MINISTRY OF FOREIGN AFFAIRS OF DENMARK

Mykolaiv

Assistance to the Development of the Mykolaiv Masterplan

Potential of Bioenergy Sources in Power and District Heating Sectors, Report

Final

December 2023

COWI

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List of Abbreviations

CHP	Combined Heat and Power
DH	District Heating
ha	Hectare
IE	Individual Entrepreneur
kt	1000 tones
MCHPP	Mykolaiv Combined Heat and Power Plant, Private Joint Stock Company
mln	Million
MOTE	Mykolaivoblteploenergo, Municipally Owned Heat Supply Company
NEURC	National Commission for State Regulation of Energy and Utilities
OEP	Oil Extraction Plant
RES	Renewable Energy Sources
SAEE	State Agency on Energy Efficiency and Energy Savings
th.	Thousand
toe	Ton of oil equivalent
UABIO	Bioenergy Association of Ukraine
UAH	Ukrainian Hryvnia

1 Introduction

This report has been developed within the framework of the project “Mykolaiv - Denmark partnership – Technical Support Unit” financed by the Danish Ministry of Foreign Affairs (MFA). COWI has been entrusted the development of contributions to the masterplan regarding water, energy, and solid waste. The masterplan concerns the Mykolaiv City and its development in the period till 2050 (throughout this report Mykolaiv City and Mykolaiv as well as City of Mykolaiv are used synonymously). Box 1-1 below provides further information about COWI’s contribution to the Mykolaiv Masterplan.

Box 1-1 COWI’s contribution to Mykolaiv Masterplan in a nutshell

Mykolaiv Masterplan, which has been requested by the Mayor of Mykolaiv City, has a time horizon till 2050. It provides a compass for actions to be taken by the Mykolaiv City to ensure that it will develop into a thriving city attractive to its citizens and business community.

COWI and One Works assist Mykolaiv City Administration in developing the masterplan. In this work, COWI focuses on three sectors:

- Water and wastewater
- Energy, including power, district heating and renewable energy sources
- Solid waste management.

Mykolaiv City Administration meets every week with COWI and One Works to ensure proper coordination.

COWI has established a project organization consisting of a project management team and three sector teams of professionals, each headed by a Discipline Leader. Three sectoral Focal Points are responsible for monitoring cross-cutting activities, ensuring coordination between the parties and maintaining consistency in the deliverables.

To enhance transparency in the development of the Mykolaiv Masterplan, given its significant public interest and exposure, COWI has established three sector-specific Sounding Boards inviting all potentially interested parties to take part in these.

The report addresses the issues related to the use of bioenergy in Mykolaiv City and Mykolaiv Oblast and consists of 4 chapters in addition to the current. They are:

Chapter 2 focuses on existing bioenergy sources in Mykolaiv City and Oblast.

Chapter 3 provides an overview of bioenergy potential in district heating and power sectors.

Chapter 4 gives a brief overview of possible investment projects to untap the bioenergy potential.

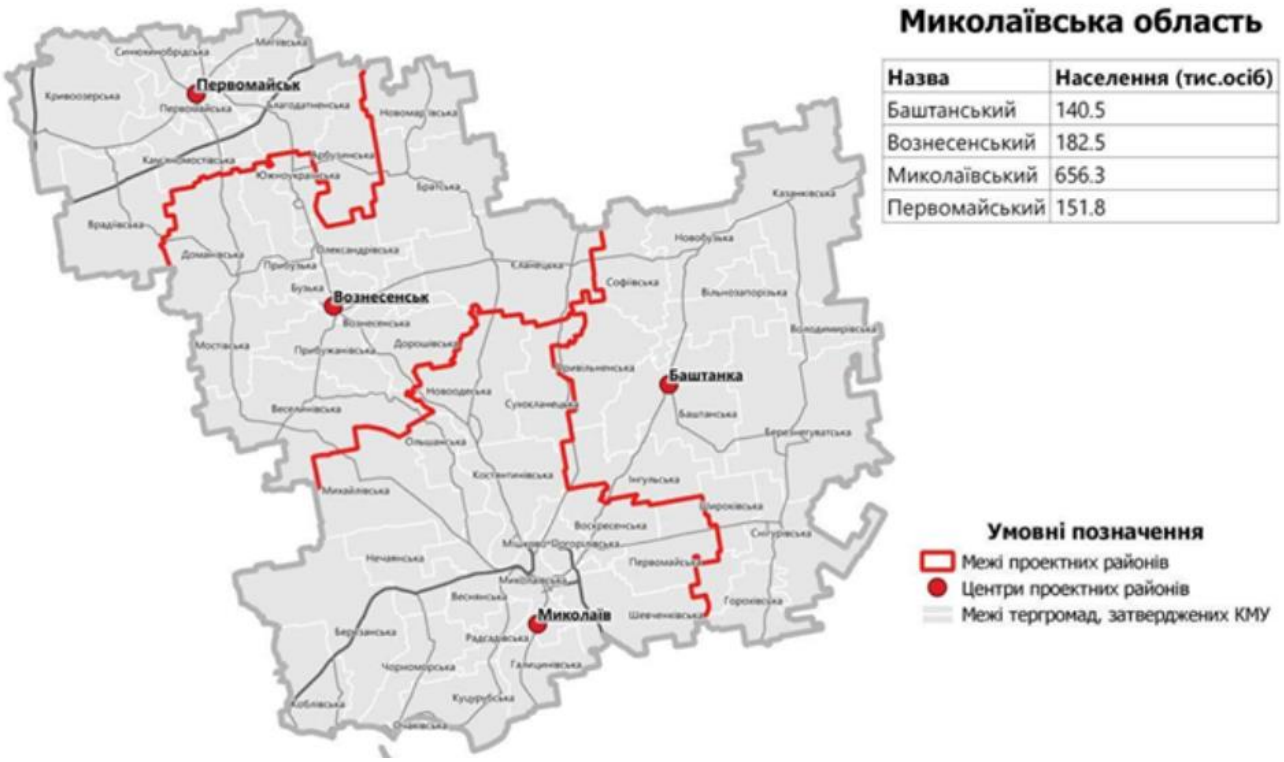
Chapter 5 describes the current legal and regulatory framework and required changes in the legal and regulatory framework.

2 Existing bioenergy sources

2.1 Current potential of biomass

Mykolaiv oblast is located in the South of Ukraine. The oblast consists of four districts (Bashtanskyi, Voznesenskyi, Mykolaivskyi, Pervomaiskyi) with Mykolaiv city as the administrative oblast centre (Figure 2-1).

Figure 2-1 Map of Mykolaiv oblast with its districts



Note: Distance between Mykolaiv city and centres of the districts: Mykolaiv – Voznesensk 90 km; Mykolaiv – Pervomaisk 165 km; Mykolaiv – Bashtanka 68 km[1]

The oblast has highly developed agriculture, in particular, the production of wheat, barley, sunflower, rapeseed, grapes and some other crops and fruits. This sector is a big source of primary agricultural residues. There are several large and up to 30 smaller oil extraction plants in the oblast[2], which are potential sources of sunflower husk (a secondary agricultural residue). At that, two biggest OEPs (“European Transport Stevedore Company” Ltd and “Liliya Tygri” Ltd) are situated in Mykolaiv’s district of the oblast.

The forest area in Mykolaiv oblast (as percentage of the oblast area) is one of the lowest in Ukraine – 4%[3]. That means that one can hardly count on wood biomass as fuel for new biomass plants. At that, the oblast has about 90 th. ha of unused agricultural land which can be used for growing energy crops for solid biofuels and biogas. Additional biogas can be obtained from cover crops.

[1] https://www.mk-oblrada.gov.ua/news.php?news=2359&group=20
[2] https://tripoli.land/ua/infrostructura/maslozavody-mezy/nikolaevskaya
[3] https://forest.gov.ua/napryamki-diyalnosti/lisi-ukrayini/zagalna-harakteristika-lisiv-ukrayini

Mykolaiv oblast is the second (after Odesa oblast) among Ukraine's regions by the area of vineyards in bearing age, which is 4200 ha. JSC "Koblevo" (a wine producer in Mykolaivskyi district) manages nearly 60% of this area (2500 ha)[4]. Grapevine prunings may be an important local biomass fuel though its amount is usually much less as compared to other types of biomass, for example, agricultural residues. Another feature of Mykolaiv oblast is its ports where transshipment of grain takes place (for example, Mykolaivskyi sea port and Olviya specialized seaport). The activity on storage and transshipment of grain generates grain dust and other types of grain waste which may potentially be used in bioenergy. The question of collection and usage of grapevine prunings and grain waste requires further research.

Mykolaiv oblast is the second (after Odesa oblast) among Ukraine's regions by the area of vineyards in bearing age, which is 4200 ha. JSC "Koblevo" (a wine producer in Mykolaivskyi district) manages nearly 60% of this area (2500 ha) . Grapevine prunings may be an important local biomass fuel though its amount is usually much less as compared to other types of biomass, for example, agricultural residues. Another feature of Mykolaiv oblast is its ports where transshipment of grain takes place (for example, Mykolaivskyi sea port and Olviya specialized seaport). The activity on storage and transshipment of grain generates grain dust and other types of grain waste which may potentially be used in bioenergy. The question of collection and usage of grapevine prunings and grain waste requires further research.

The assessment of existing biomass resources includes the following types of biomass:

- Primary agricultural residues (straw of cereals and rapeseed; stalks and other byproducts of maize and sunflower production; cover crops) for solid biofuels and biogas.

  Following the conservative approach, the agricultural residues are assessed only for agro-enterprises[5], which makes up to about 2/3 of the whole amount. Agricultural residues of households are not included.

- Manure of cattle and pigs for biogas production.

- Following the conservative approach, only the manure is of agro-enterprises is included in the assessment[5].

- Sunflower husk.

  This type of biomass is generated at oil extraction plants. Data on sunflower oil production by OEPs of Mykolaiv oblast[6] were used to assess the resources of sunflower husk.

- Energy crops for solid biofuels and biogas (here and then *in case of growing energy crops on unused agricultural land*).

The unused agricultural land in the oblast is determined as a difference between the arable land and sown area plus fallow.

[4] https://www.koblevo.ua/manufacturing
[5] *Required initial data are available on website of the Statistics Depertment of Mykolaiv oblast* http://www.mk.ukrstat.gov.ua/
[6] https://tripoli.land/ua/infrostructura/maslozavody-mezy/nikolaevskaya

- Cover crops for biogas (here and then *in case of growing cover crops on 20% of the sown area*).

  It is assumed that 20% of the sown area of each oblast district can be used for growing cover crops for biogas.

Results of the assessment of biomass resources in Mykolaiv oblast (based on 2021 data) are presented in Table 2-1. The economic potential of biomass available for energy is about 518 ktoe/yr (1860 kt) for solid biomass and 310 ktoe/yr (375 mln m^3 CH_4/yr) for biomethane. Main parts of the solid biomass potential (in toe) are straw of cereals, byproducts of sunflower production, sunflower husk and energy crops (Figure 2-2). The biggest amount of biomethane can be produced from cover crops (Figure 2-3).

