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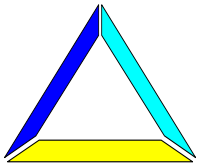


AgOverview

Overview on Renewable Energy in Agriculture and Forestry in Ukraine

Disclaimer:
This paper was prepared by the authors using publicly available information and data from various Ukrainian, EU and WTO sources. All conclusions and recommendations included in this article in no circumstances should be taken as the reflection of policy and views of the German Federal Ministry of Food, Agriculture and Consumer Protection.

List of Abbreviations

CHP – combined heat and power plant
DH – district heating
ETBE - ethyl tertiary butyl ether
EE – energy efficiency
HOA - high-octane oxygen containing admixture to gasoline
IEA – International Energy Agency
LFG – landfill gas
MSW – municipal solid wastes
NG – natural gas
PV – photovoltaic
RE – renewable energy
RES – renewable energy sources
R&D – research and development
TPEC – total primary energy consumption
tce – ton of coal equivalent (LHV = 29.3 MJ/kg)
toe – ton of oil equivalent
VAT – value added tax
WPP – wind power plant

1 Background, Objectives and Overview

Renewable energy offers interesting perspectives for agriculture and forestry in Ukraine. It is broadening the range of available energy sources, creating new market outlets for agricultural producers besides food production. It contributes to national energy security by diversifying energy supply sources. Linked food and energy markets will increase competition and the most efficient producers will benefit most of new markets in future.
This policy paper has been prepared to present the perspectives of various energy sources based on national and international experiences. It covers bioenergy, hydro, wind, solar and geothermal energy. Major emphasis has been put on bioenergy. The paper outlines the current situation and perspectives of these energy sources for the Ukrainian Government and national and international investors. A separate policy paper on the economics of biofuels (bioethanol and biodiesel) is under preparation.[1]

Currently, the share of renewables in total energy supply in Ukraine is quite modest: 2.8% with large hydro energy and 0.8 % without it (Table 1). The Government Energy Strategy[2] projects their growth. The Ukrainian Government is aware of the perspectives of renewable energy and launched various programs to develop strategies and specific projects[3], e.g. to produce bioethanol and biodiesel. In 2000 the Law of Ukraine "On alternative kinds of liquid and gas fuels" was adopted. Its purpose is to encourage production and utilization of liquid bio-fuels, biogas, producer gas, coal methane and other alternative fuels. At the same time awareness has been created to increase energy efficiency in Ukraine. A National Agency for efficient use of energy resources and an interministerial working group for reducing gas use in Ukraine have been created recently.

Table 1

Share of RES and biomass energy in different countries

Countries (2004)	Share of renewable energy in total energy consumption, %	Share of biomass energy in total energy consumption, %
Iceland	70.7	
Norway	40.1	
New Zealand	29.7	
Sweden	24.7	19
Finland	22.9	21
Austria	21.3	12
Canada	15.7	6
Switzerland	14.9	
Portugal	14.2	
Denmark	13.7	8
Ukraine (2005)	**2.7**	**0.5**
Ukraine (2030) under approved "nuclear" Energy Strategy	6.0	3
Ukraine (2030) under proposed "EE and RES" strategy	16.5	8.4

Source: Geletukha G.G., Dolinsky A.A. Presentation at Third International Conference on Biomass for Energy (18-20 September 2006, Kiev, Ukraine)

[1] Ludwig Striewe: The Perspectives of Biofuels in Ukraine, December 2006
[2] Energy Strategy of Ukraine for the period till 2030, adopted in March 2006
[3] Program "Ethanol" (adopted on 4.07.2000); Conception of the Program for biodiesel production till 2010 (adopted on 28.12.05); Program for biodiesel production till 2010 (is developed but not adopted yet); Energy Strategy of Ukraine for the period till 2030, chapter VII "Priority directions and volume for energy saving, potential for the development of non-traditional and renewable energy sources (adopted on 15.03.06); Projects adoped for the realization in 2002-2005 in the framework of the State program "Environmentally friendly geothermal energy of Ukraine" (Program was adopted on 17.01.1996; list of projects was adopted on 27.12 2001); Complex program for the construction of wind power plants (adopted on 3.02.1997).

Most of Ukraine's renewable energy today is concentrated in large hydro power and biomass-fired heating boilers and stoves. There are also several wind power plants and geothermal heating systems. Ukraine has a scientific and industrial base for manufacturing renewable energy technologies, but the quality and reliability of existing Ukrainian technologies have to be improved. The most significant challenges in expanding renewable energy are cost competitiveness and financing. Subsidies for traditional energy and other market and legislative distortions (e.g. state subsidising of coal and NG industry, cross-subsidising of electricity tariffs, rather mild ecological legislation as for pollution of the environment) do not ease these challenges. Ukrainian policy makers have introduced a number of incentives to stimulate renewable energy production and use, but most of these incentives have not been enacted. More effective policies and regulations as well as the political will to implement and finance the announced programs are needed to enhance the use of renewable energies and fully capture their environmental, economic and social benefits.

As the implementation of renewable energy schemes needs considerable investments in new technologies currently not available in Ukraine it offers also interesting opportunities for foreign direct investment and suppliers of equipment from Western Europe, including Germany.

2 Renewable Energy Market and Industry Sources

2.1 Renewable Energy Definitions

There is no universally accepted definition of renewable energy. The IEA defines it as energy generated from solar, wind, biomass, geothermal, hydropower and ocean resources, as well as solid biomass, biogas and liquid biofuels. Renewable energy is different from municipal and industrial waste, which can be either renewable (containing biodegradable materials) or non-renewable. However, in many cases both categories of waste are reported together.

In Ukraine the definition of renewable energy is somewhat broader. It is often used as a synonym for non-traditional or alternative energy, which includes peat, low-potential heat of the earth (for use in heat pumps) and the "secondary" energy sources such as waste heat, municipal and industrial waste, pressure of blast-furnace gas and pressure of natural gas during its transportation. Some Ukrainian sources also include coal-bed methane, natural gas from small-scale difficult fields and other non-renewable fuels the extraction of which requires innovative technologies, in the definition of alternative energy sources.

Small hydro power is another controversial term. IEA considers hydro plants as small if their capacity is below 10 MW; in Ukrainian sources small hydro is defined below 30 MW.

