

World Sustainable Energy Days 4 - 6 March 2020, Wels/Austria

ADDED VALUE OF DIFFERENT OPTIONS FOR AGRO RESIDUES UTILIZATION IN UKRAINE



Alex Epik, Vitalii Zubenko



Scientific Engineering Centre "Biomass"



Institute of Engineering Thermophysics, National Academy of Sciences of Ukraine

05/03/2020, Wels, Austria

Case study for one of the agrocompanies in Ukraine – key indicators

- 50,000 ha total arable land under cultivation, out of which
 20,000 ha for corn cultivation;
- Average corn yield 8.5 t/ha, gross yields 170,000 t/year
- Main activities: crops cultivation, elevation services, grain storage and drying;
- 2 out of 6 drying facilities are operating on biomass (elevation residues), peak drying capacity 1,500 t/day;
- Plans for doubling biomass-based drying capacities and increasing of corn gross yields to 700,000 t/year;
- Small-scale livestock: 600 cows + 600 pigs;
- Quite typical example for the average agrocompany in Ukraine

Biomass source streams identified for case study agrocompany

					Usage for energy			
	2018	(fact)	2022 (es	2022 (estimated)		production in 2018		
	natural		natural		natural		% (from	
Type of waste	tonnes	MWh	tonnes	MWh	tonnes	MWh	2018)	
Corn field residues (corn								
stover)	50,000	207,679	190,000	789,179	0	0	0%	
Wheat straw residues	3,300	12,793	3,440	13,336	0	0	0%	
Sunflower residues	0	-		-	0	0	0%	
Soy residues	0	-		-	0	0	0%	
Total field biomass	53,300	220,472	193,440	802,514	0	0	0%	
Manure from 600 cows+600								
pigs	-	2,152	-	2,152	0	0	0%	
Elevation waste from elevator								
# 1 (gross, direct data)	4,200	16,864	7,800	31,318	740	2,971	18%	
Elevation waste from elevator								
#2 (gross, direct data)	2,023	8,123	5,600	22,485	8	32	0,40%	
Eleveation waste from other								
elevators (estimated)	4,000	16,060	4,000	16,060	400**	1,605	10%	
TOTAL for all biomass streams	63,523	263,670	210,840	874,529	1,148	4,608	1.7%	
* in case of manure-to-biogas u	isage							
** 1 out of 6 total								

Energy balance of drying facilities using elevation residues

Elevator/parameter	Elevator #1	Elevator #2	Elevator #1 after	Elevator #2 after
	2010	2010	CAPUTISION	cxpullision
Heat capacity of dryers installed, MW _{th}	14	8	27	21
Drying capacity installed, t/hour grain				
28 → 14%wt.	72	36	135	98
Simultaneous storage capacity installed,				
t of grain	100,000	24,000	100,000	70,000
Grain dryed, t/year	113,530	68,117	212,080	178,639
	4 5 7 7	1 0 1 0	4 577	4 0 2 2
Hours on nominal capacity, hours/year	1,577	1,919	1,577	1,823
Final energy output needed for drying,	14 001	0 700	20 222	21.906
	14,901	8,780	28,/3/	21,890
<u>Iotal volumes</u> generated elevation	1 200	2 022	7 9/6	
residues, natural tonnes	4,200	2,025	7,040	5,565
elevation residues MWb	16 917	8 148	31 601	22 494
Final energy from generated residues	10,517	0,140	51,001	22,737
MWh	13,195	6,682	25,913	18,895
Ratio "Final energy from generated				
residues/final energy output needed for				
drying"	88.6%	76.1%	90.2%	86.3%
Factual utilization of own residues				
generated at elevators in 2018, t/year	740	8	-	
Patio				
"used residues / generated residues"	15.6%	0.30%	-	

Substantiation of corn residues removal from field

According to worldwide agropractices and available data from specialized long-term (decades) agroresearches*, the "sustainable" field corn residues removal factor is in range 15-100%.

The lowest figure of **15% is taken for further considerations**.

Residues available for removal from field (2019)

Crops	Holding areas, ha	Average yields, t/ha	TOTAL annual cumulative yields (2019), t/year	TOTAL estimated quantity of agroresidues generated in the field, t/year	Removal factor	Conservative figure of sustainable residues removal (2019), t
Corn	21,299	8.7	185,171	333,308	15%	49,996
Sunflower	12,952	2.7	34,668	55,470	0%	-
Soy	13,850	2.7	36,911	31,596	0%	-
Winter wheat	3,538	5.2	18,418	22,103	15%	3,315
TOTAL	51,639	-	275,170	442,477		53,312

Residues available for removal from field (after expansion)

Crops	Holding areas, ha	Average yields, t/ha	TOTAL annual cumulative yields (2022), t	TOTAL estimated quantity of agroresidues in the field, t	Removal factor	Conservative figure of sustainable residues removal (2022), t
Corn	70,000	10.0	700,000	1,260,000	15%	189,000
Sunflower	13,000	2.8	36,400	58,240	0%	-
Soy	13,000	2.8	36,400	31,158	0%	-
Winter wheat	3,500	5.5	19,250	23,100	15%	3,465
TOTAL	99,500		792,050	1,372,498		192,465

* UN FAO, JRC Europe, Ecofys, Wageningen University, Council of Agricultural Research and Economics, Ukrainian Institute of Bioenergy Crops and Sugar Beet, Soil Protection Institute of Ukraine, University of Wisconsin, etc.