Table 2-1 Assessment of biomass resources (the economic potential) in Mykolaiv oblast (2021)

Biomass type	Oblast as a whole		Bashtanskyi district		Voznesenskyi district		Mykolaivskyi district		Pervomaiskyi district	
Solid biomass[1]	**kt**	**ktoe**	**kt**	**ktoe**	**kt**	**ktoe**	**kt**	**ktoe**	**kt**	**ktoe**
Agricultural residues (primary)[2]**:**										
Straw of cereals (excl. maize)	484.1	165.4	129.2	44.1	114.7	39.2	158.7	54.2	81.5	27.9
Straw of rapeseed	126.4	43.2	26.3	9.0	34.1	11.6	57.8	19.8	8.2	2.8
Byproducts of grain maize production	171.4	32.8	20.0	3.8	19.1	3.6	15.7	3.0	116.6	22.3
Maize stalks (separately)	90.0	17.2	10.5	2.0	10.0	1.9	8.2	1.6	61.2	11.7
Byproducts of sunflower production (stalks. heads)	631.0	90.5	182.6	26.2	165.0	23.7	145.2	20.8	138.4	19.8
Sunflower stalks (separately)	498.2	71.4	144.1	20.7	130.3	18.7	114.6	16.4	109.3	15.7
Sunflower husk[3]	233.1	91.8	8.2	3.2	0.3	0.1	205.9	81.1	18.8	7.4
Energy crops[4] (poplar as an example)	213.8	94.4	56.7	25.0	53.3	23.5	69.7	30.8	34.0	15.0
Solid biomass, total	1859.8	518.0	422.9	111.4	386.4	101.8	653.0	209.6	397.5	95.2
Biomethane	**mln m^3 CH_4**	**ktoe**	**mln m^3 CH_4**	**ktoe**	**mln m^3 CH_4**	**ktoe**	**mln m^3 CH_4**	**ktoe**	**mln m^3 CH_4**	**ktoe**
Biomethane from crop residues	43.6	36.1	10.5	8.7	9.8	8.1	12.4	10.3	11.0	9.1
Biomethane from manure[5]	4.2	3.5	0.4	0.3	0.4	0.3	1.0	0.8	2.4	2.0
Biomethane from energy crops[4] (maize silage)	135.0	111.8	35.8	29.7	33.7	27.9	44.0	36.4	21.5	17.8
Biomethane from cover crops[4]	191.8	158.9	50.9	42.1	47.9	39.6	62.5	51.8	30.5	25.3
Biomethane, total	374.6	310.2	97.6	80.8	91.8	76.0	119.9	99.3	65.4	54.2

1) Solid biomass: kt of fresh matter for agricultural residues and kt of dry matter for energy crops.
2) Agricultural residues include only those of enterprises, which is about 2/3 of the whole amount. Agricultural residues of households are not included.
3) Sunflower husk generated at oil extraction plants.

4) Suggested division of areas under energy crops and under cover crops between the oblast districts is based on existing proportions of their sown areas. For the calculations, sown areas under winter crops for grain and green fodder (2021) were used.
5) Only agro-enterprises with >100 cattle heads and >200 pig heads are included.

Figure 2-2 Structure of solid biomass economic potential in Mykolaiv oblast, ktoe (2021)

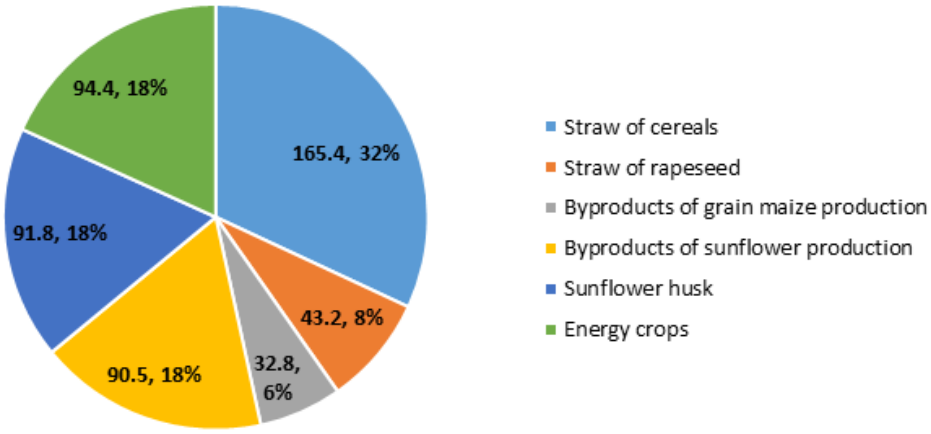
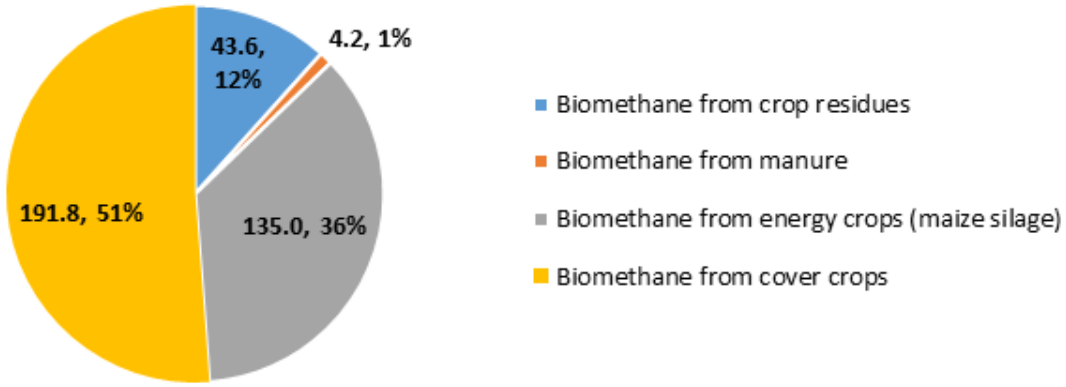


Figure 2-3 Structure of biomethane production potential in Mykolaiv oblast, mln m3 CH4 (2021)



Mykolaivskyi district of the oblast has the biggest potential of solid biomass (mainly due to a big amount of sunflower husk) and the biggest potentials of biomethane production (

Figure 2-4, Figure 2-5).

Figure 2-4 Distribution of solid biomass economic potential in the districts of Mykolaiv oblast, ktoe (2021)

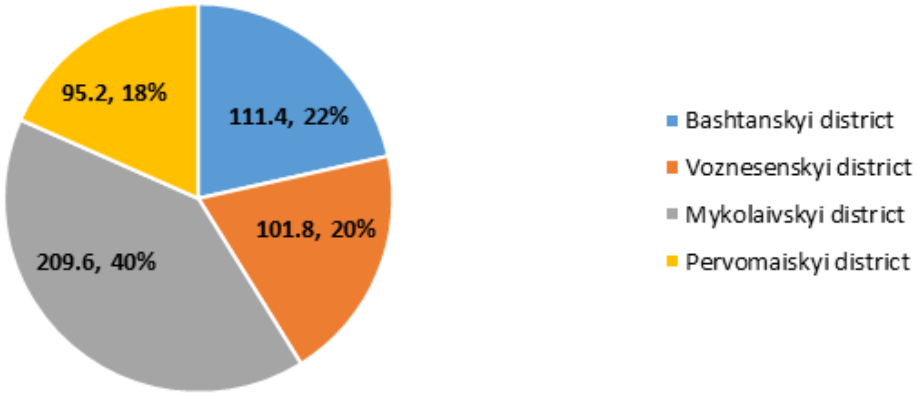
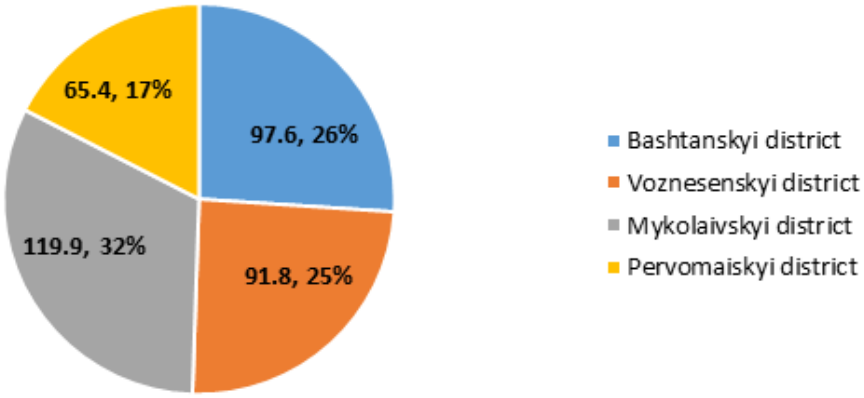


Figure 2-5 Distribution of biomethane production potential in the districts of Mykolaiv oblast, mln m3 CH4 (2021)



2.2 Assessment of the future biomass potential

Assessment of the future biomass potential in Mykolaiv oblast (by 2050) is based on UABIO's general approach to Ukraine's bioenergy potential in 2050. Regarding agricultural residues and energy crops, the assumptions are[7]:

Increase in the yield of crops, primarily cereals.

The analysis of the current state and existing trends in the agriculture of Ukraine, as well as data on the yield of grain crops in Ukraine and EU countries (FAOSTAT statistical data[8]) shows that, in particular, the yield of wheat in Ukraine may increase by 1.2 times by 2050, and maize by 1.25 times.

Expansion of area under energy crops and rise of their yield.

[7] *Presentation by Tetiana Zheliezna at the USAID project seminar on 03.10.2023* https://uabio.org/materials/15291/ https://uabio.org/wp-content/uploads/2023/10/ZHelyezna_Seminar-USAID_03-10-2023.pdf

[8] *FAOSTAT. Crops* https://www.fao.org/faostat/en/#data

The area under woody and herbaceous energy crops in 2050 is expected to double. The yield growth is supposed to be 1.5 times for woody/herbaceous crops and 1.25 times for maize silage (biogas).

10% of woody energy crops will be used for biogas production via thermochemical gasification. The obtained biogas then will be upgraded to biomethane via methanation.

Based on the assumptions above, the economic potential of biomass available for energy in 2050 is expected to be about 720 ktoe/yr (2363 kt) for solid biomass and 359 ktoe/yr (433 mln m3 CH4/yr) for biomethane (

Table 2-2). Two biggest parts of the solid biomass potential (in toe) will be straw of cereals and energy crops like poplar (Figure 2-6). Two main (comparable) feedstocks for biomethane production will be cover crops and maize silage (Figure 2-7).

Table 2-2 Assessment (forecast) of future biomass resources (the economic potential) in Mykolaiv oblast (2050)[1].

Biomass type	Oblast as a whole		Bashtanskyi district		Voznesenskyi district		Mykolaivskyi district		Pervomaiskyi district	
Solid biomass	**kt**	**ktoe**	**kt**	**ktoe**	**kt**	**ktoe**	**kt**	**ktoe**	**kt**	**ktoe**
Agricultural residues (primary):										
straw of cereals[2] (excl. maize)	580.9	198.5	155.0	53.0	137.6	47.0	190.5	65.1	97.8	33.4
straw of rapeseed	126.4	43.2	26.3	9.0	34.1	11.6	57.8	19.8	8.2	2.8
byproducts of grain maize production[2)]	214.2	40.9	25.0	4.8	23.9	4.6	19.6	3.8	145.7	27.9
maize stalks (separately)[2]	112.5	21.5	13.1	2.5	12.5	2.4	10.3	2.0	76.5	14.6
byproducts of sunflower production (stalks. heads)	631.0	90.5	182.6	26.2	165.0	23.7	145.2	20.8	138.4	19.8
sunflower stalks (separately)	498.2	71.4	144.1	20.7	130.3	18.7	114.6	16.4	109.3	15.7
Sunflower husk	233.1	91.8	8.2	3.2	0.3	0.1	205.9	81.1	18.8	7.4
Energy crops[2] (poplar as an example)	577.1	254.9	153.1	67.6	144.0	63.6	188.2	83.1	91.9	40.6
Solid biomass, total	2362.9	719.7	550.2	163.7	504.8	150.5	807.1	273.5	500.8	131.9
Biomethane	**mln m³ CH_4**	**ktoe**	**mln m³ CH_4**	**ktoe**	**mln m³ CH_4**	**ktoe**	**mln m³ CH_4**	**ktoe**	**mln m³ CH_4**	**ktoe**
Biomethane from crop residues[2]	49.9	41.3	11.9	9.8	11.1	9.2	14.0	11.6	12.9	10.7
Biomethane from manure	4.2	3.5	0.4	0.3	0.4	0.3	1.0	0.8	2.4	2.0
Biomethane from energy crops[2] (maize silage)	168,8	139,8	44,8	37,1	42,1	34,9	55,0	45,6	26,9	22,2
Biomethane from cover crops	191.8	158.9	50.9	42.1	47.9	39.6	62.5	51.8	30.5	25.3
Biomethane from woody energy crops[3] (poplar)	18.6	15.4	4.9	4.1	4.6	3.8	6.1	5.0	3.0	2.5
Biomethane, total	433.2	358.8	112.9	93.5	106.1	87.9	138.6	114.8	75.7	62.7

1) All the basic assumptions are the same as for the assessment of biomass potential for 2021. See relevant notes under Table 2-1.
2) Types of biomass (biofuels), the potential of which is expected to increase by 2050 as compared with 2021.
3) New part of biomethane production potential in 2050 as compared with 2021.