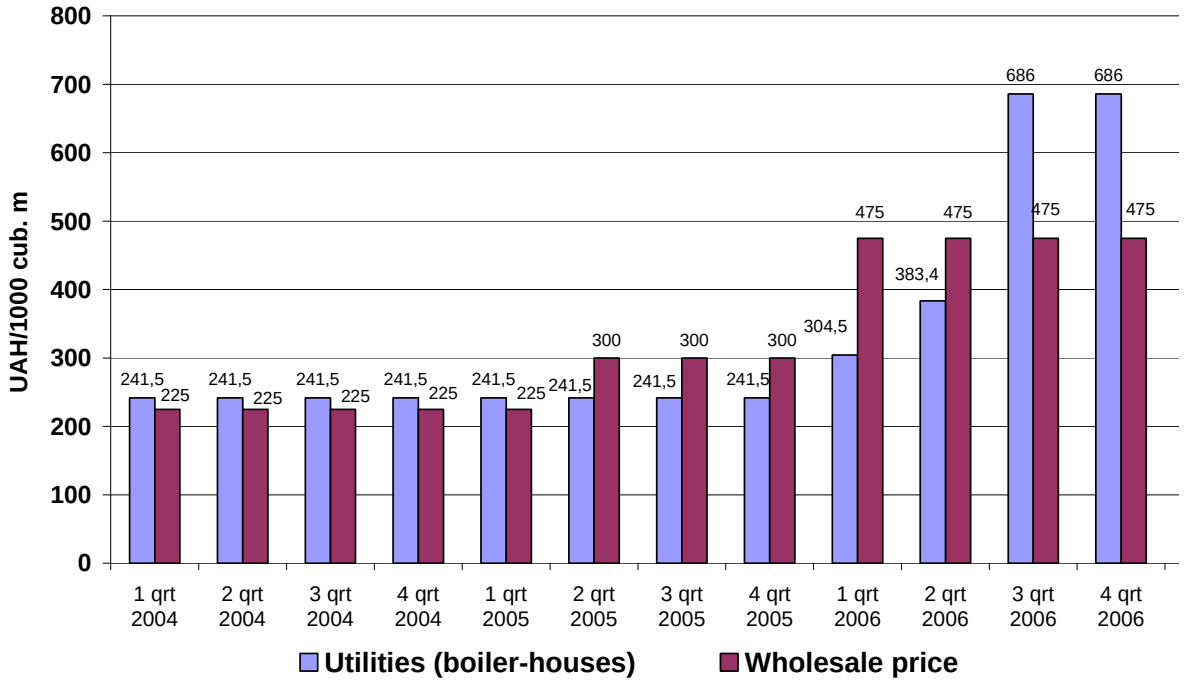
Market Position

Ukraine is a nation heavily dependent on imported fossil fuels. Reduction of natural gas consumption is one of the most relevant issues for Ukraine which is now in a difficult energy position. The cost of natural gas increased by more than two times in 2006 (Fig. 1). As a result, a number of branches of the national economy found themselves on the edge of viability. That is why Ukraine must urgently look for alternative energy sources and introduce energy saving technologies. Wide application of renewable energy technologies, first of all biomass, can be one of the ways for the reduction of natural gas consumption.

Europe shows that the energy production from RES is developing dynamically in most countries. The share of renewable energy was 74.3 mill tons of oil equivalent (mill toe) in EU countries in 1995 that came to about 6% of the TPEC (Table 2). The share of biomass was more than 60% amounting to about 3% of TPEC. In some countries the share of biomass in TPEC exceeds the average European index significantly. In Finland it is 23% (world leader among developed countries), in Sweden - 18%, in Austria - 12%, in Denmark - 8%, in Canada and Germany – 6%, in the USA - 3%. According to the program for RES development (White Paper) RES will cover 12% of TPEC in 2010 in EU, including biomass (about 74% of the total renewable energy contribution in 2010 in EU countries). It is obvious that biomass is the most powerful and progressively developing sector of renewable energy in EU.

Figure 1

Natural gas prices in Ukraine (2004-2006)



Source: Geletukha G.G., Dolinsky A.A. Presentation at Third International Conference on Biomass for Energy (18-20 September 2006, Kiev, Ukraine)

Table 2

Heat and power production from renewable energy in the EU

Type of renewable energy sources	Energy production				Total investments in 1997-2010, milliard $	Reduction of CO_2 emission by 2010, mill t/yr.
	1995		2010			
	mill toe	%	mill toe	%		
Wind energy	0.35	0.5	6.9	3.8	34.56	72
Hydro energy	26.4	35.5	30.55	16.8	17.16	48
Photovoltaics	0.002	0.003	0.26	0.1	10.8	3
Biomass	**44.8**	**60.2**	**135**	**74.2**	**100.8**	**255**
Geothermal energy	2.5	3.4	5.2	2.9	6	5
Solar thermal collectors	0.26	0.4	4	2.2	28.8	19
TOTAL	74.3	100	182	100	198.12	402

Source: Energy for the Future: Renewable Sources of Energy. White Paper for a Community Strategy and Action Plan. Bruxelles, 1997, 53 p.

Currently, renewable energy (including large hydro power stations) accounts just for some 2.8% of total primary energy supply in Ukraine. Only hydropower and biomass are commercially used; other renewable energy technologies are still on the stage of research and development or demonstration, and their share in energy supply is insignificant (Table 3).

Table 3

Renewable Energy Technologies in Ukraine

Technology	***Energy product***	***Status in Ukraine***
Biomass		
Combustion	Heat /Electricity (CHP)	Used for cooking and heating by residential and commercial sector. Used for heat and steam production by industry and district heating. Electricity generation (CHP) is insignificant. More than 1000 wood fired boilers operate in forestry and wood processing industry.
Gasification: power/fuel production	Electricity, heat (CHP)/ Hydrocarbons, methanol, H_2	R&D
Hydrolysis and fermentation	Ethanol	R&D and demonstration; some industrial production
Pyrolysis/production of liquid and solid fuels	Bio-oils / charcoal	R&D
Extraction and digestion	Biodiesel / biogas	R&D, several pilot projects. One operating large-scale CHP biogas plant
Wind		
Wind Turbines	Electricity	70 MW installed power capacity
Wind mills and water pumping	Movement, power	Used in agriculture
Hydro		
Hydro power stations	Electricity	Large-scale capacity: 4,600 MW; small-scale: less than 100 MW
Geothermal		
Geothermal power/heat stations	Heat, steam, electricity	13 MW installed thermal capacity
Solar		
Photovoltaic solar energy conversion	Electricity	Manufacturing PV panels and systems, mostly for export
Concentrating solar power	Electricity	n.a.
Solar heating and cooling	Heat, steam, cold	Manufacturing solar collectors for domestic use
Low-temperature solar energy use	Heat	Used for water and space heating, drying, cooking.

n.a.- non available.

Source: IEA analysis. Table based on IEA (2003) *Renewable Energy into the Mainstream*, IEA Renewable Energy Working Party, Paris.

The state enterprise "Energy Company of Ukraine", either directly or through its subsidiary Ukrhydroenergo, owns Ukraine's hydro and wind power facilities. It sells hydro and wind power on the wholesale market at tariffs regulated by NERC. Owners of small, distributed renewable energy systems (farms, industrial companies, households) are at the same time energy producers and consumers. Heat and electricity produced by such systems are not sold on the market. Therefore viable statistical data including various energy sources should be regarded with caution.

The main current constraint to the expansion of renewable energy sources is comparatively high costs. Direct and hidden subsidies for traditional energy and other market distortions hamper the development of renewables. For example, the state subsidizes coal industry because most Ukrainian mines are unprofitable and production cost of coal is much higher (up to 4 times) than its sale price. Another example is supply of NG to population. NG is supplied at a price which is below the real cost price. There is cross-subsidising in electricity tariffs. It means that tariffs for industrial consumers are high and tariffs for population are low, so industry in fact subsidizes population. Low prices of energy carriers do not stimulate people to save energy and to use RES. Besides, there is no tax on CO_2 emission and no energy tax on the use of fossil fuels as it is in such countries as Denmark, Finland, and Sweden. The oil sector has a very strong lobby on top level in Ukraine. Suppliers of gasoline and other kinds of oil products are not interested in substitution of their products by alternative liquid fuels (bio-diesel, bio-ethanol). The nuclear power industry also has strong lobby among authorities. The new

Energy Strategy of Ukraine till 2030 puts major emphasis on the development of nuclear power plants.

