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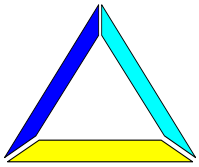


AgOverview

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.

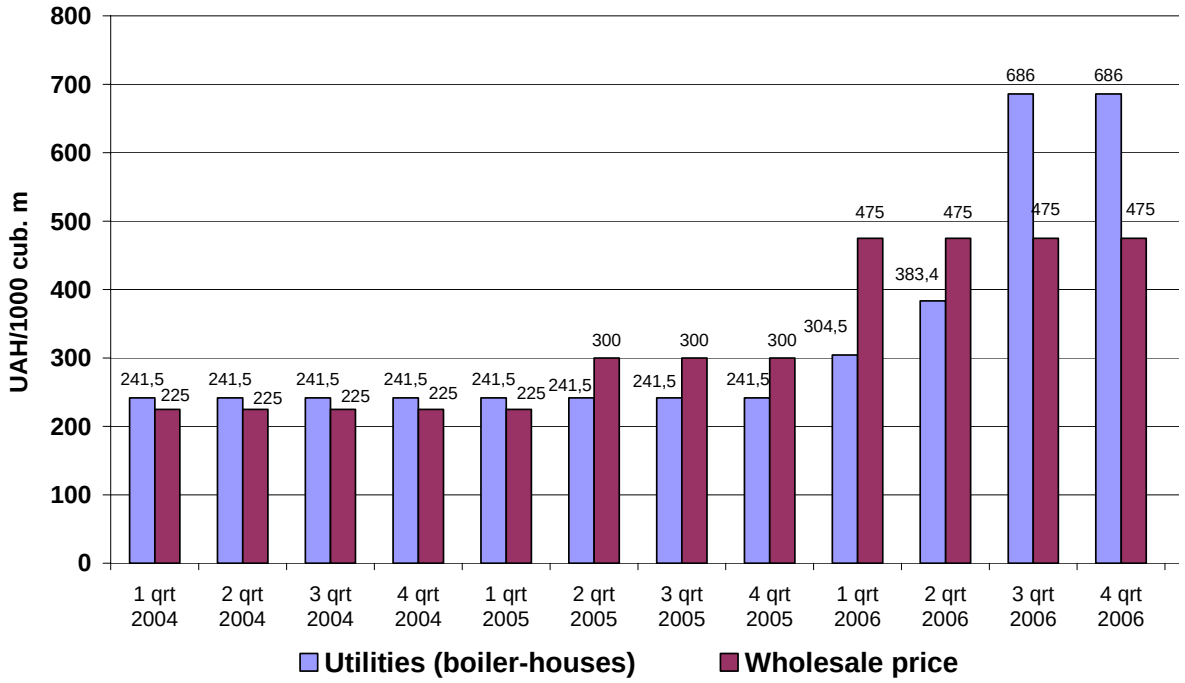
Market Position

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)

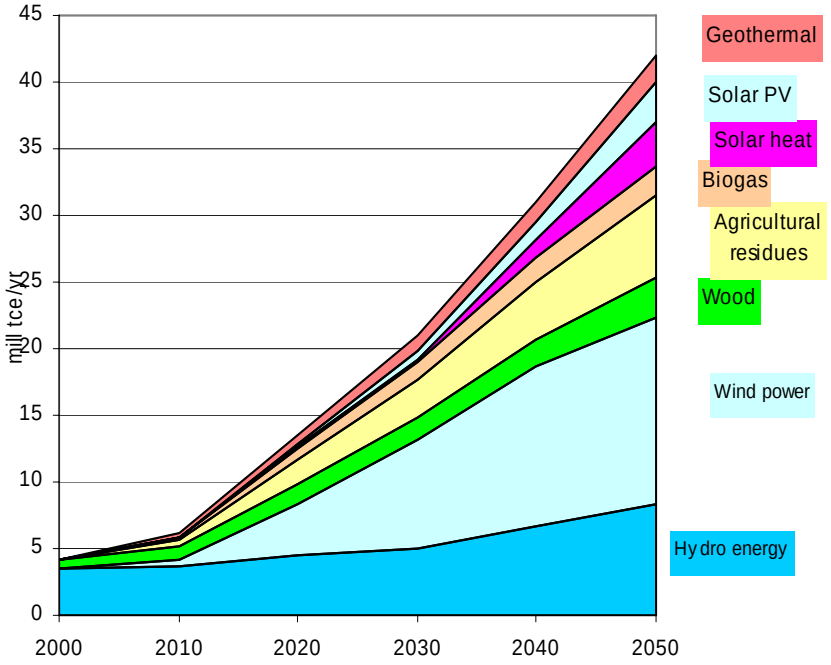
Renewable energy sources	RES, mill tce		
	2005	2030 Approved "nuclear" Energy strategy	2030 Alternative "EE and RE" strategy
Biomass energy	1.3	9.2	20.0
Solar energy	0.003	1.1	2.7
Small hydro power	0.12	1.13	1.3
Large hydro power	3.89	5.5	5.5
Geothermal energy	0.02	0.7	1.1
Wind energy	0.018	0.7	8.6
Total 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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Kyiv, November 2006

ANNEX A

List of relevant Ukrainian organisations

Name	Contact details
Ministry of Agrarian Policy of Ukraine	Kyiv, 24 Khreschatyk street t. (+380 44) 278-71-18 www.minagro.gov.ua
National Agency for Efficient Energy Use	04112, Kyiv, 1 Gonty street t. (+380 44) 455-57-10 www.necin.com.ua
Scientific Engineering Center “Biomass”	03057, Kyiv, 2A Zhelyabov street t./f. (+380 44) 456-94-62 www.biomass.kiev.ua
Public organization Renewable Energy Agency	03057, Kyiv, 2A Zhelyabov street t./f. (+380 44) 456-94-62 www.rea.org.ua
Institute of Renewable Energy	02094, Kyiv, 20A Chervonogvardiyska street t./f. (+380 44) 537-26-57 www.ive.org.ua

ANNEX B

On the approval of Development Program of biodiesel production for a period till 2010

25.05.2006 15:12
Project

CABINET OF MINISTERS OF UKRAINE
ORDER
from "___" _____ 2006 N ___

Kyiv

"On the approval of Development Program of biodiesel production for a period till 2010"

In order to create conditions for organization of biodiesel production in Ukraine, in accordance with the Presidential Decree dated from 26.09.2003 No. 1094 "On arrangements for production development of fuel from biological raw materials", the Cabinet of Ministers enacts:

1. To Approve Development Program of biodiesel production for a period till 2010, that is added.
2. The Ministry of Agrarian Policy:

to handle the state of execution of the Development Program of biodiesel production till 2010 and annually inform Cabinet of Ministers of Ukraine on this issue.

Prime minister of Ukraine **Yekhanurov Y.**

IT IS APPROVED
by the order of Cabinet of Ministers of Ukraine
from _____2006 N_____

Development Program

of biodiesel production
for a period till 2010

Passport of the Program

1. Name: Development Program of biodiesel production for a period till 2010.
2. Development base: Presidential Decree dated from September 29, 2003 No. 1094, Cabinet of Ministers Order dated from December 28, 2005 No. 576-p.
3. State customer and coordinator: Ministry of agrarian policy of Ukraine.
4. State customers co-executors: National Academy of science of Ukraine, Ministry of fuel and energy, Ministry of transport and communications of Ukraine, Ministry of environment protection of Ukraine.
5. Objective: rise of ecological and energy security level of Ukraine, decrease of national economy's dependence from mineral oil import, ensuring agrarian sector economy and transport with biofuels of domestic production, Ukraine's execution of international obligations in the field of environment protection and following requirements of Kyoto Protocol to the UN Framework Convention on climate changes.
6. Start: 2006 end: 2010
7. Phases of execution: fragmentation is not foreseen
8. Total amount of financing, including State Budget expenditures: Total size of Program financing is 12137550 tsd UAH, including state financing in amount of 1035510 tsd UAH.
9. Expected results: social-economic results of the Program execution will be determined by the rise of ecological and energy security level of the country. Full Program execution would contribute to the solution of problems with stable energy supply of the agrarian sector in the costs of own renewable sources so as following requirements of ecological security, prevention of the total loss of country's geno-, demo- and ecofonds, provision of balanced and inexhaustible nature management on the main part of the Ukraine's territory, rise of the employment rate, ensuring of international obligations fulfillment in the field of environment protection, european (international) ecological standards.

According to estimations, as a result of execution, defined in Program, GDP volume would increase by 4.94 bln UAH, supplementary budget income would be 0.53 bln UAH.

10. Control of the execution: Cabinet of Ministers of Ukraine, Ministry of agrarian policy of Ukraine.

Part 1
Problems of supplying agrarian sector and other sectors of economy with fuel and means of solution

Development program of biodiesel production in Ukraine for a period till 2010 (Program) is developed in connection with necessity to create sources of fuel supply of agricultural producers at the stable prices, assured markets for sale of vegetable raw materials, diminishment of power mediums import.

Causes of origin of supply problem of agricultural producers with fuel is an essential state dependence from energy and price situation at the state oil market, so as decrease of agricultural production volumes, thus a corresponding decrease of state budget incomes.

