Bioenergy Association of Ukraine

Options of heat utilization from biogas

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Bioenergy Association of Ukraine

IV SAF meeting

Effective operation of biogas facilities

11 April 2019

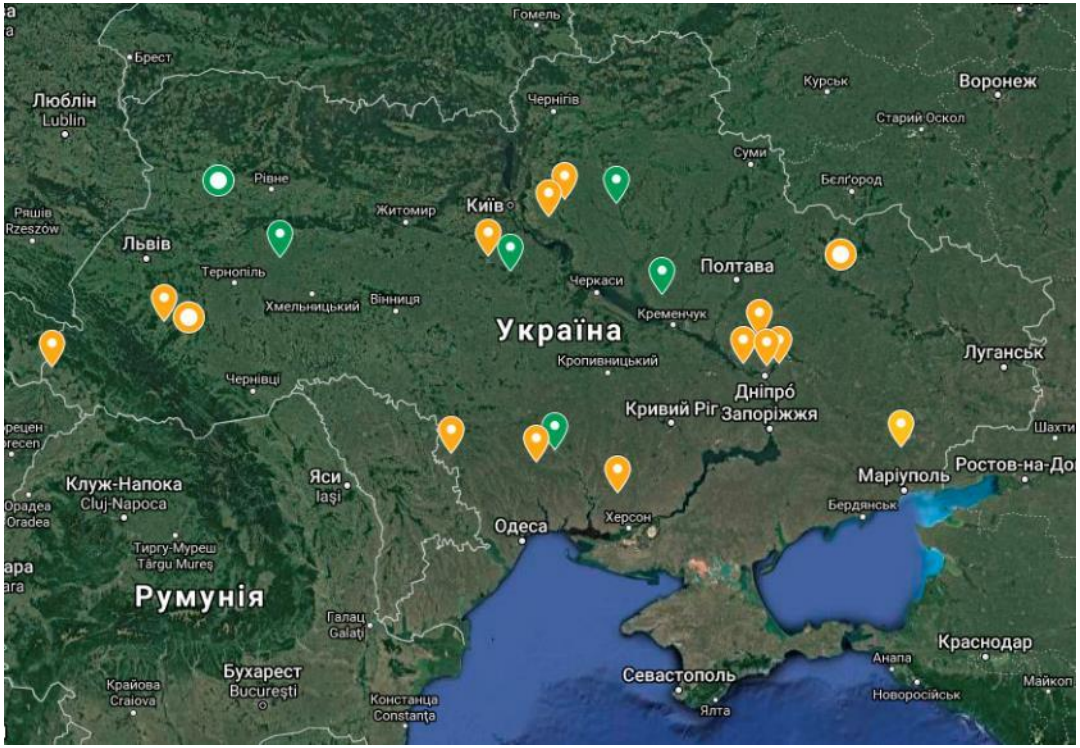
Ukrainian biogas projects operating under green tariff for electricity

#	Company	Location	Capacity, MW	Raw materials	Start of of Green Tariff	Power production in 2018, GWh
1	Oril-Lider (chicken farm), MKhP	Elizavetivka, Dnepropetrovsk region	5,7	Chicken manure, silage	21/11/13	42,2
2	Goodvalley (Danosha), pig farm	Kalush, I-Frankivsk region	1,3	Pig manure, silage	07/08/14	6,6
3	Rokitne sugar factory	Rokitne, Kiev region	2,4	Sugar beat press, silage	28/5/15	11,7
4	Komerzbudplast, egg farm	Beloozersk rayon, Kherson region	3,1	Chicken litter	07/11/16	11,3
5	Teofipol energy company, sugar factory	Teofipol, Khmelnitskiy region	5,1	Sugar beat press, silage	02/10/17	31,7
6	Ecoprod agrarian company	Volnovakha, Donetsk region	1,5	Cow manure, silage	11/01/18	6,7
7	Gorodishe-Pustovarivska agrarian company (sugar)	Prilutskiy rayon, Khernihiv region	2,4	Sugar beat press, silage	31/07/18	2,3
8	Trade house Vipexim	Okny, Odessa region	1,2	Manure, silage	28/09/18	-
9	“Kyiv Bio Center"	Bzov, Kiev region	0,3	Manure, silage	22/12/16	-
	TOTAL		**23,0**		**2013-2018**	**113,1**
Biogas projects without green tariff: Agro-Oven (160 kW), Elita (250 kW), UMK (630 kW), Astarta (500 kW), Demis-Agro (130 kW), Sigma (310 kW)						
Plans: MKhP- 20 MW (Vinnitsa region), Goodvalley – 1 MW (I-Frankivsk reg). Gals Agro – 4 MW (2 biogas plants – Kiev and Chernihiv regions), Teofipol (Khmelnitskiy region) – 15 MW						

** By NERC: http://www.nerc.gov.ua*

Біоенергетична асоціація України

Development of biogas projects in Ukrainian agriculture (2019)