Figure 2-6 Forecasted structure of solid biomass economic potential in Mykolaiv oblast, ktoe (2050)

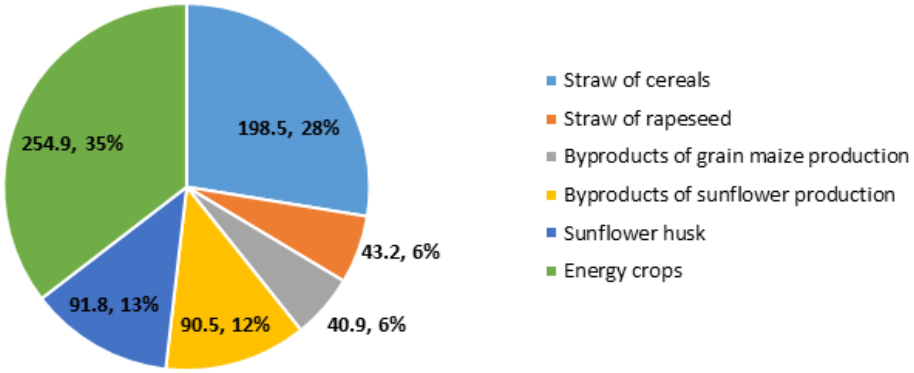
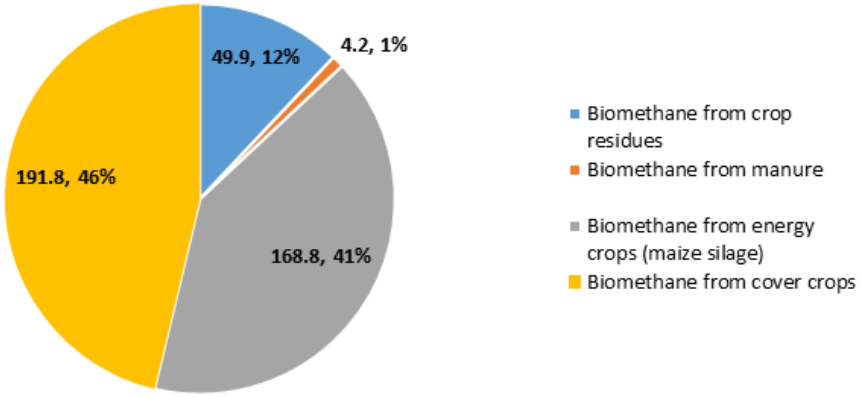


Figure 2-7 Forecasted structure of biomethane production potential in Mykolaiv oblast, mln m3 CH4 (2050)



2.3 Analysis of the current and forecasted prices of solid biomass/biofuels

Prices of solid biomass/biofuels in Ukraine are neither stable nor even; they differ a lot for different regions, suppliers and seasons of year. The general tendency of several last years has been an increase in average prices.

Average prices of biomass pellets/briquettes during 2020-2023

This analysis was performed by UABIO for public procurements for the period of 2020-02.2023 for the category of "biomass pellets/briquettes" as a whole without the division into individual types of biofuels[9]. Nevetherless, the results are quite demonstrative as they reflect some typical trends and tendencies in prices of solid biofuels.

Based on data on public procurements of biomass pellets/briquettes, the average price in February 2023 was 9114 UAH/t[10] against 3032 UAH/t in 2020 (Figure 2-8). At that, the average price has

[9] *Public procurements of biomass pellets/briquettes during 2020-February 2023* https://uabio.org/publichni-zakupivli-tverdogo-biopalyva/
[10] *1 EUR = 38.4 UAH as of 30.10.2023 according to the National Bank of Ukraine (https://bank.gov.ua/)*

been rising despite the number of contracts concluded (Figure 2-9). Concrete prices have been deviated a lot up and down from the average price (Figure 2-10).

Figure 2-8 Average price of biomass pellets/briquettes, UAH/t[9]

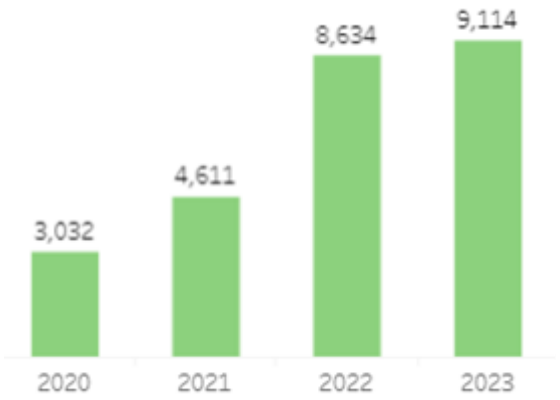


Figure 2-9 Number of contracts concluded during 2020-02.2023 (public procurements)[9]

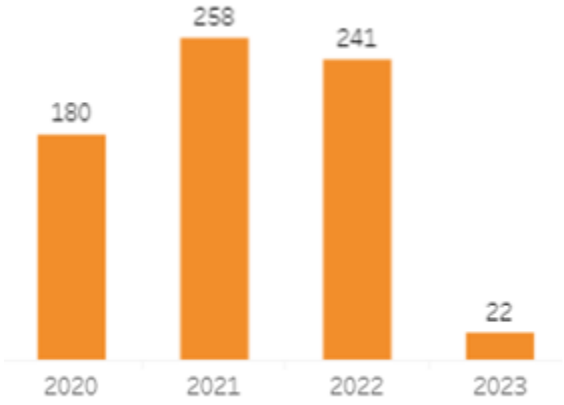
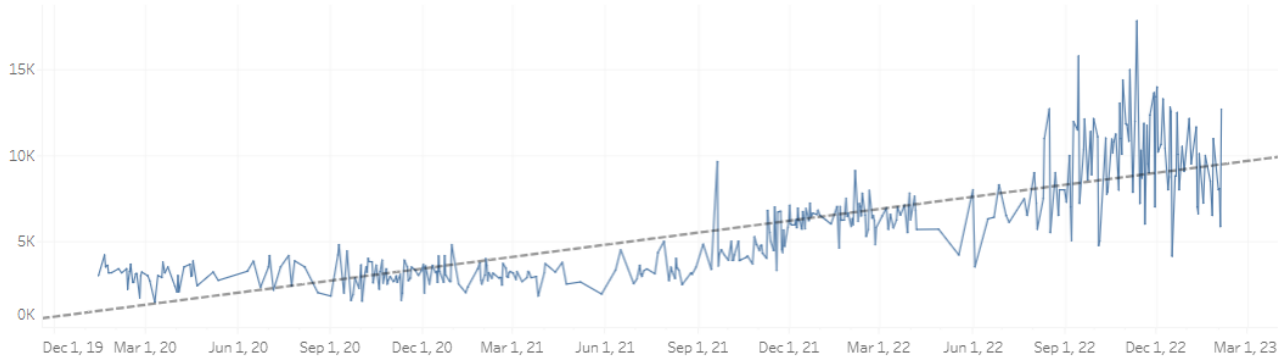


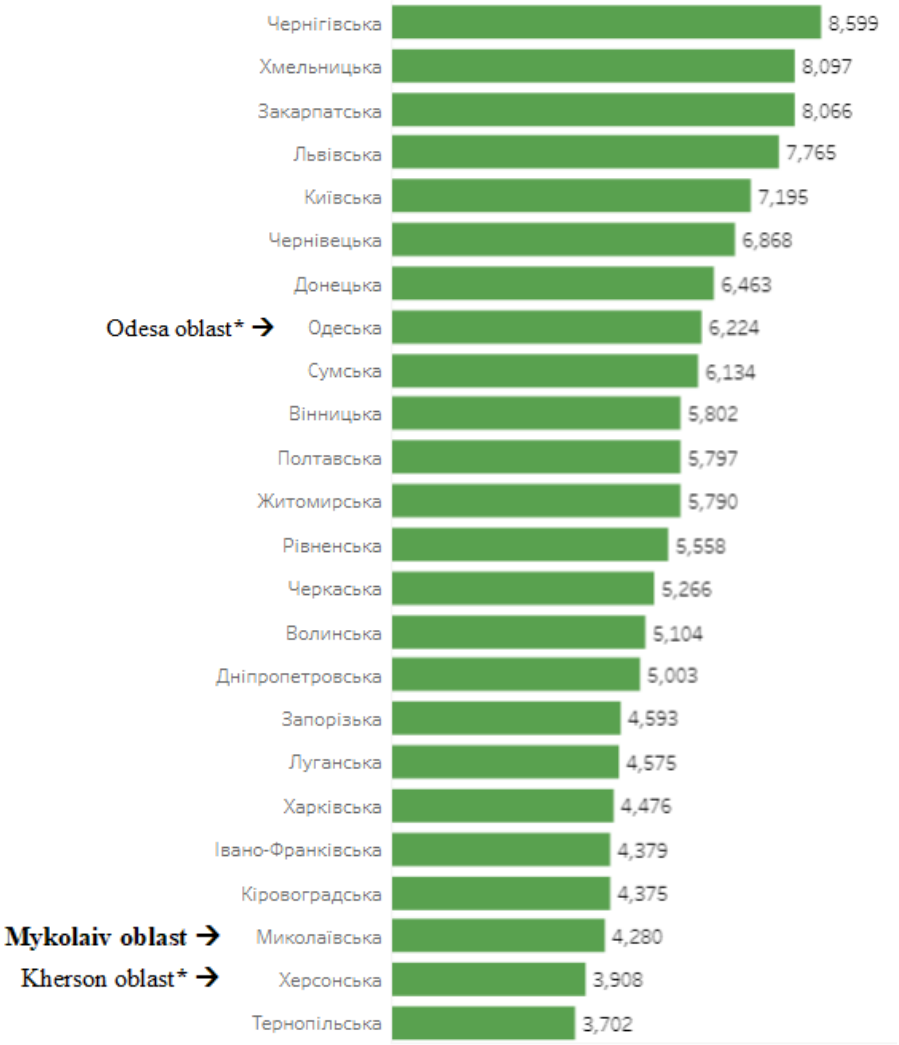
Figure 2-10 Data on fluctuation from the average price of biomass pellets/briquettes during 2020-02.2023 (public procurements), UAH/t[9]



The average price of biomass pellets/briquettes in Mykolaiv oblast during 2020-02.2023 (4280 UAH/t) was one of the lowest among Ukraine's regions, the highest price being in Chernihivska oblast (8599 UAH/t) (Figure 2-11). In two oblasts that adjoin Mykolaiv oblast and are close to Mykolaiv city the average price of biomass pellets/briquettes is 6,224 UAH/t for Odesa oblast (higher than in Mykolaiv oblast) and 3908 UAH/t for Kherson oblast (lower than in Mykolaiv oblast).

Average prices of biomass pellets/briquettes by individual suppliers in Mykolaiv oblast and two neighbouring oblasts (Odesa and Kherson oblasts taking into account the location of Mykolaiv city) are presented in Table 2-3. One can see an extremely wide range of the average prices of different suppliers. Leaving aside the highest and the lowest prices, the average range of average prices is 3,000-4,000 UAH/t for Mykolaiv oblast, 6,000-8,000 UAH/t for Odesa oblast (the biggest number of suppliers in 2020-2023) and about 3,500 UAH/t for Kherson oblast (the fewest number of suppliers in 2020-2023).

