for energy production in Ukraine (2011/2012)[36]

Biomass type	Annual consumption*		The share of biomass in total energy consumption	The share of economically viable potential
	Natural units	Thousand tce		
Cereal and rape straw	77,000 t	37	1,6%	1%
Firewood (population)	2 mill m^3	478	21,4%	80%
Wood (except population)	3 mill t	1330	59,5%	
Sunflower husk	665,000 t	318	14,2%	59%
Bioethanol	180,000 t	48	2,1%	4%
Biodiesel	~0	~0	~0	~0
Biogas from agricultural waste	10 mill m^3	7	0,3%	2%
Landfill gas	26 mill m^3	18	0,8%	7%***
TOTAL		2236**	100%	

**For energy production. Pellets export is not considered*
***Consistent with the data of the State Statistics Committee of Ukraine (2,24 million tce in 2011)*
****With flaring*

36 – UABio Position paper #6. http://www.uabio.org/img/files/docs/position-paper-uabio-6-ru.pdf

3.1.2. Existing Biogas Plants

In Ukraine, there are few examples of biogas technologies implementation. The first one among active full-scale biogas plants on animal waste was built in 1993 on a pig farm "Zaporizhstal". For a long time it has been the only biogas plant been operated in Ukraine. In ten years biogas plant of "Agro-Oven" company was launched. In five more years such companies as "Elite", "Ukrainian Milk Company" have started their biogas projects implementation. As of 2013 five biogas plants have being operated on the basis of agricultural enterprises in Ukraine (Tab. 3.2).

The biogas plant at "Zaporizhstal" pig farm has been implemented for the purpose of liquid waste treatment and energy consumption reduction; today heat utilization is realized for the pig factory

Fig. 3.2. "Elite" biogas plant, Teresino village, Kiev region

Tab. 3.2. Existing biogas plants in Ukraine[37]

Enterprise	Start-up year	Livestock population	Raw material types	Raw material volume, t/day	Digester volume, м^3	Installed power capacity, kW	Technology supplier
Pig farm "Zaporizhstal", Zaporizzhya	1993	8000-12000	Pig manure	20…22	595	-	Bigadan Ltd", Denmark
Pig farm of corporation "Agro-Oven", Elenovka village, Dnipropetrovsk region	2003	15000	Pig manure, fat from poultry slaughter	80	2 x 1000	180	BTG, the Netherlands
Agricultural company «Elita», Teresino village, Kiev region.	2009	1000	Manure (90% cattle+10 % pigs)	60	1500	250	LIPP, Germany
Cattle farm of "Ukrainian dairy company", Velykyi Krupil village, Kiev region	2009	4000 + 2000	Cattle manure, maize silage (planned)	400	3 x 2400 + 1000	625 + 330	Zorg, Ukraine
"Mironovskiy Hleboproduct", poultry farm "Orel-Leader", Dnipropetrovsk region	2012	30 million heads/year	Poultry litter + silage	140 t of litter + 80 t of silage	10 x 3500	2000 (5000)	NVT, Netherlands

37 – UABio position paper #4 : http://www.uabio.org/img/files/docs/position-paper-uabio-4-ru.pdf

own needs. On the pig farm of corporation "Agro-Oven", produced electricity is consumed for biogas plant and enterprise own needs; meanwhile cogeneration unit is not connected to a power grid

After two years the biogas plant operation belonging to "Elite" company was suspended in 2011 due to the unprofitability while the absence of the "green" tariff. The only biogas plant connected to the electricity grid by far is biogas plant at the cattle farm of "Ukrainian dairy company." The company has been allowed to supply and sale the electricity generated at the special tariff (lower than the market rate on the grid electricity for industries). The company planned to increase capacity to 1.0 MW_e through the treatment of the additional plant substrates.

Corporation "Mironovskiy Hleboproduct" has started the construction of a biogas plant at the poultry farm "Orel-Leader" in the Dnipropetrovsk region in spring 2012. Biogas plant processing the poultry litter was put into operation in December 2012. In July 2013, power capacity of mini-CHP plant was 2 MW_e, the company plans eventually reach an installed capacity of 5 MW_e. "Mironovskiy Hleboproduct" corporation is going to achieve energy independence within a single enterprise by using energy from biogas. The project also provides the digestate processing following the organic fertilizers production.

Biogas plant at the poultry farm "Orel-Leader" is a pilot project for a corporation that plans to construct a similar projects at “Myronivska poultry farm” and poultry farm "Druzhba Narodov Nova" (Crimea).

At the brewery "Slavutich" in Zaporizzhya operates a biogas plant of "Enviro Hemie GmbH" company from 2012. The purpose of installation was wastewater treatment. For this goal biological wastewater treatment methods firm BIOMAR® were applied. An anaerobic reactor Biomar (EnviroChemie with a working volume of 4900 m^3) is used; biogas yield is 2000...4000 m^3/day. The biogas is fed into the gas boiler.

Fig. 3.3. Biogas plant at cattle farm of "Ukrainian dairy company”, Velykyi Krupil village, Kiev region

Fig. 3.4. Biogas plant design at the poultry farm "Orel-Leader", Dnipropetrovsk region (http://www.mhp.com.ua/)

3.1.3. Biogas Plants under Construction and Announced Biogas Projects

In September 2011, the construction of biogas plant on the basis of a pig farm has started at village Kopanky, Kalush district, Ivano-Frankivsk region. The enterprise and the biogas plant are owned by Danish company «Danosha Ltd». Biogas plant power capacity is to be 1 MWe and the biogas

production equals approximately 13,000 m^3/day. The project cost is around 5 million EUR. Planned pig manure processing is 90 th. t/year and maize silage processing is 10 th. t/year. Biogas plant construction lasted for about 2 years, and its tentative launch is scheduled for autumn 2013. In total "Danosha" intends to construct 4 biogas plants in the Ivano-Frankivsk region.

Agricultural Corporation "Ukrlendfarming" plans to implement an ambitious program of thirty biogas plants construction in 18 regions of Ukraine at the enterprises specializing on the production of eggs and egg processing products. There has been announced the biogas plant construction at the poultry farms in Khmelnytsky and Kherson regions with the capacity of 4 MW_e and 3 MW_e, respectively, which would also produce organic fertilizers. Electricity will be sold to the grid by "green tariff ", the thermal energy will be used for the own needs. The commissioning of the first biogas plants processing the poultry litter and other wastes is planned for 2014.

In 2012 agricultural Corporation Astarta-Kiev announced the biogas plant construction at a Globinsky sugar factory (Poltava region) financed by the EBRD loan of up to 12 million USD for 7 years term. The processing capacity will be more

Fig. 3.5. Biogas plant at «Danosha Ltd», village Kopanky, Ivano-Frankivsk region

than 120 thousand tons of sugar beet pulp per year, which will allow to produce about 14.4 mill m^3 of biogas and thus to halve the natural gas consumed by the company in the process of sugar production. As of July 2013, there was carried out biogas plant pre-commissioning, startup is planned for September 2013. The next one in line for a similar project is Narkevitsky sugar factory (Khmelnitsky region). The planned processing capacity of biogas plant is 1,200 tons of pulp per day.

The company "ZORG" announced the completion of biogas plant construction on the pig farm "Demis -Agro" ltd in the village Podgorodneye, Dnipropetrovsk region. CHP power capacity is 125 kW_e. Besides "ZORG " declared about the projects of biogas production from cattle manure and maize silage with the capacity of 1360 kW_e in Peresadovka, Mykolaiv region (as of July 2013 the project readiness was 40 %) and biogas production from silage and grape stillage in Voznesensk, Mykolaiv region (125 kW_e).

Biogas plant construction is planned at Volnovaha, Donetsk region. The facility is to be build and operated by the company "EcoProd". Designed capacity is 5.8 million m^3 of biogas per year, installed power capacity - 1.2 MW_e. Funding includes seven-year loan of 3.1 million EUR provided by EBRD and the 15-year loan of 1.1 million Euros from the Clean Technology Fund, the World Bank (CTF).

3.1.4. Companies and Proposals Presented on the Market

Information about some of the potential technology and equipment suppliers, both Western and Ukrainian presented at the Ukrainian market, or having an interest in this field (distributing the promotional information and/or visiting the exhibition and other events) is shown in Table 3.3 in alphabetical order.

