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UKRAINIAN CLIMATE OFFICE

HARVESTING GREEN ENERGY:

THE POTENTIAL OF UKRAINE-EU BIOMETHANE COOPERATION

Authors: Anna Bohushenko, Oleksii Epik, Dmytro Naumenko, Agata Łoskot-Strachota, Georg Zachmann, Maciej Zaniewicz (ed.)

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EXECUTIVE SUMMARY

BACKGROUND ON BIOMETHANE

- Biomethane is a renewable gas produced from processing raw biogas. It has a chemical composition similar to natural gas and is compatible with existing natural gas networks and appliances.
- Biomethane has approximately 80% lower carbon emissions than natural gas.
- The production of biomethane can create additional economic value from the disposal of agricultural and other organic waste.
- Producing or importing biomethane contributes to reducing the EU's reliance on gas imports, particularly from Russia.
- The biomethane market in both the EU and Ukraine is still developing, offering opportunities for collaborative growth, albeit with uncertainties around the scale of production, demand, and trade.

BACKGROUND ON BIOMETHANE IN THE EU

- The EU's interest in biomethane has grown in response to the Russian invasion of Ukraine and the related energy crisis.
- In its RePowerEU plan, announced in 2022, the European Commission (EC) set a target to reduce dependency on Russian gas, which then accounted for about 40% of EU imports.
- A goal of RePowerEU was to increase biomethane production in the EU from 3.5 billion cubic metres (bcm) in 2021 to 35 bcm in 2030.
- The biomethane market in the EU is only emerging, with some countries clearly more advanced and others still not producing any biomethane at all.
- A common legal framework for the EU biomethane market is still being developed, aiming to facilitate both EU production and the cross-border transport of biomethane within the EU, as well as imports.
- However, an analysis of ongoing EU investments and national policies supporting the industry indicates that **the gap between the EC's target and expected biomethane production in 2030 could be between 15 and 24 bcm/year**.

BACKGROUND ON BIOMETHANE IN UKRAINE

- Ukraine's biomethane industry is still in its early stages and faces challenging conditions. One of the main obstacles to its development is the lack of competitiveness against subsidised natural gas. **The absence of domestic Ukrainian demand for biomethane limits the industry's potential for growth**.
- The ongoing war presents a major challenge to industrial growth, bringing significant political uncertainty, security risks to assets, infrastructure, demand and personnel, along with war-related economic risks, all of which deter investments. However, Russian invasion has also highlighted the importance of developing a decentralized energy production, which can act as an opportunity for the biomethane industry.
- Despite the challenges, two biomethane plants are operational in Ukraine, and additional facilities with a combine capacity of 111 million cubic metre (mcm)/year are expected to be online by the end of 2024. **All current projects are focused solely on exports to the EU**.

POTENTIAL PRODUCTION AND TECHNICAL ASPECTS

- **The estimated potential for biomethane production in Ukraine by 2030 is about 1 bcm, with a potential by 2050 projected to range anywhere between 6 to 22 bcm/year**.
- Ukrainian biomethane plants are planned to be located near feedstock sources and connected to the local gas distribution network. As a result, biomethane will usually be consumed either directly on-site or within the local distribution networks where it is injected. This approach is the simplest and most cost-effective, avoiding the need for compressing biomethane to the high pressures required for the transmission pipelines.
- Biomethane exports to the EU will primarily use swap-type operations based on the mass balance method. In chemical terms, exported gas will largely remain natural gas, either produced within Ukraine or originating from transit flows.
- These operations will be limited to the level of gas demand within distribution networks, which is approximately 8.7 to 11.5 bcm/year. This volume could increase if biomethane were directly injected into transmission pipelines, although at a higher production cost.
- The current Ukrainian gas infrastructure does not pose any technical barrier to connecting new plants and facilitating biomethane exports to the EU..

EXPORT POTENTIAL TO THE EU

- Carbon pricing, market-based fuel and energy prices (natural gas, electricity, heating) and renewable energy incentives all create a more favourable market for biomethane in the EU.
- However, complex bureaucratic procedures, strict quality requirements (equivalent to natural gas standards), a lack of clear strategic direction, and EU's ambiguous policy on imports are acting as obstacles to the development of robust biomethane export industries in potential EU partner countries
- **By 2030, Ukraine could potentially export up to 1 bcm of biomethane to the EU, and as much as 7 bcm by 2050**, covering up to 6% of the anticipated gap between the EU's target and expected production capacity for 2030.
- The profitability of Ukrainian biomethane imports depends on many variables: the cost of biomethane production (influenced by feedstock costs, capital expenditures, and economies of scale), the applicable carbon price, the price of natural gas in both Ukraine (politically fixed) and the EU (market-driven), as well as competition from other EU and non-EU producers.
- **Biomethane from Ukraine's lowest-cost (large-scale) plants are already competitive in the EU natural gas market.**
- Current conditions, however, do not support the economic scaling of biomethane imports from Ukraine beyond 1 bcm by 2030.
- Therefore, Ukrainian imports will only offer a limited option for diversifying supply sources and providing price security against natural gas market shocks in the coming decade.
- **Conditions favourable to scale up biomethane imports from Ukraine are only likely to emerge after 2030, assuming stability in the natural gas market and a carbon price aligned to the EC Emissions Trading System (ETS) trajectory**.
- Biomethane imports from Ukraine should not be regarded as a "silver bullet" for EU supply but rather as one component of a broader diversification strategy.

BARRIERS TO BIOMETHANE EXPORTS AND POTENTIAL SOLUTIONS

- Technically, Ukrainian producers are already capable of injecting biomethane into the grid, enabling a corresponding volume of biomethane to be transferred to the EU and accessed by EU consumers from their grid.
- The main barriers to this process are regulatory in nature and could, in principle, be resolved relatively quickly, provided there is political will from the EU, its Member States, and Ukraine to facilitate such a trade.
- On the Ukrainian side, connection procedures could be streamlined, a sectoral development strategy should be developed, and cross-sectoral coordination, registry, quality control and monitoring requirements and procedures should be aligned with EU standards.
- On the EU side, Ukrainian imports should be integrated into the EU Union Database for Biofuels (UDB) and the quality and monitoring requirements for biomethane standardised.

CERTIFICATIONS

- **A reliable certification system ensuring the proof of origin, quality control and quantity monitoring will be critical for the production and export of biomethane from Ukraine to the EU**.
- Currently, exports are facilitated through voluntary certification systems. However, with the introduction of the integrated UDB in the EU from January 2024, it will now be necessary to integrate the Ukrainian database into the EU system.
- Ukraine imports will only be feasible if the EU's UDB allows Ukrainian biomethane into their system and supports the integration of the Ukraine database with theirs.
- **Failure to integrate the two databases acts as the greatest barrier to the scale up of Ukrainian biomethane exports to the EU, and could even lead to the cessation of the current exports**.

CONCLUSION

- Ukraine has the potential to produce substantial amounts of biomethane, which EU consumers are willing to purchase to reduce the costs of decarbonising their societies.
- Given the current structure of the gas network, biomethane exports will not work based on tracing individual biomethane molecules, but on ensuring a robust certification chain is in place.
- Reliable certification is essential for investors, as any failure in the system could jeopardise all Ukrainian biomethane exports to the EU.
- Facilitating biomethane trade offers clear advantages for both the EU and Ukraine , including enhanced supply security, increased competitiveness, and progress towards decarbonisation.

1. INTRODUCTION

1.1. WHAT IS BIOMETHANE?

Biomethane is a renewable gas that is produced by purifying biogas, which is generated through the anaerobic decomposition of organic matter or the thermal gasification of biomass. Raw biogas primarily comprises methane (50-75%), carbon dioxide (25-45%)[1] and other trace gases. The purification process removes these impurities, raising the methane concentration to a level comparable to that of natural gas (approximately 98%). This makes **biomethane suitable for direct use in existing gas networks, industrial applications, and as a fuel for transportation (e.g., bioLNG and bioCNG)**.

The primary method of biogas production is **anaerobic digestion**. This process typically uses agricultural biomass, such as straw, manure, by-products from processing waste, food waste, sewage sludge and other waste as substrates[2]. Microorganisms decompose these materials producing biogas, with digestate as a by-product which can be used as fertilizer.

The second method for biogas production is **thermal gasification**[3]. This technique involves gasifying woody biomass and waste (e.g., municipal solid waste) at high temperatures using oxygen and steam to produce synthetic gas (syngas), a mixture of carbon monoxide, hydrogen and CO_2. The syngas is then methanised and purified to yield biomethane. Generally, anaerobic digestion is used for high-moisture waste of non-cellulosic origin (agricultural waste), while gasification is employed for lower moisture waste of cellulosic origin (e.g., wood and municipal solid waste.

Biogas can also be **obtained from landfills**, where it forms as a result of naturally occurring anaerobic digestion.

1.2. WHY BIOMETHANE IS IMPORTANT

Over the next 25 years, Europe is expected to undergo significant transformations in how it sources energy, as the EU's climate goals drive the electrification and decarbonisation of the Member State economies. However, in some sectors, it will be challenging or economically unfeasible to fully replace gaseous fuels with electricity. As a result, the use of alternative fuels will be necessary to achieve the required reductions in carbon emissions.

1. Podgórska, M., Narloch, P. (2022). "Review of Biogas Purification Methods for Biomethane," Rynek Energii https://www.cire.pl/filemanager/Materia%C5%82y%20Problemowe%20(Wies%C5%82aw%20Drozdowski)%20/482477d75573a6c702aac679cc805a20740979a20e-c5becaf4f2d6ce39196714.pdf.

2. Green Gases: Biomethane and Hydrogen in Poland," Forum Energii, www.forum-energii.eu/en/green-gases-biomethane-and-hydrogen-in-poland

3. Ibidem

Among the most promising alternative fuels are hydrogen (in its green, purple and blue forms[4]) and biomethane. Both renewable gases will play crucial roles in replacing[5]:

- Oil in heavy transportation, where electric motors are impractical due to the weight of the batteries.
- Natural gas in district or individual household heating systems.
- Coal and natural gas in the power network, particularly for system balancing through OCGT (Open Cycle Gas Turbines).
- Gray hydrogen[6] in the chemical industry, oil in the petrochemical industry, and coal in the steel industry.

The main advantage of biomethane over natural gas lies in its manageable climate footprint, as a **theoretically inexhaustible resource**. Biomethane production contributes to a circular economy by creating value from waste and reducing emissions associated the decomposition of agricultural or other organic waste. Subsequently, biogas production helps reduce uncontrolled methane emissions from these sources. **The total reduction in greenhouse gases from replacing natural gas with biomethane is approximately 80%**[7].

1.3. PURPOSE AND SCOPE OF THE REPORT

The aim of this report is to assess whether importing biomethane from Ukraine to the EU is feasible and achievable. To determine this feasibility, we explored the following key areas:

— Potential for biomethane production in Ukraine

We based our assessments on available estimates, primarily from the Bioenergy Association of Ukraine (UABIO) and official government documents (Chapter 2). They were supplemented with our analysis of infrastructure constraints in Ukraine, which defined the production ceiling for the most cost-effective biomethane (Chapter 4).

— Cost of producing biomethane in Ukraine

Our analysis utilised UABIO's minimum and maximum cost estimates, which we verified through interviews with industry representatives in Ukraine (Chapter 2).

4. **Green hydrogen** — obtained during electrolysis powered by electricity from renewables;
Purple hydrogen — obtained during electrolysis powered by electricity from a nuclear power plant;
Blue hydrogen — gray hydrogen obtained from natural gas, during the production of which carbon dioxide was captured and stored

5. «Green Gases: Biomethane and Hydrogen in Poland», op.cit.