Figure 2-11 Average price of biomass pellets/briquettes in Ukraine's regions during 2020-02.2023 (public procurements), UAH/t[9]



** Oblasts adjoining Mykolaiv oblast and close to Mykolaiv city*

Table 2-3 Average prices of biomass pellets/briquettes by individual suppliers in Mykolaiv, Odesa and Kherson oblasts[9]

Suppliers*	Average price of biomass pellets/briquettes during 2020-02.2023, UAH/t
Mykolaiv oblast	
Individual entrepreneur Chuprova I.I.	8,600
Individual entrepreneur Serhienko O.O.	8,350
Druzhba Ltd.	6,359

Individual entrepreneur Vasilieva L.V.	5,500
Individual entrepreneur Zubkova I.B.	5,345
Kevprod Ltd.	3,687
Dykyi Sad Ltd.	3,370
Individual entrepreneur Korenda V.A.	3,185
Alttop Ltd	3,325
ND System Plus Ltd.	3,076
Individual entrepreneur Platmir H.V.	2,815
Individual entrepreneur Karpov O.A.	2,800
Individual entrepreneur Olkhovskyi A.H.	2,800
Syntez Ltd.	2,354
Individual entrepreneur Biliuk S.M.	2,050
Region-Agro Ltd.	2,000
Cobalt Energy Ltd.	1,775
Odesa oblast	
Individual entrepreneur Nikitenko I.V.	16,490
Individual entrepreneur Tymofeeva O.O.	15,799
NDP Ecodim Ltd.	12,948
Miraygroup Ltd.	10,980
ILEM Ltd	8,874
Individual entrepreneur Bortetska L.F.	8,300
Individual entrepreneur Beril S.D.	8,146
Rayk Ltd.	7,414
Individual entrepreneur Dudka O.O.	6,800
Private Enterprise Auto-Grand	6,700
Individual entrepreneur Biliuk S.M.	6,735
Individual entrepreneur Raylian V.V.	6,195
Individual entrepreneur Tabunschik V.V.	6,106
Individual entrepreneur Gaydarzhi D.V.	6,000
VK Korna Ltd.	6,000
Individual entrepreneur Platmir H.V.	5,570
Individual entrepreneur Biliuk S.M.	5,005
Individual entrepreneur Kontsur N.V.	3,660
Trade Fuel Company Ltd.	3,752
Brig Trade Ltd.	3,749
Kevprod Ltd.	3,581
Individual entrepreneur Nosatiuk O.I.	2,600
Riat Ltd.	2,345
Private Enterprise Bessarabia Irrigate	2,150
Kherson oblast	
Individual entrepreneur Savoniuk O.I.	7,000
Individual entrepreneur Arbetman P.P.	3,500
Individual entrepreneur Shevchenko N.V.	3,300
Tetra-P Ltd.	2,940

** Some supplier can operate (supply) in several oblasts.*

Current prices of individual types of solid biofuels

The search of prices has been made for procurements implemented through Prozorro[11] system in 2023 in Mykolaiv, Odesa and Kherson oblasts. Results have been obtained for the following types of solid biofuels: sunflower husk pellets, sunflower husk briquettes, wood pellets, and wood briquettes. For each position, the range of prices is rather wide; the prices of wood pellets/briquettes being generally more expensive than those from sunflower husk (Table 2-4). Most suppliers are individual entrepreneurs.

Table 2-4 Current (2023) prices of individual types of solid biofuels in Mykolaiv, Odesa and Kherson oblasts[12]

Type of solid biofuel	Supplier	Price, UAH/t	Time of bargain
Mykolaiv oblast			
Sunflower husk pellets	Private Enterprise NIKOINTERM	6,155	October 2023
	IE Savoniuk O.I.	6,050	September 2023
	IE Savoniuk O.I.	5,940	August 2023
	IE Kovtun R.M.	5,500	January 2023
	NIKTEPLOPOSTACH Ltd.	4,200	February 2023
	IE Havrylenko O.E.	3,850	July 2023
	IE Allakhverdiev E.R.	3,525	July 2023
Wood pellets	Temnyi Promin Ltd	9,000	October 2023
	IE Iazhborovskyi M.O.	7,500	September 2023
Sunflower husk briquettes	IE Serhienko S.V.	7,460	August 2023
	IE Kononenko D.F.	5,800	October 2023
Wood briquettes	MykolaivPalyvo Ltd.	11,800	September 2023
	MykolaivPalyvo Ltd.	11,100	September 2023
	IE Boyko V.M.	10,750	September 2023
	IE Natalchishin P.O.	10,375	October 2023
	IE Boyko I.O.	10,000	September 2023
	IE Raylian V.V.	9,780	August 2023
	IE Siryk T.V.	9,680	October 2023
	IE Boyko I.O.	9,500	August 2023
	IE Iazhborovskyi M.O.	9,000	October 2023
	MykolaivPalyvo Ltd.	8,570	September 2023
Briquettes from bran	IE Iaroschuk O.S.	5,000	September 2023
Odesa oblast			
Sunflower husk pellets	Trade fuel company Oblpalyvo Ltd.	11,500	February 2023
	IE Babii V.A.	7,200	January 2023
	NDP Ecodim Ltd.	6,787	September 2023
	IE Makaruk O.V.	5,750	July 2023
	VPK Liger Ltd.	5,733	January 2023
	IE Kovtun R.M.	4,960	October 2023

[11] *Prozorro is a public electronic procurement system where state and municipal customers announce tenders to purchase goods, works and services, and business representatives compete for the opportunity to become a state supplier* https://en.wikipedia.org/wiki/Prozorro

[12] *Data from Prozorro system for public procurements* https://prozorro.gov.ua/search/tender https://www.dzo.com.ua/tenders/current *(instrument for searching Prozorro tenders and procurements)*

Wood pellets	IE Nikitenko I.V.	12,700	September 2023
	TOPOBLPALYVO Ltd.	12,000	September 2023
	IE Liakhovets O.V.	9,900	September 2023
	IE Raylian V.V.	9,800	June 2023
	IE Kolomichenko S.B.	9,700	May 2023
	IE Biliuk S.M.	9,540	September 2023
	IE Biliuk S.M.	9,450	October 2023
	IE Liakhovets O.V.	9,000	August 2023
Sunflower husk briquettes	IE Timchenko A.O.	6,900	March 2023
	IE Kim M.O.	5,900	October 2023
Wood briquettes	IE Yelkina N.I.	12,000	March 2023
	Beymil Activ Ltd.	11,400	June 2023
	IE Zaliznychenko R.L.	11,100	January 2023
	IE Britkov V.V.	11,000	June 2023
	IE Raylian S.V.	10,300	August 2023
	IE Ziablov O.M.	10,000	August 2023
	IE Zaliznychenko R.L.	9,500	June 2023
Kherson oblast			
Wood pellets	IE Biliuk S.M.	9,980	August 2023
	IE Iazhborovskyi M.O.	6,450	May 2023
Wood briquettes	IE Karpov O.A.	10,000	September 2023
	Kaskad-Energo Ltd.	10,000	February 2023
	IE Iazhborovskyi M.O.	7,500	April 2023
	IE Iazhborovskyi M.O.	6,500	June 2023
	IE Iazhborovskyi M.O.	6,000	October 2023

Straw fuel has not been found in Prozorro procurements for Mykolaiv oblast in 2023. From other sources, information on straw trade with inclusion of clear price details in Mykolaiv oblast is very limited:

- Baled straw 650 UAH/t (big bales) (Pervomaiskyi district, Mykolaiv oblast.[13]
- Baled straw about 2500 UAH/t (small bales) (Voznesenskyi district, Mykolaiv oblast.[14]

Forecast for future prices of solid biomass

Though it is very difficult to predict prices of solid biomass in the future, it may be done based on some assumptions. First of all, it is expected that within a year Ukraine will introduce commercial prices for natural gas and power for all types of consumers. In other words, the current subsidised prices of natural gas and power for population will not exist anymore. This is an important required precondition for further obtaining financial support from Ukrainian partners (USA).

Usually, the price of natural gas influences biomass prices most of all. Now, there are three different NG prices in Ukraine: for population (the lowest), for budget-finances consumers and for

[13] *Reference is valid on 31.10. 2023: https://apkua.com/ua/agroboard/i-164706/izmelchennaya-soloma-v-tyukakh-vysokogo-kachestva/*
[14] *Reference is valid on 31.10. 2023: https://www.olx.ua/d/uk/obyavlenie/soloma-pshenichna-v-tyukah-IDTtTgh.html*

industry (the highest) (Table 2.5). After cancelling the subsidized NG price for population, biomass will mostly compete with the winter commercial price of NG, which is about 50 EUR/MWh15. To be competitive, the price of biomass should be about twice as low that is about 25 EUR/MWh. This assumption is only valid for solid biomass fuels like wood chips and baled straw/maize stalks, for which the corresponding price will be about 73 EUR/t (2800 UAH/t) and 100 EUR/t (3890 UAH/t). These forecasted prices are higher than the current ones, especially for baled straw/maize stalks (see Table 2-5). Adjustment of prices of biomass like wood chips and baled straw/maize stalks to 25 EUR/MWh is expected within the period until 2030.

Table 2-5 Current cost of fuels and energy carriers in Ukraine

Type of fuel / energy carrier	Average cost including transport and VAT (as of February 2023)		LHV		Cost of energy unit including VAT		
	A (value)	unit	B	unit	A/B UAH/GJ	UAH/MWh	EUR/MWh
NG for population	7420	UAH/1000 m^3	33.5	MJ/m^3	221	789	21
NG for budget-finances consumers	16500	UAH/1000 m^3	33.5	MJ/m^3	492	1757	46
NG for industry	26000	UAH/1000 m^3	33.5	MJ/m^3	776	2771	72
Coal	10800	UAH/t	25	MJ/kg	432	1543	40
Heavy oil	26000	UAH/t	42	MJ/kg	619	2211	58
Electricity for population	1.68	UAH/kWh	-		467	1680	43
Electricity for not domestic consumers	6	UAH/kWh	-		1666	6000	156
Electricity for not domestic consumers via heat pump with COP = 2.7	6	UAH/kWh	-		617	6000	156
Wood chips (W=40%)	**2500**	**UAH/t**	**10.5**	**MJ/kg**	**238**	**850**	**22**
Wood pellets	**9000**	**UAH/t**	**17**	**MJ/kg**	**529**	**1889**	**49**
Sunflower husk pellets	**7000**	**UAH/t**	**17.5**	**MJ/kg**	**400**	**1429**	**37**
Baled straw/maize stalks (W=15%)	**2000**	**UAH/t**	**14.6**	**MJ/kg**	**137**	**489**	**13**

As for biomass pellets, it is a special market of solid biomass as pellets are biomass fuel of higher quality. On the one hand, to be competitive with natural gas in Ukraine, their price should not exceed NG price that is must be < 50 EUR/MWh. That means that that the price of biomass pellets should be below ~240 EUR/t (9300 UAH/t). For comparison: as of February 2023, the average cost of wood pellets in Ukraine was 9000 UAH/t (see Table 2-5).

On the other hand, if a Ukrainian producer/supplier of biomass pellets is planning to export them to Europe, the cost (prime cost-plus transportation) must be competitive with the price of biomass pellets in the EU. According to biomass exchange Baltpool, the average price of wood pellets in Lithuania during 09.2021-09.2023 was about 70 EUR/MWh[16] (**330** EUR/t). Taking into account the

[15] *Dutch TTF https://www.investing.com/commodities/dutch-ttf-gas-c1-futures*
[16] *https://www.baltpool.eu/en/biomass-trade-statistics-september-of-2023/*

average transportation cost of pellets from Ukraine to Europe 120 EUR/t (25 EUR/MWh), the price of biomass pellets in Ukraine again should be < 50 EUR/MWh (< 240 EUR/t, < 9300 UAH/t).