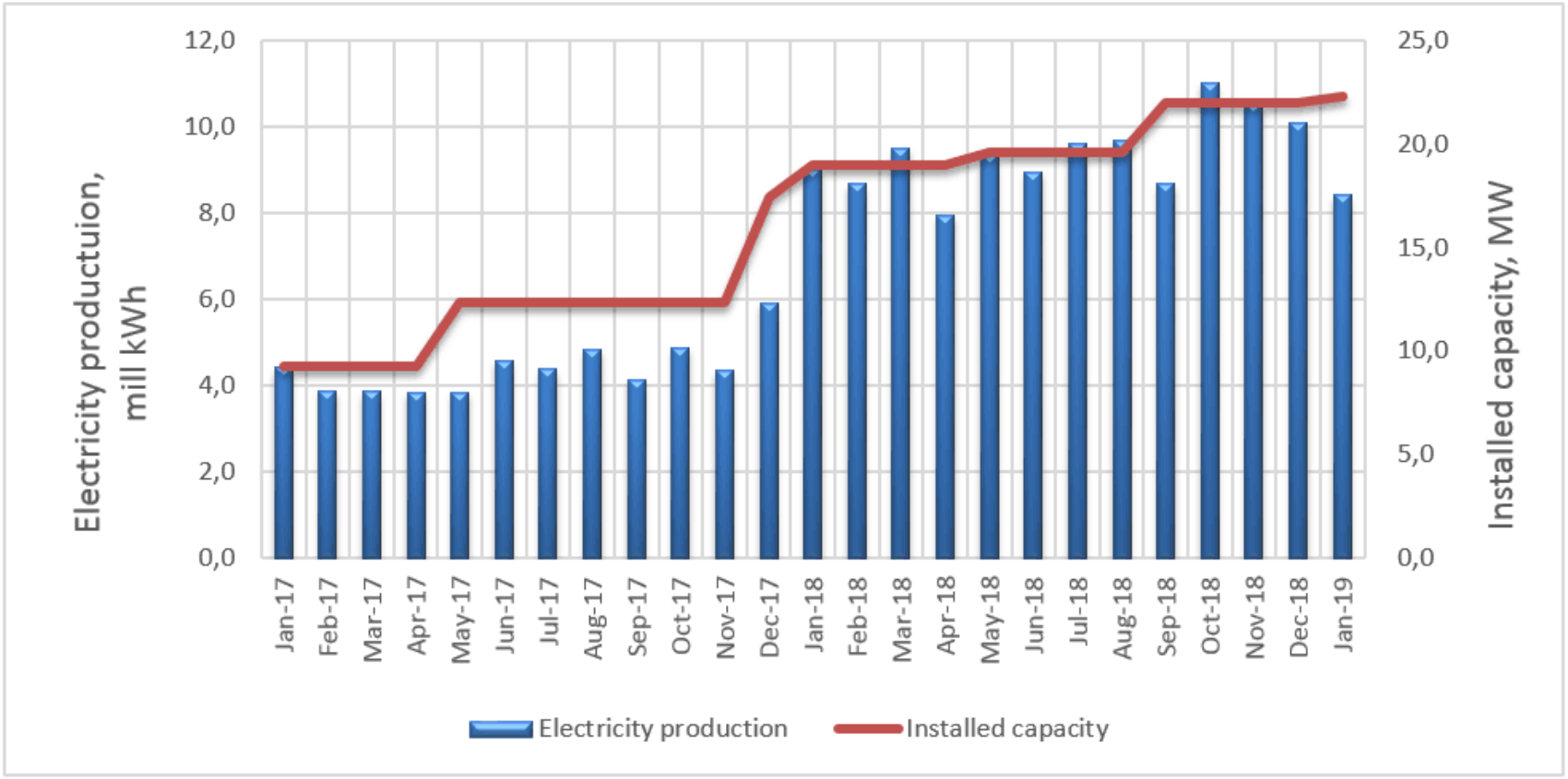
- Total number of biogas projects – **18**
- Total number of green tariff permissions (01.01.19) - **12**
- Installed capacity – **27,3 MW** (projects from 0,125 to 5,7 MW)
- Electricity production in 2017 – **53 GWh**
- Electricity production in 2018 – **113 GWh**