According to EU requirements concerning the usage of biological and other types of fuel from renewable sources, their share in the energy consumption of EU member-state's will be 2.75 percent till the end of 2006 and 5.75 percent till the end of 2010. Thus,

having proclaimed its political choice to join the EU, Ukraine would have to produce and consume in 2010 not less than 520 tsd ton of biofuel.
Taking into account the above-stated, the problem can be settled by biodiesel production development, that would make possible to provide agricultural sector (other economic sectors in future) with fuel and at the same time guarantee the execution of corresponding EU requirements.
Those objectives can be reached in following ways:

1) set up separate indicative plans of biofuel production volume increase for fuel producers;
2) introduce a control mechanism of following by such producers the constituted indicative plans, including introduction of the sanction system for their violation;
3) oblige fuel sales stations for consumers to maintain store of bio- or traditional fuel with biofuel additives;
4) introduce an incentive system for biofuel utilization by agricultural machinery and transport.

One should mention the necessity of standards development and adoption in this field.
Such steps could be made at the level of Cabinet of Ministers of Ukraine and create an effective mechanism for achievement of goals, established in the Presint's of Ukraine Order "On arrangements of production development of biofuel from biological raw materials" dated from march 29, 2003 No. 1094 and in the Law of Ukraine "On alternative arts of liquid oil and gas fuel" from January 14, 2000 No. 1391-XIV.
Introduction of adaptation steps is concerned the interests of the following categories of subjects of management:

- biofuel producers;
- oil companies and oil-processing enterprises;
- agricultural enterprises;
- vehicle producers;
- mineral oil traders;
- consumers (vehicle users).

State customer of colza oil methylether production (COME) and colza oil ethylether is the Ministry of agrarian policy of Ukraine.

Part 2
Program objective

Program objective: increase ecological and energy security level of Ukraine, diminishment of national economy's dependence from import of mineral oils, ensuring agricultural sector of economy and transport with competitive diesel biofuel.
Program should create conditions for the settlement of the following questions:

- creation of concentrated high-technology based rape production zones;
- ensuring of guaranteed rape sales by agricultural producers, that is needed for biodiesel production;
- creation of the state standards system in the field of production and use of alternative fuel arts;
- use in biodiesel production and consumption economic instruments and stimulus in accordance with the legislation;
- assistance of the plant construction, who would produce diesel biofuels;
- structural improvement of lands for agricultural purposes, in particular:
- optimization of land areas under rape;
- introduction of conservation farming system;
- following the sience-based crop rotation;

- execution by Ukraine international obligations in the field of environment protection and following Kioto Protocol to the Framework UN Convention on climate changes;
- ensuring a creation of new generation combustion engines for biodiesel usage, so as provision of technical and economical users' conditions for large-batch reequipment (adaptation) of available combustion engines for biodiesel use".

Part 3
Comparative analysis of possible variants of creation of diesel biofuel production and substantiation of the optimal choice

For a assured providing of agricultural works in agroindustrial complex according to technological norms there is an annual need in biodiesel in amount of 1870 tsd tons and in petrol – 620 tsd tons. To produce such an amount of fuel about 4.5 mln tons of oil is used, that is mostly imported. Permanent increase of its costs leads to the price growth for mineral oil, and consequently for agricultural products. That is why a traditional way of satisfaction of agricultural production needs only in the costs of mineral oils is not promising. It is more worthwhile to switch to the supply of agricultural producers with biofuel, that is produced from rape. Experience of such counties as USA, Germany, Austrian, France, Czech, where 10-14% of arable land is used for rape growing testifies pro this variant.

Program determines strategy of rape-growing development: creation of regional areas of concentrated winter and spring rape growing from 50 to 70 tsd ha, ensuring technical base development for diesel biofuel production and transfer of technical equipment form diesel fuel to biofuel.

Increase of sawn areas under rape till 10% from the total arable land in Ukraine and processing 75% of harvest to biofuel would enable the solution of stable energy supply problem of agrarian sector of economy at the expence of own renewable source, that is more ecologically safe for environment, than a traditional diesel fuel.

In EU countries biofuel is used, as in pure form (Germany) so as in mixture with diesel fuel (Czech, France).

In Czech in particular is used a system of combined diesel biofuel, that consists of mixute of diesel fuel and biofuel (Czech Republik standard – CS No. 656508, EU – EN 14214).

The majority of EU countries apply tax privileges (including zero excise rate for pure biofuel and reduced excise for mixed types of diesel fuel).

Thus in Czech republic legislative basis, that is given below foresees privileges for utilization and production of mixed fuel (with 31% COME share) as an environment friendly (that means more safe than traditional fuel) fuel type:

1) Statement on excise tax No. 353/2003 Coll foresees:

Excise tax on mixed fuel (with 31% COME share) makes up 6.866 Czech korunas for 1000 liters of fuel. At the same time excise tax on traditional diesel fuel is 9.950 Czech korunas for 1000 liters. Tax aid makes up 3.084 Czech korunas for 100 liters for environment friendly fuel.

2) Governmental directive on defining conditions of granting financial aid for nonfood use of rape seeds for the purposes of methylether from rape oil production, as a compensation for increased expenditures and lower efficiency of methylether, that is admixed to mixed fuel (with 31% COME share) foresees:

compensation for increased expenditures of COME and mixed fuel, also for decreased energy efficiency of mixed fuel is realized in amount of 9.500 Czech korunas for 1 ton of COME for producers of such a mixed fuel (with 31% COME share).

Support is limited by by 100,000 tons COME per year, that are added to the mixed fuel with 31% COME share.

Taking into account positive experience of biofuel production development of the EU countries it is worthwhile to use in Ukraine diesel biofuel as pure so as in mistures of traditional and biofuel.
The main component for COME production is rape seeds. Thanks to chemical processes COME fuel is produced on the base of rape oil. This fuel according to its physicochemical features approximates to the characteristics of diesel fuel. Potential volumes of rape seeds growing, COME production and its share in the liquid fuel types are indicated in the table 1.

Table 1

Index	Unit	Year				
		2006	2007	2008	2009	2010
Potential rape seeds growing in Ukraine	tsd tons	1200	2000	3000	3600	5400
Quantity of rape, that is worthwhile to utilize for COME production	tsd tons	-	-	300	900	1890
Quantity of rape, that is worthwhile to utilize for COME production (% from the total amount of rape)	%	-	-	10%	25%	35 %
Potential COME production	tsd tons	-	-	100	300	623
Technological norms of diesel fuel need for agricultural producers in Ukraine	tsd tons	1870	1870	1870	1870	1870
COME share in total diesel fuel volume, used by agricultural producers	%	-	-	5	16	33

Figures, indicated in table 1, define only potential, not established (fixed) biodiesel production volumes. Achievement of these indexes is possible only on the assumption of 3 biofuel plants construction till 2008 with overall productivity of COME production about 300.000 tons, and construction till 2010 of not less than 20 plants with 5000-100.000 tons productivity, overall capacity not less than 623 tsd tons of biofuel.
Production costs of one ton of COME for plants whose capacity is about 100.000 tons would make up 3020-3100 UAH/ton (depending on rape yield and demand on rape seeds on the market). Besides some additional products will be produced – about 1.8 tons of shrot and 0.05 tons of refined glycerin by total costs about 1260 UAH (all indexes are given counting on prices for indicated products in the first quarter of 2006).
For comparison – average production costs of COME in EU member states in 2005 were from 0.509 to 0.688 euro/kg.
Regulation of the supply problem of agricultural enterprises with diesel biofuel would create conditions for widening the sphere of its utilization – for vehicles of common use with diesel engines. In it's turn it needs a further period of conducting of:
estimations of prices for new generation combustion engines for diesel biofuel use and costs of reequipment (adaptation) of available combustion engines for diesel biofuel use in the pure form;
estimations of volumes of areas, rape and plants quantities, needed for transfer of vehicles for common use with diesel combustion engines to COME use in the following variants: 5% admixtures; in pure form;
estimations of costs for diesel biofuel for vehicles of common use (in application variants in pure form and in 5% mixed form).

Part 4
Ways and methods of creation of diesel biofuel production

For execution of the Program should be created a mechanism of its legislative, financial, scientific, organizational ensuring and a monitoring system. Law of Ukraine "On alternative arts of liquid and gas fuel" foresees in particular stimulation of new technologies introduction for production of alternative fuel arts.
According to the mentioned law, legislative act should be prepared, that are directed on the development optimization of rape-growing and plant construction, who would produce diesel biofuel in Ukraine.
In Ukraine should be foreseen a creation of the system of state standards in the field of production and utilization of alterntive fuel arts, in particular of diesel biofuel with ecological and technical indexes of its consumer characteristics, discharge intensity in different branches of social production, protection of labor and health indexes.

Part 5
List of arrangements and tasks of the Program

The main tasks of the Program are:

1) creation of source of raw materials for diesel biofuel production. Following steps are to be made:
   - perfection of energy-saving technologies of growing rape varieties for diesel biofuel production;
   - enlargement of rape growing areas and yields growth for the rise of diesel biofuel production volumes;
   - creation of concentrated rape growing areas in order to approach production sources of raw materials to places of diesel biofuel production.
2) Creation of technical base for growing, storage and primary rape processing, including:
   - Development and completion of system for machinery and equipment for growing and storage of rape and production of rape oil (for lowering production costs of raw materials);
   - Complex of arrangements for creation of new generation combustion engines for diesel biofuel use of transport and agricultural technique in order to transfer them to diesel biofuel.
3) Drafting of regulations on diesel biofuel production and use, including:
   - technical conditions for diesel biofuel with future creation of system of state standards in the field of production and use of diesel biofuel with technical indexes of its consumer quality and ecological indexes, indexes concerning labor and health protection

List of execution arrangements of the main objectives of the Program with determination of execution terms and volumes of financing are given in the Annex to the Program.