Tab. 3.3. Potential equipment suppliers for biogas plants at Ukrainian market

	Company	Technology	CHP capacity range	Experience in regions	Link
1	Agraferm Technologies AG	Mixing reactors. Dry and wet digestion	250-1415 kW_e	About 45 biogas plants in Europe, including 30 in Germany	www.agra-ferm-technologies.de
2	BD Agro Renewables Big Dutchman Group	Mixing reactors	UniFerm Unit System with capacity range 250-780 kW_e MegaFerm System with capacity range 500-5000 kW_e	More than 50 biogas plants in Germany and Eastern Europe	www.bdagro.de
3	BINOWA Gmb	Three-step process CENTRIGAS® (the absence of mechanical agitation)	35 kW_e - 2,3 MW_e	35 biogas in Germany, Poland, Latvia, USA and other	www.binowa.de
4	Biogas Nord	BiNoLiquifeed technology with a preliminary hydrolysis	4 MW_e – the biggest project	More than 400 biogas plants in 16 countries. Germany, the Netherlands, USA, Italy, Great Britain, Belarus etc.	www.biogas-nord.com www.biogas.de
5	EnviTec	Mixing reactors	Standard biogas plants with CHP capacity 500 kW_e, 1 MW_e, 1,5 MW_e, and 3 MW_e.	Biogas plants with the total installed capacity of 202 MW, more than 15 European countries, India, USA	www.envitec-biogas.com
6	IHB Bioenergie GmbH	n/a	n/a	1 biogas plant in Spain, participation experience in more than 110 biogas plant in Germany and Europe	www.ihb-bioenergie.de
7	Lipp	Mixing reactors. The reactors are made of steel with the use of the compounds in double welt Lipp	From 150 kW_e	Projects around the world.	www.lipp-system.de

8	MT-Energie	Traditional technology of the continuous two-stage process. The technology of biogas purification and supply into NG distribution networks MT-Biomethan GmbH	100-2126 kW_e, 250-1400 m^3 biomethane/h	More than 600 biogas plants. Southern and Eastern Europe	www.mt-energie.com
9	Schmack Biogas (Viessmann Group)	4 standard biogas systems: COCCUS® Titan, COCCUS® Farm, EUCO® Titan, EUCO® Mono, Possibility of processing substrates with different moisture content (dry and wet digestion).	biogas plants with CHP capacity from 180 kW_e to 20 MW gas	250 biogas plants with the total capacity of 100 MW. Worldwide (information from the web-site).	www.sch-mack-biogas.viessmann.com
10	ZorgBiogas	Mixing reactors	40-2126 kW_e	3 "turnkey" biogas projects in Ukraine, 7 in Kazakhstan, Turkey, Latvia, Slovakia, Moldova, Italy. 41 project (documentation, supervision, equipment) in 11 countries	www.zorgbiogas.ru
11	UABio	Bioenergy association	Bioenergy including biogas	Ukraine	www.uabio.org
12	SEC Biomass	Engineering and consultancy service	Bioenergy including biogas	More than 10 biogas projects (project design documentation, supervision, feasibility studies, research projects) in Ukraine, Russia	www.biomass.kiev.ua
13	Ecotenk	Biogas plants for agro-based industries, utilities, processing plants, small biogas plants with the volume of 6-100 m^3	n/a	Pilot biogas plant-1, 1.2 m^3 biogas per day, biogas reactor setup for wastewater treatment. Ukraine	www.ekotenk.com.ua

3.2. EXISTING BIOGAS PROJECTS IN MUNICIPAL SECTOR

A few examples of implemented biogas projects exist at MSW landfills (Table 3.4), as well as at Bortnychi wastewater treatment plant (Kiev).

Almost all of the projects listed in the table 3.4, have been realized as Joint Implementation projects under the Kyoto Protocol. Usually in such projects at the first stage biogas was assumed to be combusted by an enclosed flare with an efficiency of over than 99.5%, which enabled methane oxidizing to carbon dioxide and water, and thus generating the so-called GHG emission reduction units (ERUs), which possess the market value. It was also expected that after the project launch and refinement of the available biogas volume, it can be used for electricity production.

After the finishing of the first period of the Kyoto Protocol at the end of 2012, carbon market prices have fallen, the prospects for the ERUs sale are unclear, so biogas combustion in the flare has lost its relevance as a commercial activity. Prospects for biogas utilization from solid waste are now associated mainly with the use of "green" tariffs for electricity produced from biogas.

Electricity generation from biogas is implemented at three Ukrainian landfills – in Mariupol, Kiev and Borispol. Kiev landfill #5 project, implemented by LNK is currently the most successful Ukrainian biogas project. At the landfill there operates a line of five biogas engines made by TEDOM with an installed capacity of 177 kW_e each. 3.26 GWh of electricity were produced, delivered to the grid and sold at economically reasonable tariff determined by NERC at the Kiev landfill in 2012. The company is increasing project scale: gas reciprocating engine with power capacity of 1063 kW_e manufactured by GE Jenbacher is scheduled to enter into operation in 2013. In addition, in June 2013 the company LNK has launched a similar plant

Fig. 3.6. LFG collection and flaring (Mariupol, Donetsk region)

Fig. 3.7. TEDOM biogas engines with capacity of 5×177 kW_{el} at the landfill #5, Kiev region

with capacity of 1,063 kW_e at Boryspil landfill. In May 2013, the opportunity to sell electricity produced from biogas at Boryspil landfill by the green tariff (134.46 kopecks/kWh without VAT) has been provided in accordance with the NERC Decree #492 from 25.04.2013 as amended by NERC Decree #526 dated 16.05.2013.

Thus, currently biogas is utilized for the power production at three Ukrainian landfills; therefore no more than 2-3% of the economic potential of the sector is used.

Tab. 3.4. Existing biogas collection and utilization systems at landfills

Landfill	MSW disposed, million tons	Landfill area, ha	Landfill operation period	Start of LFG collection	Utilization technology
Alushta	1,0	3,2	1960-	2008	Flare HOFGAS-Ready 500
Yalta	1,3	5,0	1973-2010	2008	Flare HOFGAS-Ready 800
Lviv	4,0	26	1957-	2009	Flare HOFGAS-Ready 2000
Mariupol	2,5	14	1967-2009	2010	Flare HOFGAS-Ready 800, Internal combustion engine 170 kW_e
Kremenchug	2,8	15	1965-		Flare Haase
Lugansk	2,0	11,6	1979-2010	2011	Flare Biogas Ltd, UK, 600 m^3/h
Zaporizzhya	3,2	11	1952-	2011	Flare Haase
Vinnytsia	3,0	10	1980-	2012	Flare Haase
Kiev	10	36	1986-	2012	Internal combustion engine TEDOM 5x177 kW_e
Boryspil	0,9	6	2003-	2013	Internal combustion engine GE Jenbacher 1,06 MW_e

Fig. 3.8. Biogas engine GE Jenbacher with capacity of 1063 kW_{el} at Boryspil landfill

4 PROSPECTS FOR MARKET EXPANSION OF BIOGAS TECHNOLOGIES IN UKRAINE

4.1. POTENTIAL MARKET FOR BIOGAS PLANTS

The potential market of biogas plants is formed by enterprises generating a sufficient amount of organic waste suitable for the biogas production. Ukrainian agriculture possesses high potential for the biogas plants implementation, mainly on the basis of livestock breeding enterprises, as well as sugar mills, breweries and distilleries.

The overall market of waste mono-digestion installations at individual enterprises is estimated to be about 800 plants with biogas-based CHP capacity 100 kW_e – 20.0 MW_e, and the total installed capacity is up to 700 MW_e (Tab. 4.1). Construction of biogas plant with capacity of less than 100 kW_e is unfeasible, if power production is the main income source. In animal husbandry of Ukraine there remain a large number of small enterprises. This leads to the fact that no more than 10 % of all businesses have the potential to construct biogas plant, which works only on its own production waste.

In 2008 Ukraine had 5079 cattle farms. On 453 farms with livestock at least 840 heads there could be potentially realized the biogas plant with a mini - CHP installed capacity of over 100 kW_e. In this case, the total installed capacity of these plants would be 96.9 MW_e. According to the State Statistics Committee of Ukrain[38], at the beginning of 2012 there were operated 3,996 cattle breeding farms, including 106 enterprises with more than 2,000 head of cattle. Thus, the number of cattle farms in 2012 dropped by over 1083 companies since 2008, but this decline mainly concerned the small enterprises.

In pig breeding industry, biogas plants potential with CHP capacity over 100 kW_e in 2008 was 65 plants with total installed capacity of 15.1 MW_e. At the beginning of 2012, there were operated 4,258 enterprises, 177 enterprises had more than 3,000 head of livestock. Number of enterprises also reduced significantly comparing to 2008 by 1376 units, mainly due to small enterprises munber reduction. Herewith, the number of medium and large enterprises with 3,000 head of livestock increased by 35 units.

The total number of poultry farms in Ukraine in 2011 was 667 units, 174 enterprises had a population of over 50 thousand heads. As of 2008, 150 poultry farms could potentially implement biogas projects with CHP installed capacity of over 100 kW_e with total installed capacity of 143.5 MW_e. Since 2009, the number of poultry farms has decreased by 119 units, also mainly due to the small enterprises. Some reduction occurred in the segment of medium-sized and large enterprises the

Tab. 4.1. The potential of biogas plants implementation running on livestock waste and some types of food industry waste*

Type of enterprise	The total number of enterprises in Ukraine	CH_4 production capacity from all waste and by-products, thousand m^3CH_4	Biogas plants implementation potential, units									
			TOTAL			Including installed power capacity, MW_{el}:						
			Biogas plants number	Installed power capacity	Potential use share, %	0,1...0,2	0,2...0,5	0,5...1,0	1...5	5...10	10...20	> 20
Sugar mills	60	594,8	50	354,0	45,2	n/a	n/a	n/a	26	12	11	1
Breweries	51	75,4	16	32,2	98,8	5	3	0	7	0	1	0
Distilleries	58	95,6	50	39,5	95,6	n/a	18	21	11	0	0	0
Cattle farms	5079	473,2	453	96,9	47,3	400	42	7	4	0	0	0
Pig farms	5634	107,7	65	15,1	32,4	41	20	2	2	0	0	0
Poultry farms	785	346,8	150	143,5	95,7	70	33	16	24	4	3	0
TOTAL	11 667	1 693	784	681,2	60,6	516	116	46	74	16	15	1

**as of 2008*

38 – Agriculture of Ukraine. Statistical Digest, 2011 / State Statistics Committee of Ukraine. - Kiev, 2012. www.ukrstat.gov.ua

number of poultry farms with livestock than 50 thousand heads dropped by 25 companies. Worth mentioning that poultry production in Ukraine is characterized by a high level of consolidation where three major entities control about 75 % of the market[39].