Біоенергетична асоціація України

Electricity production and installed capacity of biogas plants in Ukraine



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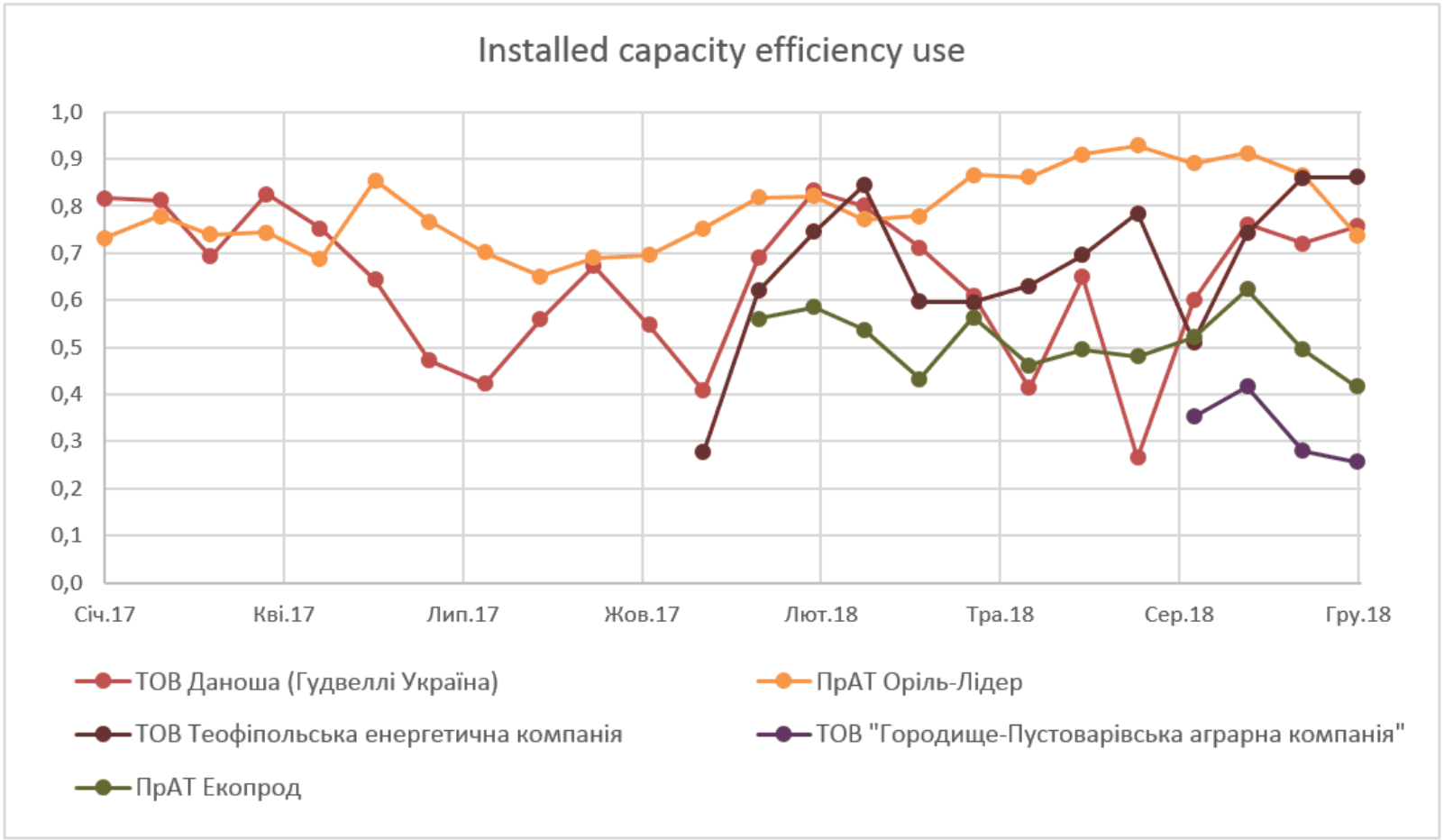
Біоенергетична асоціація України