6. Obtained during steam reforming of natural gas or from coal gasification. Its production is associated with greenhouse gas emissions.

7. Gas for Climate, «The Future Role of Biomethane», https://gasforclimate2050.eu/wp-content/uploads/2023/12/The-future-role-of-biomethane.pdf.

— Internal demand for biomethane in Ukraine

Understanding the domestic demand is crucial to determining if Ukrainian biomethane can be available for export. We analysed the Ukrainian natural gas market, the primary competitor to biomethane, and the business models of currently operating biomethane plants. This analysis was informed by opensource data and interviews with industry representatives (Chapter 2).

— Export potential of Ukrainian biomethane

This core question synthesised analyses of production capacity, domestic market potential, sector stakeholder plans, and infrastructure capabilities. We cross-verified these findings with UABIO data and official government documents to present a comprehensive range of potential estimates (Chapter 2).

— EU demand for imported biomethane

We used the REPowerEU plan, presented by the European Commission in 2022, as a benchmark. This plan's 2030 target for EU biomethane production served as a reference throughout our analysis. We compared the EC's target with current projects and national NECP plans to identify the potential supply gap by 2030 (Chapter 3).

— Economic viability of Ukrainian biomethane in the EU market

This analysis involved comparing the simulated price of Ukrainian biomethane and natural gas in the EU, factoring in the ETS carbon price. Additionally, we considered alternatives like green hydrogen and projected declines in demand for gaseous fuels based on European Commission scenarios (Chapter 3).

— Infrastructure constraints for biomethane production and export

We examined both gas transmission (Ukraine and EU) and distribution infrastructure in Ukraine, analysing different connection types for biomethane plants to the existing distribution and transmission networks (Chapter 4 & Annex 1).

— Regulatory environment for biomethane production and export

An unfavourable regulatory environment can impede technical potentials, which is especially pertinent for nascent technologies like biomethane. We conducted an in-depth analysis of regulations, types of biomethane certification, and biofuel registry processes (Chapter 5).

— EU conditions for biomethane imports from Ukraine

Political will is essential for executing even the best-planned and regulated processes. We analysed political risks and the EU political process to determine if resistance from EU decision-makers could impede biomethane imports from Ukraine (Chapter 3 & 5).

2. EXPORTING BIOMETHANE FROM UKRAINE TO THE EU

2.1. EXISTING BIOMETHANE PROJECTS

The current market for biomethane in Ukraine has evolved through biogas initiatives spearheaded by local agricultural companies who invested in their own biogas production facilities over the past decade[8]. Their investments were driven by motivations such as reducing energy costs, managing waste, generating electricity and heating for their own uses, or even selling excess electricity (produced by co-generation units powered by biogas) to the electricity grid under a feed-in tariff (FiT) or the 'green tariff' support scheme[9]; capitalising on carbon pricing mechanisms such as the Joint Implementation mechanism under the Kyoto Protocol.

There is insufficient support to the domestic biomethane industry

Despite these initiatives, the market segment has struggled to grow due to inadequate price incentives. The current FiT for typical biogas projects results in a substantial payback period of 10 to 12 years. Although new renewable support schemes—such as auction systems, net billing, "green" obligations, direct consumer contracts, and participation in balancing/day-ahead markets—show promise for biogas business development, they are not expected to generate sufficient price levels to make biomethane economically viable in the near term.

Ukraine's first biomethane plants

The first biomethane investment projects emerged in 2022, with GalsAgro producing Ukraine's first commercial biomethane at its Chernihiv region plant in April 2023. The second plant owned by VITAGRO, was operational by early 2024. By July 2024, UABIO reported to the Ministry of Finance that six companies in Ukraine were poised to become biomethane producers with plans to export to the EU[10]. Of these, five aimed to inject biomethane into gas pipelines, while one planned to produce bioLNG for transportation by truck. However, as of September 2024, only the two aforementioned companies have operational biomethane plants, with combined capacity of 6 mcm/year:

- **GalsAgro**: Operates six biogas plants, with one upgraded for biomethane purification. However, it's currently not operational as a biomethane plant due to an unfavourable regulatory environment.
- **VITAGRO**: Operates one greenfield biomethane plant and has another in the project planning stage. On October 1st 2024, VITAGRO injected its first cubic meters of biomethane into the local gas distribution network, where it is consumed locally. The company plans to begin exporting to the EU by the end of 2024 using the mass balance approach.

8. Source: Geletukha, G. «Prospects of biomethane in Ukraine», UABIO, https://www.energy-community.org/dam/jcr:2faa4d31-3eb8-4cc8-a6ff-9b8b322e3c09/S1_4_UABIO_Geletukha.pdf.

9. The «green tariff» for electricity generated by biogas units in Ukraine is 12.39¢/KWh. This tariff is set to expire at the end of 2030 and has not been available for new installations since 1 Jan 2023. Currently, the electricity price for commercial consumers in Ukraine ranges from approximately 11 to 14¢/KWh.

10. «Analysis of the Regulatory Impact of the Draft Order of the Ministry of Finance of Ukraine «On Amendments to Certain Normative-Legal Acts of the Ministry of Finance of Ukraine Regarding Customs Affairs», Ministry of Finance of Ukraine, https://mof.gov.ua/storage/files/%D0%90%D0%A0%D0%92_%D1%84%D1%96%D0%BD%D1%96%D1%882.pdf.

Emerging interest in new biogas investments for export

Large Ukrainian agrobusinesses show significant interest in investing in large-scale biomethane production, with a focus on exporting to the EU. The Ukrainian domestic market for biomethane is expected to become attractive in the medium-term, as natural gas prices, carbon tax regimes and "green" support schemes in Ukraine align more closely with those of the EU. However, the market is likely to be dominated by large domestic players who control their own feedstock and can leverage economies of scale, limiting competition from international players.

Notably, ten large agribusinesses, including the large poultry producer MHP, have indicated that they could launch five additional biomethane projects by the end of 2024, increasing the combined production to 111 mcm/year. Medium-term plans foresee up to 30 plants, with a combined production capacity between 220 and 250 mcm/year. As a result, total exports to the EU could potentially reach approximately 7 bcm/year by 2050 (refer to Section 2.4 and Annex 3 for further details).

2.2. PRODUCTION COSTS

The cost of producing one cubic metre of biomethane is a key factor in determining the economic feasibility and payback period of biomethane projects. This is because biomethane competes with natural gas in end-use, but with higher production costs. The price differential between biomethane and natural gas is a critical determinant of the sector's viability, especially under specific market conditions and support schemes designed to increase biomethane production

The cost of key components

The cost of biomethane production is composed of the following main components[11]:

- **Feedstock costs**: This includes the primary cost of the feedstock and associated logistics, such as collection, transportation, and supply expenses.
- **Capital Expenditure (CAPEX)**: This encompasses the costs for the main and auxiliary equipment on the plant site, facilities for feedstock-to-biogas conversion, biogas-to-biomethane upgrading modules, other necessary equipment, as well as expenses for grid connection and injection.
- **Operating Expenses (OPEX):** These include all other costs required for the continuous operation of a biomethane facility, excluding feedstock costs.

Due to the limited availability of public data on production costs and substantial variations in figures, we reference estimates from UABIO[12] preliminary data from the first two operating biomethane plants in Ukraine, as well as own projections:

11. Birman, J., Burdloff, J., de Peufeilhoux, H., Erbs, G., Feniou, M., & Lucille, P.-L. Geographical Analysis of Biomethane Potential and Costs in Europe in 2050, ENGIE, https://www.engie.com/sites/default/files/assets/documents/2021-07/ENGIE_20210618_Biogas_potential_and_costs_in_2050_report_1.pdf.

12. UABIO, «BIOMETHAVERSE: The second newsletter of the project», https://uabio.org/en/materials/15909/.

- **UABIO estimates**: The most efficient cost of biomethane production in Ukraine is estimated at **€524/tcm** (or approximately **€50/MWh**) in a feasibility study for a large biomethane plant with capacity of approximately **1,140m³/hour**[13].
- **Initial real-life production data**: Interviews with producers indicate that for plants with average capacity of approximately **500m³/hour**, production costs are approximately **€650/tcm** (or approximately **€61/MWh**)[14].
- **Average costs**: These are expected to range between **€750/tcm** and **€850/tcm** (or approximately **€71/MWh** to **€81/MWh**). This range includes smaller-scale production cases, use of externally purchased feedstock[15], and other production technologies.

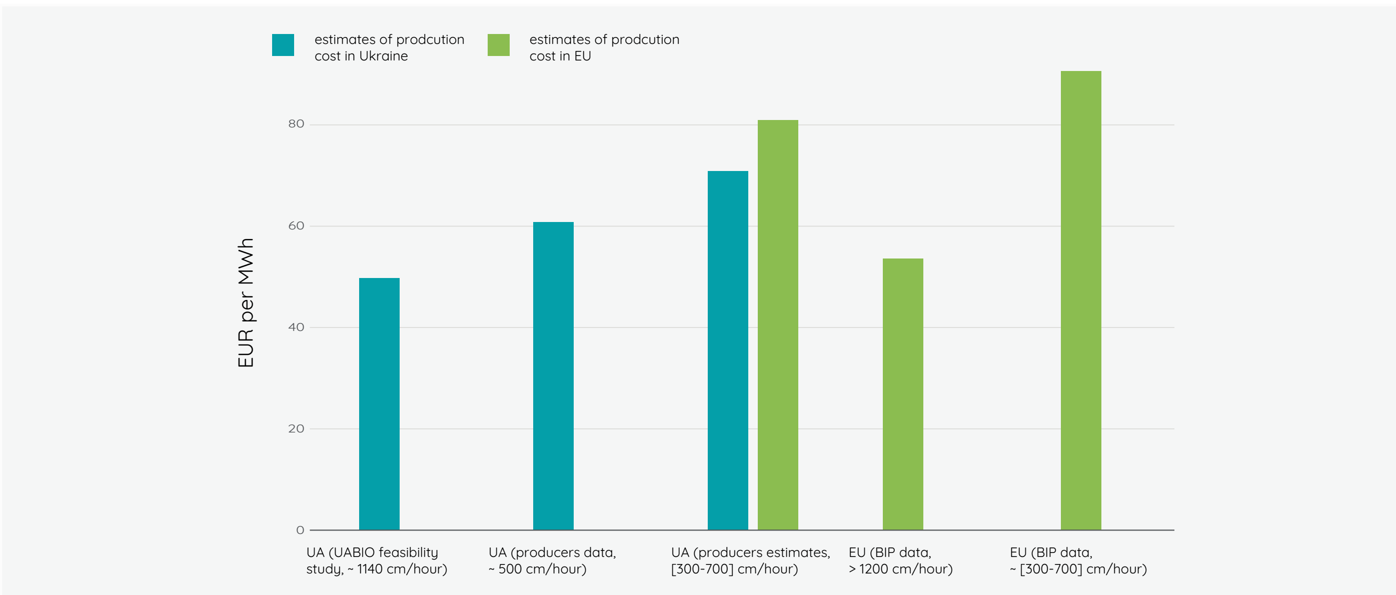
Economy of scale

A useful proxy for estimating biomethane production costs in Ukraine can be drawn from the average production costs of EU biomethane producers, as determined by Task Force 4.2 of the Biomethane Industrial Partnership (BIP) initiative. In 2021, BIP data indicated that production costs ranged from €54/MWh for large-scale producers (with capacities exceeding 1200 m³/hour) and €91/MWh for smaller plants (with capacities between 300 and 780m³/hour)[16].