Thus, despite large number of livestock enterprises in Ukraine (a total of more than 11 thousand units in 2008), only a small number of those can implement biogas plants of over 100 kW_e working exclusively on livestock waste (less than 800 projects), with a total capacity of up to 700 MW_e. In recent years there has been observed a tendency of reducing the number of small businesses and the consolidation of the rest. The consequence of this process is the gradual increase in the potential of biogas production from animal waste.

Manure co-digestion with other waste substrates, including specially grown energy crops, such for example as maize silage, may significantly increase the total number of biogas production projects with energy generation. Adding 30% maize silage to manure flow leads to 2.5-3 times increase of biogas production and, consequently, increase power capacity of biogas projects.

In the product treatment segment of agriculture the most important for the biogas production are the enterprises of the sugar industry, breweries and distilleries.

As of 2012 the number of working sugar plants in Ukraine was 60 enterprises[40]. Production capacities of sugar mills reach from a few thousand to 100 thousand tons for sugar-making season. In fact all sugar factories in Ukraine represent the potential interest for biogas projects implementation. In 2009, 50 companies of the industry could implement biogas plant with CHP over 1 MW_e (Tab. 4.1) designed to process 75 % beet pulp, 25% molasses, 50 % beet tops and 100% of other waste (roots, substandard beet) at sugar-making period of 120 days. This assessment takes into account the competitive use of sugar refining by-products for animal forage, as well as in beer, alcohol, bakery and confectionary industries. Part of the beet tops collected is supposed to stay on the fields.

Ukrainian sugar industry is completely privatized. Even today in Ukraine, about 70% of sugar beet is produced in a vertically integrated holding companies, which include the Company "Agroprodinvest", Agro-Industrial Association, "Group of companies "Ukrros", "Rise-sugar " LLC, "Astarta-Kyiv" LLC, the group of companies "Mriya Center", Corporation "Ukrprominvest "etc. (Tab. 4.2).

In 2010, the largest companies owned 34 sugar factories from 75 total numbers. There is a tendency of gradual consolidation of companies producing sugar, either by the number of plants belonging to them, or the share of sugar produced, while reducing the total number of inefficient plants.

Beer industry in Ukraine is represented by 36 breweries, 11 of which are owned by the five largest players in the beer market (Tab. 4.3).

16 breweries could potentially implement biogas projects with CHP of over 100 kW_e and a total installed capacity of 32.2 MW_e.

In Ukraine there are more than 80 distilleries[41], which production capacity is about 60 million dal of alcohol per year[42]. No more than half of this capacity was involved in recent years. To date, there are 57 working plants. They all belong to the State Enterprise "Ukrspirt". At 50 working distilleries there can potentially be installed biogas plants with CHP capacity of above 200 kW_e, with a total installed capacity of 39.5 MW_e.

Alcohol in Ukraine is principally produced of coarse grains (60 %) and molasses (40 %)[43], which determines the type of distillery dreg, biogas production potential and processing technology. In specialized ministries of Ukraine there is a belief that use of 1/3 capacity potential (about 20 million dal) is sufficient for traditional ethanol production, and 2/3 is appropriate to repurpose for bioethanol production, mainly from sugar beets. In this case, alcohol production waste from sugar beet could also be potentially considered as a raw material for biogas production.

39 – Doing Agribusiness in Ukraine / Ukrainian Agribusiness Club, 2013. (in Rus)

40 – Source: http://economics.unian.net/ukr/news/150820-golova-asotsiatsiji-ukrtsukor-sogodnishnya-tsina-na-tsukor-tse-svogo-rodu-sos.html

41 – Hevak Z. Development of the alcohol in Ukraine: Past and Prospects / Innovative Economy, Ternopil. - P.217-219.(in Ukr) http://archive.nbuv.gov.ua/portal/soc_gum/inek/2010_4/217.pdf

42 – Ukrainian refineries are able to process 40 million of alcohol to bioethanol per year - Ministry of Agriculture of Ukraine/ finance.ua (23.05.2013, in Ukr). http://news.finance.ua/ua/~/1/0/all/2013/05/23/302442

43 – Alcohol and alcoholic beverages market (2009).(In Ukr) http://www.ukrexport. gov.ua/ukr/prom/ukr/3699.html

In the sphere of municipal wastewater, sewage biogas projects with CHP of over 100 kW_e are possible for the cities with a population of over 100-150 thousand people. In Ukraine, a total of 45 biogas projects with capacity from 100 kW_e to 2.7 MW_e can be implemented, with a total installed capacity of 18.2 MW_{el}.

Tab. 4.2. Performance of sugar Corporation in Ukraine[44]

Company	The number of sugar mills		Processing of sugar beets, thousand tons		Sugar production, thousand tons	
	2009	2010	2009	2010	2009	2010
«Astarta-Kiev» LLC	5	5	1 552,7	1 556,5	225,3	198,0
Group of companies «Ukrros»	3	6	946,5	1 030,1	130,2	116,4
«Agroprodinvest» LLC	2	2	667,1	982,8	103,1	120,4
«Rise-sugar» LLC	1	1	691,4	534,6	101,3	76,1
Group of companies «Mriya-Center»	6	7	714,7	907,6	74,9	91,3
«Radekhivsky sugar» LLC	1	1	484,4	676,1	61,9	78,8
Agroindustrial firm «Svitanok»	2	2	313,6	314,2	52,5	45,2
CJSC «Western company «Dacor»»	1	1	326,6	481,2	47,2	56,6
«Panda» LLC	1	3	279,0	452,2	32,9	50,3
«Gals» Ltd	2	2	217,0	267,2	29,7	32,8
«Podolsky sugar mills» LLC	2	3	161,5	398,8	22,4	41,7
«Teofipolsky sugar plant» public JSC		1	280,4	451,8	36,2	52,5
Total, units	26	34	6 634,9	8 053,1	917,6	960,1
Total, %	46,4	43,8	71,8	61,8	72,4	62,1
Plants not integrated into holdings	30	41	2 598,1	4 976,5	349,5	586,1
Total in Ukraine	56	75	9 233,0	13 029,6	1 267,1	1 546,2

Tab. 4.3. Performance of brewing holdings in Ukraine

Company/holding	The share of the beer market in Ukraine in 2012[45], %	Number of plants
SUN InBev Ukraine	32,0	3
Carlsberg Ukraine	29,5	3
Obolon	24,5	3
Anadolu Efes Ukraine	5,2	1
First private brewery	2,8	1
Other	6,0	25
Total	100	36

44 – O.Dankevych. Ukrainian sugar production prospects / Efficient Economy. Dnepropetrovsk State Agrarian University, 2012. (in Ukr) http://www.economy .nayka.com.ua/?op=1&z=1494

45 – Source: http://uk.wikipedia.org/wiki/Список_пивоварень_України

4.2. ENERGY CROPS CULTIVATION FOR BIOGAS PRODUCTION

An important role in biogas production in Ukraine's agrarian sector should be played by energy crops grown specifically for the biogas production. For this purpose, part of arable land can be used according to their competitive application for growing traditional food, forage and industrial crops.

In Ukraine in 2011 there were 32.5 million hectares of arable land: 19.2 million hectares (59.1 %) were in service of agricultural enterprises, 11.8 million hectares (36.2%) were owned or used by the population, and remaining 4.7% were in use of other customer categories. About 15% of the total arable land area (3.6 million hectares) have not been used and could potentially be applied for energy crops cultivation, including biogas production.

One of the prospects in terms of land energy use efficiency is maize grown for silage with biogas production purpose. The potential methane production from the green mass of highly productive hybrid maize stalks (collected before ripening grain on the milk-waxy stage) is from 3000 to 7000 m^3 CH_4/ha (gross) depending on the sort, variety of lands, agro-climatic conditions. There are other crops potentially suitable for the biogas production. These crops include sweet sorghum, Jerusalem artichoke, clover, maize and other plant species.

Large companies and holdings which own significant land banks and are able to organize the combined cultivation of both traditional and energy crops, have an advantage in terms of organizing the optimal crop rotation. In 2011 3.2% of Ukrainian companies had at their disposal 38.3% of the total cultivated area. Thus, more than half of agricultural enterprises in Ukraine had sown area of 50 hectares or less, and the total share of these lands was less than 3% of the total cultivated area (Fig. 4.1).