Prospects for biomethane production and consumption

The production of biomethane started in Ukraine in April 2023 based on the biogas plant of Gals-Agro Company (Chernihiv oblast). The planned production capacity is 3 mln m3/yr; the feedstock includes manure, sugar beet pulp and maize silage. The second biomethane plant is expected to be launched by the end of 2023 in Khmelnytsk oblast (Vitagro company). The plant will be producing 3 mln m3/yr of biomethane from manure, straw and maize silage.

Current circumstances is that now the only feasible option for Ukrainian producers of biomethane is its export to Europe. This is due to the fact that biomethane price in the EU (90-100 EUR/MWh) consists of NG price (about 50 EUR/MWh) plus a special premium (on average 40-50 EUR/MWh). Application of the premium is possible due to the functioning of EU Emissions Trading System (EU-ETS)17.

The production of biomethane in Ukraine for domestic consumption is not profitable under the current conditions as the price of biomethane should be about 900 EUR/1000 m3 (96 EUR/MWh), which is higher than the price of NG even for industrial consumers (677 EUR/1000 m3). Positive influence on feasibility of the domestic consumption of biomethane may have the introduction of domestic trade for GHG quotas and monetized premium for biomethane. According to Ukraine's Minister of Environmental Protection, this trade system might be implemented in 2024-202518. Ukrainian bioenergy experts forecast that 50% of biomethane produced in Ukraine will be exported and 50% will be domestically consumed by 2050.

[17] *The EU ETS is a cornerstone of the EU's policy to combat climate change and its key tool for reducing greenhouse gas emissions cost-effectively. It is the world's first major carbon market and remains the biggest one.* https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets_en

[18] https://interfax.com.ua/news/greendeal/892083.html

3 Potential of bioenergy in DH and power sectors

To determine the amount of biomass available for DH and power sector in Mykolaiv oblast, it is necessary to assess the current consumption of biomass in the oblast. Data on selected bioenergy plants (excluding wood boilers) are presented in Table 3-1. As many bioenergy installations runs on sunflower husk, the potential of this biomass type in Mykolaiv oblast seems to be fully utilized. On the contrary, the potential of maize and sunflower stalks is practically untapped and a considerable part of straw potential is also available.

Table 3-1 Selected bioenergy plants of Mykolaiv oblast[19] [20]

Bioenergy plant, location	Capacity	Fuel/feedstock	Fuel / feedstock approximate consumption, kt/yr (*expert estimation*)
Boiler plant (Bunge, Vynske boiler). Mykolaiv city	22.8 MW_{th}	**sunflower husk**	18.0
Boiler plant (Kernel, Vynske boiler). Mykolaiv city	17.5 MW_{th}	**sunflower husk**	14.0
Boiler plant ("Ahroproduct"). Mykolaiv city[1)]	10 MW_{th}	**sunflower husk**	8.0
Boiler plant (Trykratskyi bread product industrial complex, DKVR boiler). Voznesenskyi district, Trykratne village	2 MW_{th}	**sunflower husk**	1.6
Boiler plant ("Lokos-KLV" Ltd.). Mykolaiv city	0.5 MW_{th}	**sunflower husk**	0.4
Boiler plant ("Dykyi Sad" Ltd, Kriger boiler[21]). Mykolaiv city	0.82 MW_{th}	wood chips	13.1
Boiler plant ("Teplobud-1" Ltd[22]). Mykolaiv city	1 MW	biomass[4)]	no data
Boiler plant ("Nikteplopostach" Ltd[22]). Mykolaiv city	1 MW	biomass[4)]	no data
Boiler plant ("Nikteplopostach" Ltd[22]). Mykolaiv city	2 MW	biomass[4)]	no data
Boiler plant ("Teplobud-2" Ltd[22]). Mykolaivskyi district, Nadbuzke village	1 MW	biomass[4)]	no data
Boiler plant (Communal Enterprise "Teplo-Servise"[22]). Voznesenskyi district, Voznesensk town	0.3 MW	biomass[4)]	no data
Boiler plant (Communal Enterprise "Mykolaivski Heat Network"[22]). Mykolaivskyi district, Ochakiv town	3 MW	biomass[4)]	no data
Boiler plant (Communal Enterprise "Mykolaivski Heat Network"[22]). Mykolaivskyi district, Ochakiv town	0.5 MW	biomass[4)]	no data
Boiler plants (Communal Enterprise "Mykolaivski Heat Network"[22]). Mykolaivskyi district (Ochakiv town, Berezanka and Bratske urban villages, Sapetnia village); Bashtanskyi district (Berezneguvate urban village); Voznesenskyi district (Veselynove urban village); Pervomaiskyi district (Pervomaisk town)	4 MW	biomass[4)]	no data
Boiler plant (Housing and Communal Enterprise "Mykolaivske"[22]). Mykolaivskyi district, Mykolaivske village	0.3 MW	biomass[4)]	no data
Boiler plant ("Iugpromservice 2009" Ltd[22]). Mykolaivskyi district, Chornomorka village	0.2 MW	biomass[4)]	no data
Boiler plant ("APK Yevhroil" Ltd.[22]). Mykolaiv city	0.5 MW	biomass[4)]	no data
Boiler plant (Bashtanskyi cheese plant). Bashtanskyi district, Bashtanka town	1.6 MW_{th}	biogas	no data

[19] https://uabio.org/materials/maps/192/
[20] *https://www.energo.ua/ua/assets*
[21] *https://kriger.com.ua/en/projects/*
[22] *SAEE's data as of February 2023.*

Boiler plant (Farm "Oazis"). Mykolaivskyi district, Ivanivka village	0.5 MW_{th}	straw[2)]	0.5
Thermal power plant (Bandurskyi OEP, Vynske boiler). Pervomaiskyi district, Bandurka village	13.6 MW_{el}	**sunflower husk**	131.5
Thermal power plant ("Pivden Bio Energy" Ltd.). Mykolaiv city	3 MW_{el}	**sunflower husk**	29.0
CHP plant ("APK Yevhroil" Ltd.). Mykolaiv city	5 MW_{el} (10 MW_{th})	**sunflower husk**	48.4
CHP plant ("Singa Energy" Ltd.). Mykolaivskyi district, Berezanka town	5.1 MW_{el}	wood chips	81.4
Biogas plant ("Agricultural enterprise Zelenyi Gay" Ltd.). Voznesenskyi district, Buzke village	0.250 MW_{el}	maize silage	no data
Biogas plant (Agricultural private JSC "Ukraine"). Voznesenskyi district, Mostove village	0.400 MW_{el}	cattle manure, maize silage	no data
Biogas plant (Kometsbudplast Ltd). Mykolaivskyi district	3.12 MW_{el}	poultry manure	no data
Landfill gas plant, Mykolaiv city	1.063 MW_{el}	MSW	no data
Total consumption, kt/yr		***sunflower husk***	***250.9[3)]***

1) As of 31.10.2023, Ahroproduct Ltd. is in the process of dissolution https://youcontrol.com.ua/en/catalog/company_details/30738298/

2) In addition, some number of straw heat generators operate within grain dryers in Mykolaiv oblast. Manufacturer of the straw heat generators is Public Corporation "Brig" located in Pervomaisk town of the oblast[23].

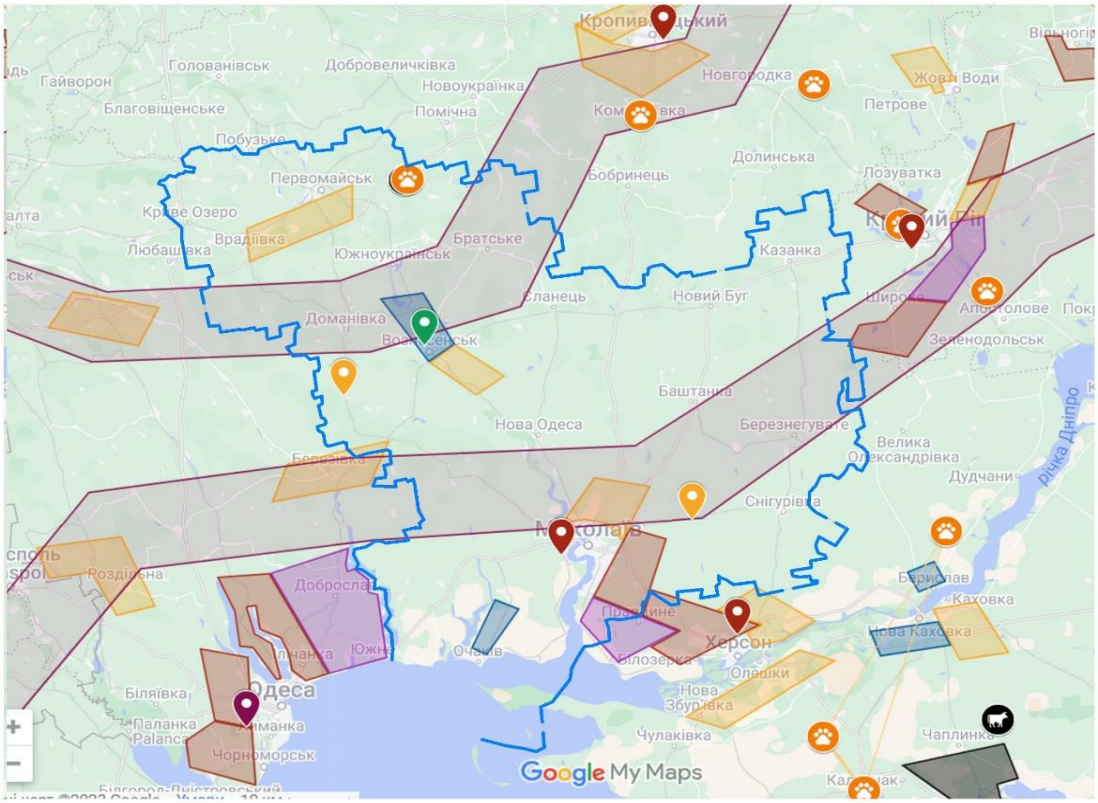
3) The estimated consumption of sunflower husk exceeds the potential of sunflower husk in Mykolaiv oblast.

4) No information on specific biomass type.

There are 4 biogas plants in Mykolaiv oblast producing power from biogas; three of them runs on agricultural feedstock, one uses MSW. In addition, agricultural company "Promin" in Pervomaiskyi district (the biggest farm in Mykolaiv oblast), is planning to construct a 2 MW_{el} biogas plant (Figure 3-2).

[23] https://uabio.org/wp-content/uploads/2020/01/posibnyk-onovlenyi-2016.pdf

Figure 3-1 Biomethane zoning of Mykolaiv oblast[24]



Notes:

- 4...20 million nm3/year, 50...200 ths. nm3/minimal month
- 20...90 million nm3/year, 200...3,000 ths. nm3/minimal month
- 90...275 million nm3/year, 800...5,000 ths. nm3/minimal month
- more than 275 million nm3/year, more than 5,000 ths. nm3/minimal month
- Zones of PSG, GPU, transit points
- Zones of oil and gas extraction fields
- Zone of GRP of Krymskyi Titan plant (potential conservated large gas consumer)
- 10-15 km zone around trunk transmission pipelines

Biogas plant	Feedstock, capacity
Biogas plant “Zelenyi Gay"	maize silage; 250 kWel
Biogas plant “SPraT Ukraine"	cattle manure + maize silage; 400 kWel
Biogas plant “Kometsbudplast”	poultry manure; 3120 kW
Landfill gas plant in Mykolaiv city	1.063 MWel
Agrarian enterprise LLC "Promin” (8600 cattle; 6800 pigs; 6800 ha)	the enterprise is planning to build a 2 MWel biogas plant25

[24] https://www.google.com/maps/d/viewer?mid=1ttZ12uWjd2NxxH-xc3Lin61fN_4JrE1D&ll=47.434861956862505%2C32.08990985386352&z=8

[25] https://pigua.info/uk/post/interview/stov-promin-sekret-efektivnosti-racionalne-vikoristanna-resursiv

Based on biomass resources assessed for 2021, available information on the existing consumption of biomass, distances between Mykolaiv city and centres of other cities (which is important for solid biomass transportation) and expert estimation, the potential of biomass that can be used in DH and power sector is about 263 ktoe/yr (851.5 kt/yr) for solid biomass and 276 ktoe/yr (333 mln m3 CH4/yr) for biomethane.