However, some forms and uses of renewable energy are already economically viable in Ukraine. Large hydropower is the most mature and least-cost technology. Tariffs for hydropower are the lowest on the Ukrainian wholesale market. Biomass-fired boilers are often competitive compared to gas fired boilers in areas with available biomass resources. Other renewable energy sources can be more cost-effective than conventional energy in some applications, including off-grid[4] (distributed) electrification and heating, biomass-fired or geothermal district heating and specific industrial uses. The sharp growth of oil prices in recent years leads to growing competitiveness of biofuels. The Government supports the future development of renewable energy sources. However, cost-competitiveness of most renewable energies have to be carefully evaluated both from the point of view of energy providers and from the point of view the economy. Market distortions and cross-subsidization should be carefully analysed and be avoided wherever possible. The most important factors to consider are: the availability of resources and their costs (in financial and economic terms), production costs, future price trends, ecological considerations, availability of know how and other local conditions.

Cost of renewable energy technologies goes down as their use grows. International experience shows that targeted governmental policies can significantly reduce costs and increase the economic attractiveness of renewables by creating a "virtuous circle". Supportive policies lead to increased use of renewable energies, which brings their costs down. Lower prices open new market opportunities, which leads to further cost reductions due to economies of scale.

Estimation of costs of RE technologies for the application in IEA countries and in Ukraine is presented in Tables 4 and 5. Assessment for Ukraine shows that local capital costs are lower than that in the world whereas energy production costs are approximately in the same range. Exclusion is solar PV: power production cost is now too high and not competitive for commercial use. As for quality and reliability of Ukrainian equipment it should be considered that for various reasons they are lower in comparison with international standards.

[4] In case of frequent irregularity in power supply from the grid (cut-offs) availability of own autonomous biomass-based power unit can be of great help. Especially it applies to enterprises/farms which have their own cheap or even zero cost biomass in big volume (waste wood at wood working enterprises, manure at pig/cattle breeding farms etc.)

Table 4

Capital costs and renewable energy production costs in IEA countries

RES	Capital costs	Production cost of energy
Bioenergy	100-160 US$/kWth (wood and straw fired boilers) 2860-5450 US$/kWel (gasification plant in Switzerland)	20 US$/MWh (Co-firing: power production) 100-150 US$/MWh (Innovative gasification plants: power production) 0.76 US$/l (Bioethanol in Sweden) 0.77 US$/l (Biodiesel in EU)
Wind energy	850-950 US$/kWel (onshore wind turbines) 1100-2000 US$/kWel (offshore wind turbines)	50 US$/MWh (Typical) 35-40 US$/MWh (The very best sites)
Geothermal energy	1300-2500 US$/kW (5-30 MW plants)	50-80 US$/MWh (New plants)
Solar thermal collectors	124-186 US$/$m^2$ (well designed systems)	190 US$/MWh (average price for solar heated water) 120 US$/MWh (in Germany with state subsidy of 136.65 US$/$m^2$)
Solar PV	5-9 US$/Wel (For building-integrated, grid-connected PV systems)	200-300 US$/MWh (Today's lowest generation costs) 250-450 US$/MWh (General range)
Small hydro power	not available	40-60 US$/MWh (General range) 20 US$/MWh (Under favourable circumstances)
Large hydro power	2400 US$/kWel	30-40 US$/MWh

Sources: Renewable Energy. Market and Policy Trends in IEA Countries. OECD/IEA, 2004
Renewable Energy: RD&D Priorities. OECD/IEA, 2006.

Table 5

Typical capital costs and renewable energy production costs in Ukraine (assessment), 2006

RES	Capital costs	Production cost of energy
Bioenergy (wood and straw fired boiler)	40-80 US$/kWth	7.6 US$/MWh
Bioenergy (biogas plant)	200-500 US$/m3 digester	24 US$/MWh
Biodiesel production plant	640 US$/t biodiesel	0.5 US$/l
Wind energy	1140 US$/kWel	36 US$/MWh
Geothermal energy	700 US$/kWth	65 US$/MWh
Solar thermal collectors	100 US$/m2	30 US$/MWh
Solar PV	4000 US$/kWel	2000 US$/MWh
Small hydro power	2300 US$/kWel	60 US$/MWh

Source: Own estimates

Resources and Potential

Since efficiency of most renewable energy technologies is site-specific, detailed information on available resources is very important for their successful development. Renewable energy resources in Ukraine are fairly well studied and reported, but the economic potential of these resources is quite hard to determine. In 2001 a group of Ukrainian scientists compiled a comprehensive atlas of renewable energy resources of Ukraine upon the request of the former State Committee on Energy Conservation. The Atlas[5] shows the geographical distribution of different renewable energy resources and calculates their physical, technical and economic potential. The Atlas reveals that Ukraine

[5] The Atlas is available at the Committee's website: http://www.necin.com.ua

has quite big potential of all types of RES, gives general picture of present status of RES utilization and recommendations for further development. For example, it is recommended to use flat solar collectors while concentrating collectors can be applied only in Southern regions of Ukraine. Construction of WPP is considered to be reasonable mostly in the area of the Azov Sea and the Black Sea coast, and Carpathians where average annual wind velocity is more than 5 m/sec. Potential of Ukraine's small rivers, different types of biomass, geothermal energy and non-traditional energy sources is analyzed in the Atlas. Other estimates of renewable energy potential also exist. For example, the Institute of Engineering Thermophysics of the National Academy of Sciences of Ukraine published a detailed study in 2002 that estimated the total technical potential of biomass wastes at 86.3 TWh/yr or 10.6 mtce (7.4 mtoe) per year. Now the experts from the Institute include also liquid biofuels, energy crops and fuel briquettes in the energy potential of biomass in Ukraine and estimate it at 281 TWh/year or 24.2 mtce (16.9 mtoe) per year.

The "Energy Strategy of Ukraine for the period till 2030" adopted in March 2006 estimates the annual technical potential of renewable energy, waste and non-conventional energy sources at about 79 mtce. At that consumption of RES is forecasted at 18.3 mtce in 2030 (6% of total primary energy consumption). The Scientific Engineering Center "Biomass" in cooperation with non-governmental organisations developed an alternative strategy for RES development till 2030. According to it the share of RES will be 16.5% of total primary energy consumption or 39.2 mtce in 2030 (Table 6).

Table 6

Consumption of RES in Ukraine (the baseline scenario of the approved Energy Strategy vs. the alternative scenario)

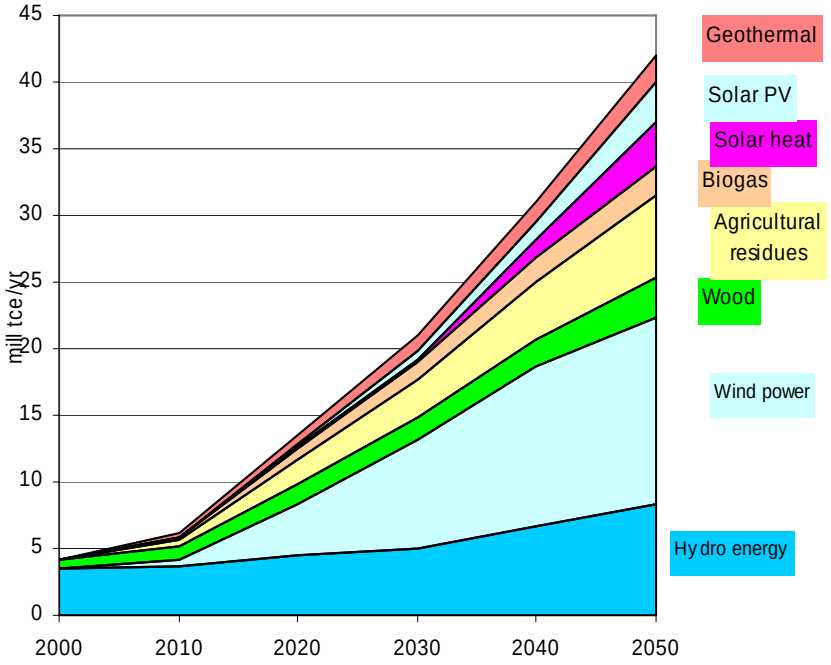
Renewable energy sources	RES, mill tce		
	2005	2030 Approved "nuclear" Energy strategy	2030 Alternative "EE and RE" strategy
Biomass energy	1.3	9.2	20.0
Solar energy	0.003	1.1	2.7
Small hydro power	0.12	1.13	1.3
Large hydro power	3.89	5.5	5.5
Geothermal energy	0.02	0.7	1.1
Wind energy	0.018	0.7	8.6
Total RES	5.4	18.3	39.2
Total energy consumption, mtce	200.6	302.7	237.5
RE/ total energy consumption, %	2.7	6.0	16.5