There observes a trend of increasing land assets by large and medium-sized companies, and Ukraine comes closer to lifting the moratorium on sale of agricultural land[46]. Today, 101 large agricultural holdings control one third of all arable land in Ukraine (6.5 million hectares) (Tab. 4.4). Thus, there is a sufficiently large number of companies that possess large areas of land, which potentially can be organized for energy crops cultivation with biogas production purpose to meet the requirements of optimal crop rotation. Geographically agricultural land holdings are concentrated mainly in the central and north-eastern part of Ukraine.

In 2012, 4868.4 thousand hectares (15% of all arable lands) were used for maize growing, including 4371.9 thousand hectares under maize for grain and 496.5 thousand hectares for maize silage, haylage, green fodder. It is interesting to note that 20 years ago in Ukraine there were grown almost 10 times more maize for silage than today. In 1990, 4,636.9 hectares were involved for maize silage cultivation.

Worth mention the increase of area under sorghum to 170 hectares, major part of which is a hybrid. With the gradual climate change sorghum might be a good alternative to maize for the farmers of Ukraine's steppe zone[47].

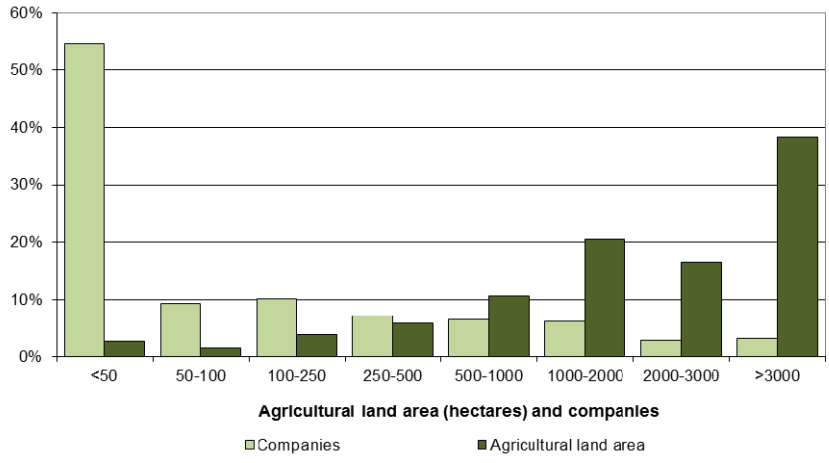


Fig. 4.1. The agricultural enterprises structure by the sown area in 2011

46 – TOP-100 landowners of Ukraine 2012. (in Rus) http://latifundist.com/rating/top-100-latifundistov-ukrainy
47 – Doing Agribusiness in Ukraine / Ukrainian Agribusiness Club, 2013. (in Rus)

Tab. 4.4. The structure of arable land cultivated by large agricultural holdings in Ukraine

Index	Total	Cultivated land area, thousand ha			
		7,5-20	20-50	50-100	100 and more
Number of holdings	101	29	32	24	16
The total land bank, ha	6491,7	358	953,1	1645,6	3535
The share of the total area of arable land cultivated by agricultural enterprises in Ukraine	33,3%	1,8%	4,9%	8,4%	18,1%

4.3. BIOGAS PROJECTS IN AGRICULTURE

4.3.1. Biomethane Production

In the process of electricity production from biogas certain portion of heat is utilized for own biogas plant needs (heating bioreactors, the drive mechanisms), but the major part is often discharged into the atmosphere due to the lack of thermal energy consumer in the plant vicinity. In recent years, projects for the production of upgraded biogas (biomethane), followed by injection into the natural gas distribution networks or use as a motor fuel, spread throughout the world improving biogas energy utilization efficiency.

Gas filling stations on biomethane are projected in Germany and its use as a fuel for public transport is to be expanded. In the northern EU countries, using biomethane as a vehicle fuel is the long-term practice. Biomethane can be applied for agricultural and special vehicles.

Biomethane use in Ukraine has potentially good perspective. The country has a well-developed gas network infrastructure of high pressure pipelines and medium pressure local networks, and the tradition of using methane as motor fuel. Biomethane can be exported to countries interested in the consumption of "green" energy. Germany and the Netherlands have already expressed an interest in biomethane import from Ukraine.

Biogas purification to natural gas quality is quite energy-intensive process. Implementation of economically viable project of biomethane production requires substantial amounts of feed stock materials, therefore the production on the only waste basis from one enterprise is irrational. As base material can be involved maize silage, which is one of the most energy efficient and common type of materials used worldwide for biogas/biomethane production. The economic feasibility of such project will be mainly depend on maize silage cost, gas network distance, project scale, price of substituted natural gas, as well on the presence or absence of bio-methane production incentives. As an incentive there can be a system of green certificates for biomethane produced or sold to the consumer, which is successfully applied in some countries.

4.3.2. Optimal Organization Models of Biogas Projects in Agriculture

Biogas projects in the agricultural sector can be arranged in the following ways:

- biogas production based on waste of a single enterprise (for example, livestock manure, pulp from sugar mills, distillery dreg), with one type of waste to be dominant (scheme M1, Fig. 4.2); in the

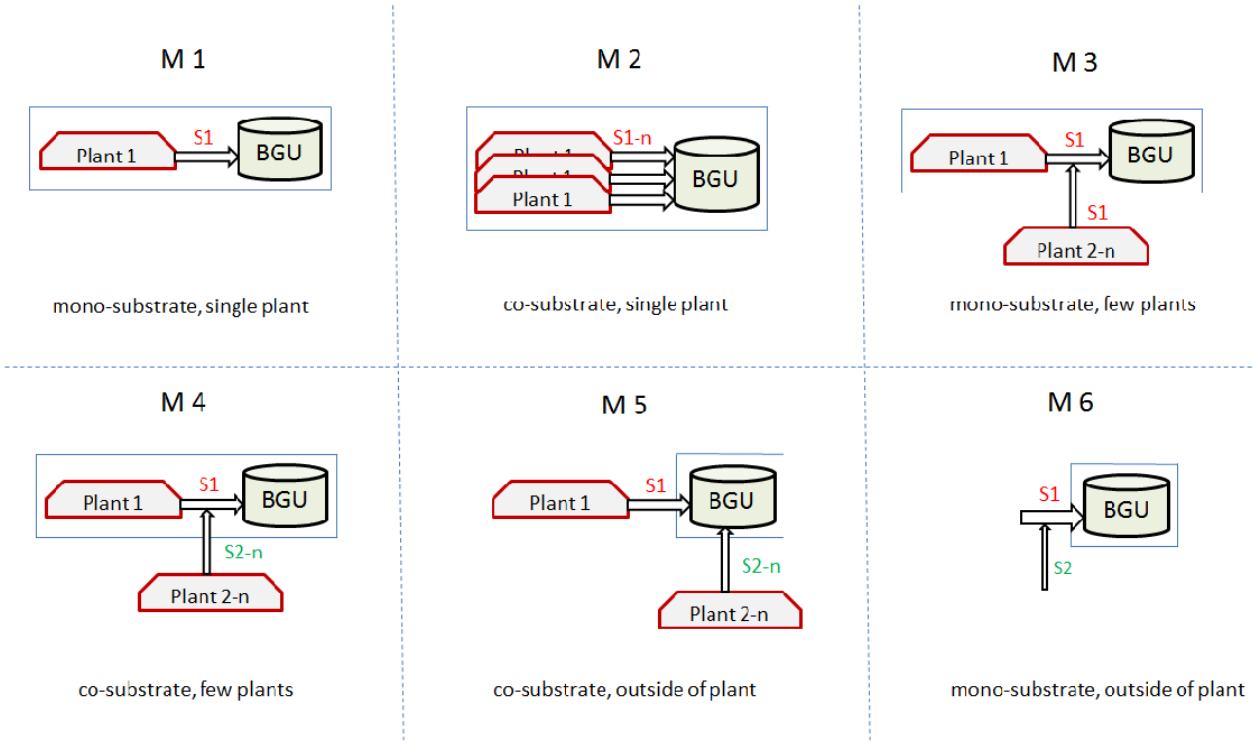


Fig. 4.2. Possible schemes for biogas production in the agricultural sector

presence of different waste types and by-products (for example, pulp, molasses, beetroots at sugar factories) their co-processing is possible (M2);

- biogas production based on waste generated by different enterprises, linking the project to a single enterprise (M3 with same raw materials type; M4 with different types of raw materials) or separately located centralized biogas plant (M5);
- biogas production using mainly energy crops on separately located biogas plants (M6 with partial use of manure waste).

The most viable in Ukraine's conditions is scheme M1/M2 where the companies' waste have conventional "zero" cost. It is important that such wastes had quite a large specific gas production potential (such as beet pulp, dried poultry litter, brewer's grain, fat waste). In the case of a legislative possibility solution to use green tariff on electric energy from biogas produced not only from waste but also from agriculture products, biogas projects of scheme M6 can be potentially promising. In each case, biogas plant construction feasibility by one of the possible schemes is determined by the local framework conditions and economic indicators.

In the residential sector biogas projects based on municipal waste can be arranged as follows:

- Biogas collection and utilization in municipal solid waste landfills and dumpsites;
- Biogas production from organic part of MSW collected by one or more utilities, mechanical and biological treatment stations;
- Biogas production from sediments of wastewater treatment plants.