The biggest potentially available bioenergy resources for DH and power sector in Mykolaiv city are (Table 3-2, Figure 3-2, and Figure 3-3):

- straw of cereals (about 86 ktoe/yr),
- stalks of sunflower (36 ktoe/yr),
- energy crops (110 ktoe/yr),
- biomethane from maize silage (121.5 mln m3 CH4/yr),
- biomethane from cover crops (173 mln m3 CH4/yr).

Table 3-2 Potential of biomass available for the use in DH and power sector in Mykolaiv city

Type of biomass	Economic potential of biomass				Available share of the economic potential[2]	Potential for DH and power sector	
	Total potential (four districts of the oblast)		Potential within about 100 km from Mykolaiv city[1]				
Solid biomass[3]	kt	ktoe	kt	ktoe	%	kt	ktoe
Straw of cereals	484.1	165.4	280.6	95.9	90%	252.6	86.3
Straw of rapeseed	126.4	43.2	88.0	30.1	90%	79.2	27.1
Maize stalks	90.0	17.2	18.5	3.5	100%	18.5	3.5
Sunflower stalks	498.2	71.4	251.8	36.1	100%	251.8	36.1
Energy crops	427.5	188.8	249.4	110.1	100%	249.4	110.1
Solid biomass, total	1626.2	486.0	888.4	275.7	95%	851.5	263.1
	Total potential (four districts of the oblast)						
Biomethane	mln m3 CH4		ktoe		%	mln m3 CH4	ktoe
Biomethane from crop residues	43.6		36.1		90%	39.3	32.5
Biomethane from manure	4,2		3,5		90%	3,8	3,1
Biomethane from energy crops (maize silage)	135.0		111.8		90%	121.5	100.6
Biomethane from cover crops	191.8		158.9		90%	172.6	143.0
Biomethane, total	374,6		310,2		90%	337,2	279,2

1) For solid biomass: the potential includes biomass potentials in Mykolaiv district and 1/2 of biomass potentials in Voznesenskyi district and Bashtanskyi district.
2) For solid biomass: the share of economic potential of biomass within 100 km from Mykolaiv city (10% of the straw is supposed already to be utilized for energy).
For biomethane: the share of economic potential of biomass of the whole oblast (10% of the produced biomethane is supposed to be utilized for own needs of the producer).
3) Solid biomass: kt of fresh matter for agricultural residues and kt of dry matter for energy crops.

Figure 3-2 Structure of solid biomass resources available for DH and power sector of Mykolaiv city, ktoe (2021)

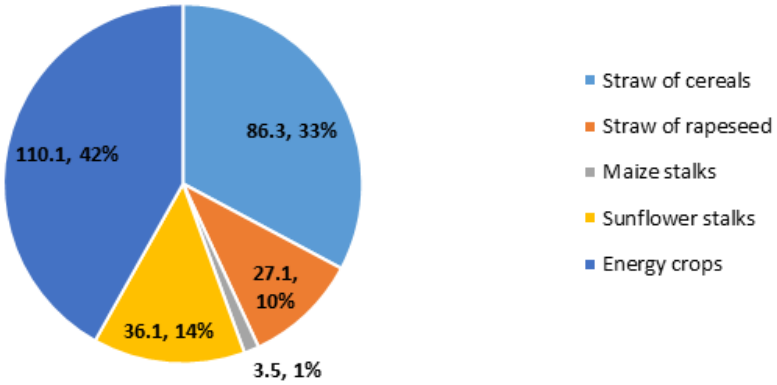
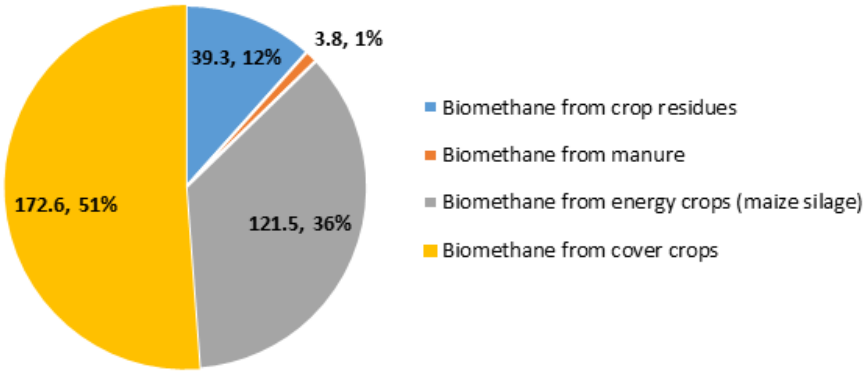


Figure 3-3 Structure of biomethane resources available for DH and power sector of Mykolaiv city, mln m3 CH4 (2021)



Despite the above results, we believe that future bioenergy projects in Mykolaiv city may include those running on sunflower husk. Reasons for that are that (1) Mykolaiv oblast may increase its production of sunflower; (2) sunflower husk could be transported (delivered) from the neighbouring and other oblasts; (3) analysis of recent tenders on Prozorro system shows that there are suppliers in Mykolaiv oblast and two neighbouring oblasts able to deliver sunflower husk pellets/briquettes. That is why bioenergy projects on sunflower husk are included in the list of possible investment projects for Mykolaiv city.

To obtain information on actual amount of available biomass/solid biomass fuels, a Questionnaire was sent out on behalf of COWI to Mykolaiv city Administration (the template is presented in Annex I).

4 Possible investment projects to unblock the potential

Project 1

Title	Construction of biomethane plant at agricultural company «Promin» (Pervomaiskyi district) to provide consumption of biomethane in Mykolaiv city
Sector	Energy
Objective(s)	Decarbonization of Mykolaiv city gas sector at the expense of biomethane consumption
Key outputs	• Launching the operation of biomethane plant at agricultural company «Promin» Ltd. • Production of 4 mln m3/yr of biomethane • Actual or virtual providing the consumption of biomethane for gas boiler plants/CHP plant in Mykolaiv city. Most probably it will be virtual providing based on mutual accounting of biomethane supplied into a gas pipeline and consumed in Mykolaiv city. • Reduced consumption of natural gas by boiler plants/CHP plant in Mykolaiv city.
Key tasks	• To perform feasibility study for the construction of biomethane plant at agricultural company «Promin» Ltd. • To study possibility and feasibility of supply of the produced biomethane into existing nearby GTS/GDS pipelines.
Expected timeline of project	• Project design, tenders for equipment supply, permissions: 8 months. • Manufacture and delivery of equipment: 12 months. • Construction-and-assembling operations: 8 months. Total: 28 months If some activities above are performed in parallel or some stages are already done, the total project time may be reduced to about 24 months.
Estimated investment cost (CAPEX)	CAPEX for a plant of 4 mln m^3/yr biomethane production: about 353 mln UAH (9 mln EUR)[26], including: Cost of Equipment: 272 mln UAH (6.9 mln EUR). Cost of Civil Works: 81 mln UAH (2.1 mln EUR).
Expected environmental impacts	The objectives of the EU Taxonomy that are addressed: • Climate change mitigation. The project impact is positive as the produced biomethane can replace natural gas which leads to GHG emissions reduction.

[26] *1 EUR = 39.25 UAH (the exchange rate on 20.11.2023 according to the National Bank of Ukraine https://bank.gov.ua/en/)*

	• Protection and restoration of biodiversity and ecosystems. The project impact is positive as digestate from the biomethane plant can be used as fertilizer which maintains and improves soil quality. Production of heat/cool from bioenergy
Critical observation points	• Current situation related to the war. • Agricultural company "Promin" Ltd. (the biggest farm in Mykolaiv oblast) is located in Pervomaiskyi district at a distance of about 160 km from Mykolaiv city. There seem to be no GTS pipelines close to "Promin", the nearest zone of transmission pipelines being at a distance of about 35-40 km[27]. If "Promin" starts the production of biomethane, the question is how it will be supplied to a gas pipeline. The issue should be studied addressing two points: (1) whether it is possible and feasible to lay a new pipeline towards the nearest existing GTS pipeline (35-40 km) and (2) whether there is a local GDS pipeline located much closer to "Promin" we are not aware of. In case the connection to the nearest GTS/GDS pipelines is not possible/feasible, the project can be redesigned for power production from biogas.
Related studies, projects and programmes	• The National Recovery Plan. • The Program of complex modernization of CHP plants and heating plants of Naftogaz Group. • Denmark and the Mykolaiv oblast signed a memorandum on reconstruction in March 2023. Danish Government provides financial support for the reconstruction of heating system in Mykolaiv city[28].
Readiness of project documents, including design documents	Agricultural company "Promin" Ltd. is planning to construct a biogas plant to cover its needs in electricity and to sell the surplus biogas. Before the Russian invasion in 2022, "Promin" planned to start the construction of the biogas plant in 2024[25]. That means that at least some design documents related to the biogas plant might be available. The matter needs further clarification with the company.
Background	The problem addressed is the need in decarbonization of Mykolaiv city gas sector. This is important because it is in line with general Ukraine's energy policy aimed at climate change mitigation, green transition and strengthening of energy security.
Beneficiary	Agricultural company "Promin" Ltd. PUC Mykolayivoblteploenergo (MOTE). PJSC Mykolaiv Combined Heat and Power Plant (MCHPP).
Other stakeholders	City of Mykolaiv. NSC "Naftogas Ukraine".

[27] *See Figure 3-1 in Chapter 3 "Potential of bioenergy in DH and power sectors". The figure is made based on Biomethane Zoning map developed by UABIO experts:* https://www.google.com/maps/d/viewer?mid=1ttZ12uWjd2NxxH-xc3Lin61fN_4JrE1D&ll=47.975023376498044%2C31.20963047169507&z=10

[28] https://www.pravda.com.ua/news/2023/11/7/7427672/

Project 2

Title	Installation of modular gas-piston power plants in communal boiler houses in Mykolaiv city
Sector	Energy
Objective(s)	• Providing manoeuvring electric capacity for Ukraine's energy system in Mykolaiv oblast. • Providing backup power in case of power outage.
Key outputs	• Balancing the energy system if needed • Supplying heat to the DH system of Mykolaiv city • Replacing natural gas by biomethane (when available).
Key tasks	• To decide how many modular gas-piston power plants are required and can be installed. • To connect the installed power plants to the electric grid and DH system of Mykolaiv city. • To develop strategy for future supply of biomethane.
Expected timeline of project	• Project design, tenders for equipment supply, permissions: 4 months. • Manufacture and delivery of equipment: 6 months. • Construction-and-assembling operations: 2 months. Total: 12 months
Estimated investment cost (CAPEX)	CAPEX for 1 module of 1 MW_{el}: about 45.5 mln UAH (1.2 mln EUR)[26], including: Cost of Equipment: 35 mln UAH (0.9 mln EUR). Cost of Civil Works: 10.5 mln UAH (0.3 mln EUR).
Expected environmental impacts	The objective of the EU Taxonomy that potentially is addressed is Climate change mitigation. The potential project impact is positive as the installed modular gas-piston power plants are expected to switch from natural gas to biomethane in the future. That will contribute to GHG emissions reduction.
Critical observation points	• Current situation related to the war. • Risk of low electricity market price that may affect the project feasibility. The risk is possible but seems to be low probable as up to now the electricity price has only been rising.
Related studies, projects and programmes	• The National Recovery Plan.