Source: Geletukha G.G., Dolinsky A.A. Presentation at Third International Conference on Biomass for Energy (18-20 September 2006, Kiev, Ukraine)

The Renewable Energy Agency estimates that annual renewable energy use can grow to about 100 TWh by 2030 and over 200 TWh by 2050, which would allow Ukraine to substitute 22 mtce/year of fossil and nuclear energy in 2030 (7.3% of total energy supply) and up to 42 mtce/year in 2050 (Fig. 2).

Figure 2

Projected Use of Renewable Energy Sources in Ukraine by 2050, mtce.



Source: Geletukha et al. (2003) Energy Supply in Ukraine: Outlook to 2050 // Green Energy, #4(12), Kyiv

While the Atlas and other publications provides valuable information on the availability of renewable energy resources in different regions of Ukraine, the estimates of technical and economic potentials are only indicative and are likely to change over time. The technical potential will likely grow with the development of available technologies. The economic potential of renewables in the medium and long term will very much depend on their cost compared to prices for fossil fuels. The latter are difficult to predict, which makes the prospects for renewables' competitiveness unclear. The cost of renewable energy technologies will also very much depend on technical progress and governmental policies.

A challenge for renewable energy expansion is financing. A 0.75% charge on all electricity sales is directed to a special fund for financing renewable energy development (the Law of Ukraine "On Power Industry", N 575/97 of 16.1097). The fund accumulates some $20 million per year.[6] The fund is mainly used for construction of wind plants; while other renewable energy sources get practically no supported by the state budget. Moreover, for 2006 this 0.75% charge is cancelled by the Law on State Budget-2006 (article 23, chapter 77). Potential users of renewable energy (agricultural enterprises, rural settlements, residents of houses not connected to district heating and gas networks) generally have limited access to commercial financing. District heating companies, potential users of biomass, too, have limited funds to invest into converting boilers for biomass use (most boilers were historically designed to use gas).

R&D and Industrial Production

Ukraine has several scientific organisations that work on renewable energy research, development and demonstration. Their activities are under funded, hindering technological improvements and market deployment of renewable energy technologies. Yet, Ukraine has a sufficient scientific, technological and engineering base for manufacturing certain renewable energy technologies domestically. Many companies in

[6] Prusakov D. and O. Rakovich (2006) «Development of Joint Implementation projects in the field of wind energy"», *Energy Policy of Ukraine* #2 2006, Kyiv

the military sector and space industry have converted to manufacturing renewable energy systems or their components.

Several Ukrainian engineering laboratories have designed wind turbines with the capacity from 0.2 to 400 kW. Windenergo, a joint venture with an American company Wind Power created in 1994, has produced about 750 turbines with a 107 kW capacity under a Wind Power licence. Their cost is about $420/kW, which is lower than in US ($800-1400/kW) due to lower labour and material costs in Ukraine. However, this particular type of turbine has a low efficiency (10-18%) and hence is not very cost-effective. In 2003 Dnipropetrovs'k plant Yuzhmash bought another licence from a Belgium company Turbowinds and is planning to start production of new 600 kW turbines with the projected efficiency 38%. All components for both 107 kW and 600 kW turbines are produced domestically. There are plans to produce new generation turbines with the capacity 2.5 and 3 MW and efficiency close to 50%.

Several companies based in Ukraine historically produced photovoltaic panels (PV) for the Soviet Union space programmes. Today, the plant Kvasar in Kyiv produces up to 2 MW of photovoltaic systems per year and nearly 120 MW of photovoltaic silicon panels, nearly all of which are exported to Europe because there is no market for PV products in Ukraine. Ukraine also has about 10 companies that manufacture solar collectors at a cost of $60 to $150 per m^2. The payback period is estimated to be 5 to 10 years. All domestic manufacturers combined produce just several hundreds m^2 of collectors per year.

While the cost of Ukrainian technologies is somewhat lower than that of technologies from other countries, their quality and reliability is generally lower, too. Additional financing into R&D would be necessary to improve their performance and reliability, and further reduce costs.

Bioenergy

Bioenergy is probably the most promising renewable energy sector in Ukraine. At present energy production from biomass in Ukraine is about 38 PJ/yr (or 10.6 TWh, only heat) that corresponds to 0.65% of total primary energy consumption. Most energy is generated at the expense of wood residues combustion. The following bioenergy equipment is applied:

- Many wood processing enterprises and forestry enterprises converted their coal boilers and heavy oil boilers for the combustion of their own wood residues. The total amount of such boilers is about 1000 representing about 75% of all the boilers operating in the wood processing industry and forestry. As usual, the converted boilers have very low efficiency and high emissions.
- A lot of wood fired boilers of Ukrainian manufacture are in operation at different Ukrainian enterprises, mainly hot water boilers of up to 1 MW capacity. Two large-scale steam boilers were put into operation in the framework of the Netherlands-Ukraine technical assistance program.
- A few farms have straw fired boilers (below 1 MW) and heat-generators of 200-500 kW (for small local DH systems and grain drying). All the boilers (except one) are of Ukrainian manufacture. The only foreign boiler (980 kW, Danish manufacture) was installed in the framework of the Denmark-Ukraine technical assistance program.
- Many domestic wood fired boilers and stoves are in individual use especially in rural areas.
- A few farms utilise small-scale individual biogas units.
- A few husk fired boilers of domestic design operate at sunflower oil extraction plants.

Ukraine has various sources of biomass including agricultural residues, targeted production of energy crops, and wood and wood waste. Annual agricultural residues production (straw, stems and ears of maize, stems and husks of sunflower) is estimated at 49 million tons, of which agricultural companies use approximately 34 million tons for their own purposes.[7] The rest can be potentially used for energy production. Wood is

[7] Geletukha et al. (2002) Development of Bioenergy Technologies in Ukraine // Ecotechnologies and Resource Saving, N3.

also available for energy purposes in Ukraine. Forests cover some 16% of the Ukrainian territory; most of them are located in the Carpathians and Polissia. Ukrainian experts estimate that up to 1.4 million m^3 of felling residues, 1.1 million m^3 of wood processing waste, and 3.8 million m^3 of firewood can be used for energy purposes in Ukraine every year. Energy potential of biomass in Ukraine is presented in Table 7.