Biogas project efficiency in Ukraine



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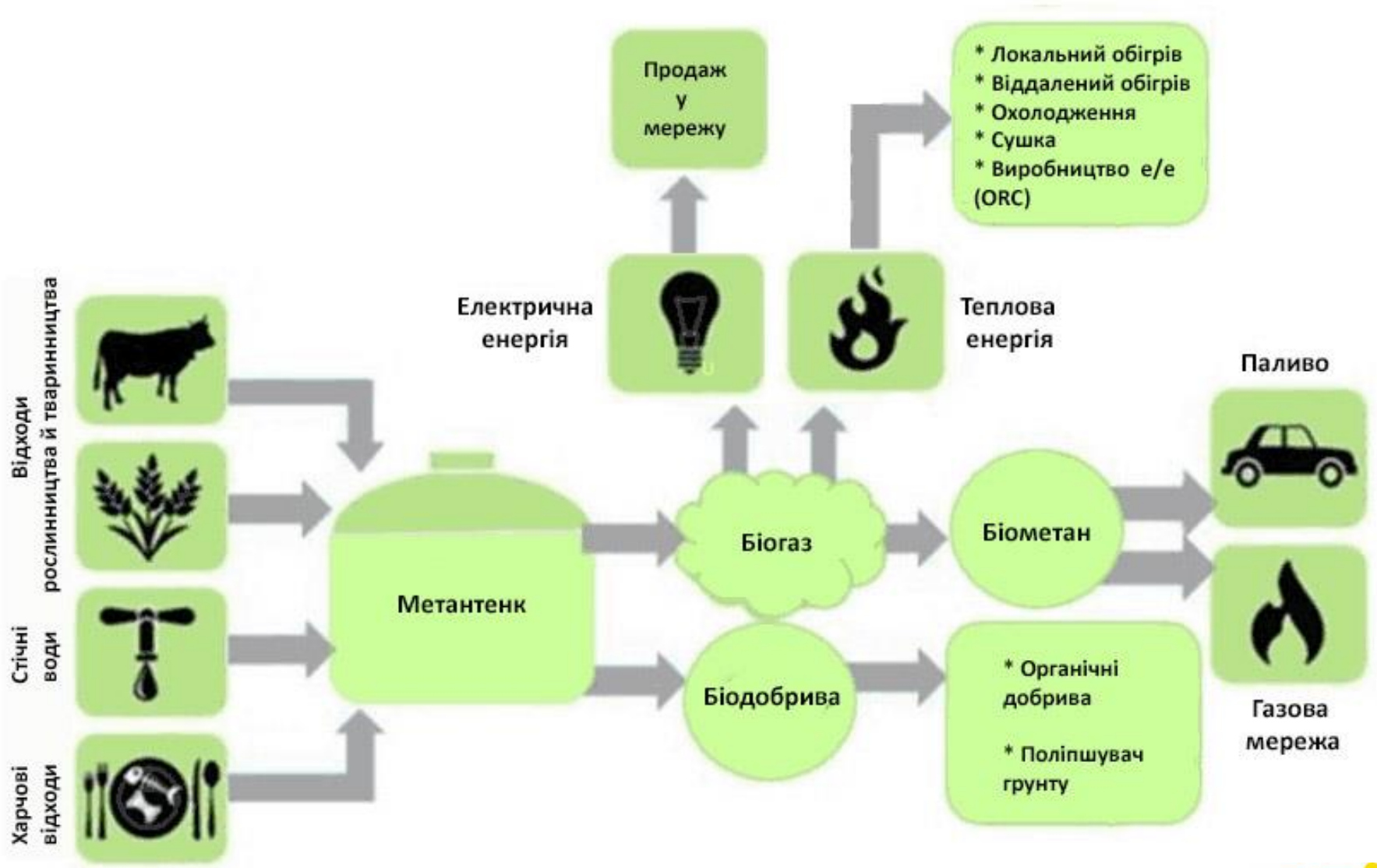
Біоенергетична асоціація України

Possibilities of biogas utilization with energy production

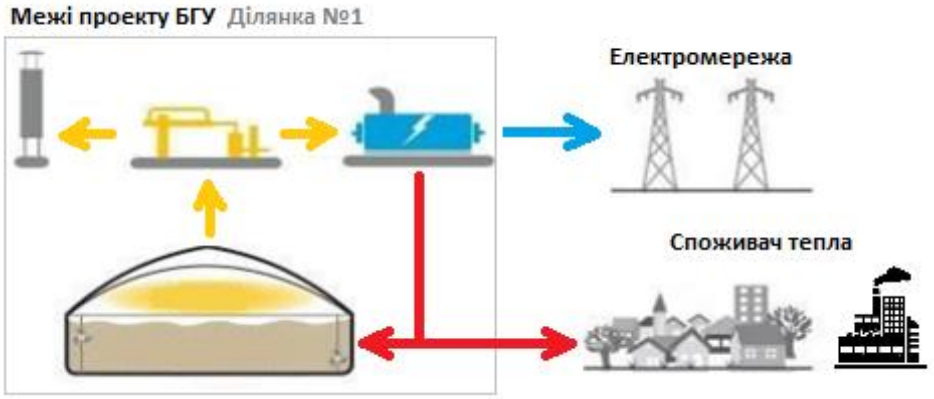


Біоенергетична асоціація України

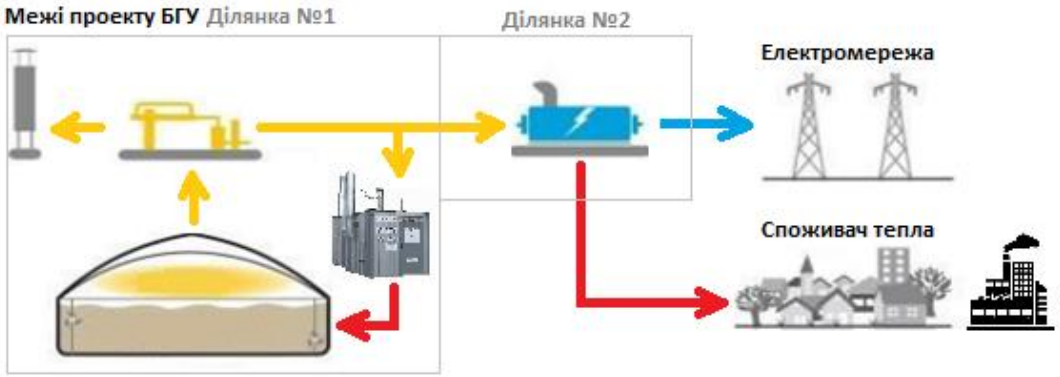
Business models for mini-CHP based on biogas