Additional estimates from the European Biogas Association and ENGIE SA report an average production cost range of €80/MWh, with the most cost-efficient projects averaging between €60/MWh to €66/MWh. ENGIE SA projects that, over the long term, the average levelised cost of energy (LCOE) of biomethane production could drop below €70/MWh due to technological advancements and the benefits of economy of scale.

These Ukrainian and EU data points collectively highlight that economy of scale significantly impacts production costs, with larger plants demonstrating greater cost-efficiency.

Figure 1: The costs range for production of 1 cm of biomethane in Ukraine and EU



Source: UABIO, BIP, Ukrainian companies' production data and estimates

13. Geletukha, G. «Prospects of Biomethane in Ukraine», op.cit.
14. This assumes a scenario where a biomethane producer own its raw materials and can fully leverage the benefits of economy of scale.
15. There are at least five biogas plants in Ukraine, where poultry manure is used in significant quantities in the range from 40 to 460 t/day. It is from 10 to 60% of the used mixtures of substrates at individual stations.
16. https://bip-europe.eu/wp-content/uploads/2024/08/BIP_TF4.2_study.pdf

The cost of feedstock is key

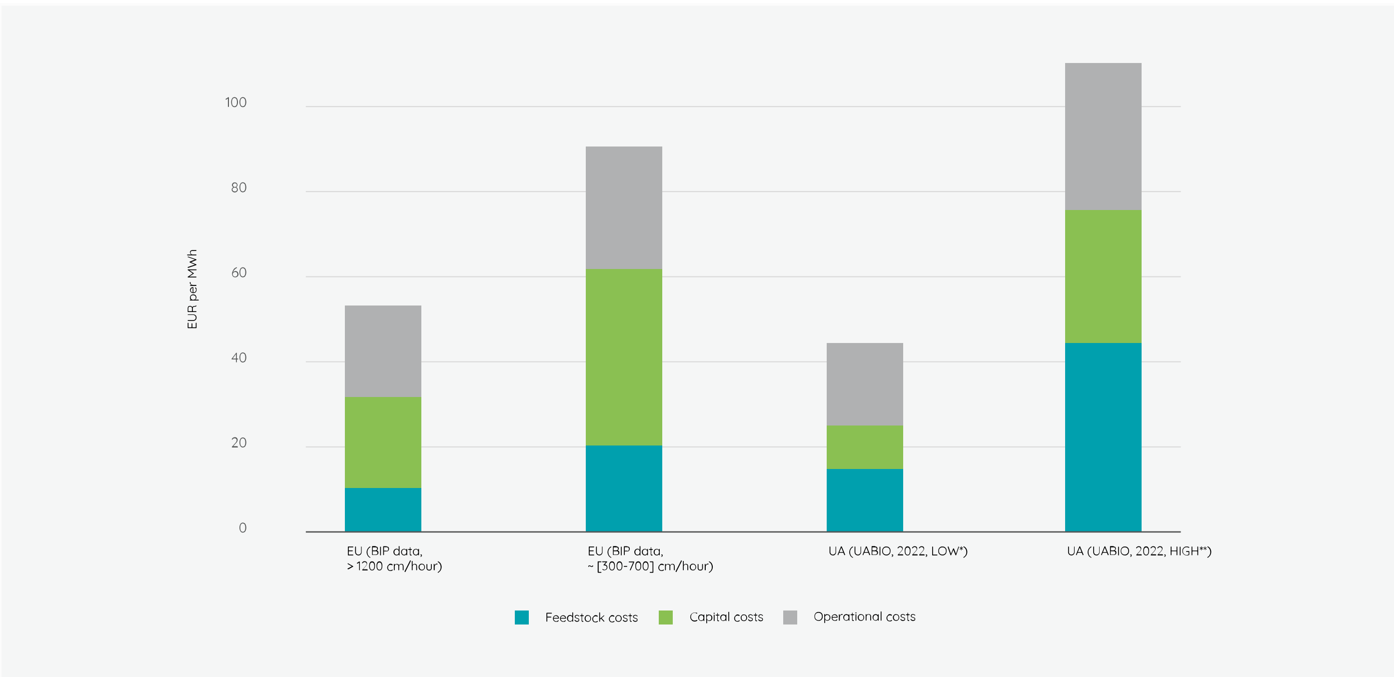
The most significant component influencing the cost of biomethane production is the feedstock. Feedstock costs largely depend on the type of feedstock used, the production approaches, and technologies applied during the biogas production process, which is subsequently purified into biomethane. In Ukraine, common feedstock types for biogas production include livestock manure, sugar beet pulp and maize silage.

The potential for expanding biomethane production includes utilising agricultural crop residues, crops cultivated on degraded, abandoned, or marginal lands, and the practice of growing cover crops (refer to Annex 2 for a detailed breakdown of biogas/biomethane potential by feedstock type). Additionally, production can be expanded through the gasification of non-agricultural biomass types, methanation from hydrogen, and the use of microalgae and other alternative feedstock sources.

The CAPEX advantage for large companies

Economies of scale are particularly evident in capital costs, an advantage especially pertinent in Ukraine. The national agricultural sector is dominated by large, capital-intensive, vertically integrated agrobusinesses. These companies benefit from having all components for biomethane production integrated within their structures, enabling them to potentially achieve lower costs per MWh. This is due to reduced operational and feedstock cost components compared to smaller producers.

Figure 2: Comparative view of estimated costs for EU and Ukraine biomethane plants



* On-site raw materials, own estimate for costs, large plant
** Raw materials at cost of EUR 40 per ton (maize silage), small plant
Source: BIP data for EU, UABIO estimates for Ukraine (2022)

OPEX are a consistent factor

Operating costs for biomethane production, excluding internal energy use, demonstrate limited economies of scale, meaning they decrease at a slower rate compared to capital costs as scale increases. OPEX consistently accounts for approximately 25% of total production costs across all production scenarios. For larger plants, labour and additives represent the most significant cost components. While for smaller plants, labour, pretreatment, and plant maintenance are the largest expense categories.

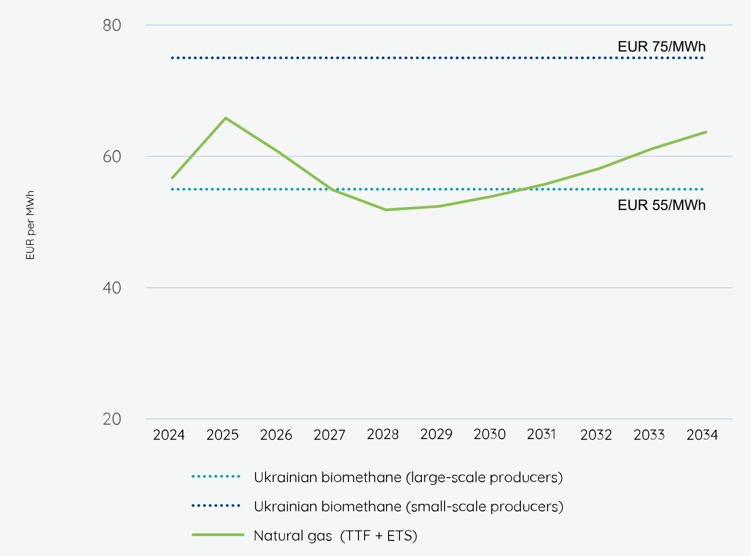
2.3. BIOMETHANE PRICE ESTIMATES

Ukrainian biomethane face challenges to compete with natural gas in domestic market...

The minimum reported production costs[17] for biomethane is approximately **€650/tcm**, which is significantly higher than the current price of natural gas for industrial consumers and public sector entities, estimated at approximately **€435/tcm**[18]. Additionally, there is no national «green premium» for domestic biomethane sales, unlike most EU countries. This lack of incentive mechanism results in very limited space for Ukrainian biomethane. Without EU-aligned support measures, such as , biomethane will remain uncompetitive for consumers in the near future[19].

Therefore, the current economics of biomethane production and the regulatory environment in Ukraine, support an export-oriented market only for Ukrainian biomethane. Having said this, **Ukrainian biomethane is already competitive in the EU market under the EU Emissions Trading Scheme**.

Figure 3: Comparison of reference prices for Ukrainian biomethane in the EU market and forecast of natural gas + ETS price (without transportation costs)



Sources: TTF natural gas prices forecasts from CME Group[20]; for ETS prices (https://www.eeagrants.gov.pt; https://bip-europe.eu; https://www.kobize.pl; https://ember-climate.org/)

17. Obtained during our interviews with GalsAgro and VITAGRO companies.

18. This is the commercial price of natural gas offered by NJSC Naftogaz. The final price of natural gas for household consumers and district heating companies is regulated by the state and kept artificially low at approximately $200 USD/tcm, under the Public Service Order (PSO) subsidy.

19. However, the government is considering introducing support schemes for bio-CNG and bio-LNG in the transport sector, which may emerge as new market segments of the domestic biomethane markets.

20. To estimate the potential long-term price of Ukrainian biomethane on the EU market, we used the latest long-term forecast for the ETS through 2050 as the basis for calculating the ETS premium, assuming an emission factor for natural gas of 0.21tCO_2/MWh. This ETS premium was applied to the TTF forward price up to 2034. The resulting final reference price for biomethane (TTF + ETS premium) was then compared to the average cost-covering price levels for Ukrainian biomethane producers. These cost-covering prices were determined to be approximately €55/MWh for large producers and €75/MWh for small producers, based on the cost data outlined in Section 2.2.

The most efficient Ukrainian biomethane projects, which feature significant production volumes and low-cost, self-supplied feedstock, are currently profitable under the current ETS price (€70/tCO_2). However, further cost reductions are required to remain competitive[21].

It should be emphasized that these projections and calculations of cost-effectiveness indicative and subject to the significant uncertainty surround future gas and ETS emission prices. The key point is that U**krainian biomethane is already within a competitive price range compared to natural gas**. However, **the profitability margin is** thin, making any downward fluctuations in natural gas market prices a substantial risk to the viability of Ukrainian biomethane, **particularly within this decade**.

A carbon price level exceeding €148/tCO_2 would result in all potential Ukrainian biomethane projects, including small-scale projects that rely on external feedstock, being profitable in the EU market. According to a recent UABIO feasibility study, a biomethane project in Ukraine with a capacity of 10 mcm/year, an LCOE of approximately €50/MWh, and a potential peak selling price of €90/MWh in the EU would achieve an attractive payback period of 3.6 years and an Internal Rate of Return (IRR) of 28% (as noted in Section 2.2).

Therefore, the domestic price environment makes the development of domestic biomethane market almost impossible in the nearfuture. As a result, all upcoming production volumes and business cases are directed towards the EU market. A significant increase in domestic biomethane demand would require a comprehensive overhaul of the regulatory framework for the support of the renewable sector, aligned with EU standards.

2.4. PRODUCTION AND EXPORT FORECASTS

Ukraine is one of the most promising countries in Europe for biomethane production, thanks to its well-developed and competitive agriculture sector and vast feedstock resources. Although current production volumes are relatively low – primarily due to regulatory and financial constraints – the prospects for growth in the biomethane sector remain highly promising.

Biomethane production in Ukraine is project to increase from 6 mcm in 2023, to 1 bcm in 2030

By the end of 2024, five companies plan to launch seven new biomethane plants with a combined installed capacity of 111 mcm/year (detailed in Annex 3). In the medium to long term, approximately ten agrobusinesses are considering entry into the biomethane market, with plans to construct over 30 biomethane plants with a total capacity of approximately 220 mcm/year. UABIO's medium-term projection anticipates biomethane production reaching 250 mcm/year by 2027, and up to 1 bcm in 2030 (refer to Section 3.4).