Table 7

Energy potential of biomass in Ukraine

Type of biomass	Energy potential, mill tce/year
Straw of cereal crops	5.6
Stems, ears of maize for grain	2.4
Stems and husk and sunflower	2.3
Biogas from manure	1.6
Sewage gas	0.2
Landfill gas	0.3
Wood wastes	2.0
Fuel from municipal solid waste	1.9
Liquid fuels from biomass (biodiesel, bioethanol, etc)	2.2
Energy crops (willow, poplar, etc)	5.1
Peat	0.6
TOTAL	**24.2**

Source: Geletukha G.G., Dolinsky A.A. Presentation at Third International Conference on Biomass for Energy (18-20 September 2006, Kiev, Ukraine)

Combustion of biomass

Some industries and district heating companies burn biomass in their boilers to get heat and steam. Certain households in rural areas also use wood and wood waste for heating purposes. Total consumption of wood biomass for energy purposes is about 1 mill tce/yr. Scientific Engineering Center "Biomass" estimates that there is a potential market for different types of biomass-fired boilers with total capacity 9200 MW (Table 8). Use of these boilers would allow saving of 5.2 billion m^3 of natural gas per year; their total investment cost, 2.67 billion UAH ($0.53 billion), is lower than the market price of 5.2 billion m^3 of gas.

SEC "Biomass" experts consider that wide introduction of bioenergy technologies in Ukraine should start with putting into operation modern boilers for combustion of straw, peat and wood waste. Other biomass-to-energy technologies (biogas, liquid fuels, energy crops) are also very important but only biomass fired boilers can replace natural gas for heat production right now because of their lowe investment costs and the shortest payback periods.

Heat production from biomass is competitive right now even in the case of application of foreign equipment. Under certain conditions like utilization of own residues at zero cost (for example, wood waste at wood processing enterprise, surplus straw on a farm) and the use of domestic equipment (boilers of Ukrainian manufacture) heat production from biomass may be more feasible than that from expensive fossil fuels.

Table 8

Priority (most feasible) bioenergy equipment, which may be installed in Ukraine up to 2015

Type of equipment	Capacity of Ukraine market, units	Installed capacity		CO2 reduc-tion, mill t year	Opera-tion time, h/year	NG replace-ment, bill m^3 year	Total invest-ments, mill UAH
		MW_{th}	MW_e				
Wood-fired DH plants, 1-10 MWth	500	500	---	0.51	4400	0.26	100
Industrial wood-fired boilers, 0.1-5 MWth	360	360	---	0.46	6000	0.24	72
Domestic wood-fired boilers, 10-50 kWth	53000	1590	---	1.65	4400	0.84	318
Farm straw-fired boilers, 0.1-1 MWth	15900	3180	---	3.27	4400	1.67	954
Straw-fired DH plants, 1-10 MWth	1400	2800	---	2.88	4400	1.47	840
Peat-fired DH boilers, 0.5-1 MWth	1000	750	-	1.03	4400	0.52	150
Small-scale LFG power plants	90	20	80	3.26	8000	0.2	240
TOTAL		**9200**	**80**	**13.06**		**5.2**	**2674**

Source: Geletukha G.G., Dolinsky A.A. Presentation at Third International Conference on Biomass for Energy (18-20 September 2006, Kiev, Ukraine)

Table 9

Feasibility indicators of Ukrainian wood fired boilers under serial production

Feasibility indicators	*Capacity of wood fired boilers, kW*				
	100	250	500	1000	1500
3 Cost of boiler, thous. UAH	35	75	135	210	392
Consumption of wood fuel, t/year	360	900	1791	3583	5374
Saving of natural gas, thous. m^3/yr	86	215	430	860	1290
Payback period, years	1.2	1.1	1	0.7	0.8

Source: Geletukha G.G., Dolinsky A.A. Presentation at Third International Conference on Biomass for Energy (18-20 September 2006, Kiev, Ukraine)

Table 10

Feasibility indicators of Ukrainian straw fired boilers under serial production

Feasibility indicators	Capacity of straw fired boilers, kW					
	60	130	250	500	700	1000
4 Cost of boiler, thous. UAH	32	62.4	91.8	160	238.7	302.8
5 Type of straw bale	small - 12 kg		round - 250 kg		big - 500 kg	
Consumption of straw, t/year	68	146	281	563	788	1100
Saving of natural gas, thous. m^3/yr	22	48	92	185	259	361
Payback period, years	3.7	3.5	2.5	2.3	2.2	2.2

Source: Geletukha G.G., Dolinsky A.A. Presentation at Third International Conference on Biomass for Energy (18-20 September 2006, Kiev, Ukraine)

Biodiesel

The total area of Ukraine is about 604 thous. km^2, of which agricultural lands occupy 70%. Ukraine has rather good conditions for growing rape seed as raw material for bio-diesel production. Presently about 300 thous. ha of land are used for growing rape seed with an annual growth rate of about 50 to 80 % during the last three years. If rape seed would be grown on 3 mill ha with average yield 1.5-3.0 t/ha, 75% of the harvest will be enough to produce 2.7 mill t of bio-diesel. This is equivalent to 2.3 mill t of diesel fuel and amounts to about 64% of annual production of diesel fuel by Ukrainian petroleum

refineries. According to data from the Ministry of Agriculture average yield of rape seed in Ukraine is only about 1.3 t/ha that is very low for profitable production of bio-diesel. To achieve higher yields and increasequality of rape seeds it is necessary to invest in farm production technology. Despite very low average figure some farms have yields of rape up to 3.0 t/ha. Another precondition for profitable production of bio-diesel is the utilisation of valuable by-products – glycerin and grist.

Lands of so called Chernobyl zone are especially interesting for rape seed production in Ukraine. According to estimation of experts[8], 100 thous. ha of the contaminated lands are suitable for growing technical crops and 500 thous. ha of cleaner lands are suitable for growing technical and food crops. Most of rapeseeds and rapeseed oil have been exported to Europe. Presently there are no proven facts about industrial (commercial) production of bio-diesel in Ukraine. Activity on production of bio-diesel and its energy usage is mainly at research and development level.

Lately some positive trends have taken place concerning further development of bio-diesel production in Ukraine and its approach to commercial level. The Ministry of Agriculture, several regional administrations and private companies announced plans to build plants for producing biofuels from rapeseed in Zhitomir, Sumy, Vinnitsa, Khmelnitsky and other regions. Each plant would reportedly cost about $35 million and would produce 100,000 tons of biofuels per year.[9] The Ministry of Agriculture supports rapeseed harvesting and biofuel development. It plans to increase the surface of rapeseed fields from 234 000 ha in 2005 to 1.3-1.5 million ha in 5 years[10].

Biogas

Ukraine used to produce biogas at wastewater treatment plants, but production stopped in many cases when digesters had deteriorated. Total biogas utilization was the equivalent of 0.02 TWh in 2000.[11] A modern biogas plant was constructed in the Dnipropetrovs'k region and has been in operation since December 2003, a demonstration landfill biogas utilization project has been implemented in Lugansk. According to Ukrainian experts, landfill gas generated from municipal solid wastes during their degradation under anaerobic conditions at open dumps and landfills should be considered as separate type of biomass. Annually about 15 mill t of MSW are generated in Ukraine. The main part of MSW is disposed of at open dumps (more than 90%). There are 700 landfill sites in Ukrainian cities that annually receive approximately 9 million tonnes of solid municipal wastes. Nearly 140 of these landfill sites could be used for collecting landfill gas. Of 140 landfills 90 ones are the most large-scale and contain up to 30% of all MSW of Ukraine. They are the most economically rational for LFG extraction and utilisation (Table 11). According to the Scientific Engineering Center Biomass, up to 400 million m^3/year of landfill gas could be theoretically collected and used for energy purposes.[12] According to the Renewable Energy Agency, technical potential of biogas is 2.3 bill m^3 from manure, 0.33 bill m^3 from sewage sludge, 2.3 bill m^3 from landfill gas, which corresponds to 28.2 TWh/year. This Agency estimates that biogas production in Ukraine may reach 10.2 TWh/year by 2030 and 17.4 TWh/year by 2050[13]. Equipment for biogas production is large-scale CHP biogas plants which are to be installed on cattle farms, pig farms and poultry factories. Total installed capacity is estimated as 711 MWth + 325 MWe (Table 11). Electricity produced by the plants is supposed to be used for own needs and the rest will be sold to the grid.