Collection and, in the case of economic feasibility, the energy utilization of biogas in MSW landfills and dumpsites is the most affordable measure, the effectiveness of which is mainly depends on MSW landfills and dumps operation level.

For the digestion of organic solid waste - kitchen residues, wastes of food industry and landscape gardening waste - there can be used a variety of methods. The most common one is "wet" digestion method, where similar traditional agricultural biogas plants technologies are applied. In this case, the MSW can be digested separately or as additional substrate. Methods of "dry" digestion of solid waste in the columns or containers got spread to some extension as well.

To make solid waste digestion in bioreactors technically possible, solid waste sorting or separate source collection should be arranged, especially in the case of wet methods application; and to ensure its economical attraction, the tariff for MSW removal and treatment should be increased significantly.

Energy projects of biogas from sewage sludge at municipal waste water treatment stations may be suitable for fairly large cities (from 100-150 thousand inhabitants). For highly concentrated wastewater and sludge, digestion is, first of all, an

effective way to reduce the organic contaminants concentration.

The methods of biogas energy utilization

The most common ways of biogas energy use are:

- Combustion at gas reciprocating engines in CHP unit following power and heat (or cold) production, or only electricity production;
- Direct combustion in boilers, furnaces and other equipment for thermal energy production (can be used for municipal/industrial heating, cooking, feeding, etc.);
- Injection into the natural gas grid after ballast gases removal. After purification, analogue of the natural gas (biomethane) with 96 ... 98% methane content is derived;
- Using as a motor vehicle fuel after deep purification and compression.

All of these methods are used worldwide to some extent, but the dominant one is electricity production in biogas-based CHP unit due to widespread stimulation mechanism of "green" tariff. Recently in the world practice the number of biogas projects aimed at the biomethane production and injection into the gas network is rapidly growing.

It is expected that the majority of new biogas projects in Ukraine will also be directed to the electricity generation, although projects for biomethane production and injection into natural gas distribution network may have good prospects. The latter requires a legislative regulation, to date the mechanisms and framework conditions for such projects implementation in Ukraine are not available.

The main criteria for the feasibility of biogas projects implementation are the presence of a stable source of raw materials supply and the value of the products obtained in biogas production and utilization process.

The presence of a stable source of raw materials supply

Biogas plants are designed to achieve optimal performance for a certain type and number of the feedstock. Therefore, the quality and quantity of raw materials should not change significantly during the project life cycle. Raw material amount reducing for a long period (a month or more) can have a negative impact, especially on biogas plant economic performance, as bioreactors load reduction will not significantly affect the biological process, while the biogas yield and therefore energy production will decline substantially. A sharp and essential increase in bioreactors loading is not allowed, since it may slow down the biological process and, in some cases, biogas yield break up. The same can occur while substantial qualitative change of the feedstock characteristics.

Thus, first priority biogas projects can be those tied to a stable operating enterprise. Production technology at such enterprise should not be changed frequently and dramatically, if it results in significant quantitative and qualitative changes of waste generated. For example, the animal non-bedding husbandry method changeover to bedding method should be considered when choosing a manure processing technology, as bedding material processing may require additional treatment, but in some cases turns out to be impractical (e.g., in the case of sawdust).

In recent years, one of the most dynamic sectors of Ukraine's agro-industrial complex is the poultry breeding of meat (mainly) and egg production. This sector can be called the most promising for the biogas plants implementation in terms of generated waste volume and urgency of their utilization problem, especially in large poultry farms. Taking into account the technological limitations of poultry litter mono-digestion, such projects require additional substrates use, where maize silage may be the most appropriate and available in the required quantity, with regard to the potentially large scale biogas projects on big poultry farms.

Biogas project profitable products

The economic feasibility of the biogas project is determined by the market value and a guaranteed payback of marketing products.

To date, the most probable paid back product can be electricity generated in biogas-based CHP. Legal field for this exists, which defines the mechanisms of such electric energy delivery into the power grid and green tariff obtainment.

To increase the biogas project profitability one should strive for the maximum possible utilization of useful heat produced by the biogas combustion in gas reciprocating engines. Additionally, it allows utilize up to 40% of the energy contained in the biogas. Potential consumers of heat can be manufacturing departments and office buildings, separate production facilities located nearby, drying plants, housing and social infrastructure, small towns heating networks.

A promising alternative is the direct biogas substitution of the natural gas consumed by enterprises in the production cycle. These enterprises should primarily include sugar mills, breweries and distilleries. Experience has shown that it is possible, for example, to reduce the consumption of up to 60% natural gas in a sugar factory in this way[48]. Given the fact that sugar-making period is restricted (90-120 days per year), biogas projects at sugar mills worth organizing with the possibility of year-round work. This will require additional raw materials (presumably plant silage substrates). In this case, it would be advisable to supply the off-season produced purified biomethane into the NG distribution network, with the ability to use the natural gas from the network during the operation of the enterprise. Breweries and distilleries can displace natural gas by biogas virtually all year-round.

If the digested mass is not to be used by the company for its own needs, it is advisable to sell the organic fertilizer to consumers. The market price of such fertilizer can be estimated on the comparison basis with the market value of nutrients contained in the mineral fertilizer.

4.3.3. Development Concept of Biogas Production till 2030

Taking into account technical and economic feasibility, as well as the current structure and the size of agricultural enterprises in Ukraine (cattle and pig farms, poultry farms, sugar mills, distilleries, breweries), biogas plants market is estimated at about 1,600 plants with CHP capacity from 100 kW_e. Total installed capacity of biogas plants could be around 820 MW_e and 1100 MW_{th}. Is it advisable to use green raw materials (presumably maize silage) in conjunction with manure waste of livestock enterprises, which is justified by both technological and economic reasons. The proportion of at least 1/3 silage from the manure waste mass is considered to be appropriate. Maize silage use at sugar refineries is feasible in case of biogas plant operation throughout the year, not just during the sugar-making season, when the waste is generated.

It is assumed that in the short term (until 2020) and medium term (until 2030), it is reasonable to develop 9% and 51% of economically viable biogas market respectively. Total annual electric power output at the same time can add to 0,449 billion kWh in 2010 and 2,54 billion kWh in 2030. With an overall investment of 15 billion UAH into more than 800 biogas plants of various capacities up to 2030, the volume of produced biogas could reach 1.65 billion m^3 per year (Tab. 4.5).

Thus about 2/3 of total biogas volume will be produced from maize silage, and 1/3 volume is to be produced from waste. The growth of the maize silage required volume will need 0.15 million hectares of arable land, accounting for only 0.5 % of the total area, or 4.3 % of the available area of arable land (as of 2011).

The potential of using waste heat from the CHP will come to 0,395 million Gcal in 2020 and 2.234 million Gcal in 2030. In order to develop this potential, biogas utilization for both power and heat generation should be stimulated, which in the long term will enable to arrange a combined power and heat production from biogas or biomethane in places with the most useful energy recovery.

The number of new jobs created by 2030, both by direct and related activities, will be about 5,200 units, greenhouse gas emissions reduction will reach 6 million tonnes of CO_{2eq}/year.

Construction of small biogas plants (equivalent to the installed capacity of less than 100 kW) is also reasonable, however their use is likely to be motivated by waste treatment needs. Biogas of small units can also be used as a substitute for natural gas or local heat generation. Another reason for such facilities implementation may be the production of high-quality organic fertilizer. Creating energy facility on the basis of small-scale biogas plants with electricity production is not attractive in the Ukrainian market, especially from the economic point of view.

48 – D. Greer. Feeding it back. http://www.biomassmagazine.com/articles/1735/feeding-it-back/

Tab. 4.4. The concept of the biogas plants implementation in the AIC of Ukraine to 2030[49]

Power capacity range	Number of plants	Total biogas output	Total installed power capacity	Total installed thermal capacity	Annual net power production	Annual net heat production	CO_{2e} emission reduction	Investments	Jobs creation	Area under maize cultivation
MW_{el}	units	Mill m^3/yr	MW_{el}	MW_{th}	mill kWh	mill Gcal	mill t/yr	mill UAH	units	th. ha
2020										
0,1-0,5	123	93,3	23,6	31,1	166,7	0,147	0,5	1 103,3	738	9,1
0,5-1,0	12	31,3	7,9	10,4	56,0	0,049	0,2	291,3	99	2,9
1,0-5,0	5	53,0	13,4	17,6	76,6	0,067	0,2	422,3	41	4,6
>5,0	3	114,7	29,0	38,2	149,1	0,131	0,3	828,4	39	10,6
Total	143	292,3	74,0	97,3	448,4	0,395	1,2	2 645,3	917	27,2
2030										
0,1-0,5	696	528,0	133,6	175,8	943,7	0,831	2,6	6 224,8	4 178	51,6
0,5-1,0	70	177,3	44,9	59,0	316,9	0,279	1,0	1 648,9	562	16,5
1,0-5,0	29	299,9	75,9	99,8	433,6	0,382	1,0	2 390,4	232	26,1
>5,0	16	649,1	164,3	216,1	843,9	0,743	1,4	4 688,7	220	59,9
Total	811	1654,4	418,6	550,8	2 538,0	2,234	6,0	14 972,8	5 193	154,1

49 – SEC Biomass data

5 COMPARATIVE CHARACTERISTICS OF BIOENERGY DEVELOPMENT IN UKRAINE AND GERMANY

5.1. STATUS OF BIOGAS SECTOR

Germany is the world leader in biogas energy production and use, which gives background for a detailed study and application in Ukraine of the best practices and the positive experience gained in this country. Over the last decade, the average annual growth of biogas CHP plants installed capacity in Germany amounted to 37.2 %, with the corresponding 16.6% growth rates of biogas plants number. The reason for this rapid growth is the basic conditions for economic development, including agriculture, and the establishment of the state framework conditions promoting biogas technologies development. Energy production from biogas is one of the priority of renewable energy sources development, occupying a prominent niche in the overall energy balance of the country. Despite the indisputable leadership on this area, including among the EU countries, Germany continues increasing biogas production in agricultural and municipal sectors. However accumulated experience makes adjustments to the existing framework conditions, which main objective is a balanced policy between energy production, food and forage, environmental protection and sustainable development. In this regard, the country is pursuing a policy based on decision-making flexibility, clarity, balance and reality of the sector development goals.