21. The profitability analysis above assumes that the price of natural gas follows a predictable trajectory based on current futures contracts. Ukrainian biomethane stands to gain additional competitiveness if unexpected price fluctuations occur, similar to those experienced during the 2021/22 energy crisis. However, it is important to note that the price of biomethane, depending on contract terms, may also rise in response to such market shocks.

The full production potential for Ukrainian biomethane is estimated to range of 5.9 bcm/year to 21.8 bcm/year by 2050. The lower estimate, comprises:

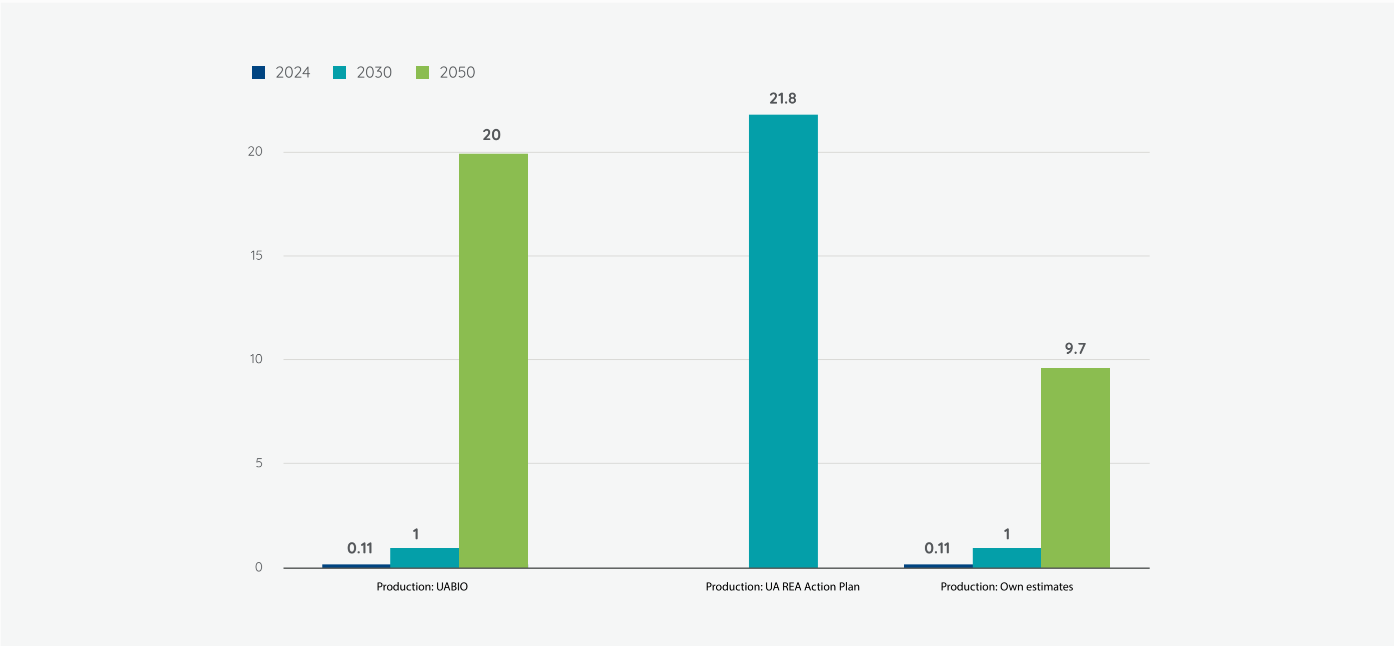
1. 30-35% of the potential from available primary field-generated agroresidues — 3.7 bcm/year[22];
2. 100% of all available manure, secondary waste from food and processing industries, landfill organic waste, sewage sludge — 2.2 bcm/year.

The upper estimate of 21.8 bcm/year includes additional theoretical potentials:

3. Cultivated crops (maise silage) on 1 million hectares — 3.8 bcm/year (not currently possible but feasible, given the availability of abandoned or degraded land).
4. Cover crops — 9.8 bcm/year.
5. Thermochemical gasification of woody biomass - 1 bcm/year.
6. Increased agricultural productivity — 1.5 bcm/year.

The balanced estimate we propose includes a potential of 10 bcm/year and comprises components #1, #2, and select combinations of #3 through #6 mentioned above. This estimate ensures that the total potential does not exceed the aggregate sum of components #1, #2, #3.

Figure 4: Biomethane production potential in Ukraine [bcm/y]



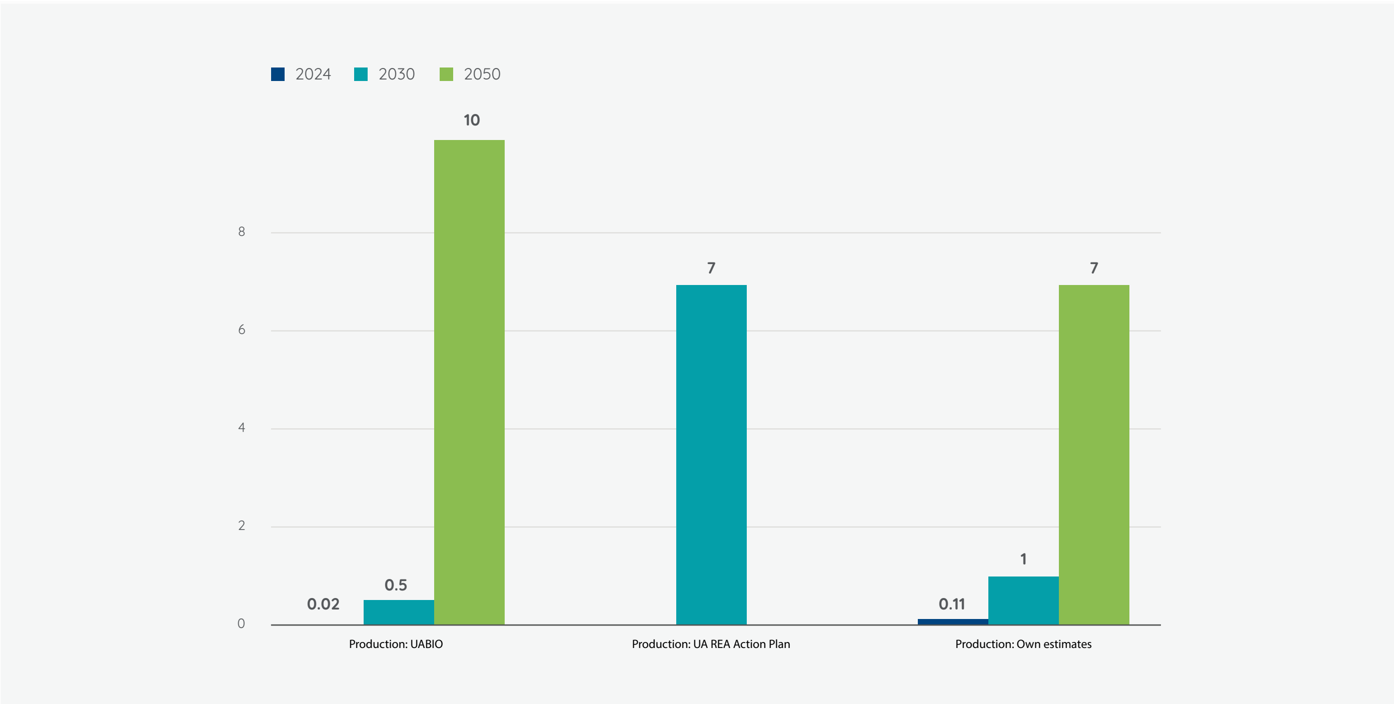
In addition to the theoretical potential sources previously mentioned, there are other unspecified sources of biomethane, such as methanation process using renewable external H_2 and CO_2 as by-products from biogas purification, which could contribute an additional 10 bcm/year of biomethane, and biomethane derived from algae, estimated at 0.5 bcm/year). These sourced are not currently included in our assessment due to the limited near-term deployment prospects compared to other components #3 — #6.

22. This figure represents the sustainable potential of agroresidues. Removing 100% of all agroresidues from fields for energy production is unsustainable and can have negative effects on agricultural practices and related economic sectors. Therefore, there is a rate of technical removal of agroresidues that is suitable for energy utilization without adversely impacting the agricultural sector. The sustainable potential of agroresidues in Ukraine is estimated at 7-11.2 Mtoe (or 8-12.5 bcm in biomethane equivalent). From this, approximately 30-35% is considered viable for biomethane production, equating to an average of 3.7 bcm/year as previously mentioned. The remaining 65-70% of agroresidues is expected to be utilised in other sectors and through different technologies, such as direct combustion as solid biomass, pelletising, gasification, pyrolysis, torrefaction, biogas production without upgrading to biomethane, and liquid biofuels.

The maximum potential estimate of 21.8 bcm/year is comparable to the total volume of domestic natural gas production in Ukraine, which stood at 18.7 bcm in 2023 (refer to Annex 2 for further details)[23].However, there is considerable uncertainty surrounding the future development of Ukrainian biomethane production and export. This uncertainty is influenced by various factors, including the status of the war, domestic demand, and EU import demand, making demand forecasts rough scenario-based.

The recently adopted Renewable Energy Development Plan aligns with UABIO's 2050 estimate of 21.8 bcm/year for the total biomethane production potential in Ukraine. More notably, the projected volume of potential biomethane exports to the EU by 2050 is approximately 7 bcm/year (equivalent to 20% of the EU's 35 bcm/year demand), which is 3 bcm/year lower than UABIO's projection.

Figure 5: Biomethane export from Ukraine to the EU forecasts [bcm/year]



In our opinion, by 2030, the conditions necessary for substantial internal consumption of biomethane in Ukraine are unlikely to develop, meaning that all production will be directed toward export. Beyond 2030, further growth in biomethane production is expected to be targeted not only at European markets, but also at the domestic market. We therefore agree with the Ukrainian government's forecast, which projects approximately 7 bcm/year of biomethane exports to the EU, out of an total production of approximately 10 bcm/year.

23. Ibidem

2.5. IMPACT OF WAR

The full-scale Russian invasion of Ukraine has brought renewed attention to Ukrainian's biomethane sector as a potential solution to the country's ailing agri-food industry; it has also increased investment risks and stalled the development of necessary policies and regulations to stimulate growth. A significant challenge has been the lack of coordination among key ministries – including the Ministry of Agriculture, the Ministry of Energy, the Ministry of Infrastructure Development, and the Ministry of Environment – as well as insufficient prioritisation in the Ukrainian Parliament, delaying essential legislative changes to enable biomethane exports to the EU.

The ongoing large-scale war, with no clear end in sight, raises additional concerns about the distribution of production facilities across the country. While large-scale biomethane plants could leverage substantial economies of scale, Ukraine's entire territory remains vulnerable to Russian missile and drone attacks. This situation underscores the need for a more decentralised development approach, favouring small and medium-sized plants to mitigate the risk of significant and concentrated losses. Most raw materials for biomethane production are located in regions that have been heavily impacted by the conflict, such as central, south-eastern and northern Ukraine. These areas host the largest concentrations of livestock, crop cultivation (e.g., maize, wheat and sunflower), and the most productive agriculture lands with climates best suited for cover crops.