[8] 1. T. Zhelyezna, G. Geletukha, Prospects for the Production of Liquid Biofuels in Ukraine. Paper submitted to Conference & Exhibition WORLD BIOENERGY 2006, 30 May-1 June 2006, Jonkoping, Sweden
2. T. Zhelyezna, G. Geletukha. State-of-the-art and prospects for production of bio-ethanol and bio-diesel in Ukraine. Paper submitted to 14th European Biomass Conference & Exhibition "Biomass for Energy, Industry and Climate Protection", 17-21 October 2005, Paris, Franca. Issued on CD.

[9] One tonne of rape is needed to produce about 270 kg of biofuel. Ukraine produced 59 100 tonnes of rape in 2003 and 148 880 tonnes in 2004.

[10] Information given by Information Agency UNIAN on 13.06.05 on website http://www.apk-inform.com (Agrarian-Industrial Complex on-line inform).

[11] Geletukha et al. Ukraine: outlook to 2050. Available on website http://www.rea.org.ua/index.php?page=projects&sub=2&lang=en

12 Matveev et al. (2004) Prospects of the landfill gas recovery and utilization systems implementation at the Ukrainian municipal solid waste landfills, 2nd International Ukrainian Conference on Biomass for Energy, 20-22 September 2004, Kyiv

13 Geletukha et al. Ukraine: outlook to 2050. Available on website http://www.rea.org.ua/index.php?page=projects&sub=2&lang=en

The Joint Implementation (JI) mechanism of the Kyoto protocol is a driving force for LFG projects at the moment. Feasibility indicators of landfill gas collection and utilization projects in Ukraine (case of Khmelnitskiy landfill) are presented in Table 12.

Table 11

Potential Market for Biogas Plants by 2020

Type of equipment	Approximate capacity of Ukrainian market, units	Installed capacity		CO_2 reduc-tion, mill t/year	Opera-tion time, h/year	Natural gas replace-ment, bill m^3/year	Total investments, mill UAH
		MWth	MWe				
Large-scale biogas plants	2900	711	325	22.36	8360	1.15	1465
Small-scale landfill gas power plants	90	20	80	3.26	8360	0.21	404
TOTAL	2990	731	405	25.62		1.1	1869

Source: Geletukha at al. The use of local fuels for energy production in Ukraine // Industrial Heat Engineering, 2006, v. 28, N 2

Table 12

Feasibility indicators of landfill gas collection and utilization projects in Ukraine (case of Khmelnitskiy landfill)

Feasibility indicators	LFG extraction and flaring		LFG-to-electricity utilisation	
Investments, EUR	295 200		1 621 000	
Annual operating costs, EUR/yr	17 700		97 300	
Financial parameters	Without ERUs sale	With ERUs sale (8 EUR/t CO_2-eq.)	Without ERUs sale	With ERUs sale (8 EUR/t CO_2-eq.)
Average annual revenues, EUR/yr	-	486 787	514 326	1 012 270
Simple payback period, yr	-	1.7	4.5	1.9

ERU – emission reduction unit

Source: Geletukha G.G., Dolinsky A.A. Presentation at Third International Conference on Biomass for Energy (18-20 September 2006, Kiev, Ukraine)

Hydro

Hydro power is the most developed renewable energy source in Ukraine today. Large hydro is a mature technology and hydro power currently is the least expensive power source on the wholesale market. Of the country's 4,700 MW of hydro power capacity, the majority is in large-scale hydro. Eight power stations on the Dnipro River have the total capacity of 3907 MW and the Dnistrovska station on the Dnistr River – an additional 700 MW. Combined, they produce 11-13 TWh/year. Ukraine has some 70 operational small-scale hydropower stations, of which 50 are active and generate 0.25 TWh/year. Additionally, there are some 100 small hydropower stations that are not operational but could be eventually restored. Ukraine also has plans for 5 additional hydro power plants with a total capacity of 8,143 MW (EBRD 2005). Ukrainian environmental organisations project that hydropower production may reach 15.1 TWh/year by 2030 (including 3.7 TWh/year of small hydro) and up to 25 TWh/year in 2050.[14]

Wind

Ukraine has eight wind power plants: four in Crimea and one each in the Sea of Azov; near Mariupol; near Mykolaiv; and near Truskavets in the Carpathians. These plants have a total of over 70 MW of capacity[15]. Before 2006 wind energy development was funded from a charge of 0.75% on all electricity sales. At the beginning of 2006 the charge was cancelled, and fixed sum of money (about 80 mill UAH/year) for the support of wind energy was included in the state budget. Wind is the most expensive source of power on the wholesale market. The estimated technical potential of wind energy capacity is 16 000 MW, which could generate up to 30 TWh/year. The Ukrainian Energy Strategy of 2006 projects that wind power will generate 2 TWh/year in 2030 that will substitute consumption of 0.7 mtce/year.

[14] Ukrainian Environmental Organisations (2006)
[15] Woronowicz 2000, Vasko 2000, EBRD 2005, Windenergo 2005

Solar Energy

There were about 1,000 collectors (10,000 m^2) installed in Ukraine in 2002, according to experts' estimates.[16] Ukraine has potential for developing solar heating, particularly in the southern part of Ukraine, where solar radiation intensity reaches 1,450 kWh/m^2/year (the country's average is 1,200 kWh/m^2/year). Solar heating could be attractive in areas with low population density, where district heating is not economically justifiable. Ukrainian environmental organisations project that solar collectors may supply up to 23 TWh/year of heat in 2050.

Photovoltaic (PV) systems are practically not used in Ukraine because of their high cost. Most PV panels manufactured in Ukraine are exported.

Geothermal

Ukraine has 13 MWth of geothermal capacity installed; there are plans to increase geothermal use for district heating to 250 MWth by 2010. There is also potential for small geothermal power plants using existing wells at abandoned oil and gas fields; a 1.5 MW pilot project in Poltava was being installed in 2005. The best conditions for geothermal energy development are in the Carpathian area, Crimea, Kharkiv, Poltavsk, Donetsk, Lugansk and Chernigiv regions. The Ministry of environment estimates thermal water reserves at 27.3 million m^3/day. The technical potential is estimated at 53.5-97.7 TWh/year, but according to experts' estimates no more than 8 TWh/year could be used by 2030 and 14 TWh/year in 2050.[17]

3 Policy, Legal and Regulatory Framework

Policy Institutions

Renewable energy sources are formally the responsibility of the newly established National Agency for Efficient Energy Use. The Ministry of Fuel and Energy, via the Energy Company of Ukraine, controls hydro and wind power plants. The Ministry of Agriculture promotes biofuels production and increased cultivation of rapeseeds and other crops for energy purposes. Ukraine also has a number of non-governmental institutions that provide policy recommendations on renewable energy issues to the government and policy makers.