Supply chain of baled corn



* accounted in OPEX of utilization facilities

Final cost at the "gate" of utilization installation: Final "selling price" for NPV>0 for supply chain: <u>1018 UAH/t w/o VAT</u> 1050 UAH/t w/o VAT

Option # 1: Stationary pelletizing of baled corn residues



Capacity: 6.25 t/hour, 41,000 t/year

Feedstock: baled corn residues

Equipment: Pelletizer – CPM, Auxiliary – Ukrainian origin

CAPEX: 2.1 million EUR

Cost of pellets: 71.6 EUR/t

Price for sell (big bags): 96 EUR/t with VAT

NPV, EUR	1,037,604
IRR, %	16.0%
PB, years	5.7
DPB, years	7.70
PI	1.49

Option # 2: Selling of baled corn to third parties



Capacity: 48,600 t/year

Feedstock: field corn residues

Equipment: Vehicles – international, Capital buildings – Ukrainian

CAPEX: 3.75 million EUR

Cost of bales: 1018 UAH/t

Price for sell: 1050 UAH/t

NPV, EUR	344,467
IRR, %	9.0%
PB, years	8.4
DPB, years	9.3
PI	1.01

Option # 3: Natural gas replacement at gas-fired dryers by baled corn



Capacity: 8 MWth (40 t/hour grain drying) Feedstock: baled corn residues Equipment: TEFF heat generator CAPEX: 331,000 EUR Gas replacement: 550,000 nm³/year Operation during year: 90 days

Economic indicators of investment project (for different gas prices)

Gas price for enterprise, UAH/ths. m ³ excl. VAT	5 667	6 233	7 083	8 500	9 917	11 333
% rise of price	0%	10%	25%	50%	75%	100%
NPV, EUR	-66 173	4 896	111 500	289 174	466 848	644 521
IRR, %	4.5%	8.2%	13.3%	20.9%	28.0%	34.9%
PB, years	10.9	8.7	6.6	4.7	3.6	2.9
DPBP, years	16.00	14.62	9.49	6.01	4.37	3.42
PI	0.80	1.01	1.34	1.87	2.41	2.95

Option # 4: CHP on baled corn



Capacity: 5 MWel + 8 (20) MWth

Feedstock: baled corn residues

Equipment: all international, construction works – Ukrainian

CAPEX: 15.7 million EUR

Electricity sell: PPA for 20 years with 10% discount from "green" tariff level

Economic indicators of investment project (for different sub-options)

Different sub-	5 Mwel + 0 MWth	5 Mwel + 8 MWth	5 MWel + 20 MWth
options	(power-only regime)	(power+drying)	(power+heat supply)
NPV, ths. EUR	-6,272	-3,953	-
IRR, %	2.5%	4.6%	16%
PB, years	17.4	13.8	-
DPBP, years	>15	>15	9.0
PI	0.62	0.76	-

Option # 5: Biogas-to-electricity from baled corn + manure



Capacity: 5 MWel

Feedstock: baled corn (145 TJ) + manure (4.2 TJ)

Equipment: all international, construction works – Ukrainian

CAPEX: 17.5 million EUR

Electricity sell: PPA for 20 years with 10% discount from "green" tariff level

NPV, EUR	-2,716,535
IRR, %	3.9%
PB, years	>15
DPB, years	>15
PI	-

Option # 6: Mobile pelletizing of field corn residues









Capacity: 41,000 t/season (year) Feedstock: field corn residues Equipment: all international vehicles CAPEX: 6.1 million EUR Cost of pellets: 76.5 EUR/t (field edge) Price for sell (bulk): 96 EUR/t with VAT

NPV, EUR	-2,063,218
IRR, %	4.0%
PB, years	>15
DPB, years	>15
PI	-

Added value for proposed options in comparison with core business





Conclusions – economic indicators for all proposed options

Option of residue utilization	Total CAPEX, million EUR, with VAT	Capacity	COGS, excl. VAT	Selling price, excl. VAT	Payback period	GHG emission reductions/ tCO2/year
Stationary pelletizing of baled corn residues (details - para 5.3)	2.1	41,000 t/year	71.6 EUR/t	80 EUR/t	5.7 years	26,888
Selling of baled corn to third parties (details – para 5.7)	3.75	48,600 t/year (in bales)	36.4 EUR/t	37.5 EUR/t	7.4 years	n/a
Natural gas substitution at gas-fired dryers by baled corn (details – para 5.2)	0.331	8 MWth	-	-	8.7 years (+10% gas price) 10.9 years (current gas price)	1,678
CHP on corn stover (details – para 5.6)	15.6	5 MWel + (8 MWth)	-	-	13.8 years	25,084
Biogas-to-electricity from baled corn + manure (details – para 5.5)	17.5	5 MWel	-	-	>15 years	21,668
Mobile pelletizing of field corn residues (details – para 5.4)	6.1	41,000 t/year	76.5 EUR/t	80 EUR/t	>15 years	23,330

Thank you for attention!



Institute of Engineering Thermophysics of NASU Tel./fax: +3 044 453 28 56; +3 044 456 94 62 E-mail: epikbiomass@gmail.com www.ittf.kiev.ua



Scientific Engineering Centre "Biomass" Tel./fax: +3 044 332 91 40; +3 044 223 55 86 E-mail: epik@biomass.kiev.ua; info@biomass.kiev.ua www.biomass.kiev.ua