Another war-related issue cited by surveyed companies is the increased cost of the logistics of raw material, especially from the de-occupied regions. This has shifted business models for existing and prospective biomethane projects toward "farm-level" facilities that minimise reliance on feedstock supply from external agricultural producers.

The war has also undermined many other aspects of the biomethane production business model, including:

- **Attracting foreign capital**: Investment now requires significant risk coverage through war insurance or guarantees, or comes with a higher cost of capital.
- **Availability of Skilled Personnel**: Mobilization has resulted in a shortage of skilled workers, suggesting that biomethane projects might need to be classified as critical to national energy infrastructure, similar to other energy companies.
- **Risk of Power Supply and Grid Injection Interruptions**: Missile and drone attacks on power and gas storage and transmission infrastructure pose a significant risk. Although biogas projects are partially self-sufficient in power and heat through their cogeneration units, they remain vulnerable to targeted attacks.

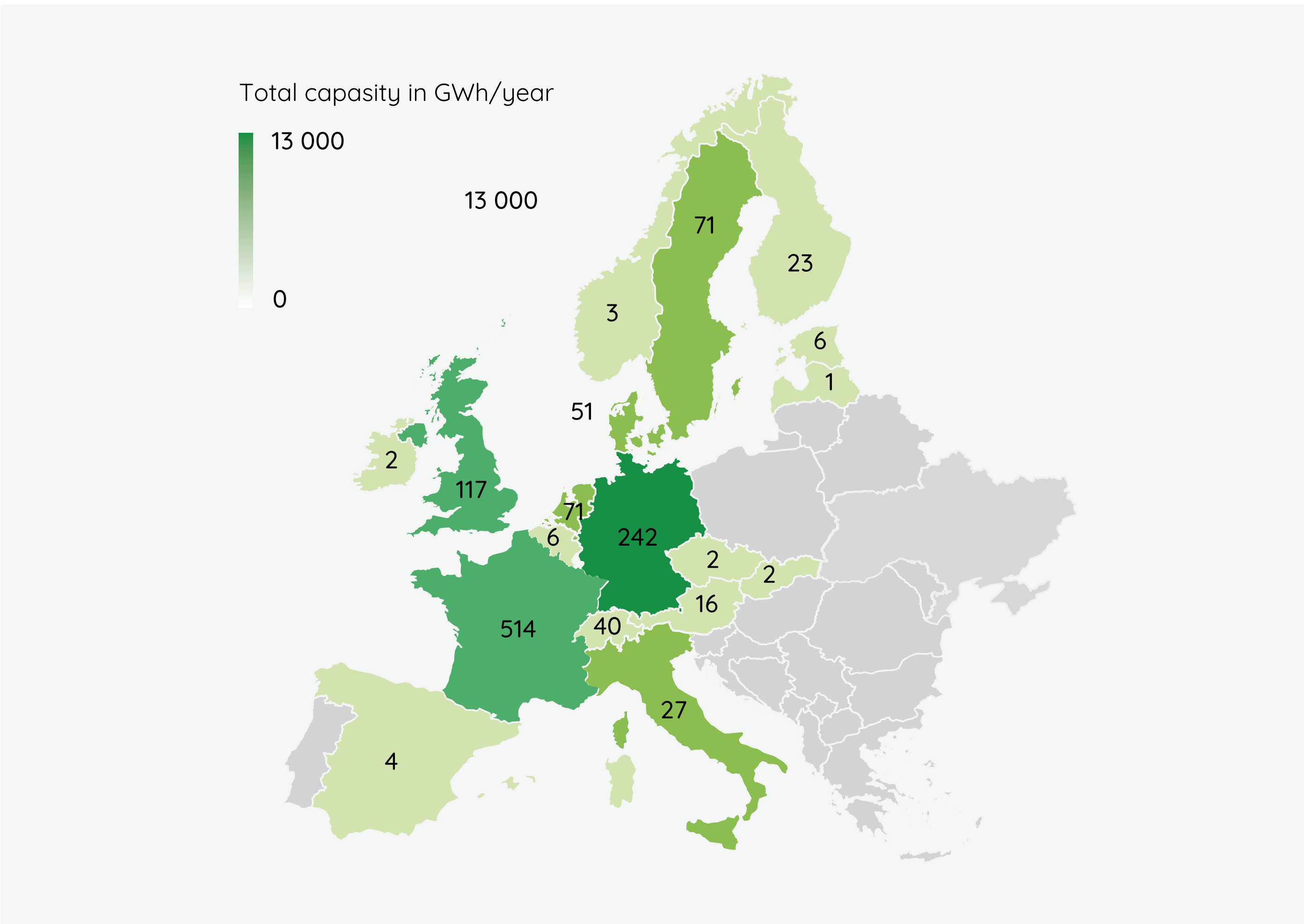
3. POTENTIAL DEMAND AND CHALLENGES IN THE EU

3.1. EUROPEAN BIOMETHANE PRODUCTION

Production of biomethane in the EU and specific Member States

The EU is the world's largest producer of biomethane. In 2022, EU produced around 3.5 bcm of biomethane[24]. Biomethane production in Europe has increased sixfold in the last decade and by 18% by 2021. The number of biomethane plants is growing, with more than 1,300 active plants in the EU, Switzerland, Norway and the United Kingdom in 2022. Most biomethane production facilities (number of plants) and capacities (mcm produced) are located in France (41%) and Germany (22%)[25].

Figure 6: Number of biomethane facilities in Europe



24. European Biogas Association, «EBA Statistical Report 2023 Launch Webinar», 5 December 2023, https://www.europeanbiogas.eu/wp-content/uploads/2023/12/EBA-Statistical-Report-2023-Launch-webinar.pdf.

25. Morino, E. M., Roth, A., Peterse, J. «Market State and Trends in Renewable and Low-Carbon Gases in Europe», Gas for Climate, December 2023, https://gasforclimate2050.eu/wp-content/uploads/2023/12/GfC_MarketStateTrends_2023.pdf.
For map see also: "European Biomethane Map: Infrastructure for Biomethane Production 2023," GIE and EBA, https://www.gie.eu/wp-content/uploads/filr/8394/GIE_EBA_BIO_2023_A0_FULL_204_wlinks.pdf.

Although the European Union is arguably the most advanced biogas and biomethane market in the world, it's still at a very early stage of development[26], and the situation varies considerably between Member States. There are countries where the biomethane market is clearly developing and targets are set for the share of biogas in total gas consumption by 2030. This is the case of Denmark (the ambition is that biogas, mainly biomethane, should cover 100% of Danish gas consumption in 2030[27]). and France (according to the French NECP, biogas should account for 15% of gas in the French grid[28], and according to the French TSOs, renewable and low carbon gases should account for 20% of gas consumption in 2030[29]). Others' support its use in specific sectors (e.g., Germany in the power generation sector, or Italy in the transport sector)[30]. Finally, there are countries where biomethane production has not yet begun (e.g., Poland or Spain).

Sectoral data on biomethane consumption in the EU is also inconsistent. According to the European Biogas Association (EBA), about 30% of the use is unknown, 22% in the building sector, 19% in transport, 15% in energy and 14% in industry. The use of biomethane in the individual Member States also varies considerably — in Germany it is mainly used for electricity or heat generation, while in the Scandinavian countries it is used in the transport sector. In 2021, Sweden alone accounted for more than 67% of EU biomethane consumption in the transport sector.

Limited availability of comparable, aggregated data for the EU

The challenge in analysing the biomethane market in the EU is the limited availability of up-to-date, aggregated data for all EU countries. There are no easily comparable datasets for different gas markets in the EU that would allow a good comparison of the demand for natural gas and also decarbonised gases, etc.

EU-produced biomethane meets 1% of EU's demand for gas in 2022

Natural gas consumption in the EU in 2022 was 362.6 bcm[31], while biomethane production was at 3.5 bcm[32] which could cover about 1% of the annual natural gas demand. These shares are expected to increase with the growth of biomethane production and the recent decline in natural gas demand in the EU, which is expected to increase only slightly in the near future (by a few percent in 2024).

26. «Special Section: Biogas and Biomethane», International Energy Agency, https://www.iea.org/reports/renewables-2023/special-section-biogas-and-biomethane.

27. Final update of Dan mark's National Energy and Climate Plan for the period 2021-2030, https://commission.europa.eu/document/download/13353c72-43bc-486e-bc82-9e8ea7588734_en?filename=DK_FINAL%20UPDATED%20NECP%202021-2030%20%28English%29.pdf.

28. France's Integrated Energy and Climate Plan, https://commission.europa.eu/document/download/ab4e488b-2ae9-477f-b509-bbc194154a30_en?filename=FRANCE%20%E2%80%93%20FINAL%20UPDATED%20NECP%202021-2030%20%28English%29.pdf.

29. E. Wu, Montel News, «France's greener gas output to rise 5-fold by 2030 – TSOs», https://montelnews.com/news/6a480296-d0d1-4e0b-8d09-d2eee2d3c611/frances-greener-gas-output-to-rise-5-fold-by-2030-tsos

30. Sesini, M., Cretì, A., Massol, O. «Unlocking European Biogas and Biomethane: Policy Insights from Comparative Analysis», Renewable and Sustainable Energy Reviews, Vol. 199, 2024, Article 114521. https://doi.org/10.1016/j.rser.2024.114521.

31. Eurostat, «Supply, Transformation and Consumption of Gas», https://ec.europa.eu/eurostat/databrowser/view/nrg_cb_gas__custom_12034212/default/table?lang=en.

32. Natural gas demand in the EU in 2023 was 330 bcm. There is still no reliable data for biomethane production in the EU in 2023.

Biomethane production in the EU grows slowly and is not on path to meet the target

According to estimates from biogas and biomethane industry associations such as the EBA and Gas for Climate, EU countries have the potential to produce up to 41 bcm/year of biomethane by 2030 (considering the availability of sustainable feedstock).

The highest biomethane production potential is in Germany (8 bcm), France (approximately 7 bcm), Italy (approximately 6 bcm), Spain (4 bcm) and Poland (approximately 3 bcm)[33]. According to the same source, EU biomethane production could reach more than 150 bcm by 2050 (40% of current natural gas consumption).

The European Commission's plans, expressed in RePowerEU, call for 35 bcm of the estimated 41 bcm potential to be tapped by 2030. However, according to the already published National Energy and Climate Plans (NECP) of the EU Member States - roadmaps for the energy transition of national economies - biomethane production in the EU could only reach about 20 bcm by 2030[34].

Even less optimistic conclusions can be drawn from an analysis of past and planned investments. According to EBA estimates, current investment trends imply an additional production capacity of approximately 6.3 bcm/year of biomethane production, resulting in a capacity of around 11.5 bcm in the EU by 2030[35].

Depending on the pace of development of the industry, the **gap between the European Commission's target and actual biomethane production in 2030 could range from 15 to 23.5 bcm/year**.

3.2. POTENTIAL EUROPEAN DEMAND FOR BIOMETHANE IMPORTS

Domestic biomethane supply's slow growth

All biomethane the EU currently consumes is domestically produced[36]. AAs highlighted above, the EU is likely to miss its 35 bcm biomethane production target by more than 15 bcm. In principle, biomethane imports could contribute to closing the corresponding gap, avoiding a higher reliance on natural gas imports[37].

33. Alberici, Sacha, Wouter Grimme, and Gemma Toop, «Biomethane Production Potentials in the EU: Feasibility of REPowerEU 2030 Targets, Production Potentials in the Member States and Outlook to 2050», Gas for Climate, July 2022, https://www.europeanbiogas.eu/wp-content/uploads/2022/07/GfC_national-biomethane-potentials_070722.pdf.