National Electricity Regulatory Commission (NERC) regulates tariffs for hydro and wind electricity. The regulation do not always account for specific characteristics of renewables such as intermittency. NERC also formally regulates heat tariffs from biomass-fired co-generation plants. Quite often heat produced at such plants is not competitive with heat produced at municipal heat-only boilers, which are regulated by local authorities that tend to push tariffs downward (Chapter 11).

Policy Goals

The 1996 National Energy Strategy until 2010 and the 1997 Cabinet of Ministers' Program for State Support of Non-traditional and Renewable Energy Sources set a target to meet 10% of domestic energy need from non-traditional and renewable energy sources by 2010. It is clear today that this target will unlikely be implemented.

A number of sector programs have set targets for specific renewable energy sources. For example, the Comprehensive Program to Build Windmills to 2010, approved by the government in 1997, has a goal of installing 190 MW of wind capacity by 2010, though the government now says it is unlikely to meet this goal. The Comprehensive Programme on Using Non-traditional and Renewable Energy Sources in Architecture and Urban Construction, developed in mid-1990s, envisaged installation of 766.5 thousand m^2 of solar collectors by 2005 and 8737.9 thousand m^2 by 2010,[18] but these targets will not be met.

The 2006 Energy Strategy estimates that Ukraine will increase the use of renewable energy, waste and non-traditional energy sources nearly four times from 15.5 mtce in

[16] Matveev I. B., A.E. Konechenkov, «Conception for solar energy development in Ukraine », Electronic Magazine of the ESCO Ecological Systems, N9, September 2002

[17] Geletukha G. et al. (2003) *Energy supply in Ukraine: Outlook to 2050* // Green Energy, #4 (12)

[18] Rabinovich, M. D., A. R. Fert, «Использование солнечной энергии для теплоснабжения на Украине» (The use of solar energy for heat supply in Ukraine). Intersolar, www.intersolar.ru

2005 to 57.7 mtce in 2030. This would require investing some 60.4 billion UAH in the sector. The highest growth is expected in the use of solar energy, coal-bed methane and low-potential heat, although from a very low base (Table 13).

Table 13

Projected Use of Renewable and Non-traditional Energy Sources, Optimistic Scenario
mtce / Year

	2005	2010	2020	2030	*Growth from 2005 to 2030, %*	Investment requirements, billion UAH
Bioenergy	1.3	2.7	6.3	9.2	*707.7*	12
Secondary and non-conventional energy sources	13.8	15.0	15.7	16.4	*118.8*	*n.a*
Solar energy	0.003	0.032	0.284	1.1	*36666.7*	*n.a*
Small hydropower	0.12	0.52	0.85	1.13	*941.7*	9
Geothermal energy	0.02	0.08	0.19	0.7	*3500*	*n.a*
Coal-bed methane	0.05	0.96	2.8	5.8	*11600*	*n.a*
Wind energy	0.018	0.21	0.53	0.7	*3888.9*	*n.a*
Low potential heat	0.2	0.3	3.9	22.7	*11350*	*n.a*
Total	**15.51**	**19.83**	**30.55**	**57.73**	***372.2***	**60.4**

n.a. – not available
Source: Ministry of Fuel and Energy (2006). Energy Strategy of Ukraine for the period till 2030, adopted in March 2006

The Energy Strategy projects that electricity production based on renewable energy will grow to 50 million kW*h in 2010, 0.8 billion kW*h in 2015, 1.5 billion kW*h in 2020 and 2.0 billion kW*h in 2030.

According to the optimistic scenario of the Energy Strategy, renewable energy (including low potential heat) will account for 12% of total primary energy sources in 2030 (6% without low potential heat), and off-balance energy utilisation – for another 6.5%. The experts developing the Alternative Energy Strategy estimate the share of non-traditional and RES in TPEC at 23.5% in 2030 (Table 14).

Table 14

Consumption of primary energy resources in Ukraine (the baseline scenario of the approved Energy strategy vs. the alternative scenario)

Resources	**2005**		**2030** Approved "nuclear" Energy strategy		**2030** Alternative "EE and RE" strategy	
	Mill tce	%	**Mill tce**	%	**Mill tce**	%
Natural gas	**87.9**	43.8	**56.9**	18.8	**56.9**	24.0
Coal	**43.5**	21.7	**101.0**	33.4	**83.1**	35.0
Oil	**25.7**	12.8	**34.0**	11.2	**34.0**	14.3
Other types of fuel (CBM, biomass, RES, peat, etc.)	**11**	5.5	**16.8**	5.5	**55.9**	23.5
Ambient energy (heat pumps)	**0.2**	0.0	**22.7**	7.5	**-**	-
Generation of electricity without fossil fuel combustion, total inc.: Hydropower Nuclear power	**32.0** **3.89** **28.11**	15.9 1.9 14.0	**70.9** **5.5** **64.78**	23.4 1.8 21.4	**7.6** **5.5** **2.1**	3.1 2.3 0.9
Thermal energy of NPPs	**0.3**	0.2	**0.4**	0.1	**-**	-
Total	**200.6**	100	**302.7**	100	**237.5**	100

Source: Geletukha G.G., Dolinsky A.A. Presentation at Third International Conference on Biomass for Energy (18-20 September 2006, Kiev, Ukraine)

One reason why Ukraine has failed to implement policy goals related to renewables may relate to the fact that these goals were not based on a solid cost-benefit analysis of policies intended to promote renewables. Worldwide, there are three groups of policies that affect technology and market development of renewables[19]:

- Research and Innovation Policies support the development of renewable energy technologies from basic and applied research up to the demonstration phase either by providing budget financing or attracting private financing.
- Market Deployment Policies facilitate introducing technologies into the market by enhancing public awareness, improving technology cost-competitiveness and technical performance and encouraging producers and end-users of these technologies. Such policy support is generally introduced for a limited time necessary to make new technologies competitive.
- Market-Based Energy Policies provide a competitive market framework, and may internalise externalities in terms of energy security, environmental protection and economic efficiency.

Policies and Legislation

Ukraine has adopted a large number of programs, laws and regulations related to renewable energy in recent years. However, the impact of these measures has been rather weak because of a lacking comprehensive policy and enforcement mechanisms.

The Law on Alternative Energy Sources[20], adopted in 2003, defines the legislative, economic, ecological and organisational basis for the use of renewable and non-traditional energy. The earlier drafts of this law suggested mechanisms of financial, economic and regulatory support for producers and consumers of renewable energy sources, but following two President's vetoes, all financial stimuli and support measures were excluded from the final text. However, the Law is an important document as it indicates that increased use of renewable energy is a policy priority for Ukraine.

The Ukrainian policy and law makers have tried to stimulate biofuels production since mid-1990s but the result has been modest so far. The Law on Alternative Liquid and Gas Fuels[21], adopted in 2000, introduces the framework for financial mechanisms to stimulate biofuels and other "alternative" fuels that are not necessarily renewable. The state program "Ethanol" was adopted in 2000 but has actually not been implemented. A presidential decree of September 2003 called for introducing effective measures to stimulate production of fuel ethanol, biodiesel and biogas. In December 2005 the Cabinet of Ministers adopted the Conception of a Program of Developing Diesel Biofuel Production which presumes that Ukraine should produce and consume about 520,000 tonnes of biofuels in 2010. To achieve this target, about 170 million Euros should be invested in equipping each biofuel production plant (of 100,000 t output) and developing energy crop fields.