In Ukraine energy production from biogas is at an early stage for now, the only insufficient incentive mechanism came in force just in April 2013. This seems to be quite inert state policy that does not allow the biogas sector to develop dynamically, in spite of the existing potential and adequate awareness and willingness of potential market participants. From the point of basic conditions, comparing to Germany, Ukraine possesses even better platform for biogas technologies development. With almost half the population, the territory of Ukraine is almost twice bigger than Germany. Compared with the last one, due to the lower forest cover percentage, Ukraine has almost 3 times more arable land, which basic foundation is formed by black soil.

To convert favorable basic conditions to the intensive development of energy production from biomass and from biogas in particular, a framework conditions similar to those in Germany need to be created. A comparison of the financial mechanism to stimulate biogas technologies development by establishing green tariff for electricity produced from biogas, shows why such technologies in Ukraine will not develop under the existing framework conditions, or their development will be non-systemic. Unlike green tariff mechanism in Ukraine, in Germany there exists a fixed-bonus system of green tariff accrual. Differentiated fixed tariffs are established for electricity from biogas, depending on the project scale. Another difference is the premium to the basic rate of green tariff, depending on the raw material and technology. This allows choosing specifically the development direction, depending on the formed conditions. The system of varied tariffs can stimulate not only the amount of electricity produced from biogas, but also to regulate the methods of its achievement. For example, biogas plants, using more than 80 % of manure are separately stimulated, maize silage is limited to the amount of 60%. Special premium is also used to encourage heat utilization. Bonus of 0.01 to 0.03 Euro/kWh is used for projects that supply biomethane into the gas distribution network. A similar system of flexible incentives would be appropriate in Ukrainian conditions either.

inal rates for electricity sold (0.18 ... 0.21 Euro/kWh) are significantly higher than Ukrainian analogues (0.1239 Euro/kWh), making it possible to cover 3% of final electricity demand through biogas in the country in 2011. An important difference is that the green tariff is awarded in Germany before the start of facility construction, which indicates the confidence and loyalty of mutual interest between the state and the investor. In Ukraine, this tariff is available only after the facility commissioning, creating additional risks for potential investors.

The rapid development of biogas technologies in agriculture in Germany was made possible mostly due to the land resources use for growing energy crops (mainly maize silage). After the debate on the rationality of such way, the amendments are made to dislocate priorities of the raw materials selection for biogas production, although maize silage will continue playing a dominant role in future. In Ukraine, the plant material is not considered yet as a resource for the production of renewable energy and biogas as well despite the fact that more than 10% of arable land in Ukraine today is not used for the cultivation of agricultural products. At the same time, in Germany arable land is completely used, meanwhile 8.1% of land resources are under energy crops for biogas production. It allows covering both food and foraging needs, as well as to a large extent the energy needs of the country. In many ways this is achieved through the efficient land use resulting in the highest yield. For example, grain yields in Ger-

Tab. 5.1. Some agricultural and bioenergy indexes in Ukraine and Germany

Index	Unit	Ukraine	Germany
		Value	
Territory	km^2	603 549	357 021
Population	millions	45,6	80,2
The average annual temperature	^0C	5…13	8…10
The average annual rainfall (2011)	mm	565	700
Total final energy consumption (2010)	million toe	131,2	336,1
Energy consumption per person	toe/person	2,9	4,2
including: from renewable energy sources	toe/person	0,035	0,3
Gross domestic product per capita (PPP) (2012)	th/person	7,3	41,4
Arable land (2011)	million ha	32,5	11,9
Sown area (2011)	million ha	27,7	11,7
Availability of arable land (2011)	million ha	3,6	-
The number of cattle	million heads	5,0	12,5
The number of pigs	million heads	7,8	28,1
The number of poultry	million heads	230	129
The potential of renewable energy production from biomass	million tce	38,2	41,7
including biogas from agricultural waste and by-products	million tce	1,929	4,488
biogas from sewage	million tce	0,075	0,666
landfill gas	million tce	0,260	1,041
biogas from energy crops	million tce	6,86…22,05	8,055
Land use for the energy crops cultivation	million ha	0,0	2,124
including : crops for biogas production	million ha	0,0	0,962
	% arable land	0,0%	8,1%
Arable lands fertilizing	kg N_{tot} /ha	22,4	148,3
	kg P_2O_5/ha	5,9	23,8
Grain crops yield	c/ha	22…35	62…72
Total biogas output	million tce	0,0246	9,538
The share of electricity from biogas in the total final energy consumption (2011)	%	n/a	3,0
The value of green tariff for agricultural raw materials (products and waste)	€/kWh	0,1239	0,06…0,143
Premiums on the basic green tariff rate	€/kWh	no	0,04…0,08
			0,14…0,16
			0,25
Local content requirement	-	yes (30...50%)	no
Green tariff award	-	After commissioning	Before start of the construction
GHG emissions in agriculture	mill t CO_{2e}	34,5	56,8
including: animal breeding	mill t CO_{2e}	15,1	40,2

many over the last 10 years has been systematically higher than in Ukraine (6.2 ...7.2 t/ha in Germany, and 2.2 ... 3.5 t/ha in Ukraine). Yields of maize silage in 2011 in Germany amounted to 47.6 t/ha, while in Ukraine respectively 22.5 t/ha. Higher yields and increased use of agricultural lands in Ukraine can be considered as a potential resource for the energy crops cultivation.

A fertilizer input is an important issue from the point of soil fertility as well as organic fertilizer proportion. Compared to Germany, mineral fertilizers use in Ukraine is 4...6 times lower, which is the main reason for the low yield of food and forage crops in the country. Organic fertilizers are used in Ukraine at only 2% of the sown area, which is extremely low. Waste and agricultural products, processed in biogas reactors, can become a substitute fertilizer resource to mineral ones, the use of which is widely practiced in Germany. Low level of organic fertilizers use in Ukraine is caused by underdeveloped market for organic fertilizers and organic products comparing to Germany.

German law on renewable energy (EEG), on waste management (Abfallgesetz), Decree on agricultural lands fertilize (Düngermittelverordnung) stimulate biogas production. In all of these legislative acts permissible rates for harmful substances (minimum and maximum) are defined, methods of waste management (storage, processing, transportation to the field, disposal) are described. It is necessary to make amendments to the Ukrainian law on the organic waste treatment, as well as to the administrative regulations governing the agricultural lands fertilizing.

An important direction of biogas technologies energy efficiency in Germany is framework conditions for the useful heat utilization from CHP operating on biogas and also biomethane injection into the gas network. In Ukraine there is a lack of such initiatives. Creating the framework conditions for the biomethane production would replace imported natural gas, as well as to create an additional export resource which purchase is already interesting for a number of EU countries including Germany.

Germany's experience to promote RES development, particularly biomass and biogas, is of a great interest for Ukraine. The establishment of such framework conditions in Ukraine would allow the country to repeat the successful story of the RES, bioenergy and biogas technologies development in Germany.

Table 5.1 shows some indicators, which comparison is of interest concerning the development of agriculture and bioenergy in Ukraine and Germany in 2010-2011.

5.2. BARRIERS TO THE DEVELOPMENT OF BIOGAS PRODUCTION AND OVERALL BIOENERGY COMPLEX

Law of Ukraine “On Amendments to the Law of Ukraine “On Electricity” concerning stimulation of power generation from alternative energy sources” (№ 5485-VI of 20.11.2012) from our point of view, creates a number of significant barriers to bioenergy and other renewable energy sources (RES) development in our country.

Unreasonably low green tariff rate for power generated from biogas

Green tariffs for power generated from renewable energy sources have been enacted in Ukraine since 2009. Green tariff values valid before the adoption of a new Law #5485-VI in November 2012 and which will be effective until the law comes into force on April 1, 2013 for various types of RES are presented in Table 5.2.

In general, the Law on Green Tariffs in its original version (2009) can be considered as a progressive and effective mechanism to stimulate power production from RES. It was and is now practically the only operating mechanism that supports projects in this area. At that some questions con-

concerning Green Tariffs for power produced from biogas, MSW and by combined use of fossil and renewable resources remained unregulated in the law.

