Economic aspects of bioenergy technologies in Ukraine

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Bioenergy technologies are just at the beginning of their development in Ukraine. The matter of implementation of bioenergy technologies is of great importance for the country due to significant lack of domestic energy resources and high level dependence on imported energy carriers.

Direct combustion

At present among different bioenergy technologies first of all direct combustion of biomass can achieve commercial level in Ukraine. Now Ukraine does not produce any biomass-fired boilers. However results of fulfilled technical and economic assessment shows that heat production from biomass can be profitable in Ukraine even if foreign equipment is used.

Feasibility study was carried out for two wood-fired steam boiler of Dutch manufacturer KARA and for an automatic straw-fired boiler of Danish manufacturer Lin-ka. The results are presented in Table 1. In case of Dutch steam boilers capital outlays include cost of boiler, auxiliary equipment, automatic and control system, multi-cyclones, chimney, expenses on boiler mounting of putting into operation. Cost of boiler house and heating network is not included. The following parameters were varied: annual period of operation, fuel cost, fuel moisture etc. Operation time of 8360 h/year corresponds to boiler producing process steam, and 4400 h/year corresponds to boiler operation during heating season. In case of automatic straw-fired boiler of Danish manufacturer Lin-ka capital outlays include cost of boiler, chimney, buildings, installation, and freight.

Fuel constituent of heat produced from natural gas runs up to 2.3 $/GJ under gas price of 80 $/1000 Nm^3. Typical price of heat produced in gas boilers is 4 $/GJ in Ukraine. Then heat production from wood residues and straw is profitable in Ukraine even using foreign boilers. The most profitable is production of process steam due to long operation time.

There are rather big amount (about several hundreds) of boilers for combustion of wood and wood residues in timber industry and wood processing industry of Ukraine. As a rule all these boilers were originally designed for using gas, oil and coal as a fuel, and later enterprises-owners converted them for wood by own strength. Usually retrofitted boilers have low efficiency and high emission into the atmosphere. Lately some modern boilers operating on biomass (wood residues, straw) have been installed in Ukraine within the frame of the Netherlands-Ukraine and Denmark-Ukraine technical assistance projects.

Pyrolysis

At present carbonization and slow pyrolysis technologies are used in Ukraine mainly for charcoal production for technological purposes of metallurgy industry and pharmacology and for treatment of wastewater and gas. At that raw material as a rule is hard wood. Fast pyrolysis technologies are practically unknown in Ukraine. Ukraine has rather big potential of biomass for energy production in the view of agricultural residues: straw, maize stems, sunflower stems etc. They are rather cheap types of biomass. For example, straw price is 3-3.5 $/t. These agricultural residues can be used as a raw material for fast pyrolysis plants. From economic point of view portable plants of ablative pyrolysis (with 50-200 kg/h capacity on raw material) and stationary plants consisting of two fluid bed reactors (with 1-5 t/h capacity on raw material) can be the most perspective for Ukraine. Use of portable plants especially gives the opportunity to reduce liquid fuel price because in this case capital outlays and operating costs don't include expenses on baling, storage and drying of biomass. Works in the direction of fast pyrolysis technologies should be begun with construction of pilot and demonstration plants.

Table 1. Data on feasibility study of wood-fired and straw-fired boilers

Parameters	5 MW_{th} KARA wood-fired boiler with step moving grate			2 ? W_{th} KARA under screw wood-fired boiler			0.8 ? W_{th} Linka straw-fired boiler
Capital outlays, thous. $	750	750	750	250	250	250	133
Fuel moisture, %	60	60	60	40	40	40	15
Operation time, h/year	4400	8360	8360	4400	8360	8360	4400
Operating costs, thous. $/year							
Amortisation[1)]	50.25	50.25	50.25	16.75	16.75	16.75	8.91
Profit (ann. interest is 10%)	75	75	75	25	25	25	13.3
Labor[2)]	0.83	1.67	1.67	0.83	1.67	1.67	0.83
Fuel	94.0	0	53.3	21.5	0	12.2	3.3
Maintenance	5	5	5	5	5	5	0.9
TOTAL	225	132	185	69	48	61	27
Fuel consumption[3)], t/year	14685	31350	31350	3357	7166	7166	895
Heating value, MJ/kg	6	6	6	10.5	10.5	10.5	14
Fuel costs[4)], $/t	6.4	0	1.7	6.4	0	1.7	3.7
Heat production, GJ/year	70488	150480	150480	28195	60192	60192	11278
Prime cost of heat[5)], $/GJ	3.19	0.88	1.23	2.45	0.80	1.01	2.42
Saved natural gas, mill m^3/year	2.01	4.30	4.30	0.81	1.72	1.72	0.32
Saved natural gas[6)], thous $/year	161.12	343.95	343.95	64.45	137.58	137.58	25.78
Pay-back period[7)], year	12.24	2.22	2.64	6.73	1.91	2.11	6.42

1. The total period of amortization is 15 years.
2. Labor cost as 0.834 thous. $/year is for 3 men (1 man per shift) for 6 months; 1.67 is the same for 12 months.
3. It was calculated taking into account average capacity during heating season, that is 0.89 of the nominal capacity.
4. Fuel cost as 0 $/t is for combustion of own wood waste not having commercial value; 1.7 $/t is prime cost of fuelwood at wood processing plants; 6.4 $/t is price of fuelwood including transportation to biomass-fired boiler.
5. Prime cost of heat is calculated as operation costs divided by annual heat production.
6. Price of natural gas is accepted as 80 $/1000 Nm^3.
7. Simple payback period is calculated as capital costs divided by difference between cost of saved natural gas and operating costs. At that operating costs don't include amortization and profit.

Landfill gas

According to fulfilled estimation potential of landfill gas in Ukraine is about 1.35 billion m^3/year. Its energy potential amounts to 0.63 mtoe. Due to rather low electricity price in Ukraine (0.03 $/$kWh_e$) the most profitable scheme of utilization of landfill gas can be its use by industrial plants situated not far from landfills. For example according to this conception landfill gas from Obukhov landfill can be incinerated in boilers of Tripolskaya coal power plant (the distance between landfill and power plant is only 7 km).

Conclusion

At present only technologies of direct combustion have achieved commercial level in Ukraine. Heat production from biomass is profitable even under condition of use of foreign equipment. If biomass-fired boilers are produced in Ukraine, capital outlays will be 30-50% lower. Electricity production from biomass can be competitive only in the case of significant rise of electricity price in the country.

The main efforts in the area of fast pyrolysis technologies, gasification, extraction and use of landfill gas should be focused on pilot and demonstration projects. From economical point of view these technologies have future perspectives for commercial development in Ukraine.