34. Morino, E. M., Roth, A., Peterse, J., Market State and Trends in Renewable and Low-Carbon Gases in Europe, Gas for Climate, December 2023, https://gasforclimate2050.eu/wp-content/uploads/2023/12/GfC_MarketStateTrends_2023.pdf.

35. https://gasforclimate2050.eu/wp-content/uploads/2023/12/GfC_MarketStateTrends_2023.pdf

36. Ibidem.

37. France and Denmark, target a specific percentage of gas demand being covered by biomethane by 2030 (i.e., 10 and 100 % natural gas substitution, respectively)..

High uncertainty regarding the demand of biomethane

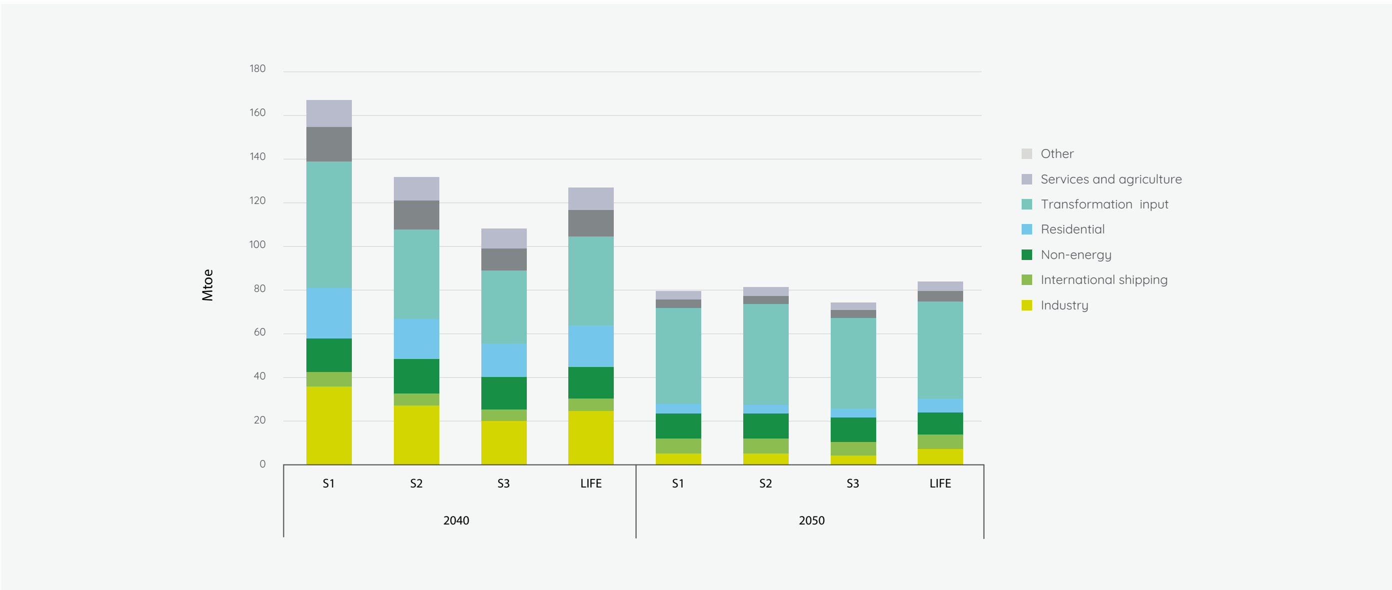
Europe's future biomethane demand is highly uncertain[38]. It will be largely be determined by the cost-competitiveness of biomethane compared to other low or zero-emission energy sources, for a broad range of applications.

Biomethane in competition with natural gas

During the transition period, biomethane will compete mostly with natural gas for existing gas consumers (e.g., heating and industry). A hypothetical upper limit is the current demand for natural gas, which is about 330 bcm in 2023. According to EU policy and current trends, this demand is expected to decrease significantly.

The European Commission's paper on 2040 climate targets forecasts that, depending on the transition scenario, the total demand for gaseous fuels in 2040 will be between 110 and 170 bcm/ year[39].

Figure 7: Energy demand for gaseous fuels



Source: Fig 30 of the IA

Technically, it is feasible to meet some of the current demand for natural gas with methane produced from green electricity. However, the cost of this complex process – which involves hydrogen electrolysis and methanation using captured carbon dioxide – currently exceeds that of biomethane. With a levelized cost of electricity of €50/MWh and some degression in equipment costs, it is estimated that the biomethane from methanation would cost approximately €120/MWhMWh[40].

38. The fact that the recent European Commission modelling exercises do not provide scenarios for future energy balances and existing reference modelling does not distinguish biomethane underlines the high degree of uncertainty.

39. European Commission, «Commission Staff Working Document: Impact Assessment Report Part 1 Accompanying the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Securing our future Europe's 2040 climate target and path to climate neutrality by 2050 building a sustainable, just and prosperous society», SWD/2024/63 final, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52024SC0063.

40. Gorre, J., Ortloff, F., van Leeuwen, C., «Production costs for synthetic methane in 2030 and 2050 of an optimized Power-to-Gas plant with intermediate hydrogen storage»," Applied Energy, Volume 253, 2019, 113594, ISSN 0306-2619, https://doi.org/10.1016/j.apenergy.2019.113594.

The remaining gas demand, split between biomethane and natural gas, will be a function of carbon prices and the price-advantage of natural gas. If carbon prices are high enough[41] this would encourage the more expensively produced biomethane to be consumed.

Biomethane in competition with hydrogen

Repurposing existing gas distribution grids to hydrogen is unlikely to be competitive[42]. Hence, **biomethane could, in selected cases, be a high-OPEX, low-CAPEX clean fuel which enables the phase out of natural gas using existing infrastructures and appliances, softening the transition to full electric or district heating**. However, hydrogen may continue play a significant role as a fuel in industry and a power-sector. For example, direct iron reduction can be conducted with methane or hydrogen.

Therefore, the future of biomethane demand in corresponding sectors will depend on its competitiveness with hydrogen. Current estimates show an advantage for biomethane on a per MWh basis, with the green hydrogen index indicating a price of €150/MWh to €200/MWh[43]. But it is expected that hydrogen might have more cost-degression potential than biomethane[44]. While uncertainties on the cost developments of both technologies remain too large to establish their future balance - it seems intuitive that both technologies have increasing marginal cost (hydrogen gets expensive as soon as it cannot be produced with excess renewables electricity; while biomethane gets expensive when it requires feedstock that competes with other uses) and that hence none of both will completely dominate the European market for 'energy-molecules'.

Biomethane demand in the electricity system

Electricity is expected to become the dominant energy source in the coming decades. In power generation, gaseous fuels are likely to shift from a primary energy source – currently at 539 TWh of gas input - to serving as a backup and flexibility fuel. By the 2030s, the majority of electricity will be produced from zero-marginal cost technologies such as wind, solar and nuclear. Flexible power sources will only become essential during periods of high demand and low wind and solar output.

According to the EU's projections (2024, Fig. 19) the volume of fossil-based power generation will drop from 1,052 TWh in 2021 to 399 TWh by 2030, and further fall to 177 TWh by 2040 under a scenario aligned with a 90% emissions reduction target. If all fossil generation were gas-based, approximately 80 bcm would still be required in 2030[45].

41. Because of ambitious domestic decarbonization targets, a robust economic development in the EU, and high mitigation cost in other sectors.

42. Rosenow, J., «Is heating homes with hydrogen all but a pipe dream? An evidence review», Joule, Volume 6, Issue 10, 2022, Pages 2225-2228, ISSN 2542-4351, https://doi.org/10.1016/j.joule.2022.08.015.

43. «HyDex & HyDexPLUS – Hydrogen Cost Indices», E-Bridge Consulting, https://e-bridge.de/kompetenzen/wasserstoff/h2index/.

44. 1.3-4.5/kg H2 = €70-€200/MWh (International Energy Agency, «Global Hydrogen Review 2022», Executive Summary, https://www.iea.org/reports/global-hydrogen-review-2022/executive-summary); €55/MWh — €110/MWh (European Biogas Association, «New Study Shows That Monetary Value of Whole-System Benefits of Biomethane Far Outweighs Current Production Costs», https://www.europeanbiogas.eu/new-study-shows-that-monetary-value-of-whole-system-benefits-of-biomethane-far-outweighs-current-production-costs).

45. European Commission, "Commission Staff Working Document Impact Assessment Report Part 3 Accompanying the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Securing our Future - Europe's 2040 Climate Target and Path to Climate Neutrality by 2050," SWD(2024) 64 final, https://eur-lex.europa.eu/resource.html?uri=cellar:6c154426-c5a6-11ee-95d9-01aa75ed71a1.0001.02/DOC_3&format=PDF

Biomethane can play a role in meeting this demand, but it will face competition from other solutions such as batteries for the intraday seasonality, hydrogen that utilises surplus renewable electricity in high production and low demand periods, natural gas with carbon capture storage (CCS), and localised biogas-to-electricity generation that does not require purification or integration into gas networks.

Therefore, the niche demand for biomethane is unlikely to be extensive and could even shrink towards 2050, unless biomethane, combined with CCS becomes a cost-competitive carbon-negative source of electricity.

Conclusion

There is no universally accepted projection of the future demand of biomethane. The EU's domestic production targets of 20 bcm in 2030 according to national targets, and 35 bcm under the RePowerEU targets, could easily be absorbed by the RePowerEU induced gas demand of 165 bcm. By 2040, even under a 90% decarbonization scenario, the demand for gaseous fuels is projected to be approximately 120 bcm. The share of biomethane in the EU's gas consumption mix, compared to other gases, will be determined by their relative economic as well as political choices.

While these volumes could theoretically be met through domestic production, the option of importing cost-effective biomethane is likely to be considered. Therefore, if Ukraine[46] were able to export certified biomethane at competitive prices with abated natural gas, it could secure a significant market share in the EU.

3.3. COST-BENEFIT ANALYSIS

Greenhouse gases (GHG) emission reduction is key to the competitive advantage of biomethane over natural gas.

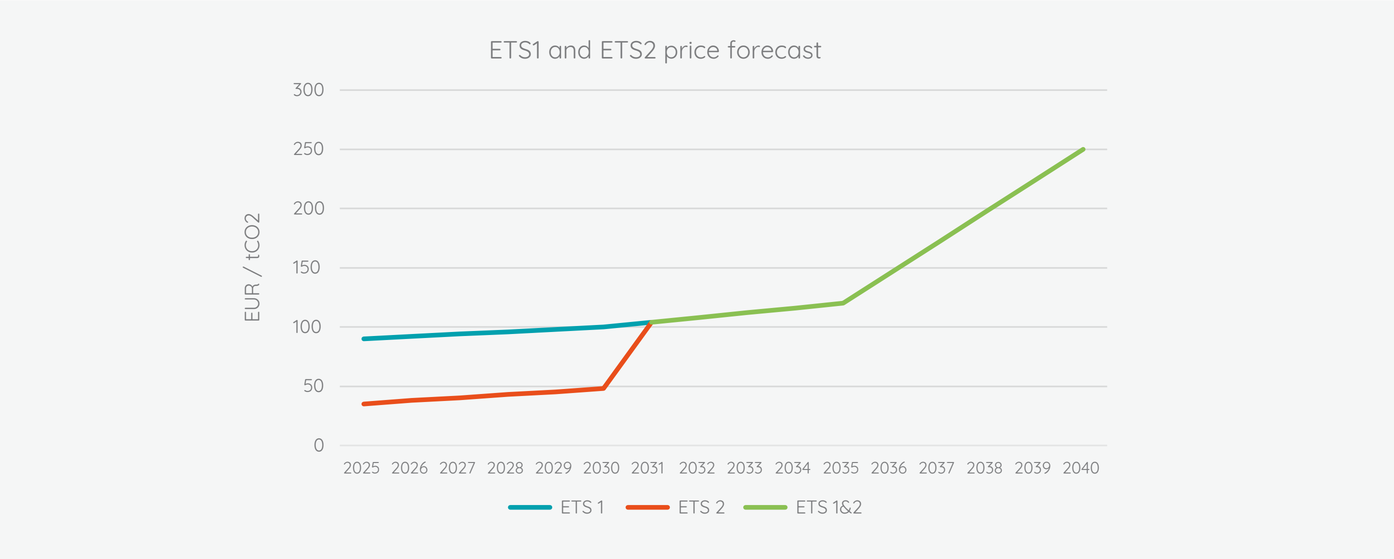
Thanks to the EU ETS and the growing demand for renewable energy sources, Ukrainian biomethane is already positioned to find demand in the EU market. Anticipated increases in the price of emission allowances and the planned introduction of a second emission trading system for transport and heating (ETS2) is expected to further increase the demand and profitability of biomethane projects in Ukraine.