Part 6
Financial provision of Program execution

For pilot projects introduction of construction of plants (industrial complexes), who would produce diesel biofuel and creation of the appropriate area of concentrated rape growing following funding sources are to be used:

1) innovation funds, funds of domestic and foreign investors;
2) state financial support;
3) funds of enterprises of agroindustrial complex;
4) lax credits at the expense of part of the funds, provided in State budget of Ukraine in the respective year for investment projects' realization of introduction of energy-saving technologies in the economic sector and alternative fuel sources production technologies

Total expenditures volume for one region of Ukraine in case of construction of one plant with the capacity of 100.000 tons of diesel biofuel per year, elevator complex with total capacity volume of 350000 tons, creation of agrotechnical complexes for rape growing on 100000 ha areas is 170 mln euro.

The abovementioned state financial support is an instrument for acceleration of biofuel production development and should be used only for building of the first pilot (demonstration) objects for biofuel production and other respective needs. Utilization of state funds is also needed for conducting scientific researches, testing technologies, research technical models, perspective types of plants, drafting normative-technical documentation, standards etc.

State support, that would be provided to the building of pilot objects could be allots, mostly on return basis in framework of funds, that are provided for this purpose in state and local budgets for 2006-2010.

For stimulating rape growing a provision of yearly state financial support for rape growing is foreseen, that would be provided by granting agricultural producers of all patterns of ownership and farming, who grow rape for diesel biofuel production in 2006 in amount of 65 UAH per -hectare of area under rape, in 2007-2010 – till 100 UAH per hectare of area under rape.

Furthermore, it is anticipated to provide yearly for selection in plant cultivation nearly 90 mln. UAH, including the development of rape growing – 10 mln. UAH

Total amount of Program financing is given in the Annex to the Program.

Part 7
Expected results

Social-economic effect of the Program execution would be determined by the growth of ecological and energy security of the country. Program execution in corpore would contribute to the solution of the problem with stable energy supply to agrarian sector of economy at the expense of the own renewable source. It would also make a contribution to:

- diminishment of national economy's dependence from mineral oil import;
- ensuring of agriculture complex development;
- improvement of ecological situation in Ukraine;
- increase of export potential of Ukraine;
- ensuring a stable growth of settlements;

- decrease of CO_2 emissions to atmosphere according to Koito Protocol requirements; harmonization of national legislation of Ukraine with the legislation of the EU, including creation of the basis for adaptation of excise tax system for energy carriers, that exists in Ukraine to the provisions of the Directive 2003/69/EU, Directive 2003/30/EU;following requirements of ecological security (use of fuel, that is produced from plants, who absorb CO_2 decreases emission of carbonic acid to atmosphere by 89-91% comparing with the use of the similar amount of diesel fuel)
- ensuring of execution by Ukraine international obligations on environment protection, world ecological standards;
- prevention of the irrevocable loss of the part of country's geno-, demo- and ecofonds; ensuring a balanced and inexhaustible nature management on the essential part of the territory of Ukraine; increase of employment level of citizens (construction of 23 biofuel plants demands a provision of 4807 new working places and guarantees work assurance for more than 24.4 tsd of workers, involved with growing, processing, storage and transport of vegetable raw materials;
- execution of the Program in corpore would provide yearly production of diesel biofuel in amount of 623 tsd tons per year, that would allow to decrease oil import till 1.88 mln tons and correspondingly reduce expenditures of currency resources (for about 4034 bln UAH counted on a approximate oil price – 2100-2200 UAH/ton). At the same time, additional state budget incomes in the form of VAT payments from the sale of 623 tsd tons of biofuel, taking into account other taxes to state and local budgets would make up nearly 0.53 bln UAH (from the approximate estimation of diesel biofuel price – about 3250-3350 UAH/ton).

Part 8
Priority arrangements of Program executing

For the execution of the Program such priority actions are planed:

1. creating the provisional interdepartmental council under the Ministry of Agricultural Policy with the participation of interested bodies of the executive power in order to coordinate:
    - conduction fundamental scientific research of diesel biofuel production development (including production, testing, certification and giving permission of diesel biofuel usage),
    - drafting normative documents of diesel biofuel production adopted to the EU legislative requirements,
    - Monitoring the Program execution and working out propositions for it's improvement
2. working during the term of the Program execution by the Ministry of Agricultural Policy, the Ministry of Finance, the Ministry of Economics and the Ministry of Fuel and Energy through the problem of investment stimulation in the field of diesel biofuel and raw materials production by creation of preferred treatment for investments and other economic activities for foreign and domestic investors;
   drafting corresponding legislative and normative acts in case of their need;
3. working through the ability for new budget programs adoption during State budget drafting for 2007, 2008, 2009 and 2010:

    - "The Priority innovation project for biofuel industrial complex building" with approximate expenses of 300 million UAH yearly (for working out and adopting of pilot projects of biofuel plants building);
    - "Innovative developments in the field of diesel biofuel certification and standardization so as technologies and technical regulation of diesel biofuel usage by agricultural machines and motor transport (executors - the Ministry of Agricultural

Policy, the Ministry of Transport and Communications and the Ministry of Fuel and Energy) with approximate annual expenses about 6 million UAH;

- "Innovative developments in the field of diesel biofuel usage expansion by tractor engine's in pure form and increasing diesel biofuel part in mixture diesel fuels" (executors - the Ministry of Agricultural Policy, the Ministry of Transport and Communications, the Ministry of Industrial Policy and the Ministry of Fuel and Energy) with approximate annual expenses about 8 million UAH;
- "Energy preserving technologies in agroindustrial complex" with approximate annual expenses of 10 million UAH for working out and implementation of energy preserving technologies and equipment for growing and recycling of rape and diesel biofuel production in agroindustrial complex (executors - the Ministry of Agricultural Policy and the Ministry of Industrial Policy)

4. Remitting annually about 10 million UAH for selection in rape growing
5. Ensuring annual state financial support of rape growing through subsidies to agricultural producers of all patterns of ownership in amount not less than 65 UAH per hectare of sowing areas.

The ability to adopt these budget programs and ultimate expense size for each of each program are defined annually during the forming of State Budget of Ukraine for the concrete year.

6. popularization ensuring (through mass media, holding seminars, consultations and exhibitions) of economic, ecological, social and other development advantages of alternative types of fuel.
7. Creating special informational data base of accumulation, systematization and expansion of economical, technical and other information on the existence of technologies and equipment for rape and diesel biofuel production in Ukraine, including the information on producers and suppliers of this equipment and popularization of sci-tech achievements in this branch.

Program Annex

List of Program's arrangements and objectives

Arrangements and tasks of the Program	Executive bodies	Executors	Terms of execution	Sources of financing: (1) – State budget; (2) – funds of enterprises; (3) – investments	Approximate volumes of financing, tsd. UAH					
					Total volume	According to years of execution				
						2006	2007	2008	2009	2010
1. In the field of source of raw materials creation for diesel biofuel										
1.1.Make an integrated assessment of domestic varieties of winter and spring rape and other oil-bearing crops on the feasibility of their seeds for biofuel processing and define varieties for certain regions of the country										
1.1.1. Conduct production test of domestic and foreign "00-varieties" of winter and spring rape	Ministry of agricultural policy of Ukraine (MAP), Ukrainian Academy of Agrarian Sciences (UAAS)	Research organizations of MAP and UAAS	2006-2008	(1)	360,00	120,00	120,00	120,00		
1.1.2. Establish a biochemical quality of commodity domestic	MAP, UAAS	Research organizati	2006-2008	(1)	150,00	50,00	50,00	50,00		

seeds "00-varieties" of winter and spring rape, produced in rape sowing regions of the country		ons of MAP and UAAS								
1.1.3. Establish on the base of production-scientific assessment of domestic "00-varieties' of winter and spring rape of biofuel varieties for use in rape sowing regions of the country and development of respective recommendations	MAP, National Academy of Sciences of Ukraine (NASU)	Research organizations (*)	2006-2008	(1)	80,00	20,00	30,00	30,00		
1.2. Organize production and sale of inoculum, recommended for the use of rape varieties for diesel biofuel										
1.2.1. Working through and adopting system for high quality domestic seed production of winter and spring rape and other oil crops for optimal diesel biofuel production	MAP, UAAS	Research organizations, research experimental stations of MAP, UAAS, agricultural enterprises	2007-2009	(1)	735,00		105,00	255,00	375,00	
1.2.2. Render assistance to institutions (firms) - originators of original winter and spring rape seed production	MAP, UAAS	Research organizations of MAP and UAAS	2007-2010	(1)	60,00		15,00	15,00	15,00	15,00
1.2.3. Render assistance to seed households (firms) for biofuel winter and spring rape seed (PH-1) production	MAP, UAAS	Research organizations, research experime	2006-2010	(2), (3)	480,00		120,00	120,00	120,00	120,00

		ntal stations of MAP, UAAS								
1.2.4.Create biofuel winter and spring rape sowing seed insurance funds	MAP, NASU	Agricultural enterprises	2007-2010	(1)	140,00		35,00	35,00	35,00	35,00
1.3.Introduce zonal resource-saving technologies for biofuel winter and spring rape cash grain production										
1.3.1. Work and adopt zonal specialized crop rotation for biofuel rape sorts production	MAP, UAAS	Research organizations, research experimental stations of MAP, UAAS, agricultural enterprises	2007-2008	(1)	190,00		95,00	95,00		
1.3.2. Adopt effective technological elements and methods for biofuel winter and spring rape sorts production in different soil-climate zones of the country										
1.3.2.1. Working scientific-production zonal recommendations for growing, harvesting, cultivation and conservation of rape crop, optimal for diesel biofuel	MAP, UAAS	Research organizations, research experimental	2007-2008	(1)	130,00		30,00	50,00	50,00	

production		stations of MAP, UAAS								
1.3.2.2. Work out technological charts for rape sorts, optimal for diesel biofuel production	MAP, UAAS	Research organizations, research experimental stations of MAP, UAAS	2007	(1)	30,00		30,00			
1.3.2.3 Organize and adopt complex control of rape and other oil crops cash grain for diesel biofuel production	MAP, UAAS	Research organizations, research experimental stations of MAP, UAAS, National agrarian university	2007-2008	(1)	200,00		100,00	100,00		
1.3.3. Organize trainings for chiefs and specialists of households (firms) – program participators and generalize and propagandize foremost experience	MAP	Research organizations, educational organizations of MAP, NAU	2007-2010	(1)	500,00		350,00	50,00	50,00	50,00
1.3.4.Prepare technological and normative materials for biofuel rape seed production effectiveness increasing	MAP, UAAS	Research organizations	2007-2010	(1)	100,00		25,00	25,00	25,00	25,00
1.4. New agricultural technologies adaptation for rape production										