There was developed in Ukraine the technology for production of high-octane oxygen containing admixture to gasoline (HOA) – Ukrainian analogue of bio-ethanol. The law giving real support to utilization of HOA was accepted in February 2006. The law envisages tax privilege for motor blend gasoline. It is considered to be motor gasoline containing more than 2 % of HOA by volume or more than 5% ETBE by volume. Excise tax on motor blend gasoline is set at 30 EUR per 1000 kg and till 2010 must not exceed 70% of excise tax on traditional motor gasoline.

Before 2006 the government financed construction of wind power plants from a special 0.75% charge on all electricity sales on the wholesale market. For 2006 the charge is cancelled, and fixed sum of money (about 80 mill UAH/yr) is envisaged in the state budget. Cogenerated electricity and heat are exempt from this charge, but it applies to electricity generated from other renewable energy sources such as hydro.

[19] IEA (2004) *Renewable Energy - Market and Policy Trends in IEA Countries*, IEA/OECD, Paris
[20] Verkhovna Rada (2003) Law N 555-15 On Alternative Energy Sources, *Vidomosti Verkhovnoi Rady, N24*, 2003, Kyiv.
[21] Verkhovna Rada (2000) Law N 1391-14 On Alternative Liquid and Gaseous Fuels, *Vidomosti Verkhovnoi Rady, N12*, 2000, Kyiv.

At the beginning of 2006 the law of Ukraine on so-called green tariffs (tariffs with a special premium) for power based on renewable sources passed the 1st reading in Verkhovna Rada.

From our point of view there are some obvious gaps in Ukrainian legislation concerning the support of renewable energy as a whole and bioenergy in particular. For example, no law supports energy utilisation of solid biomass (wood, straw and other agricultural residues). In the opinion of the experts from the Institute of Engineering Thermophysics, priority should have the development and adoption of the law for the support of solid biomass combustion.

Recently a state program for bio-diesel production has been developed. In December 2005 the Cabinet of Ministers of Ukraine issued the order "On approval of the Concept of the Program for the development of biodiesel production in Ukraine for the period till 2010". In accordance with the order, a draft Program was developed by the end of March 2006. The next reasonable step seems to be the approval of the program and its implementation by the new Government. According to the program Ukraine will produce and consume more than 520,000 t of bio-fuels in 2010. The program envisages feasibility assessments for the construction of plants for bio-diesel production. The program also determines Ukraine's strategy for growing winter and spring rape seed in concentrated zones (50-70 thous. hectares) and envisages development of state standards on bio-diesel quality and volume of consumption. Total costs for the realization of the program are valued at 12.14 billion UAH, of them 8.53% from the state budget. State subsidies are foreseen for the encouragement of growing rape seed in Ukraine: 65 UAH/hectare in 2006 and up to 100 UAH/hectare in 2007-2010. Additionally, it is planned to spend annually 10 mill UAH on improved rape seed breeding.

More than once, the Ministry of Agrarian Policy of Ukraine expressed deep interest in the development of bio-diesel production in Ukraine. So, the Ministry is now one of the main driving forces of this process.

Renewable Energy and Environment

Renewable energy policy should be closely interrelated with environmental policy to fully use the benefits of renewable energy and mitigate its potential negative environmental impacts. Renewable energy is usually more environmentally friendly than conventional energy sources, especially with regard to greenhouse gas emissions and air pollution. It has other environmental benefits as well, for example, hydroelectric schemes can improve water supplies and facilitate recovery of degraded land and habitat.[22] Renewable energy, however, can potentially cause some negative environmental impacts. For example, large-scale hydropower projects may disturb local ecosystems, reduce biological diversity, modify water quality or lead to methane emissions because of flooding old hydrocarbon reservoirs. Other renewable sources can make land unusable for competing uses, disrupt flora and fauna, and produce visual and noise pollution. These effects are usually small, reversible and site-specific, and there are many ways to minimize them. Energy and environmental policies should address these issues.

Since renewable energy sources can contribute to reducing greenhouse gas emissions, the Ukrainian ratification of the Kyoto protocol has increased attractiveness of renewables and opportunities for their financing. Several renewable energy projects are now on the final preparatory stage for the implementation as JI projects**.** For example, the project of landfill gas utilization in Lugansk can result in reducing GHG emissions by 61,700 CO_2 equivalent per year.[23]

[22] IEA (2002) *Renewable Energy*, Free information paper, IEA/OECD, Paris
http://www.iea.org/Textbase/publications/free_new_Desc.asp?PUBS_ID=1034

[23] Filonenko A., Matveev (2004) Perspectives of biomass employment for joint implementation projects aimed to reduce greenhouse gas emissions in Ukraine, Conference Biomass for Energy, Kyiv

Conclusions

Ukraine has significant potential for developing renewable energy sources, particularly biomass, but the current use of renewables is insignificant: 2.8% of TPEC including large hydro and 0.8% without it.

The critical factors for RE development in Ukraine include political, market, and technical elements. The following drivers exist for further development of RE sector:

- International pressure to continue reforms of the energy market.
- Permanent growth of traditional energy prices.
- Possibility to strengthen security of energy supply.
- Possibility to develop local economy and rural ares (money goes not to oil and gas exporting countries but remains in the region).
- Growing possibilities for biomass and biofuels export.
- Kyoto Protocol process with CO_2 emission reduction request and possibilities for CO_2 credits.
- Permanent strengthening of ecological norms.
- Employment creation.

Main barriers for effective RE development in Ukraine are:

1. Absence of clear state policy in this field and absence of actual political will for RE sector development.
2. Absence of Ministry/ Agency responsible for RE development in Ukraine.
3. Absence of any incentives for the development of RE projects.
4. Absence of working (not declarative) state program for RE development.
5. Technological barriers including lack of local know-how, supplier equipment, demonstration projects, technical information, and a weak infrastructure with which to handle, transport and store biomass.
6. Financial barriers: lack of finance of Ukrainian companies and high interest rates for bank credits.
7. Information barriers.

Subsidies for fossil fuels and other price distortions are the major constraints to larger use of renewables. Recent price rises for oil and gas will certainly make some renewables more economically attractive. Yet, the speed of their market deployment will depend on access to long-term financing, given the capital intensity of renewable energy technologies. The future prospects of renewable energy in Ukraine will depend to a large extent on the state policy. International experience demonstrates that countries with wide-scale utilisation of renewable energy sources (e.g. Germany or Brazil) have targeted governmental policies to support them.

Ukraine has adopted a large number of laws and programs related to renewable energy in recent years. However, legislation is not effectively enforced and many provisions are not implemented in practice. If Ukraine wants to enforce energy security via a wider use of renewable energies, it will have to develop a more comprehensive policy and ensure its implementation.

The goal for RES development set in the Energy Strategy (6% of TPEC by 2030) seems to be low in comparison with the highest figures existing right now in the world (Sweden – 25%, Finland – 23%, Austria 21%, Canada – 16% etc.). Estimation given in the Alternative Energy Strategy is higher: 16.5% of TPEC by 2030.

To adopt realistic policies, not just political declarations, it is important to evaluate direct and indirect costs and benefits of different policy options, which will require more rigorous efforts to collect and analyse information on energy markets, technology costs and energy demand patterns.

Wider use of renewable energy sources can reduce Ukraine's dependence on oil and gas imports thus improving energy security. Renewable energy can also reduce emissions of greenhouse gases and local air pollutants. Additionally, it has social and economic benefits as utilization of renewable energy would create jobs and contributes to local and regional economic development.

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