In 2024, the market price for ETS allowances fluctuated between €50/t CO_2-eq and €80/t CO_2-eq. According to European Commission projections, this price could rise to €90/t CO_2-eq by 2025 and €100/t CO_2-eq by 2030. After 2040, the ETS price could exceed €200/t CO_2-eq[47].

46. E.g., Ukraine is exclusively considered in the context of biomethane: European Commission, «Biomethane», https://energy.ec.europa.eu/topics/renewable-energy/bioenergy/biomethane_en.

47. EC Impact Assessment, op.cit.

Figure 8: ETS prices forecasts



Source: European Commission, Impact Assessment Report, Accompanying the document Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions

An EU ETS price premium is a key for the long-term sustainability of the Ukrainian biomethane industry.

Based on the European Commission's projections for the EU ETS price, it is possible to estimate the potential revenue that Ukrainian biomethane producers could generate by exporting excess biomethane to the EU market, compared to domestic trade. By considering the production forecast and potential physical export volumes from the «Exports [Producers / UABIO]» scenario (outlined in Section 2.2), and calculating reference prices using the TTF forward curve and ETS prices from the ETS #1 and #2 scenario, we can project that export revenues could reach approximately €0,6 billion by 2030, and €10,5 billion by 2050, assuming full utilisation of the production potential in Ukraine.

Table 1: Estimated export revenues for Ukrainian biomethane

	Unit	2025	2030	2050
Export volumes	bcm	0,12	1,00	7,00
Export price (TTF + ETS 1&2 scenario)	EUR per tcm	694,7	568,6	1499,5
Export revenues	EUR bn	0,08	0,57	10,50

Source: UABIO / producers estimates, TTF natural gas prices forecast from CME Group[48], the Commission ETS price scenarios.

48. CME Group, op.cit.

The main uncertainties in this forecast are (i) estimating the proportion of biomethane for export to the EU and (ii) the level of ETS or other premiums applied to natural gas price over the long term.

3.4. POLITICAL RISKS

The greatest risks to Ukrainian biomethane exports to the EU steam from internal challenges within the Union, including structural problems in the EU economy, shifting public sentiment, and concerns about the nature and cost of the energy transition.

Concerns over competitiveness of the EU economy

One of the major challenges facing the EU's economic competitiveness is the rise in energy prices, which disproportionally impacts energy-intensive industries and lower-income households[49]. With a stronger focus on competitiveness and affordability, certain climate instruments, such as carbon pricing and renewable energy support, may be deprioritised, at least temporarily. Consequently, the willingness to pay a premium for imported biomethane could be limited, especially if it cannot be positioned as a cost-effective means of reducing unavoidable EU mitigation expenses.

Public perception of biomethane imports

The public perception of biomethane imports from Ukraine will be critical for enabling a supportive EU policy framework. Several risks could affect this perception:

- **Environmental Concerns**: Environmental groups may question the sustainability of Ukrainian biomethane production and the impact of such imports on the credibility of existing European sustainability instruments. Even if Ukrainian biomethane is fully sustainable, it may be perceived as indirectly facilitating «foreign emission reductions», potentially undermining domestic EU mitigation efforts. This perception could be mitigated by Ukraine maintaining and implementing an ambitious Nationally Determined Contribution (NDC).
- **Certification Integrity**: The reliability of the certification system is another significant risk. If something were to create doubts about the accuracy of Ukraine's biomethane certification — such as issuing more certificates than the amount of sustainable biomethane produced — it could jeopardize EU imports and pose risks to compliant market participants. Strong governance and enforcement of the certification process is essential to attract and reassure investors.

49. Zettelmeyer, J., Tagliapietra, S., Zachmann, G., EU competitiveness challenges during the green transition: Briefing to the Eurogroup, January 15, 2024, Bruegel, https://www.bruegel.org/system/files/2024-01/Bruegel_Eurogroup_Jan15.pdf.

The risk of EU protectionism

Parts of the EU agricultural sector may view biomethane imports as competition or as a precursor to further market entry by the competitive Ukrainian agricultural sector. This risk is compounded by growing discontent over the displacement of certain EU products by Ukrainian ones (e.g., grain[50] and cement[51]). Growing resentment among EU producer groups can fuel anti-enlargement sentiment and bolster support for protectionist policies within the EU and Member States.

To support sound policies and counter potential disinformation within the EU, a thorough and iterative cost-benefit analysis should be conducted as the biomethane sector develops.

50. France 24, EU to shield farmers threatened by Ukraine imports, January 31, 2024, https://www.france24.com/en/live-news/20240131-eu-to-shield-farmers-threatened-by-ukraine-farm-imports.

51. Piotr Maciążek, «Poland is flooded with Ukrainian 'dirty cement'. Ukrainians do not need to invest in 'green cement' and increased exports by 1500%», W Zielonej Strefie, April 17, 2024, https://strefainwestorow.pl/w-zielonej-strefie/srodowisko/brudny-cement-ukraina.

4. INFRASTRUCTURE

4.1. INFRASTRUCTURAL REQUIREMENTS FOR BIOMETHANE

Biomethane can be distributed and transported using various methods, including through pipelines - both dedicated biomethane or biogas pipelines and existing natural gas pipelines. It can also be transported by road or sea in compressed (bioCNG) or liquefied (bioLNG) forms[52]. The choice of transportation method depends on the available infrastructure, the distance between the production site and the point of consumption, and certification requirements.

Dedicated biomethane pipelines provide consumers with assurance of the product's specific composition. However, due to the limited quantities of biomethane, the construction of large-diameter pipelines over long distances (capable of transporting more than 10 bcm/year per UTG string) can be difficult to justify at this stage.

Pipelines originally designed for natural gas allow biomethane transport over longer distances. Importantly, existing natural gas infrastructure is biomethane-compatible, meaning significant or additional investments are often unnecessary. This compatibility ensures that the potential for biomethane transport and storage is almost unrestricted, as existing gas networks can serve as large storage and balancing facilities due to their capacity and operational function.

Quality standards and regulations are key to utilising the existing gas infrastructure

The utilisation of existing infrastructure hinges on access and regulatory compliance related to transmission and distribution, including compliance to specific quality standards (e.g., gas composition) (discussed in Chapter 5). Biomethane transported through these networks can be directly substitute for natural gas by the end users connected to that network.

Road and maritime transport options

When pipelines are not available, biomethane can be transported by road or sea in compressed or liquefied form. However, due to the technical requirements and associated costs (primarily from compression and liquefaction processes), these methods are not cost-effective over the long term when compared to pipeline transport (road transport becomes less competitive over long distances, and maritime transport is less favourable for short and medium distances).

An advantage of bioLNG, is the existing LNG transport infrastructure, such as road and port terminals, which can be utilised with appropriate access regulations. However, LNG transport requires specific conditions and high technical

52. Krich, K., Augenstein, D., Batmale, JP., Benemann, J., Rutledge, B., Salour, D. Biomethane from Dairy Waste: A Sourcebook for the Production and Use of Renewable Natural Gas in California, Chapter 1, CIEE, UC Berkeley, 2005.

standards that would also apply to bioLNG. BioLNG should be used relatively soon after production due to potential losses over time, making it less optimal than pipeline-based transport.

Choice of transport method depends on the end consumer

The method of transporting biomethane will also depend on its intended end use. If biomethane is to replace natural gas, then utilising existing natural gas or LNG distribution networks would be the obvious choice. However, for new applications, such as in the transportation sector, other methods will need to be considered.

In the case of Ukraine and potential biomethane exports to the EU, the most technically straightforward method would be to use the existing, extensive natural gas network and cross-border connections with Poland, Slovakia, Hungary and Romania, followed by transmission through these countries' networks.

4.2. ASSESSMENT OF EXISTING UKRAINIAN INFRASTRUCTURE

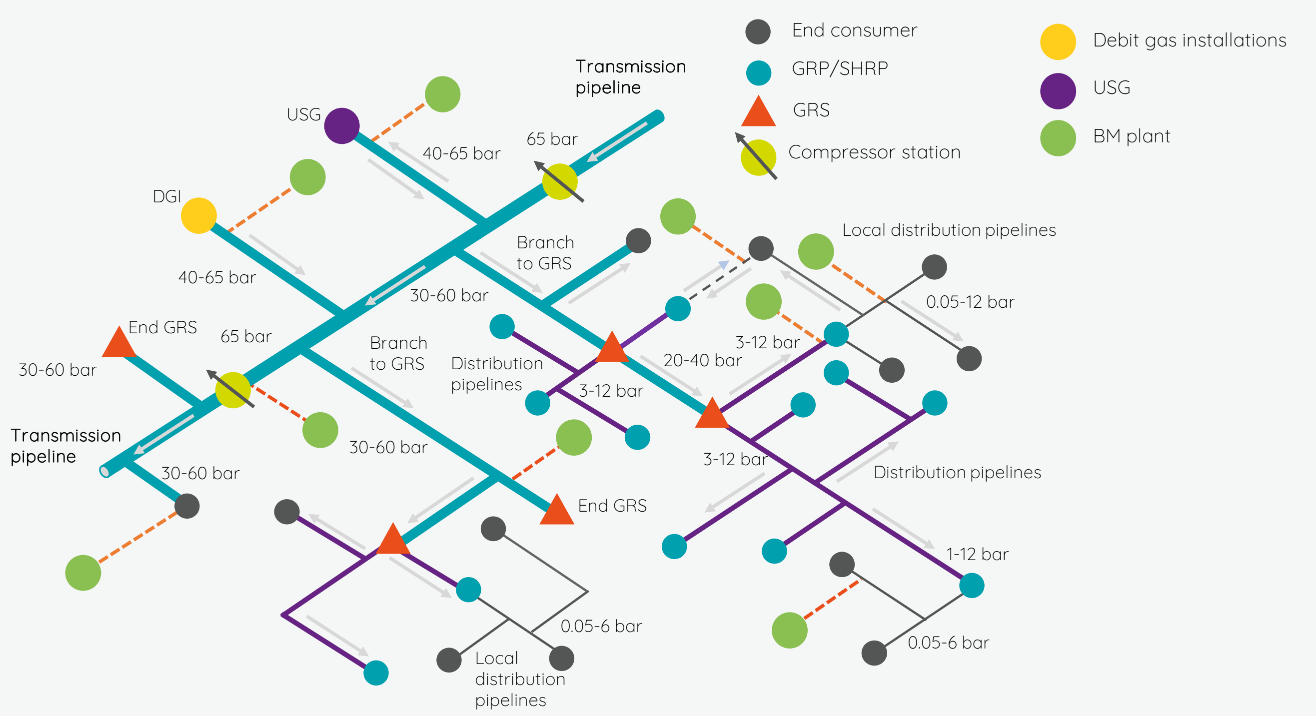
General assessment of the Ukrainian gas network

The Ukrainian gas transmission and distribution network is a complex, vertically integrated system composed of pipelines of varying pressures levels. The core network includes high-pressure transmission pipelines (trunk transit) with compression stations, branching into lower-pressure distribution networks that end at distribution stations. These, in turn, connect to local distribution network clusters with lower differential pressures, spanning from distribution stations to end users or local gas pressure reduction units serving groups of consumers. Natural gas can be supplied directly from the gas transmission system (GTS) to major consumers (large industries, CHPs and supporting infrastructure) or distributed to end users through distribution companies. Smaller distribution pipelines usually supply gas to residential consumers.