1.4.1. Working through exact agriculture system based on foreign experience	MAP, UAAS, NASU	Research organizations, enterprises of agroindustrial complex	2007-2009	(1)	360,00		120,00	120,00	120,00	
1.4.2. Introduction of exact agriculture system based on foreign experience		Enterprises of agroindustrial complex	2007-2010	(2), (3)	5200,00		1300,00	1300,00	1300,00	1300,00
1.4.3. Working out soil protecting contour reclamation project in agriculture	MAP, UAAS	Research organizations, research experimental stations of MAP, UAAS	2007-2010	(1)	10,00		6,00	2,00	2,00	
1.4.4. Adopting soil protecting contour reclamation project technology for rape production	MAP, UAAS	Research organizations, research experimental stations of MAP, UAAS, enterprises of agroindustrial complex	2007-2010	(2), (3)	450,00		150,00	100,00	100,00	100,00
1.4.5. Working out and improving predecessor composition and winter and	MAP, UAAS	Research organizations,	2007-2010	(1)	10,00		5,00	2,00	1,50	1,50

spring rape return terms and concentrated production taking into consideration the soil-climate conditions		research experimental stations of MAP, UAAS								
1.4.6. Adopting scientifically based crop rotation for rape goods production in different soil-climate conditions	MAP, UAAS	Research organizations, research experimental stations of MAP, UAAS, enterprises of agroindustrial complex	2007-2010	(2), (3)	310,00		50,00	100,00	80,00	80,00
1.4.7. Tillage improving and working under rape crops pollution control arrangement	MAP, UAAS	Research organizations, research experimental stations of MAP, UAAS	2007-2010	(1)	151,00		45,00	42,00	32,00	32,00
1.4.8. New tillage technologies introduction for different winter and spring rape cultivating zones and crops protecting from pests	MAP, UAAS	Research organizations, research experimental stations of MAP, UAAS, enterprise	2007-2010	(2), (3)	12960,00		5240	3740	2240	1740

		s of agroindustrial complex								
1.4.9. Rape fertilizing system improving and mineral fertilizer usage decreasing, and full local resources, growth-promoting factor and organic-miniral bioactive fertilizers usage in different soil-climate zones	MAP, UAAS	Research organizations, research experimental stations of MAP, UAAS	2007-2010	(1)	360,00		140	220		
1.4.10. Adopting winter and spring rape mineral fertilizing system for rape crops growing zones	MAP, UAAS	Research organizations, research experimental stations of MAP, UAAS, agricultural enterprises	2007-2010	(2), (3)	513000		74625	114350	141450	182575
1.4.11. Working verietal agricultural winter and spring rape growing techniques out for rape crops zones	MAP, UAAS	Research organizations, research experimental stations of MAP, UAAS	2007-2010	(1)	34,40		10,0	8,2	8,2	8,0
1.4.12. New winter and sprang rape growing technologies adopting in different soil-climate zones	MAP, UAAS	Research organizations, research	2007-2010	(2), (3)	1720,00		500	400	410	410

		experimental stations of MAP, UAAS								
1.4.13. Working and improving integrated protection system for winter and spring rape crops	MAP, UAAS	Research organizations, research experimental stations of MAP, UAAS	2007-2010	(1)	330,00		90	120	120	
1.4.14. Adopting integrated winter and spring rape crops protection system in order to optimize phytosanitary state of their agrocenosis	MAP, UAAS	Institute of farming UAAS – head institution, Institute of oil-bearing crops UAAS, Івано-Франківський інститут АПВ тощо.	2007-2010	(2), (3)	720,00		180	180	180	180
1.4.15. Holding qualitative state crops evaluation for crops aptitude for diesel biofuel production	MAP, UAAS	Research organizations, research experimental stations of MAP, UAAS	2007-2010	(1)	4520,00		700	900	1680	1240

1.4.16 State finansial support of rape production	MAP	MAP, regional state administrations	2007-2010	(1)	169975	1000	3415	16160	59400	90000
2. In diesel biofuel technical base development field:										
2.1. Creating technical base for rape grooving and harvesting and rape crops conservation										
2.1.1. Prove technological complex of mashines for groving, harvesting, treatment and conservation of rape	MAP, UAAS	Research organizations, research experimental stations of MAP, UAAS	2007-2009	(1)	400,00		210,00	130,00	60,00	
2.1.2. Machines and aggregate selection Підбір машин та агрегатів для підготовки ґрунту, внесення добрив, засобів захисту рослин, посіву та догляду за посівами ріпаку	MAP, UAAS	Research organizations, research experimental stations of MAP, UAAS	2007	(1)	70,00		70,00			
2.1.3. Work out, produce, test and organize production rape crops harvesting adaptor for combine harvester	MAP, UAAS, Ministry of Industrial policy of Ukraine (MIP)	Research organizations, research experimental stations of MAP, UAAS	2007-2009	(1)	220,00		70,00	110,00	40,00	
2.1.4. Modernize grain cleaning machine foe rape crops cleaning	MAP, UAAS, MIP	Research organizati	2007-2008	(1)	100,00		50,00	50,00		

		ons, research experimental stations of MAP, UAAS machineplants for agroindustrial complex								
2.2. Creating technical base for rape crops remaking into oil										
2.2.1 . Creating equipment for rape crops remaking into oil	MAP, UAAS, MIP	Research organizations, research experimental stations of MAP, UAAS machineplants for agroindustrial complex	2007-2008	(1)	470,00		270,00	200,00		
2.2.2. Creating equipment for primary purification of rape and other crops oil	- " -	- " -	2007-2008	(1)	355,00		150,00	205,00		
2.2..3. Creating technological equipment parameters series for diesel biofuel production	- " -	- " -	2007-2010	(1)	1900,00		200,00	800,00	900,00	
2.2.4 Support equipment for shrot usage for mixed fodder production	MAP, UAAS	Research organizations, research experime	2008-2010	(1)	200,00	-	-	80,00	90,00	30,00

		ntal stations								
2.2.5. . Proving raw glycerin usage and creating equipment complex	- " -	Research organizations	2007-2010	(1)	900,00	-		100,00	400,00	400,00
2.3. Package for diesel biofuel usage legislation preparing										
2.3.1. Working out and registration and affirmation of technical conditions for diesel biofuel and mixed fuels with diesel biofuel content	MAP, Ministry of fuel and Energy (MFE), Ministry of transport and communication (MTC)	Research organizations	2007-2008	(1)	350,00	-	200	150	-	-
2.3.2. Acquiring laboratory-production plant for diesel biofuel production	MAP, MFE, MTC	Research organizations, NAU	2007	(1)	2500,00		2500	-	-	-
2.3.3. Creating diesel biofuel quality laboratory	- " -	Research organizations of UAAS, MAP and NAU	2007	(1)	400,00	-	400	-	-	-
2.4. Preparing diesel biofuel production based on rape oil methyl ethers										
2.4.1.Working diesel biofuel production technologies based on rape and other crops oil	MAP, MFE, MTC	Research organizations , enterprises of agroindustrial complex	2007-2008	(1)	1020,00		510	510		
2.4.2. Working diesel biofuel formula based on methyl ethers	- " -	Research organizati	2007	(1)	610,00		610			

and mixed fuels with diesel biofuel.		ons , enterprises of agroindustrial complex								
2.4.3. Holding comparative analysis of diesel biofuel based on methyl ethers physicochemical behavior in order to define their quality according to the domestic biofuel legislator demands and according to european demands	- " -	Research organizations , enterprises of agroindustrial complex	2006-2007	(1)	150,00	70	80			
2.4.4. Working research-industrial set of diesel biofuel based on methyl ethers	- " -	Research organizations , enterprises of agroindustrial complex	2006-2007	(1)	430,00	215	215			
2.4.5. Holding diesel biofuel based on methyl ethers development testing	- " -	Research organizations , enterprises of agroindustrial complex	2007-2008	(1)	200,00		100	100		
2.4.6. Working first draft of НД for diesel biofuel based on methyl ethers	- " -	Research organizations , enterprises of agroindustrial complex	2007	(1)	80,00		80			
2.4.7 . Working technological	- " -	Research	2006-	(1)	400,00	60	170	170		