	• The Program of complex modernization of CHP plants and heating plants of Naftogaz Group. • Denmark and the Mykolaiv oblast signed a memorandum on reconstruction in March 2023. Danish Government provides financial support for the reconstruction of heating system in Mykolaiv city[28].
Readiness of project documents, including design documents	• Mykolaiv city heat supply scheme (approved in 2019 and then seized) is under restoration. • There is a map of location of 28 small BHs to be reconstructed (MOTE).
Background	Energy system of Ukraine needs balancing. The usage of modular gas-piston power plants may be an effective solution for that in Mykolaiv oblast. Another problem addressed is power outages that are very probable during the war time. Modular gas-piston power plants can provide backup power in Mykolaiv city in the event of power outage.
Beneficiary	• PUC Mykolayivoblteploenergo (MOTE). • "Ukrenergo" company.
Other stakeholders	City of Mykolaiv

Project 3

Title	**Installation of biomass boilers running on sunflower husk pellets in communal boiler houses in Mykolaiv city**
Sector	Energy
Objective(s)	• Contribution to the communal sector transition from fossil fuels to RES. • Diversification of energy carriers.
Key outputs	• Reduced consumption of natural gas. • Supply of renewable heat to the DH system of Mykolaiv city.
Key tasks	• To decide how many biomass boilers are required and can be installed. • To perform feasibility study of the project in its determined scope. • To connect the installed biomass boilers to the DH system of Mykolaiv city
Expected timeline of project	• Project design, tenders for equipment supply, permissions: 4 months. • Manufacture and delivery of equipment: 6 months.

	• Construction-and-assembling operations: 2 months. Total: 12 months
Estimated investment cost (CAPEX)	CAPEX for 1 boiler of 1 MW_{th}: about 3265 th. UAH (83.3 th. EUR)[26], including: Cost of Equipment (the boiler with all the components): 2045 th. UAH (52.1 th. EUR). Cost of Civil Works (design work, construction, starting-up and adjustment): 1220 th. UAH (31.2 th. EUR).
Expected environmental impacts	The objective of the EU Taxonomy that is addressed is Climate change mitigation. The project impact is positive as the replacement of natural gas by biomass (sunflower husk) will contribute to GHG emissions reduction.
Critical observation points	• Current situation related to the war. • Lack of biomass fuel (sunflower husk) due to its high level of consumption in the oblast. Mitigation measures may include identifying a number of reliable suppliers in Mykolaiv oblast and neighbouring oblasts and concluding preliminary supply agreements with them. • Low (subsidized) heat price for population may affect the project feasibility (if the produced heat is intended for population). However, the liberalization of NG and therefore heat prices is expected in Ukraine because it is required by Ukraine's partners as a precondition for further military assistance.
Related studies, projects and programmes	• The National Recovery Plan. • The Program of complex modernization of CHP plants and heating plants of Naftogaz Group. • Denmark and the Mykolaiv oblast signed a memorandum on reconstruction in March 2023. Danish Government provides financial support for the reconstruction of heating system in Mykolaiv city[28].
Readiness of project documents, including design documents	• Mykolaiv city heat supply scheme (approved in 2019 and then seized) is under restoration. • There is a map of location of 28 small BHs to be reconstructed (MOTE).
Background	The problem addressed is the need in decarbonization of Mykolaiv city gas sector. This is important because it is in line with general Ukraine's energy policy aimed at climate change mitigation, green transition and strengthening of energy security.
Beneficiary	PUC Mykolayivoblteploenergo (MOTE)
Other stakeholders	City of Mykolaiv

Project 4

Title	Installation of straw fired boilers in communal boiler houses in Mykolaiv city
Sector	Energy
Objective(s)	• Contribution to the communal sector transition from fossil fuels to RES. • Diversification of energy carriers.
Key outputs	• Reduced consumption of natural gas. • Supply of renewable heat to the DH system of Mykolaiv city.
Key tasks	• To decide how many biomass boilers are required and can be installed. • To perform feasibility study of the project in its determined scope. • To connect the installed biomass boilers to the DH system of Mykolaiv city
Expected timeline of project	• Project design, tenders for equipment supply, permissions: 4 months. • Manufacture and delivery of equipment: 6 months. • Construction-and-assembling operations: 2 months. Total: 12 months
Estimated investment cost (CAPEX)	CAPEX for 1 boiler of **5** MW_{th}: about 34.8 mln UAH (887.5 th. EUR)[26], including: Cost of Equipment (the boiler with all the components): 24.5 mln UAH (625 th. EUR). Cost of Civil Works (design work, construction, starting-up and adjustment): 10.3 mln UAH (262.5 th. EUR).
Expected environmental impacts	The objective of the EU Taxonomy that is addressed is Climate change mitigation. The project impact is positive as the replacement of natural gas by biomass (straw) will contribute to GHG emissions reduction.
Critical observation points	• Current situation related to the war. • Low (subsidized) heat price for population may affect the project feasibility (if the produced heat is intended for population). However, the liberalization of NG and therefore heat prices is expected in Ukraine because it is required by Ukraine's partners as a precondition for further military assistance.
Related studies, projects and programmes	• The National Recovery Plan.

	• The Program of complex modernization of CHP plants and heating plants of Naftogaz Group. • Denmark and the Mykolaiv oblast signed a memorandum on reconstruction in March 2023. Danish Government provides financial support for the reconstruction of heating system in Mykolaiv city[28].
Readiness of project documents, including design documents	• Mykolaiv city heat supply scheme (approved in 2019 and then seized) is under restoration. • There is a map of location of 28 small BHs to be reconstructed (MOTE).
Background	The problem addressed is the need in decarbonization of Mykolaiv city gas sector. This is important because it is in line with general Ukraine's energy policy aimed at climate change mitigation, green transition and strengthening of energy security.
Beneficiary	PUC Mykolayivoblteploenergo (MOTE)
Other stakeholders	City of Mykolaiv

Project 5

Title	**Construction of a 5 MW_{el} + 15 MW_{th} CHP plant running on sunflower husk in Mykolaiv city**
Sector	Energy
Objective(s)	• Contribution to Mykolaiv's energy sector transition from fossil fuels to RES. • Diversification of energy carriers.
Key outputs	• Production of renewable heat and power. • Reduced consumption of natural gas.
Key tasks	• To decide how many biomass CHP plants are required and can be installed. • To perform feasibility study of the project in its determined scope. • To connect the installed biomass CHP plant to the electric grid and DH system of Mykolaiv city.
Expected timeline of project	• Project design, tenders for equipment supply, permissions: 6 months. • Manufacture and delivery of equipment: 12 months. • Construction-and-assembling operations: 6 months.

	Total: 28 months
Estimated investment cost (CAPEX)	CAPEX for 1 CHP plant of 5 MW_{el} + 15 MW_{th}: about 530 mln UAH (13.5 mln EUR)[26], including: Cost of Equipment: 330 mln UAH (8.5 mln EUR). Cost of Civil Works (design work, construction, starting-up and adjustment): 200 mln UAH (5 mln EUR).
Expected environmental impacts	The objective of the EU Taxonomy that is addressed is Climate change mitigation. The project impact is positive as the replacement of fossil fuels by biomass (sunflower husk) will contribute to GHG emissions reduction.
Critical observation points	• Current situation related to the war. • Lack of biomass fuel (sunflower husk) due to its high level of consumption in the oblast. Mitigation measures may be identifying a number of reliable suppliers in Mykolaiv oblast and neighbouring oblasts and concluding preliminary supply agreements with them. • Low (subsidized) heat price for population may affect the project feasibility (if the produced heat is intended for population). However, the liberalization of NG and therefore heat prices is expected in Ukraine because it is required by Ukraine's partners as a precondition to continue military assistance.
Related studies, projects and programmes	• The National Recovery Plan. • The Program of complex modernization of CHP plants and heating plants of Naftogaz Group. • Denmark and the Mykolaiv oblast signed a memorandum on reconstruction in March 2023. Danish Government provides financial support for the reconstruction of heating system in Mykolaiv city[28].
Readiness of project documents, including design documents	• Mykolaiv city heat supply scheme (approved in 2019 and then seized) is under restoration. • There is a map of preliminary selected industrial sites in the city where the installation and operation of biomass CHP plants is possible.
Background	The problem addressed is the need in decarbonization of Mykolaiv city gas sector. This is important because it is in line with general Ukraine's energy policy aimed at climate change mitigation, green transition and strengthening of energy security.
Beneficiary	• PUC Mykolayivoblteploenergo (MOTE) • PJSC Mykolaiv Combined Heat and Power Plant (MCHPP).
Other stakeholders	City of Mykolaiv

Project 6

Title	Construction of a 5 MW_{el} + 15 MW_{th} CHP plant running on baled straw in Mykolaiv city
Sector	Energy
Objective(s)	• Contribution to Mykolaiv's energy sector transition from fossil fuels to RES. • Diversification of energy carriers.
Key outputs	• Production of renewable heat and power. • Reduced consumption of natural gas.
Key tasks	• To decide how many biomass CHP plants are required and can be installed. • To perform feasibility study of the project in its determined scope. • To connect the installed biomass CHP plant to the electric grid and DH system of Mykolaiv city.
Expected timeline of project	• Project design, tenders for equipment supply, permissions: 6 months. • Manufacture and delivery of equipment: 12 months. • Construction-and-assembling operations: 6 months. • Total: 28 months
Estimated investment cost (CAPEX)	CAPEX for 1 CHP plant of 5 MW_{el} + 15 MW_{th}: about 630 mln UAH (16 mln EUR)[26], including: Cost of Equipment: 390 mln UAH (10 mln EUR). Cost of Civil Works (design work, construction, starting-up and adjustment): 240 mln UAH (6 mln EUR).
Expected environmental impacts	The objective of the EU Taxonomy that is addressed is Climate change mitigation. The project impact is positive as the replacement of natural gas by biomass (straw) will contribute to GHG emissions reduction.
Critical observation points	• Current situation related to the war. • Low (subsidized) heat price for population may affect the project feasibility (if the produced heat is intended for population). However, the liberalization of NG and therefore heat prices is expected in Ukraine because it is required by Ukraine's partners as a precondition to continue military assistance.
Related studies, projects and programmes	• The National Recovery Plan.

	• The Program of complex modernization of CHP plants and heating plants of Naftogaz Group. • Denmark and the Mykolaiv oblast signed a memorandum on reconstruction in March 2023. Danish Government provides financial support for the reconstruction of heating system in Mykolaiv city[28].
Readiness of project documents, including design documents	• Mykolaiv city heat supply scheme (approved in 2019 and then seized) is under restoration. • There is a map of preliminary selected industrial sites in the city where the installation and operation of biomass CHP plants is possible.
Background	The problem addressed is the need in decarbonization of Mykolaiv city gas sector. This is important because it is in line with general Ukraine's energy policy aimed at climate change mitigation, green transition and strengthening of energy security.
Beneficiary	• PUC Mykolayivoblteploenergo (MOTE). • PJSC Mykolaiv Combined Heat and Power Plant (MCHPP).
Other stakeholders	City of Mykolaiv

5 Legal and regulatory framework

The legal and regulatory framework for bioenergy production and consumption is quite developed in Ukraine. The Law of Ukraine, "On Heat Supply,"[29] envisages a special tariff for the production of heat energy from alternative sources, including biomass. In particular, heat energy tariffs for producers that use biomass to supply heat for the state or locally financed organizations, and population are set at the level of 90 percent of the tariff for heat energy produced using natural gas. In case a producer does not have heat energy production from natural gas, the tariff is set at the level of 90 percent of the weighted average tariff. The calculation of weighted average tariffs for heat energy produced using natural gas is provided by the State Agency on Energy Efficiency and Energy Savings (SAEE) according to the Procedure, established by the Cabinet of Ministers of Ukraine.[30] The weighted average tariffs for the Mykolaiv region as of 25.09.2023 are the following: for the population's needs – 1972.04 UAH; for the needs of the state or locally financed organizations – 3432.70 UAH. The peculiarity of such a tariff is the simplicity and transparency of its establishment, as well as its dependence on tariffs for heat energy from natural gas. This mechanism of tariff formation caused the increase in biomass-based heat energy production facilities in Ukraine starting from 2017, but it should be improved as the heat energy tariff calculated according to this mechanism can be insufficient for some, especially for small, producers now.