BASIC MODEL
electricity only

MODEL №1
heating pipe



MODEL №2
biogas pipe



Potential thermal energy users

- District Heating Systems
- Existing industrial production
- New industrial production (greenhouses, fish farms, etc.)
- Seasonal consumers of heat (dryers)
- Cooling of food production (dairy farms, slaughter shops, meat processing)
- Production of electricity in ORC modules

Біоенергетична асоціація України

Input parameters for feasibility studies

PROJECT PARAMETERS	
Basic agrarian farm	Big farm with **20,000 heads** (manure with **7%** of total solids
Methane CH_4 generation potential	manure – **23,8** nm^3CH_4/t Maize silage – **104,0** nm^3CH_4/t Straw pellets – **256,5** nm^3CH_4/t Chicken manure – **102,4** nm^3CH_4/t Sugar beet pulp – **102,4** nm^3CH_4/t
Own electricity and heat consumption by biogas plant	**8%** and **30%** accordantly
Coefficient of utilization of biogas plant installed capacity	**90%**
OPEX of biogas plant and CHP (without raw materials)	**4,5%** (min 2,7… max 8,9%) from CAPEX
FINANCIAL PARAMETERS	
Electricity tariff before 01/01/2030	**12,4** cents per 1 kWh, w/o VAT
Electricity tariff after 01/01/2030	**6** cents per 1 kWh (1,83 UAH/kWh), w/o VAT
Tariff of heat from biogas	**0,9 x 1400 UAH**/Gcal, w/o VAT
Ставка дисконтування	**8%**
Discount rate	**8%**
Loan Period / Grace Period	**8 years / 1 year**
The share of loan in CAPEX	**60%**

Feasibility study for biogas project 2,1 MW_e «Green» tariff by 2030

Project parameters	MODEL Electricity by green tariff (0,1239 cent/kWh,w/o VAT, by 2030)							
	BASIC Electricity only	BASIC Electricity only	BASIC Electricity only	BASIC Electricity only	MODEL №1 (heat pipe – 106,000 €/km) Use of 60% heat at the distance from CHP		MODEL №2 (biogas pipe – 48,000 €/km) Use of 60% heat at the distance from biogas plant	
					1 km	10 km	1 km	10 км
Raw materials	Maize silage	Straw pellets - **own production**	Straw - **Pre-treatment by extruder**	Straw pellets - **purchasing**	Maize silage		Maize silage	
Raw materials price, EUR/t	**20**	**25** (straw in bales)	**25** (straw in bales)	**80** (pellets)	**20**		**20**	
Consumption of raw materials, th. t/an	29.92	12.13	12.13	12.13	29.92		29.92	
CAPEX, mill €	5.74	5.91	5.51	5.04	5.85	6.80	5.79	6.22
CAPEX, €/kW_e	**2 700**	2 779	2 592	2 370	2 750	3 200	2 723	2 926
NPV, th. €	1 833	2 183	3 342	- 528	4 165	3 221	4 222	3 797
IRR, %	**14.2%**	**14.6%**	**18.5%**	**4.3%**	**20.0%**	**16.1%**	**20.3%**	**18.3%**
SPP, years	**5.5**	**5.6**	**4.8**	**6.6**	**4.6**	**5.3**	**4.5**	**4.9**
DPP, years	7.3	7.4	6.1	-	5.8	7.0	5.7	6.2

Feasibility study for biogas project 2,1 MW_e Auction (0,9 from «green» tariff) for 20 years

Project parameters	MODEL Electricity by auctions (0,9 x 0,1239 cent/kWh,w/o VAT, for 20 years)							
	BASIC Electricity only	BASIC Electricity only	BASIC Electricity only	BASIC Electricity only	MODEL №1 (heat pipe – 106,000 €/km) Use of 60% heat at the distance from CHP		MODEL №2 (biogas pipe – 48,000 €/km) Use of 60% heat at the distance from biogas plant	
					1 км	10 км	1 км	10 км
Raw materials	Maize silage	Straw pellets - **own production**	Straw - **Pre-treatment by extruder**	Straw pellets - **purchasing**	Maize silage		Maize silage	
Raw materials price, EUR/t	**20**	**25** (straw in bales)	**25** (straw in bales)	**80** (pellets)	**20**		**20**	
Consumption of raw materials, th. t/an	29.92	12.13	12.13	12.13	29.92		29.92	
CAPEX, mill €	5.74	5.91	5.51	5.04	5.85	6.80	5.79	6.22
CAPEX, €/kW_e	2 700	2 779	2 592	2 370	2 750	3 200	2 723	2 926
NPV, th. €	3 364	3 548	4 744	1 202	5 656	4 713	5 714	5 288
IRR, %	**15.3%**	**15.4%**	**18.4%**	**11.1%**	**19.6%**	**16.5%**	**19.8%**	**18.3%**
SPP, years	**6.5**	**6.5**	**5.6**	**8.2**	**5.3**	**6.1**	**5.2**	**5.6**
DPP, years	9.0	8.9	7.4	13.4	6.9	8.3	6.8	7.4