regulations for research-industrial diesel biofuel based on methyl ether set		organizations , enterprises of agroindustrial complex	2008							
2.4.8. Holding operational testing of diesel biofuel based on methyl ether	- " -	Research organizations , enterprises of agroindustrial complex	2008-2010	(1)	300,00			100	100	100
2.4.9 . Regulate and affirm final draft of НД for diesel biofuel based on methyl ether	- " -	Research organizations , enterprises of agroindustrial complex	2009	(1)	40,00				40	
2.4.10. Preparing materials necessary for diesel biofuel based on methyl ether usage permeation	- " -	Research organizations , enterprises of agroindustrial complex	2009	(1)	50,00				50	
2.5. Production of diesel biofuel based on rape oil ethyl ethers										
2.5.1. Holding scientific-research work for getting diesel biofuel based on rape and other ethyl ethers	MAP, MFE, MTC	Research organizations , enterprises of agroindus	2007-2008	(1)	200,00		100	100		

		trial complex								
2.6. Working out production technologies of diesel biofuel with fuel bioethanol content										
2.6.1.Working out diesel biofuel with fuel bioethanol content formula and it's production technology	MAP, MFE, MTC	Research organizations , enterprises of agroindustrial complex	2007-2008	(1)	100,00		50	50		
2.6.2. Producing the pilot lot of diesel biofuel with fuel bioethanol content	- " -	Research organizations , enterprises of agroindustrial complex	2007	(1)	50,00		50			
2.6.3. Holding of laboratory, development testing and field trials of diesel biofuel with fuel bioethanol content	- " -	Research organizations , enterprises of agroindustrial complex	2007-2008	(1)	510,00		255	255		
2.6.4. Working out of legislation for diesel biofuel with fuel bioethanol content	- " -	Research organizations , enterprises of agroindustrial complex	2007-2008	(1)	50,00		25	25		
2.6.5. Registration of permit for diesel biofuel with fuel	- " -	Research organizati	2008	(1)	80,00		80			

bioethanol content usage		ons , enterprises of agroindustrial complex								
2.7. Package for diesl biofuel usage by machines with diesel engines										
2.7.1. Working out methods for the strategy of diesel biofuel production technology base taking into consideration the fuel economy, energetic and ecological index of vehicles and agricultural machines during their engines working with diesel biofuel usage in conditions of regions	MAP, MFE, MTC, MIP, Ministry of nature (MN)	Research organizations , enterprises of agroindustrial complex	2007-2010	(1)	450,00		150	150	150	
2.7.2. Holding the comparative tests of diesels working with diesel biofuel usage	MAP, MTC, MIP	Research organizations , enterprises of agroindustrial complex	2007-2008	(1)	700,00		350	350		
2.7.3. Working out the technology of diesel biofuel usage by agricultural machines and motor transport taking into consideration ensuring engines' safe functioning, motoresource preservation and following contaminant emission legislation, including the ecological compatibility	MAP, MTC, MIP, MN	Research organizations	2007-2010	(1)	180,00		60	70	50	

demands of " Euro-2" according to the EEC UN Regulations №№ 49, 83 and demands of EEC UN Regulations № 96"										
2.7.4. Holding of research and design works complex in order to solute the task of diesel biofuel usage by autotractor engines in a pure form or increasing the part of biofuel in mixed diesel fuels with ensuring engines' safe functioning, motoresource preservation and following contaminant emission legislation, taking into consideration the need to solve a problem of potentional nitric oxide with burnt gas content emission increase, and peroxide formation and corrosive water influence as a cause of fuel hygroscopic property, and solving the problem of separate general mechanical rubber and plastic engines' elements functioning	MAP, MTC, MIP, MN	Research organizations	2007-2010	(1)	180,00		60	70	50	
3. In ecological field										
3.1. Prepation and creation of state standards in diesel biofuel production and usage field with ecological index definition	MAP, MN, MFE, MTC, MIP	Research organizations	2008-2010	(1)	300,00			100	100	100
3.2. Integrated assessment of eco-energetic efficiency in agricultural tractors', combine harvesters' and vehicles' diesels	MAP, MN	Research organizations	2007-2009	(1)	340,00		120	120	100	

4. In concentrated zones of rape growing field and in biofuel industrial complex building										
4.1. Technical-economical substantiation and material and technical basis insuring for economical-innovational rape growing technologies setting	MAP	Investment organisations, enterprises of agroindustrial complex	2007-2010 техніка для обробки площі 100т.га	(2), (3)	2240000		560000	560000	560000	560000
4.2. Working out the biofuel industrial complexes building projects	MAP	Research organizations	2006-2007	(1)	1800,00	100	600	600	500	
4.3. Priority innovational projects working out and realization: biofuel industrial complexes building with rape growing zones creation (industrial complex, elevators, agro technical service, feed mill) and biofuel plant building for research and teaching purposes	MAP, MIP, National agrarian university	Investment organisations, enterprises of agroindustrial complex, specialized chemical enterprises	2007-2010	(1)	840200		290000	275100	275100	
4.4. Concentrated zones creation for rape and other oil berry crops growing with modern technologies usage in steppe, forest-steppe and marshy woodlands zones	MAP	Investment organisations, enterprises of agroindustrial	2007-2010	(2), (3)	1120000		280000	280000	280000	280000

		complex								
4.5. Industrial biofuel complexes building on the territories of concentrated rape growing zones	MAP, MIP	Investment organisations, enterprises of agroindustrial complex, specialized chemical enterprises	2007-2010	(2), (3)	7207200		1801800	1801800	1801800	1801800
5. Mechanisms for state support insuring of diesel biofuel production										
5.1. Learning of state support of biofuel production word's experience in order to implement it in Ukraine	MAP	Research organizations	2006-2007	(1)	200		100	100		
5.2. Working out of legislature package for encouragement and preferred treatment taxation for rape planting agricultural enterprises and diesel biofuel producers	MAP	Research organizations	2006-2010	(1)	600		150	150	150	150
Total expenditures, tsd UAH					12137550	1695	3027516	3060374,2	3127473,7	2920491,5
Including state finance, tsd UAH					1035510	1695	303551	298284,2	339793,7	92186,5

- - Program Executors would be determined according to the Law of Ukraine "On purchases of goods, works and services for public funds" on tender basis

ANNEX C

Critical Analysis of Main Provisions of the Energy Strategy of Ukraine up to 2030

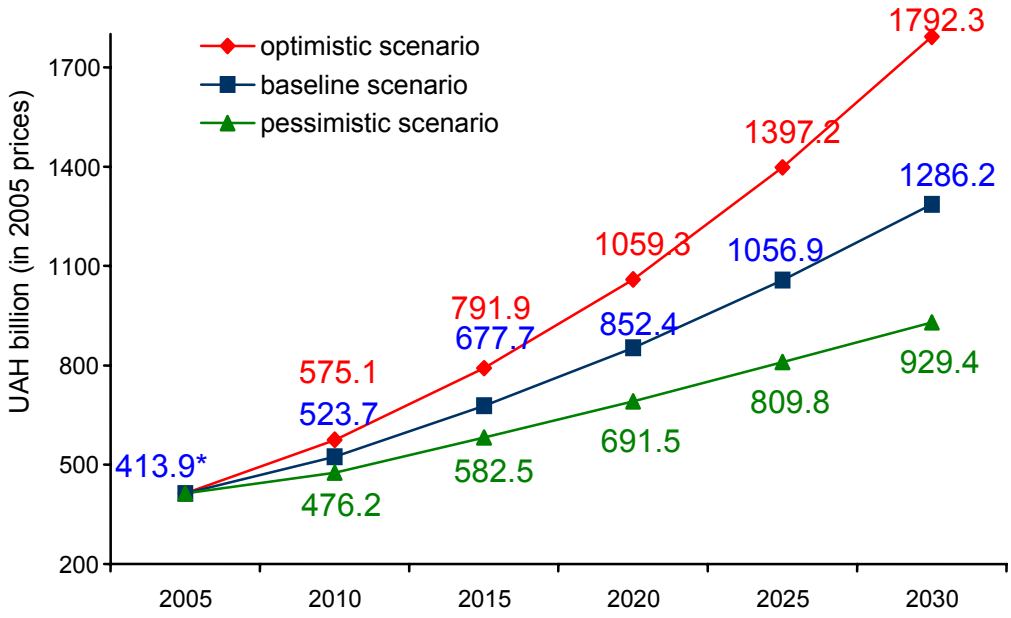
In March 2006, the Cabinet of Ministers of Ukraine approved the Energy Strategy of Ukraine up to 2030 (referred hereinafter to as the Energy Strategy or the Strategy). The Strategy generated a rather mixed response of specialists and members of the general public, due to its clearly visible "nuclear" focus. The Strategy stipulates construction of 11 new nuclear reactor units with total capacity of 16.5 GW, 9 replacement reactor units with total capacity of 10.5 GW and two additional reactor units at Khmelnitskiy NPP (1 GW each). A detailed analysis of main parameters of the Strategy shows that they all are interrelated and serve the main idea of the document - i.e. development of the power industry of Ukraine at the base of priority development of nuclear power. To substantiate these conclusions, let us review key provision of the Energy Strategy in connection with plans to develop nuclear power industry.