The Law of Ukraine, "On Alternative Energy Sources,"[31] envisages stimulating the production of electricity from biomass through the possibility of receiving a "green" tariff. The "green" tariff for electricity produced from biomass is 12.39 euro cents/kWh (without VAT). It is set by the National Commission for State Regulation of Energy and Utilities (NEURC) and is valid until the end of 2029, but new installations can receive a “green” tariff only until January 1, 2024. The procedure for establishing, revising, and terminating the "green" tariff is determined by the Resolution of the NEURC[32]. Facilities put into operation from July 1, 2015 to December 31, 2024, can receive a premium to the "green" tariff for a certain level of Ukrainian-made equipment usage. The procedure for its establishment is also determined by the NEURC[33]. The mechanism of the “green” tariff will be followed by the auctioning system. It is already designed, but not yet functioning, therefore it should be implemented as soon as possible. The auctions will be held in the electronic trading system in accordance with the Procedure, approved by the Cabinet of Ministers of Ukraine[34]. The auctions will be implemented until December 31, 2029; the period of support is 12 years from the day when the producer submits documents confirming the commissioning of the power plant.

The production of biomethane is regulated by the Law of Ukraine "On amendments to certain Laws of Ukraine regarding the development of biomethane production"[35], which defines the basic principles of biomethane production in Ukraine, namely the procedure for a biomethane register establishment, as well as the procedure for providing guarantees of biomethane origin. The procedure for a biomethane register establishment, its functionality, and providing guarantees of biomethane origin are determined by the Procedure, which has already been approved by the Cabinet of Ministers of Ukraine[36]. In order to implement the Law on the development of

[29] https://zakon.rada.gov.ua/laws/show/2633-15#Text
[30] https://zakon.rada.gov.ua/laws/show/679-2017-%D0%BF#Text
[31] https://zakon.rada.gov.ua/laws/show/555-15
[32] https://zakon.rada.gov.ua/laws/show/v1817874-19#Text
[33] https://zakon.rada.gov.ua/laws/show/z0119-16#Text
[34] https://zakon.rada.gov.ua/laws/show/1175-2019-%D0%BF#n12
[35] https://zakon.rada.gov.ua/laws/show/1820-20#Text
[36] https://zakon.rada.gov.ua/laws/show/823-2022-%D0%BF#Text

biomethane production, a number of Resolutions of the NEURC aimed at facilitating the access of biomethane production facilities to gas networks have been adopted[37][38]. The Verkhovna Rada of Ukraine has registered a draft Law aimed at creating an opportunity to export biomethane from Ukraine[39]. The draft Law on amendments to the Customs Code of Ukraine regarding the customs clearance of biomethane proposes to establish that customs control and customs clearance of biomethane transported by pipelines across the customs border of Ukraine shall be carried out under foreign economic agreements in the manner provided for natural gas. It means that all regulatory acts that are currently in force for the export of natural gas will be applied to the export of biomethane.

Besides the mentioned required changes in the legal framework to deploy the potential for bioenergy production and consumption, the following actions should be done at the national level to overcome the existing barriers:

Absence of approved long-term goals for bioenergy development. The Government should approve the Bioenergy Development Roadmap until 2050 or include long-term goals for bioenergy in the updated Energy Strategy until 2050. In addition, an effective and ambitious state program to reduce and replace the consumption of imported gas should be developed.

Undefined state position regarding energy use of agricultural residues. The Ministry of Agrarian Policy and Food of Ukraine should develop recommendations on the possible share of the use of crop residues for energy production.

The need to pay CO2 emissions tax for boilers, and thermal power plants on biomass and biogas. The draft Law on amendments to the Tax Code of Ukraine regarding establishing a zero-tax rate for carbon dioxide emissions has already been registered[40]. It envisages the creation of a register of installations using solid, liquid, and gaseous biofuel as the only type of fuel[41] to administrate the tax exemption.

Lack of profitability in case of replacing natural gas with solid biomass in individual and district heating. The reason is that the state subsidizes the cost of natural gas for the population compared to the market price of natural gas. One market price for gas for all categories of consumers, as well as subsidy monetization, is needed.

The absence of a biomass exchange. Biomass exchange is an electronic platform to trade with biomass. The draft Law on amendments to certain legislative acts of Ukraine on developing electronic trade in alternative fuels[42] should be adopted.

The absence of a competitive heat energy market, the monopoly position of the communal DH companies, and problems with the access of independent producers to heat networks. It is necessary to ensure non-discriminatory access of independent producers to the heat networks and introduce a competitive heat energy market in district heating.

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37 *https://www.nerc.gov.ua/acts/pro-vnesennya-zmin-do-kodeksu-gazotransportnoyi-sistemi-ta-kodeksu-gazorozpodilnih-sistem*
38 *https://www.nerc.gov.ua/acts/pro-zatverdzhennya-zmin-do-deyakih-postanov-nkrekp-shchodo-spriyannya-rozvitku-virobnictva-biometanu*
39 *https://itd.rada.gov.ua/billInfo/Bills/Card/42226*
40 *https://itd.rada.gov.ua/billInfo/Bills/Card/42483*
41 *https://itd.rada.gov.ua/billInfo/Bills/Card/42484*
42 *https://itd.rada.gov.ua/billInfo/Bills/Card/40449*

The biomethane register is not fully functioning, and the export of natural gas of Ukrainian origin and biomethane is limited. The start of the biomethane register work and biomethane export is crucial.

Lack of a basic Law on the production and consumption of biomethane in the transport sector. Absence of state goals and obligations regarding the share of biomethane use in transport. Development of a draft Law of Ukraine on support for biomethane usage as motor fuel, including for public transport and agricultural machinery. It is also necessary to include in the National Energy Strategy biomethane consumption goals.

As for regional and municipal levels, since Ukraine is a unitary state, local councils usually have the authorities granted to them by laws. According to the Law of Ukraine “On heat supply”, local councils are responsible for establishing biomass-based heat energy tariffs for producers, their publication as well as for approval of local development programs in the field of heating, etc.

According to the publicly available information, Mykolaiv joined the Covenant of Mayors EU initiative[43]. Mykolaiv has also adopted an Action plan for sustainable energy development and climate of the city of Mykolaiv until 2030[44]. According to the plan, among all types of RES, biomass has the biggest potential, which can be used to produce heat and electricity, thus replacing natural gas and coal. Additionally, the city of Mykolaiv has a Program for reform and development of housing and communal services in the city of Mykolaiv for 2020-2024[45], but it doesn’t envisage the possibility of biomass usage, so it can be improved and more focused on RES introduction.

Recently the Law of Ukraine "On amendments to certain legislative acts of Ukraine regarding the implementation of investment projects with significant investments"[46] has been adopted. It envisages that if projects for the production of bioethanol, biogas, and biomethane meet the requirements established by law, they can receive state support for their implementation. Local councils can be a part of the special investment agreement and therefore stimulate the deployment of biofuel production projects on their territories.

43 https://mkrada.gov.ua/documents/26278.html
44 https://mkrada.gov.ua/documents/28365.html
45 https://mkrada.gov.ua/documents/33285.html
46 https://zakon.rada.gov.ua/laws/show/3311-20#Text

Appendix A Questionnaire for enterprises in Mykolaiv oblast on biomass availability, production and consumption of biomass fuels

1. General information:

- organization name:

- department/division:

- contact person:

- position:

- phones, e-mail:

- address:

2. Wood biomass

Indicator	Units	2020	2021	Note
The area of forest felling and measures	ha			
Harvesting of marketable wood (in general),	solid m^3			

Indicator	Units	2020	2021	Note
- including firewood for heating	solid m^3			
Wood waste:				
- formed	t			
- disposed	t			
- burned	t			
Name and location of forestry *(volumes of harvesting liquid wood and firewood for heating by year)*				
Names and contact details of woodworking enterprises *(with indication of operation years, type and volume of wood waste)*				

3. Agricultural biomass

3.1 Crop production

Crop residues *(straw, corn stalks)*; pruning and uprooting of perennial agricultural plantations *(grapes, fruit trees).*

Names of companies and contact details of potential biomass suppliers	Type of biomass	Annual volumes (mass)	Note

Names of companies and contact details of potential biomass suppliers	Type of biomass	Annual volumes (mass)	Note

3.2 Livestock farming

Manure

Names of companies and contact details of potential biomass suppliers	Type of biomass	Annual volumes (mass)	Note

4. Waste

(Sunflower husks, grain waste, grain dust, etc.)

4.1 Processing enterprises

Indicator	Units	Mass (volumes)	Note *(year)*
Processed sunflower seeds at enterprises	t		
Formed waste at enterprises _____ (waste name) from the processing of agricultural feedstock _____ (feedstocks name)	t		

Indicator	Units	Mass (volumes)	Note *(year)*
Formed waste at enterprises _____ (waste name) from the processing of agricultural feedstock _____ (feedstock name)	t		
Formed waste at enterprises _____ (waste name) from the processing of agricultural feedstock _____ (feedstock name)	t		
Names and contact details of processing enterprises *(indicating the type and volume of waste)*			

4.2 Ports and logistics companies

Indicator	Units	Mass (volumes)	Note *(year)*
Formed waste _____	t		

Indicator	Units	Mass (volumes)	Note *(year)*
(waste name) from the feedstock _____ (feedstock name)			
Formed waste _____ (waste name) from the feedstock _____ (feedstock name)	t		
Formed waste _____ (waste name) from the feedstock _____ (feedstock name)	t		
Names and contact details of enterprises *(indicating the type and volume of waste)*			

5. Energy crop plantations

(miscanthus, willow, poplar, etc.)

Name and location of the project	Type of energy crops	Area, ha	Note

			(project year, status, ...)

6. Producers of solid biomass fuels

Indicator	Units	2020	2021	Note
Wood pellets	t			
Agro pellets	t			
Wood briquettes	t			
Agro briquettes	t			
Names and contact details of solid biomass fuel producers *(with indication of operation years, type and volume of biomass fuels)*				

7. Consumption of biomass fuels in Mykolaiv

Indicator	Units	2020	2021	Note
Pellets	t			
Briquettes	t			
Firewood for heating	solid m^3			

Wood chips for the heat and electricity production	solid m^3			
Names and contact details of solid biomass fuel consumer enterprises *(with indication of operation years, type and volume of biomass fuels)*				

8. Projects of bioenergy facilities in Mykolaiv

Name and location of the project	Capacity	Types of biomass fuels and annual consumption	Note (year of the project, status, initiator, ...)

9. Actual prices for solid biofuels in Mykolaiv

Biomass fuel type	Units *(t, m^3)*	Price, UAH/t (UAH/m^3)	Data	Note
Wood fuels				
- firewood				
- wood chips				
- wood pellets				
- wood briquettes				
Biomass fuel from agricultural biomass				
- chopped sunflower husk				
- sunflower husk pellets				
- sunflower husk briquettes				
- straw pellets				
- straw briquettes				
- other types of biomass fuels *(indicate the type of biomass fuel and raw material)*				

10. Additional information

10.1 Additional information on local biomass for energy (including the cultivation of energy crops)

10.2 Experience and plans of the municipality regarding the supply of biomass and biomass fuels

10.3 Other information

The questionnaire was prepared by:

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