Tab. 5.2. "Green" tariffs for electricity from renewable energy sources for businesses set into operation from 1.04.13 through 31.12.14 in Ukraine

RES	Increase ratio	Green tariff, EUR cent/kWh, w/o VAT	Green tariff, kopecks/kWh, w/o VAT
Solar	(3,5-3,7)x1,8	33,93…35,87	368,30…389,34
Biomass/biogas	2,3	12,39	134,46
Wind	1,2-2,1	6,46…11,31	70,15…122,77
Hydro	(1,2-2,0)x1,8	11,63…19,39	126,27…210,46

An attempt to resolve these problems was made in the draft Law of Ukraine № 10183 of 13.03.2012. Green Coefficients on the level of 2.7 and 3.0 for power from biogas and MSW respectively were set in the version, which was adopted in first reading on July 3, 2012. In addition, a correct definition of "biomass" that complies with the EU Directive[50] was given in this version.

Unfortunately, some fundamental changes had been made in the draft law №10183 in the version that was adopted in the second reading on November 20, 2012 and signed by the President of Ukraine, as the Law № 5485-VI which converted it from a progressive law into the one that hampers the development of renewable energy, particularly bioenergy in Ukraine.

The Green Coefficient 2.3 for power produced from biogas (for the plants which are put into operation from 01.04.2013 to 31.12.2014) proposed by the Law is absolutely insufficient for the development of biogas technologies. Under such Coefficient, the payback period of the projects will be more than 12-15 years that is unacceptable for investments. The results of the economic analysis supporting this conclusion are given in Chapter 2.5.

Incorrect definition of the term "biomass"

The Law of Ukraine №5485-VI introduces the incorrect definition of "biomass" into the Law "On power industry":

"In this Law, biomass is a non-fossil biologically renewable substance of organic origin in the form of waste from forestry, agriculture (livestock and crop sectors), fishery and technologically related industries which is subject to biodegradation as well as the part of industrial and municipal waste which is able to biological decomposition".

As compared with European practice and the definition, which was adopted in the first reading of the Law, one word – "and products" – was omitted (after the word "waste"). That is biomass must include wastes and products of forestry and agriculture, not only their wastes.

Under the current definition of "biomass" in the final version of the Law, the most prevailing types of biomass including firewood, pellets/briquettes, wood chips and energy willow (as a fuel for biomass CHPP/TPP) and also maize silage (as a fuel for biogas plants) will not be considered as biomass. All these types of biomass cannot be classified as "waste". In our opinion, only this incorrect definition may completely stop the bioenergy development in Ukraine.

In Ukraine, the waste management sphere is regulated by the Law of Ukraine "On Waste"[51] and a number of other laws and legal acts. According to the mentioned Law, waste includes any substances and materials formed during the production or consumption process, as well as goods (products) that have completely or partially lost their consumer properties and have no further use on the place of formation or identification, and which those owner gets rid of or has intention to get rid by recycling or disposal.

Thus, according to the State Classifier of waste, most raw materials of plant origin, which are currently used as a feedstock in bioenergy projects, do not fall within the definition of "biomass"[52]. In particular, the respective State Classifier defines the following waste categories for maize:

50 – Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 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

51 – The Law of Ukraine "On Waste" / Bulletin of the Verhovna Rada of Ukraine, 1998, № 36-37, p. 242. (in Ukr) http://zakon2.rada.gov.ua/laws/show/187/98-%D0%B2%D1%80

52 – State Classification of waste ДК 005-96 (in Ukr) http://search.ligazakon.ua/l_doc2.nsf/link1/FIN7371.html

0111.2.9.03 Maize plugs milled
0111.2.9.04 Stalks of maize dry

determined by this type of waste as another straw (code 0111.2.9.02).

Based on the abovementioned we consider that the definition of biomass should be corrected as follows

"In this Law, biomass is a biologically renewable substance of organic origin which is subject to biodegradation (products, waste or residues of forestry and agriculture (livestock and crop sectors), fishery and technologically related industries as well as the part of industrial and municipal waste, which is able to biological decomposition".

This definition is fully consistent with international and European practice on this issue, particularly with European Parliament and Council Directive 2009/28/EC[53], which is obligatory for the implementation by Ukraine until 01/01/2014 according to the Treaty on establishing the Energy Community.

Unjustified requirement concerning the domestic share of equipment, materials and services in the total project cost

Even before passing the new Law on Green Tariff № 5485-VI, most of experts believed that existing requirements concerning the domestic component of equipment, materials and services for the plants which claimed for Green Tariff, were unreasonably high: 30% for the projects implemented since 2013, and 50% for the projects implemented after 2014. This is due to the fact that manufacture of most types of equipment or at least their basic components does not exist in Ukraine today and is unlikely to be launched during the short period of time that remains. For example, Ukrainian manufacturers have never produced (and are unlikely to start production in the coming 10 years) such high-technology equipment as biomass boilers of over 10 MW_{th}, steam turbines of 1-10 MW_e, biogas cogeneration units of 100-1000 kW_e, and a number of other specialized equipment for bioenergy sector.

The local content requirement introduced by the Law of Ukraine № 5485 of 20.11.2012 only worsened the situation. Requirements of 50% domestic component remained, though with a delay of about half a year for biogas plants as compared with biomass plants. This requirement will apply to:

- biomass power plants, construction of which was started after 01.01.2012 and which will be commissioned after 01.07.2014;
- biogas power plants, construction of which was started after 01.01.2012 and which will be commissioned after 01.01.2015.

This requirement will inhibit developing the sector of electricity generation from renewable energy and will lead to the monopoly position of several manufacturers of such equipment. Such requirement also violates non-discrimination principles of the World Trade Organization (WTO) which implies that one state in the economic field of the other state is provided with the same conditions, benefits and privileges as any other state. In addition, the deployment of local content requirement contradicts to competition rules set by the European Union. The vast majority of countries that use incentive mechanisms such as green tariffs or green certificates do not impose simultaneously any requirements of the local content.

Terminological mistakes in the description of main pieces of equipment for electric-power objects which use energy of biomass and biogas

Local content requirement for equipment in electric-power objects which use biomass and biogas in the Law №5485 from 20.11.2012 are detailed incorrectly, with errors in terminology and without the necessary details. As some bright terminological errors one can cite the use of terms "water-heater" (instead of "boiler": can be both thermal-oil and steam), "bioreactor for hydrolysis" (instead of "digester" or "anaerobic digestion reactor") and "co-generator" (instead of "cogeneration unit").

Such errors will lead to the situation that state body authorized for the issuance of green tariff (NERC) will not approve green tariff for bioenergy objects based solely on the fact that "water heater", "bioreactor for hydrolysis" and "co-generator" will be absent among their equipment.

Although the law is applicable for all types of biogas, requirements for specific contributions to the overall cost by the local component elements is prescribed only for certain types of biogas technology (including "bioreactor for hydrolysis"),

53 – Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 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

which is generally not suitable for other (including biogas collection and utilization systems at landfills, that do not have “bioreactors” in their content at all). Therefore “bioreactors for hydrolysis” are not included in the landfill gas collection systems. Thus, application of the law for all biogas plants, except those that include a “bioreactor for hydrolysis” is in practice impossible.

The discriminatory approach to biogas plants, which had been put into operation before 01.04.2013

According to the Law of Ukraine № 5485 of 20.11.2012, objects which produce electricity from biogas and are commissioned before 03/31/2013 inclusively, do not obtain the Green Tariff. There are up to 10 such objects in Ukraine, and they were built in recent years in anticipation of Green Tariff for electricity from biogas. Not granting Green Tariff puts them in a position of inequality as compared to other biogas plants that is, in our view, deeply unfair and discriminatory.

Most of the listed above legislative barriers can be overcome if the draft Law #2946 "On Amendments to the certain Laws of Ukraine regarding the promotion of electricity generation from alternative energy sources" dated 26.04.2013[54] is improved.

The draft Law #2946 had been developed by a group of Deputies led by Mr. Medyanik with expert support of UABio, to support the practical implementation of the "green" tariff for power generation facilities that produce electricity from alternative energy sources. The draft Law proposes solutions for each of the problems existing in the current Law of Ukraine. These decisions are scientifically justified; take into account the best international practices and the real situation in Ukraine.

The draft Law #2946 was considered by the Committee on Fuel and Energy of Ukraine on June 18, 2013 and authors were recommended to finalize it. Modified version of the Law was registered on web-site of Verkhovna Rada of Ukraine on July 5, 2013. Its review is anticipated in Verkhovna Rada for September 2013.

Compared with the previous version of the draft Law, the authors have significantly taken into account the comments and suggestions of the Cabinet of Ministers of Ukraine, Chief Scientific Expert Department of the Verkhovna Rada of Ukraine and the National Energy Regulation Policy.

In particular, the authors excluded the offer of "green" tariff establishment for electricity generated from biomass co-firing with fossil fuels. This decision is related to the possible difficulties of biomass proportion monitoring and verification while co-firing with fossil fuels, as well as due to the possible negative impact of partial coal substitution by biomass on the socio-economic situation of Ukraine's coal mining regions.