1. How Much Fuel and Energy Is Ukraine Expected to Consume in 2030?

Forecasts of consumption of fuel and energy resources (FERs) in 2030 are based on anticipated growth of GDP of Ukraine in 3.1 times, from UAH 413.9 billion in 2005 to UAH 1,286.2 billion in 2030 (see Fig. 1 at page 10 of the Energy Strategy). These figures mean that the annual average GDP growth in the whole period is expected to reach 4.9%. We think that the rate seems rather optimistic, in its turn, such an assumption may result in overestimated assessment of FERs consumption in 2030. Anyway, let us assume that the GDP will really increase by 2030 in 3.1 times.

Figure 1

The Energy Strategy of Ukraine up to 2030: GDP growth forecast, UAH billion, in 2005 prices



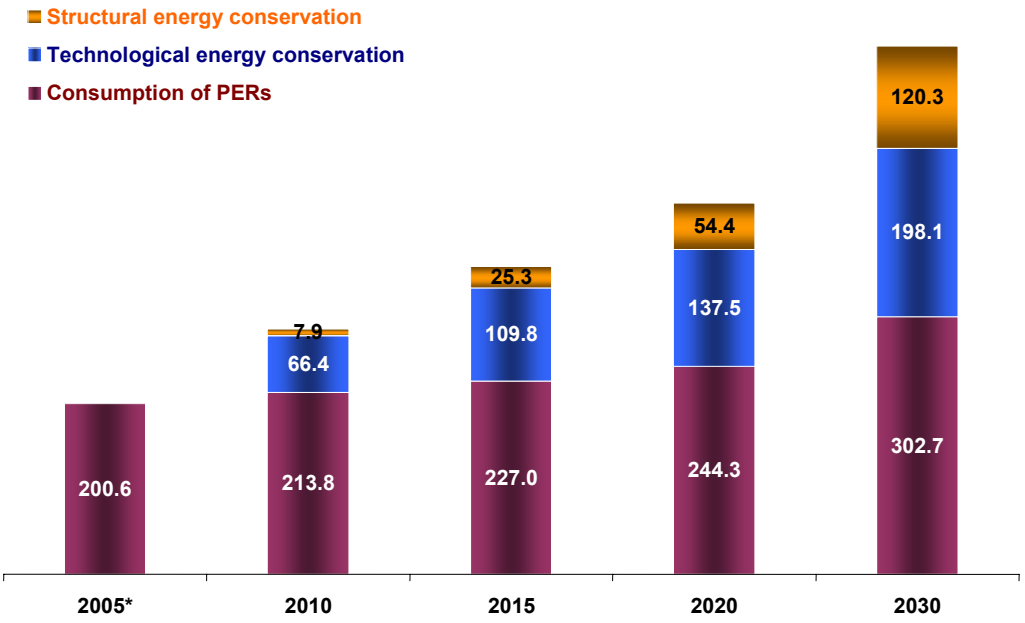
* In all sections of the Energy Strategy, data for 2005 represent preliminary data, that were available as at 08.02.2006.

According to the baseline scenario of development of the fuel and energy complex of Ukraine up to 2030, consumption of primary energy resources will reach 302.7 million ton of equivalent fuel in 2030 (see Fig. 2 at page 10 of the Energy Strategy). In other words, PERs consumption is expected to increase in 1.51 times, that corresponds to reduction of GDP energy intensity by 2030 in 3.1/1.51 = 2.05 times. According to figures of the Strategy

itself (see Fig. 3 at page 8 of the Energy Strategy), GDP energy intensity of Ukraine reaches 0.89 kg EF/$1 (purchasing power parity). Correspondingly, in 2030, GDP energy intensity is expected to reach 0.89/2.05 = 0.43 kg EF/$1 (PPP). EF = equivalent fuel = coal equivalent, LHV = 29.3 MJ/kg. For comparison: in 2005, the relevant figure for Poland reached 0.34 kg EF/$1 (PPP). Therefore, the Strategy sets the target for GDP energy intensity of Ukraine by 2030 much higher than the level Poland had already reached in 2005!

Figure 2

The Energy Strategy of Ukraine up to 2030: Expected dynamics of consumption of primary energy resources, levels of structural and technological energy conservation by 2030 (million tons EF, the baseline scenario).

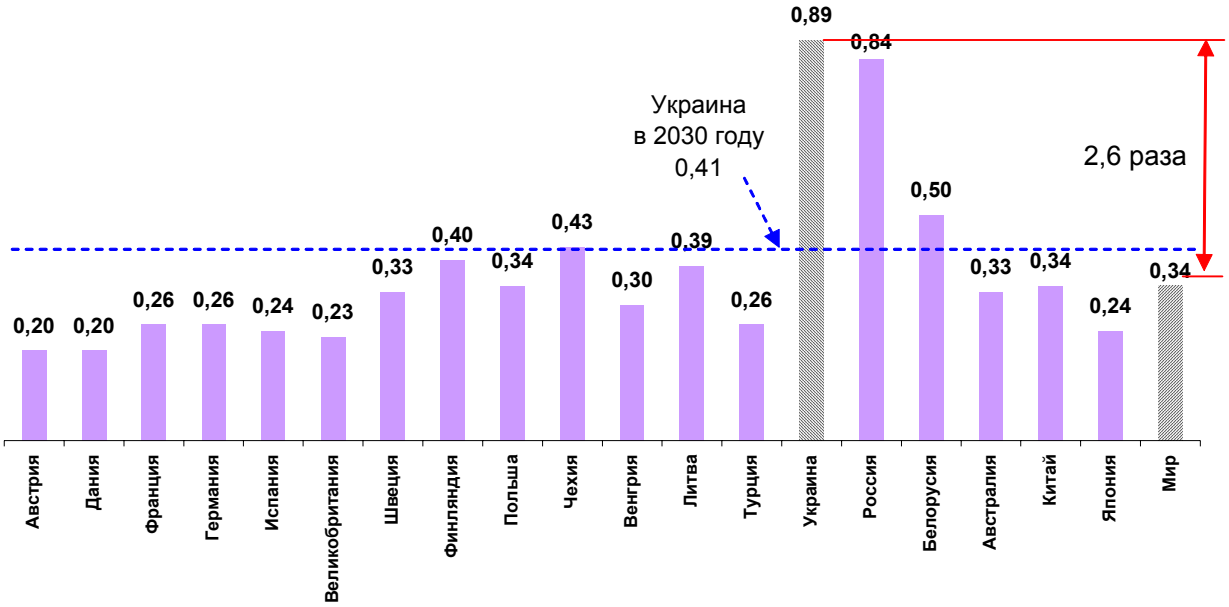


* In all sections of the Energy Strategy, data for 2005 represent preliminary data, that were available as at 08.02.2006.

One can hardly assess such targets as something other than perpetuation of Ukraine's lagging in the sphere of energy efficiency. Why did not they attempt to set the Polish figure of 2005 (0.34 kg EF/$1 PPP) as the target for Ukraine by 2030? We consider such a target fairly realistic. In the next 25 years Poland may well reduce its GDP energy intensity to the level of Western European countries, but Ukraine at least would reduce its lag. In this case, expected FERs consumption of Ukraine by 2030 would reach: 200.6*3.1*0.34/0.89=**237.5 million tons EF** (instead of 302.7 million, as in the Strategy). The estimate is lower than the Strategy's one by 65.2 million tons EF! By the way, almost the same amount (64.78 million tons EF) is allocated to nuclear power generation in the overall balance of fuel and energy sources in 2030 (by that time, 24 reactor units are expected to operate). In other words, should we succeed to reach the level of GDP energy efficiency of 0.34 kg EF/$1 (PPP), there would be no need to construct 22 new reactor units, that are planned for commissioning in Ukraine by 2030 in the Strategy.

Figure 3

The Energy Strategy of Ukraine up to 2030: GDP energy intensity of different countries, kg EF/$1 (PPP)



(*Key World Energy Statistics, 2003, 2004)

We believe, that the Strategy is based on the assumption of an inadmissibly high level of GDP energy intensity, that perpetuates lagging of Ukraine in the sphere of energy efficiency for the nearest decades. The GDP energy intensity figures of the Strategy make us to assume that no realistic assessments of energy conservation capacity in different industries were made. Besides that, forecasts of the GDP growth (and relevant energy needs) were made accounting for the contemporary structure of the Ukrainian economy, dominated now by energy intensive and resource intensive industries. The Strategy seems to ignore a fairly logical possibilities of radical changes in the structure in 25 nearest years, including even relocation of heavy industries from the country, priority development of ITs, nanotechnologies and other components of the innovative capacity of the Ukrainian economy.

2. What Types of Energy Will We Produce?

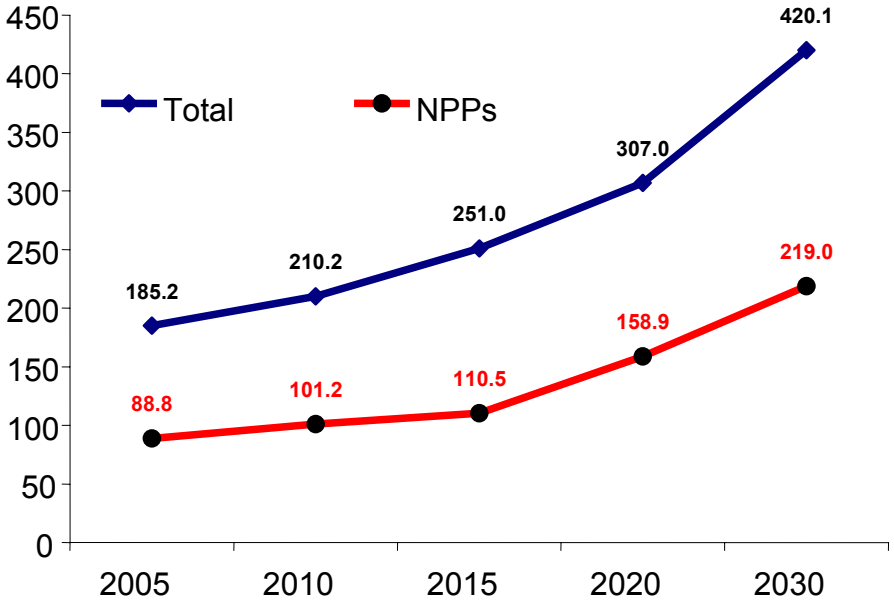
The Strategy stipulates priority growth of generation and consumption of electric energy, comparatively to consumption of other types of energy. For example, planned consumption of FERs is expected to increase in 1.51 times (see Fig. 2), while generation and consumption of electric energy are expected to increase in 2.22 times. Besides that, generation of electric energy by NPPs is expected to increase in 2.47 times (from 88.8 to 219.0 billion kWh/year) (see Fig. 4 at page 43 of the Energy Strategy).