Feasibility study for biogas project 10,6 MW_e «Green» tariff by 2030

Project parameters	MODEL Electricity by green tariff (0,1239 cent/kWh,w/o VAT, by 2030)							
	BASIC Electricity only	BASIC Electricity only	BASIC Electricity only	BASIC Electricity only	MODEL №1 (heat pipe – 218,000 €/km) Use of 60% heat at the distance from CHP		MODEL №2 (biogas pipe – 115,000 €/km) Use of 60% heat at the distance from biogas plant	
					1 km	10 km	1 km	10 km
Raw materials	Maize silage	Straw pellets - **own production**	Straw - **Pre-treatment by extruder**	Straw pellets - **purchasing**	Maize silage		Maize silage	
Raw materials price, EUR/t	**20**	**25** (straw in bales)	**25** (straw in bales)	**80** (pellets)	**20**		**20**	
Consumption of raw materials, th. t/an	200.9	81.48	81.48	81.48	200.9		200.9	
CAPEX, mill €	26.58	28.96	27.01	24.66	26.80	28.76	26.69	27.73
CAPEX, €/kW_e	2 500	2 725	2 541	2 319	2 521	2 705	2 511	2 609
NPV, th. €	4 454	11 813	17 721	- 8 189	16 780	14 834	16 882	15 855
IRR, %	**11.7%**	**15.1%**	**19.1%**	**-**	**19.1%**	**17.2%**	**19.3%**	**18.2%**
SPP, years	**5.8**	**5.4**	**4.6**	**7.5**	**4.7**	**5.0**	**4.6**	**4.8**
DPP, years	7.7	7.3	5.9	-	5.9	6.4	5.8	6.1

Feasibility study for biogas project 10,6 MW_e Auction (0,9 from «green» tariff) for 20 years

Project parameters	MODEL Electricity by auctions (0,9 x 0,1239 cent/kWh,w/o VAT, for 20 years)							
	BASIC Electricity only	BASIC Electricity only	BASIC Electricity only	BASIC Electricity only	MODEL №1 (heat pipe – 218,000 €/km) Use of 60% heat at the distance from CHP		MODEL №2 (biogas pipe – 115,000 €/km) Use of 60% heat at the distance from biogas plant	
					1 km	10 km	1 km	10 km
Raw materials	Maize silage	Straw pellets - **own production**	Straw - **Pre-treatment by extruder**	Straw pellets - **purchasing**	Maize silage		Maize silage	
Raw materials price, EUR/t	**20**	**25** (straw in bales)	**25** (straw in bales)	**80** (pellets)	**20**		**20**	
Consumption of raw materials, th. t/an	200.9	81.48	81.48	81.48	200.9		200.9	
CAPEX, mill €	26.58	28.96	27.01	24.66	26.80	28.76	26.69	27.73
CAPEX, €/kW_e	2 500	2 725	2 541	2 319	2 521	2 705	2 511	2 609
NPV, th. €	12 517	18 325	24 549	840	24 286	22 350	24 387	23 366
IRR, %	**13.9%**	**15.8%**	**18.9%**	**8.5%**	**18.9%**	**17.5%**	**19.0%**	**18.2%**
SPP, years	**7.0**	**6.3**	**5.4**	**9.8**	**5.5**	**5.8**	**5.4**	**5.6**
DPP, years	10.0	8.8	7.2	18.5	7.2	7.8	7.1	7.5

Feasibility study for biogas project 10,6 MW_e «Green» tariff by 2030

Project parameters	MODEL Electricity by green tariff (0,1239 cent/kWh,w/o VAT, by 2030)				
	BASIC Electricity only	MODEL №1 (heat pipe – 218,000 €/km) Use of 60% heat at the distance from CHP		MODEL №2 (biogas pipe – 115,000 €/km) Use of 60% heat at the distance from biogas plant	
		1 km	10 km	1 km	10 km
Raw materials	Chicken manure				
Raw materials price, EUR/t	**0**				
Consumption of raw materials, th. t/an	217.1				
CAPEX, mill €	26.07	26.29	28.25	26.19	26.19
CAPEX, €/kW_e	**2 453**	2 473	2 658	2 463	2 463
NPV, th. €	35 543	47 312	45 376	47 413	54 860
IRR, %	**29.0%**	**34.2%**	**31.5%**	**34.3%**	**32.0%**
SPP, years	**3.3**	**2.9**	**3.1**	**2.8**	**3.2**
DPP, years	4.1	3.4	3.8	3.4	3.9