The definition of "biomass" has been clarified by the following way: "biomass is a renewable non-fossil biological material of organic origin that is biodegradable (products, waste and residues of forestry and agriculture (crop and livestock), fisheries and technologically related industries) and biodegradable component of industrial or municipal solid waste". Thus, any risks of fossil fuels inclusion into the term "biomass" have been eliminated.

The norms of the draft Law are proposed to put in force not from 01.04.2013, but from 01.01.2014, which corresponds to the probable date of its adoption by the Verkhovna Rada of Ukraine.

Other barriers

Lack of regulatory framework. In addition to legislative barriers, there also exists a problem of the lack of modern regulatory construction documents (State Construction Norms) for the design and operation of biogas plants and LFG collection systems. In this case, the project owners and designers faced with the need to develop Technical Specifications for every implemented biogas plant, and government construction regulation agencies are constrained to apply the subjective approach to the building permits issuance, because of the lack of regulatory framework for such projects evaluation. All of this leads to projects launch delays, and to excessive cost for the project owners. Therefore, it is important to initiate the necessary regulatory documentation development in the field of biogas projects with leading experts and specialized organizations involvement.

Complicated procedure of green tariffs obtaining. In Ukraine, as against to most countries, green tariff obtaining is only possible after the

54 – Law "On Amendments to the certain Laws of Ukraine regarding the promotion of electricity generation from alternative energy sources" from 26.04.2013 (draft) (in Ukr)
http://w1.c1.rada.gov.ua/pls/zweb2/webproc4_1?pf3511=46816

power plants commissioning. This creates an additional risk that must be accepted by project developers and investors. In addition, according to the law, Ukrenergo or Oblenergo are obligated to reimburse the cost on power grid connection. However, the procedure for the compensation payment is determined just partially and does not work in practice. Grid connection and technical conditions obtaining to date remains the most opaque phase of the entire green tariff chain. Regulators have no uniform and available rules of setting such requirements and calculating the connection costs. During green tariff registration it is often necessary to change the designated purpose of lands.

The complexity of tax exemptions application for the import of bioenergy equipment. Another mechanisms to stimulate biogas projects implementation are legally stipulated preferences, such as the exemption from VAT and customs duties. List of equipment and components, and materials that can take advantage of the preferences is set by CMU Decree # 444-2008-p (current version from 20.12.2012). The present form of benefits obtaining procedure is opaque and unpredictable, and therefore has the discriminating character regarding the idea of RES projects implementation promoting with evidence of subjective reasoned decision on the individual items inclusion of to the list.

Lack of Ukrainian biogas projects trust fund. A backward interest in biogas technology as an independent energy sector of Ukraine, insufficient funding for research, and most important, the lack of pilot projects funding on biogas plants construction, do not allow Ukrainian manufacturer to compete at this stage with foreign biogas technologies suppliers. At the same time, target funding the complete cycle of creating the most relevant and cost-effective pilot biogas projects by Ukrainian production with subsequent replication will allow in the future to involve manufacturing facilities in the various industries of Ukraine.

The absence of an active program for the sector. An important signal from the state will also be involvement of the program approach to biogas technologies development with specific objectives, funding sources and timelines. The concept of such a program is actually approved as a national project "Energy of Biogas", but has not yet found the proper development, i.e. due to the above mentioned barriers. We believe that enhancement of the national project development, along with overcoming these barriers will provide the necessary impulse for the development of biogas technology in Ukraine and attract investment into biogas industry.

Access to the gas network for biomethane producers. Today, gas distribution network access for Ukrainian biomethane producers is not provided by the regulatory acts and therefore is practically impossible. This opportunity should be incorporated into the legislation, in particular, the necessary changes to the law "On the principles of the natural gas market functioning" adopted in 2010. Technically, this process is not difficult because the physical biomethane properties are close to natural gas.

It should be mentioned that frequently changing legislation forming the uncertainty among projects developers and investors is another barrier to the biogas production development in Ukraine.

CONCLUSION

Ukraine is a country with a deficit of its own fossil fuels. The demand for natural gas in the country is met through its own reserves only for 35%. The share of own resources to meet the oil demand is only 10-12%. Despite this issue, the draft of the updated energy strategy till 2030 comprises extremely slow development of renewable energy. It is only 10% of the total power generation installed capacity in 2030 with negligibly small bioenergy contribution.

In Ukraine there is practically no coherent national policy for the development of renewable energy in general and bioenergy in particular. Adoption by Ukraine at the end of 2012 commitments under the Energy Community to achieve 11% renewable energy in the gross final energy consumption in 2020, the development of a National Action Plan for renewable energy up to 2020 and the Action Plan for the implementation of the European Parliament and Council Directive

#2009/28/EC from 23.04.2009 are not related with updated draft of energy strategy.

A positive factor for the development of bioenergy sector in Ukraine is a continuation of the "green" tariff validity for electricity produced from solid biomass, as well as the extension of the law on biogas from 1 April 2013. In November 2012 corresponding Law of Ukraine «On amending the Law of Ukraine «On Power Industry» regarding stimulation of power production from alternative energy sources» (№5485-VI of 20.11.2012) was adopted.

In general, the law can be considered as progressive and effective mechanism for encouraging the sector of electricity production from renewable energy sources. Unfortunately, for power produced from biogas the Law sets a low Green Coefficient: K=2.3 with its further gradual decrease. Also, the new Law introduces an unjustified and unreasonable domestic content equipment requirement for power plants that have a claim on Green Tariff. The incorrect definition of "biomass" and a number of terminology mistakes also occur in the Law.

Assessment of the economic parameters of a typical biogas energy project with mini-CHP in the range of electric capacity of 0.1...2.1 MW_e shows that the discounted payback period of the project through the sale of electricity using the current "green" tariff K=2.3 is more than 10 years. Payback period reduction for up to 6...8 years is possible with "green" tariff for electricity from biogas at the range of 0.1616 Euro/kWh (K = 3.0).

In the case of maize silage use as additional substrate in biogas energy projects, the economic performance of the project depends on the price of silage. While the current market prices for silage (15…20 Euro/t) and green tariff coefficient of 2,07-2,3 the development of commercial biogas energy projects is also problematic.

Either in the case of industrial waste processing or in the case of co-digestion with plant substrates, green tariff for electricity generation from biogas of 0.1616 Euro/kWh would allow achieving an acceptable payback period of 6...8 years. An alternative would be special allowances to green tariff in the case of plants (maize silage) use on the example of Germany.

The adoption by Verkhovna Rada of the draft Law #2946 from 26.04.2013[54], developed by a group of Deputies led by Mr. Medyanik with expert support of UABio, removes most of the barriers to biogas plants development in Ukraine and is essential for the development of this sector of economy.

According to the SEC Biomass data, estimated for 2011, an economically viable energy potential of biomass was 24.5 million tce (718 PJ), and the energy potential of biomass that can be grown on more than 4 million hectares of unused agricultural land was about 13.7 million tce (402 PJ). AIC of Ukraine possesses the technical resources of available organic waste and by-products for biogas generation in the amount of 2.6 billion m^3 CH_4/year (93 PJ).

Biogas plants market size at the agricultural enterprises in Ukraine (cattle and pig farms, poultry farms, sugar mills, distilleries, breweries), is estimated to be about 1,600 plants with CHP capacity starting from 100 kW_e. Total installed capacity of biogas plants could be around 820 MW_e and 1100 MW_h. It is assumed that in the short term (until 2020) and medium term (until 2030), it is reasonable to develop 10% and 50% of economically viable biogas potential respectively. With total investment of 15 billion UAH into more than 800 biogas plants up to 2030, the volume of produced biogas could reach 1.65 billion m^3 per year.

To increase biogas energy projects potential and commercial implementation it is important to stimulate the electricity production from biogas obtained not only from biomass waste, but also with the use of specially-grown energy crops. Thus, using 6 % of arable land for maize cultivation with a conservative value of maize silage yield 30 t/ha and methane yield 100 m^3/t, can provide with 5.4 billion m^3 CH_4/year; and while increased yield to 40 t/ha and methane output to 115 m^3/t may correspondently provide with 8.3 billion m^3 CH_4/year.

The development of agriculture in Ukraine, suggesting improvement of soil fertility and crop yields, as well as the rational land and resources use in the long term perspective will significantly increase the potential for energy production from biogas. That gives an opportunity not only of partial replace the fossil energy, but export biomethane to the EU, in particular to Germany. The existing potential of agricultural land in Ukraine allows to combine food and forage production, including for export, along with the energy crops production and the subsequent generation of electricity and/or thermal energy and biomethane which is a direct substitute for natural gas. Energy use of the lands is not an alternative to food production, but the

possibility of further agriculture intensification and its profitability increase.

The development of biogas technology creates a combined positive effect, including both the energy and the environmental and social aspects, as well as contributes to the fertile land revival.

The development of biogas technology in Ukraine was considered in the framework of the Special Agency for Renewable Resources project MY 08-01 "Promoting the use of renewable resources in Ukraine, with a focus on the use of biomass production of energy". It is recognized that biogas technology is strategically an important area of bioenergy. There is no doubt that the biogas has of great future in Ukraine.