If we assume that generation of electric energy should increase proportionally to the growth of FERs consumption (i.e. in 1.51 times), planned electricity generation figure for 2030 would reach 285.70 billion kWh/year (instead of 420.1 billion kWh), or lower by 134.4 billion kWh. The latter figure is equivalent of generation capacity of 12 new nuclear reactor units (with generating capacity of 1500 MW each):

12×1500 MW×8700 h/year×0.85 = 133.1 billion kWh/year. In other words, should growth of electric energy generation be proportional to growth of FERs consumption, Ukraine could avoid construction of 12 new reactor units!

Figure 4

The Energy Strategy of Ukraine up to 2030: Annual electric energy generation in Ukraine in 2005 - 2030, billion kWh



3. How Would We Ensure the Substantial Increase of Electric Energy Generation?

According to the Energy Strategy, by 2030, 24 nuclear reactor units are expected to operate in Ukraine (including 14 new reactor units, 8 units with extended service life and 2 already operational ones). Overall, construction of 22 new reactor units is planned: 2 additional reactor units at the site of Khmelnitskiy NPP (2000 MW), 9 reactor units to replace already operational ones (10500 MW) and 11 reactor units at new sites (16500 MW). In addition, the share of coal in the national energy balance is expected to increase more than twice (from 43.5 million tons EF in 2005 to 101.0 million tons EF in 2030). Coal is expected to be used predominantly for generation of electric energy.

4. Who Would Consume the Substantial Increase of Electric Energy Generation?

The Strategy stipulates export of 25 billion kWh/year of electric energy in 2030 (see page 25 of the Strategy) and use of about 100 billion kWh/year for electric heating (the authors' estimate at the base of data of the Energy Strategy). As we have already noted, the amount is equivalent to generating capacity of more than 11 new reactor units (with generating capacity of 1500 MW each). In other words, the Strategy stipulates that 2 new reactor units would serve export supply only, while 9 new reactor units would serve electric heating! If we assume that the Strategy overestimates energy needs of the national economy (see above), a real export-oriented capacity of new reactor units might be higher in 2 or more times.

5. How Much Would the Strategy Implementation Cost?

In order to compare efficiency of investments to different options of development of the power industry of Ukraine by 2030, we will use data of the Strategy itself. For example, planned development of nuclear power up to 2030 would require the following capital investments:

- nuclear power industry UAH 208.2 billion.
- the nuclear fuel cycle UAH 21.7 billion.

Total: UAH **229.9 billion.**

The nuclear power is expected to contribute 64.78 million tons EF to the energy balance of 2030. In such a case, unit investments per 1 ton EF of the balance would reach: 229.9/64.78= UAH 3.55 thousand/ton EF.

If we analyse data of the Energy Conservation section of the Strategy, we can see that planned "economically appropriate industrial technological energy conservation" at the level of 175.93 million tons EF in 2030 is expected to be reached due to capital investments of UAH 98.8 billion. In such a case, unit investments per 1 ton EF of reduction would reach: 98.8/175.93= UAH 0.56 thousand/ton EF (or 6.3 times lower than in the case of nuclear power). Moreover, 1 ton EF of "reduction" in the energy balance would not entail any additional operational costs, unlike NPPs that need substantial expenses for fuel, O&M and final disposal of irradiated nuclear fuel.

It is worth to note here that costs of introduction of boilers for burning of solid biomass fuel reach UAH 2.34 billion (see Table 1, data of the authors). These boilers could replace 5 billion m^3/year of natural gas (5.97 million tons EF/year). In the latter case, unit investment costs per 1 ton EF in the energy balance would reach: 2.4/5.97= UAH 0.4 thousand/ton EF (or 8.9 times lower comparatively to nuclear power). Therefore, the nuclear option of development of the power industry of Ukraine is economically inefficient comparatively to energy conservation and development of renewables.

Table 1

Capacity of the Ukrainian market of biomass and peat-fuelled boilers for priority introduction (may be realistically introduced by 2015).

Installation types	App. capacity of the Ukrainian market	Installed capacity MW_{th}	Operation period, h/year	Replacement of natural gas, billion m^3/year	Reduction of CO_2 *) emissions (million tons/year)	Investment costs (UAH million)
Wood fired heating boilers, 1...10 MW	500	500	4400	0.26	0.51	100
Industrial wood fired boilers, 0.1...5 MW	360	360	6000	0.24	0.46	72
Domestic wood fired boilers, 10...50 kW	53000	1590	4400	0.84	1.65	318
Farm straw fired boilers, 0.1...1 MW	15900	3180	4400	1.67	3.27	954
Straw fired heating boilers, 1...10 MW	1400	2800	4400	1.47	2.88	840
Peat fired heating boilers, 0.5...1 MW	1000	750	4400	0.52	1.03	150
TOTAL	**72160**	**9180**		**5.00**	**9.81**	**2434**

*) comparatively to burning of natural gas

The overall thermal capacity of the above installations reaches more than 9000 MW, allowing to replace up to 5.0 billion m^3/year of natural gas and reduce CO_2 emissions by almost 10 million t/year. We believe, that the above biomass-fuelled boilers may be realistically introduced by 2015. At the level of unit investment costs of UAH 200/kW for wood and peat-fuelled boilers and UAH 300/kW for straw-fuelled boilers, the overall investment costs, necessary for implementation of the proposed concept would reach UAH 2.4 billion. If we compare the latter investment costs with cost reductions, associated with lower consumption of natural gas (UAH 550/1000 m^3 $\times$ 5.0 billion m^3/year = UAH 2.75 billion/year), we can see that the annual effect of lower gas consumption exceeds the overall costs of the boilers proposed. It is worth to note that these cost savings will be generated every consecutive year.

6. What Kind of Energy Balance Do They Offer?

The structure of consumption of primary energy resources in Ukraine (according to the baseline scenario) is shown in Table 2. Let us focus on the issue of shares of alternative and renewable energy sources (A&Rs) in the energy balance of Ukraine. The share is expected to reach: 16.8 **+** 22.7 = 39.5 million tons EF (i.e. 13% of the overall consumption of FERs) in 2030. Section 7.3. of the Strategy "Development Capacity of Alternative and Renewable Energy Sources" provides a different assessment of A&Rs. According to the section, the share of A&Rs in the overall energy balance of the country might increase up to **57.73** million tons EF (19% of the overall FERs consumption) at the level of 2030 (see Table 3). In such a case, it is unclear, where these 57.73 million tons EF/year are "hidden" in the structure of FERs consumption (see Table 2) - one can find only 39.5 million tons EF/year there. It seems, that 18.23 million tons EF/year of A&Rs simply were not accounted for in the overall energy balance. However, if we account for their contribution, we could reduce the contribution of NPPs correspondingly (the figure is equivalent to the same 12 new reactor units, that could not be constructed).

Table 2

Structure of consumption of primary energy resources in Ukraine, according to the baseline scenario (data of the Energy Strategy)

Resources	2005		2030	
	million tons EF	%	**million tons EF**	%
Natural gas	**87.9**	43.8	**56.9**	18.8
Coal	**43.5**	21.7	**101.0**	33.4
Oil	**25.7**	12.8	**34.0**	11.2
Other types of fuel (coalbed methane, biomass, biogas, peat, etc.)	**11**	5.5	**16.8**	5.6
Ambient energy	**0.2**	-	**22.7**	7.5
Electric energy generation without fossil fuel burning, total Inc.: HEPs and HESPs NPPs	**32.0** **3.89** **28.11**	15.9 1.9 14.0	**70.9** **5.5** **64.78**	23.4 1.8 21.4
Thermal energy generation by NPPs	**0.3**	0.2	**0.4**	0.1
Total	**200.6**	100	**302.7**	100

Table 3

The Energy Strategy of Ukraine up to 2030: Development of main A&Rs (the baseline scenario), million tons EF/year

Alternative and renewable energy sources	A&Rs contribution			
	2005	2010	2020	2030
Alternative energy sources, total	**13.85**	**15.96**	**18.5**	**22.2**
inc. coalbed methane	0.05	0.96	2.8	5.8
Renewable energy sources, total, inc.	**1.661**	**3.842**	**12.054**	**35.53**
Biomass energy	1.3	2.7	6.3	9.2
Solar energy	0.003	0.032	0.284	1.1
Small hydro power	0.12	0.52	0.85	1.13
Geothermal energy	0.02	0.08	0.19	0.7
Wind energy	0.018	0.21	0.53	0.7
Ambient energy	0.2	0.3	3.9	22.7
Total	**15.51**	**19.83**	**30.55**	**57.73**

The planned growth of utilisation of "ambient energy" up to 22.7 million tons EF/year is particularly questionable, as the option stipulates a broad application of heat pumps. It is clear, that electric energy, necessary to operate these heat pumps, is expected to be covered by expanded capacity of NPPs. In this connection, two questions emerge: 1) Is it possible to consider ambient energy as a renewable source of energy? We think that it should not. 2) Is it possible to utilise such a large amount of ambient energy in the energy balance of 2030? In order to get a base for comparison, let us review official statistics and plans of application of heat pumps in EU-15. For comparison - according to the White Paper on development of renewables in the EU countries, in 1995, geothermal facilities of the EU (including heat pumps) generated 0.4 million tons of oil equivalent (0.57 million tons EF), or

0.028% of the overall consumption of FERs. By 2010, they plan to reach the target of 1.0 million tons of oil equivalent (1.43 million tons EF). In other words, Ukraine plans to use heat pumps to generate 15.9 times more energy in 2030 than 15 "old" European countries plant to generate in 2010. We believe that these forecasts of the Strategy are overestimated by one order of magnitude (at least).