Feasibility study for biogas project 3,2 MW_e «Green» tariff by 2030

Project parameters	MODEL Electricity by green tariff (0,1239 cent/kWh,w/o VAT, by 2030)				
	BASIC Electricity only	MODEL №1 (heat pipe – 136,000 €/km) Use of 60% heat at the distance from CHP		MODEL №2 (biogas pipe – 48,000 €/km) Use of 60% heat at the distance from biogas plant	
		1 km	10 km	1 km	10 km
Raw materials	Sugar press pulp				
Raw materials price, EUR/t	**2.1**				
Consumption of raw materials, th. t/an	90.0				
CAPEX, mill €	10.41	10.55	11.77	10.46	10.89
CAPEX, €/kW_e	**3 253**	3 296	3 678	3 268	3 403
NPV, th. €	4 536	8 012	6 805	8 099	9 916
IRR, %	**15.5%**	**20.0%**	**17.2%**	**20.2%**	**19.0%**
SPP, years	**5.5**	**4.7**	**5.2**	**4.6**	**5.4**
DPP, years	7.2	5.9	6.8	5.8	7.1

Feasibility study for biomethane project 9,0 MW_e «Green» tariff by 2030

Project parameters	MODEL Electricity by green tariff (0,1239 cent/kWh,w/o VAT, by 2030)			
	Cogeneration on the base of existing boiler house: electricity + 60% of heat			
	New CHP	Lease of existing CHP	New CHP	Lease of existing CHP
Raw materials	Maize silage		Chicken manure	
Raw materials price, EUR/t	**20**		**0**	
Consumption of raw materials, th. t/an	200.9		217.1	
CAPEX, mill €	32.61	24.20	32.10	23.69
CAPEX, €/kW_e	**3 068**	2 277	3 020	2 229
NPV, th. €	- 27.5	4 776	30 829	35 590
IRR, %	**8.0%**	**11.9%**	**22.1%**	**29.7%**
SPP, years	**7.4**	**6.1**	**4.4**	**3.3**
DPP, years	-	8.2	5.5	4.0

Examples of straw use for biogas production

Biogas plant in Chernozemen (Bulgaria) - **1,5 MW_e**

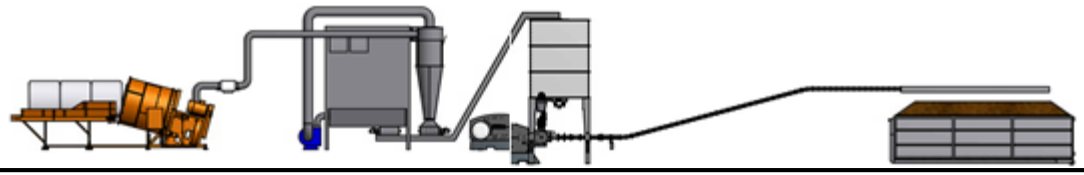
Raw material: caw manure, maize silage, **straw in bales** – totally 50,000 t/an

Straw preparation - **hammer crusher**

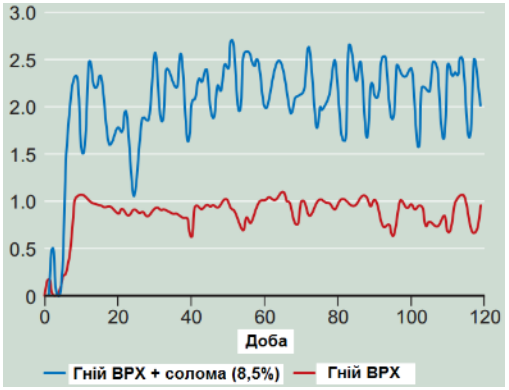
Demonstration unit in Foulum (Denmark)

Raw material: caw manure, wheat straw

Straw preparation : **briquetting**



$m^{3B}BG/m_{wk}^{3}/day$



Demonstration project VERBIO in Swedt/Oder (Germany)
16,5 MW (biomethane) – start up at full load in 2019
Raw material**: wheat straw 100%** - 40 000 t/an

Biogas use for local heating

(Lenthe, Germany)

Heating of 20 private houses with total area

4000 m^2 at a distance of 600 m from biogas plant

Drying of agrarian products - 5000 tons/year

Parameter	Value
Electricity production	4,3 mill kWh/an
Heat production	3,1 mill kWh/an
Technology	Digesters – 2 x 2300 m^3, 2 CHP, heat piping - 1,2 km
Capacity	2 x (265 kW_e + 220 kW_{th})
Raw materials	Silage, grass, sugar beet, sorgo etc., growing at 170 ha
Investment	Biogas plant – 1,6 mill EUR, heating system – 0,32 mill EUR
Pay back	7 years

** Source: BiogasHeat Project: Good Practice Examples for Efficient Use of Heat from Biogas Plants*

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Biogas use for remote district heating system

(Zeewolde, the Netherlands)

Heating of 3000 private houses and administrative buildings with total area of 15,000 m^2

Production of electricity and heat from biogas by two CHPs:

- No. 1 - 250 kW_e next to biogas plant, electricity unto the net, heat for own needs of BP and farm
- No. 2 - 1060 kW_e at 5.5 km distance from BP, biogas is supplied by pipeline (diameter 250 mm).

Farmer biogas plant

Digesters: 2*2500 m^3

Raw materials - 30 000 m^3/an

caw manure (50%),

Maize silage, grass, food production waste

Energy production from biogas and natural gas consumption

- Electricity – 7500 MWh/an
- Heat use – 7100 MWh/an
- Natural gas consumption
  (peak load and reserve capacity – 4735 MWh/an

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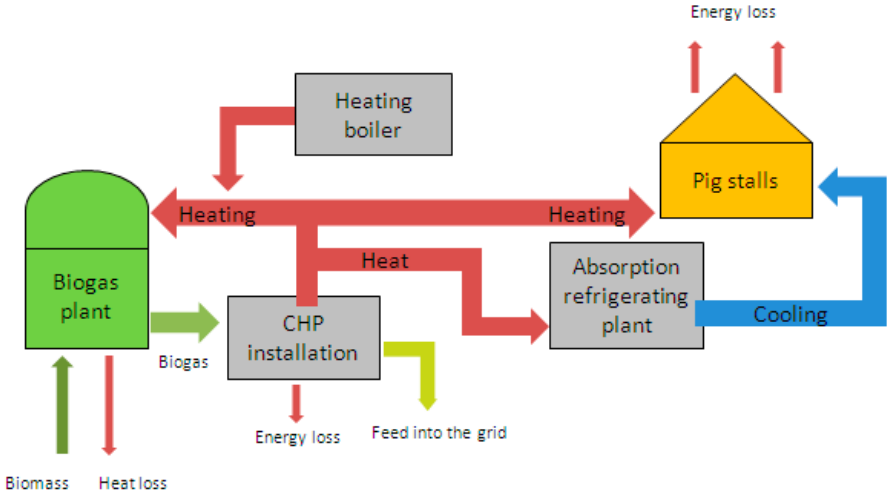
Biogas use for local heating and cooling
(Thuringia, Germany)

Heating and cooling of pig farm (1200 sows)

Production of electricity and heat from biogas by cogeneration unit of 85 kW:

- Green tariff electricity sales
- Use of heat in winter pig farms for heating
- Use of heat in summer to cool the pig farm by absorption refrigeration machine

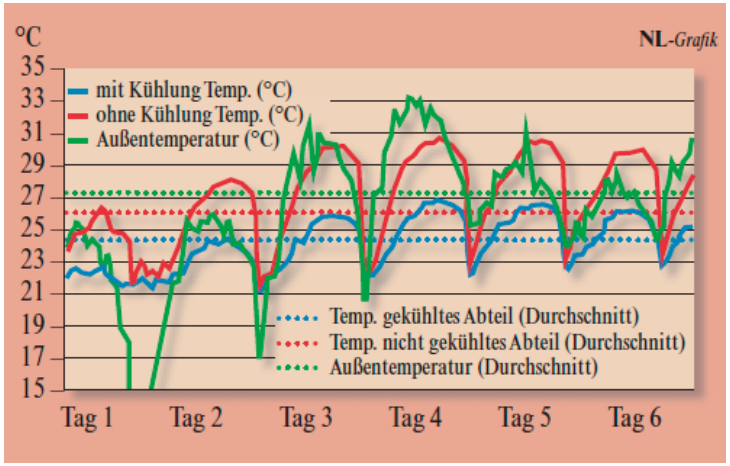


Additional investment for absorber - 60,000 Euro

Farmer biogas plant

Digester: 800 m^3

Raw materials: caw and pig manure, maize silage, grain residuals



** Source: BiogasHeat Project: Good Practice Examples for Efficient Use of Heat from Biogas Plants*

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Biogas use for additional electricity production (ORC-cycle)

(Dublovice, Czech Republic)

ORC system (using R245fa) of a biogas plant in Dublovice, Czech Republic

** Source: BiogasHeat Project:* Sustainable Heat Use of Biogas Plants. Handbook

Біоенергетична асоціація України

Conclusions

- Over the past 5 years, several major biogas projects have been implemented in Ukraine (installed capacity up to 6 MW, the main source of raw materials - **large poultry farms and sugar factories**)
- However, development of the biogas market in Ukraine is significantly lagging behind other types of renewable energy (solar energy, wind)
- Support of electricity generation from biogas by green tariff turned out to be ineffective for medium and small biogas projects based on livestock farms
- One of the options for improving the economic parameters of biogas projects is increasing the efficiency of energy utilization by **heat use** (options - local and remote heat supply, drying of agricultural products, cooling in the summer, additional production of electricity by ORC-cycle)
- Another possibility of efficiency increasing is the **use of agriculture plant residues** of, for example, prepared grain straw
- For biogas projects, it is possible to switch from incentives through the green tariff to the **system of auctions**. Such transition does not lead to a deterioration of the economic performance of the project, provided that the price of selling electricity at the auction is maintained at 90% of green tariff

We are greening the energy!
Welcome to UABio membership!

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