Let us attempt to estimate the contribution of genuine renewables (see Table 4). The share of renewables is expected to reach 18.33 million tons FE (or 6% of the overall FERs consumption) in 2030. We believe, that the target is too pessimistic. For comparison, EU member-states in general set the target figure for contribution of renewables at the level of 12% by 2010. Some countries already reached the following shares of renewables by 2001: Norway - 45%, Sweden - 29.1%, New Zealand - 25.8%, Finland - 23%, Austria - 21.5%, Canada - 15.6%, Denmark - 10.4%. Almost all countries seek to ensure a substantial growth of renewables in the nearest decades. We believe, that, similarly to the case of energy conservation targets, the Strategy perpetuates disastrous lagging of Ukraine behind developed countries in the sphere of development of renewables.

Table 4

Development of renewables (data of the Energy Strategy), million tons EF/year

Renewable energy sources	Development of renewables, by years	
	2005	2030
Biomass energy	1.3	9.2
Solar energy	0.003	1.1
Small hydro power	0.12	1.13
Large hydro power	3.89	5.5
Geothermal energy	0.02	0.7
Wind energy	0.018	0.7
Total	**5.35**	**18.33**

Our estimates suggest that much higher targets for development of A&Rs may be set (see Table 5). In this case, in 2030, the share of renewables may reach 33.7 million tons EF, or 11% of the overall consumption of FERs (in the case of the overall energy demand of 302.7 million tons EF), or 14.2% (in the case of the overall energy demand of 237.5 million tons EF, if Ukraine will opt to rely on energy conservation more intensively). Such parameters would not bring Ukraine to the group of leaders in the sphere of development of renewable energy sources, but we would take a rather decent position among European countries.

Table 5

Utilisation of A&Rs in 2030, million tons EF/year

Off-balance energy sources, total	**22.20**
inc. coalbed methane	0.93
Renewable energy sources, total, inc.	**33.7**
Bioenergy	20.0
Solar thermal collectors	2.0
Photovoltaics	0.7
Small hydro power	1.3
Geothermal energy	1.1
Wind energy	8.6
Total	**55.9**

7. What Risks Should We Expect?

There are several political and technological risks of the "nuclear" scenario of development of the power industry, that forms the backbone of the approved Strategy. The political risk of the nuclear scenario of development of the power industry of Ukraine is associated with the fact of potential threat of almost complete dependence on Russia as a supplier of nuclear fuel and equipment for NPPs, similarly to the situation with natural gas. Ukraine has only one raw material (uranium), but now Ukrainian uranium allows to meet only 30% of the nuclear power industry demand. The rest is supplied by Russia. Ukraine does not have a complete nuclear fuel cycle. Ukraine does not have technologies and capacity for processing and final disposal of irradiated nuclear fuel and radioactive waste. Nuclear fuel elements are

also supplied by Russia. All operational nuclear reactors in Ukraine were manufactured in Russia. It is fairly possible that the orientation on Russian equipment will continue. In such a way, there seems to be a clear threat of the new "nuclear needle" of Ukraine's dependence on the neighbouring country, with all associated opportunities to influence other economic and political processes in Ukraine. We believe, that replacement of the "gas needle" by the nuclear one does not meet interests of Ukraine.

There is a major technological obstacle for implementation of the scenario of electric heating, based on supply of electric energy, generated by NPPs, as it is necessary to modernise existing power supply networks radically. In the majority of cases, existing power supply networks cannot operate at higher currents, that would be necessary in the case of a broad application of electric heaters. A large-scale application of electric heating would necessitate increase of operating currents in more than 3 times. The Energy strategy should objectively account for associated costs.

The idea of application of heat pumps and heat accumulators is not duly detailed in the Strategy. It is absolutely clear, that their introduction would also require major capital investments that should be accounted for as costs of "thermal energy" generated by NPPs. Unit costs of installed capacity of heat pumps reach about $200 - $300/kW. Even if heat pumps would consume a half of electric energy, generated by new reactor units, associated capital investments into heat pumps only would reach more than $ 2 billion. We failed to find relevant cost allocations in the Strategy.

8. Is There an Alternative to the Approved Energy Strategy?

We are convinced that such alternative really exists! Our vision of the alternative is shown in Table 6. As one can see, the alternative is based on several concepts that were discussed above:

- To develop the Ukrainian economy at the base of more intensive energy conservation, seeking to reach the target of GDP energy efficiency at the level of 0.34 kg EF/1$ (PPP) by 2030 (i.e. the level of Poland in 2005). In this case, the overall FERs consumption of Ukraine would reach 237.5 million tons EF in 2030.
- To increase the level of A&Rs consumption up to 55.9 million tons EF/year.
- To decommission nuclear reactor units as they will reach the end of their planned service life without planning construction of new reactor units.
- To increase coal consumption in Ukraine up to 83.1 million tons EF/year (instead of 101.0 million tons EF, as stipulated in the approved Energy Strategy). It seems to be more realistic, comparatively to the approved Strategy and if implemented, the option would result in a lower environmental pressure.

Table 6

Structure of consumption of primary energy resources in Ukraine (the baseline scenario of the approved Energy Strategy vs. the alternative scenario proposed)

Resources	2005		2030 the approved Energy Strategy		2030 the alternative strategy	
	million tons EF	%	**million tons EF**	%	**million tons EF**	%
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 (coalbed methane, biomass, biogas, peat, etc.)	**11**	5.48	**16.8**	5.55	**55.9**	23.5
Ambient energy	**0.2**	0.0	**22.7**	7.5	**-**	-
Generation of electric energy without burning of fossil fuel, total	**32.0**	15.9	**70.9**	23.4	**7.6**	3.1
inc.: HEPs and HESPs	**3.89**	1.9	**5.5**	1.8	**5.5***	2.3*
NPPs	**28.11**	14.0	**64.78**	21.4	**2.1**	0.9
Thermal energy generation by NPPs	**0.3**	0.15	**0.4**	0.13	**-**	-
Total	**200.6**	100	**302.7**	100	**237.5**	100

9. What Should We Do?

We believe, that the following steps are urgently needed:

- To develop an alternative to the approved Energy Strategy of Ukraine, that should prioritise development of energy efficient technologies, alternative and renewable energy sources.
- To develop an energy conservation program of Ukraine, that should specify, in detail, sectors and technologies allowing to reach the target of reduction of the GDP energy intensity to the level of 0.34 kg EF/$1 (PPP) by 2030. A particular attention should be paid to the housing and utilities sector. To estimate economically appropriate capacity of such technologies, necessary investments for their introduction, operation costs and payback periods.
- To develop a program of utilisation of A&Rs, that should specify, in detail, sectors and technologies allowing to replace 55.9 million tons EF/year due to application of A&Rs. To estimate economically appropriate capacity of relevant technologies, necessary investments for their introduction, operation costs and payback periods.
- To develop and submit to the Government for review, an alternative version of the strategy, that should prioritise development of energy efficient technologies, alternative and renewable energy sources. We believe, that the existing Strategy was approved without consideration of other alternatives and the Government has the right to choose from more than one option.
- To authorise the National Agency of Ukraine for Energy Efficiency to co-ordinate development of the alterative strategy. We believe, that if the working group of the Ministry of Fuel and Energy will be authorised to develop the alternative strategy, the result would be largely the same. The agency is interested in the maximal generation capacity, as a result, it will never prioritise energy conservation and development of A&Rs in any energy strategy it develops.
- To remember that secretive methods of development of the Energy Strategy up to 2030 resulted in growing social tensions. In the course of decision-making on the alternative strategy, a particular attention should be paid to due arrangements for public participation from early stages and at all levels. Provision of timely information, transparency, openness, respectful attitudes to representatives of all public stakeholders and NGOs, including environmental ones (according to principles

of the Aarhus Convention, that was signed and ratified by Ukraine), provision of all opportunities for public participation - all these factors would allow to improve quality of the alternative strategy substantially, moreover, they would allow to generate public consensus and support of the most active part of the civil society.

- To submit the alternative energy strategy for approval of the Verkhovna Rada of Ukraine after its review and approval by the Government. An agreed political decision on these matters should be made. We believe that the issue of the Energy Strategy of Ukraine up to 2030 is a priority and its should be reviewed and decided upon without delay.