A complex, dense, but underutilised network

Ukraine boasts an extensive and dense gas distribution network with a gasification level of 92-95%, ensuring that virtually all settlements, including rural areas with access to biomethane feedstock, are connected to the distribution network. However, in recent years, the utilization of this infrastructure has been low and continues to decline.

Figure 9: Basic scheme of the Ukrainian gas network, with potential connection points for biomethane plants and distribution network layout.



Principal scheme of Ukrainian gas network indicating potential connection points for biomethane plants and distribution segments structural layout

The designed operational capacity of Ukrainian GTS is 288 bcm/year, comprising 146 bcm/year for transit and 142 bcm/year for internal consumption. Actual utilisation of the pipelines has been significantly lower. In 2021, the total flow was approximately 50 bcm/year for transit (34% load factor) and 25 bcm/year for internal use. By 2023, the total gas flow for both internal use and transit had further decreased to 68 to 74 bcm/year (25% utilisation). The gas distribution system's capacity utilization is similarly low, with an average load factor of 10% - 12%. Half of the gas distribution system (GDS) operates below 10% capacity, and only 4% exceeds a 50% load factor, primarily due to infrastructure originally designed for higher demand.

Biomethane injection and export potential

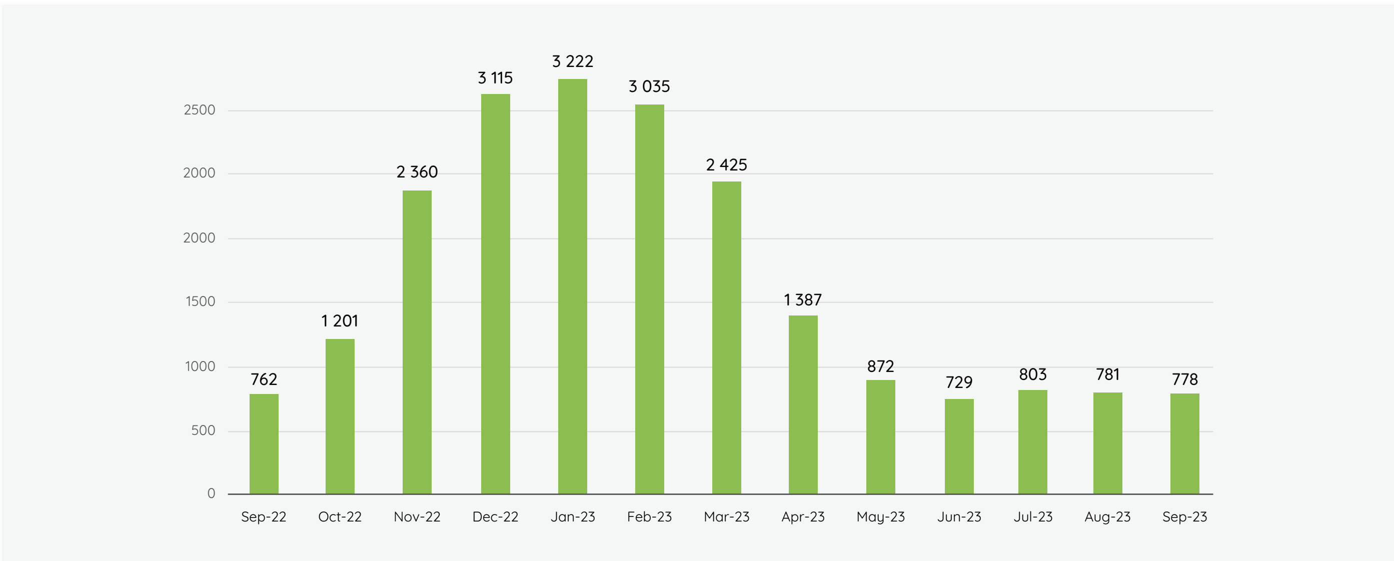
The feasibility of injecting biomethane into the Ukrainian gas grid for export depends largely on the actual load and consumption levels within the transmission and distribution networks. When biomethane is injected into the lower pressure levels of the distribution network, it is generally consumed within the connected cluster, without being physically transported into the higher-level transmission network (repressurization would be required otherwise). This effectively substitutes natural gas consumption within the system. Distribution networks, located closer to biomethane feedstock sources, offer an advantage by eliminating the need for costly compression equipment for injection. Therefore, during the initial development phase, biomethane connections are expected to be primarily to lower-pressure distribution networks rather than transmission networks. **It links the capacity of the biomethane plant to the minimal annual and seasonal consumption of the cluster.**

Swap operations for EU export (mass balance approach)

Biomethane export to the EU are expected to operate as swap transactions based on the mass balance approach. Locally produced biomethane will be physically consumed within local clusters, while an equivalent volume of natural gas transported through trunk pipelines is sold to the EU[53].

The volumes available for export depend on the minimum gas supply levels to final consumers throughout the year at both the national and local levels, influenced by seasonal and daily variations in demand. Ukraine's annual natural gas consumption typically peaks from November to April and reaches its lowest levels between June and September.

Figure 10: Seasonal consumption profiles for natural gas consumption in GTS



Source: https://expro.com.ua/upload/files/10_2023_EXPRO_Monthly_Magazine_ENG.pdf

Based on minimum consumption profile, the **current (2024) biomethane injection capacity at the national level is estimated at 8.7 to 11.5 bcm/year**[54]. This capacity is significantly lower than the maximum potential of 21.8 bcm/year but aligns closely with moderate biomethane potential estimates of 9.7 bcm/year, indicating that internal consumption can limit production and export potential.

53. Defined by Minfin Resolution № 380 dated August 1, 2024 - paragraph 1, part 10..

54. Over the past five years, average data indicate that minimum natural gas consumption in Ukraine reaches 30 to 40 mcm/day during the summer months. To account for possible fluctuations and potential decreases in gas demand, applying a conservativeness factor of 0.8 results in a 'virtual minimum annual consumption' estimate. This figure defines the minimal possible biomethane injection capacity, which ranges from 8.7 to 11.5 bcm/year.

Nevertheless, the biomethane injection potential, thus the export potential, could be higher as some biomethane plants may connect to the trunk network, which has a virtually unlimited capacity for biomethane injection and serves as a large storage and balancing facility. However, this option is more costly and feasible only in areas close to the transmission network, which may not always be near feedstock sources.

At a local level, the production capacity of individual biomethane plants are tied to the minimum consumption of the local distribution cluster they are connected to. These clusters vary widely in natural gas consumption, with potential biomethane plant connection points ranging from 0.05 mcm/month to 100 mcm/month during peak consumption in densely populated and industrialized areas. Typical connection points would have a minimum capacity of 6-12 mcm/year during the summer season.

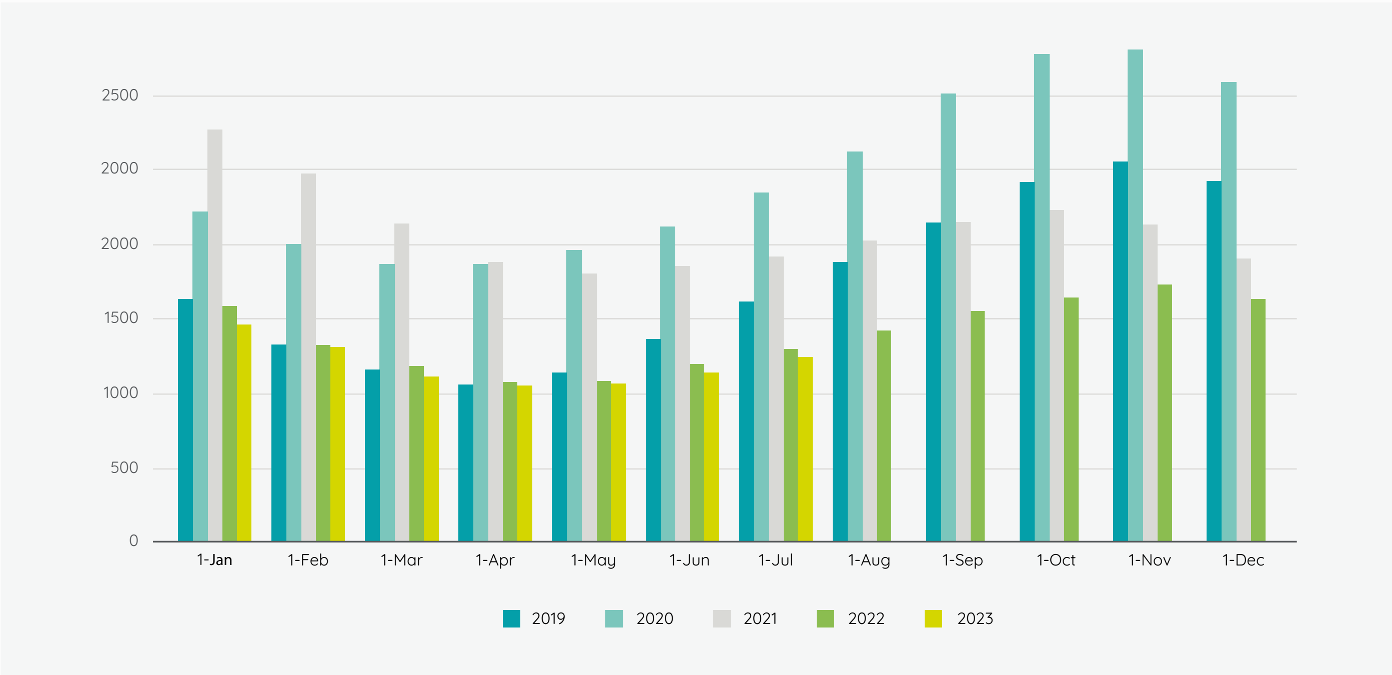
Distribution clusters with lower capacities can be interconnected through network redesign, such as linking underutilised network segments, phasing out the most distant, low-consumption sections, which could increase the productivity of the local distribution network and flexibility in consumption regulation and balancing. This process, already underway by local distribution network operators (Oblgases), aims to optimise networks in response to the current underutilisation.

Storage capacities advantages

Biomethane producers in Ukraine can also leverage the country's substantial gas storage capacities (approximately 30 bcm/year, with 50% to 70% utilisation rate in recent years) for direct storage or for balancing purposes. These storage sites, primarily located in Western Ukraine, provide strategic advantages due to their proximity to export points and available local infrastructure for compression and high-pressure grid injection.

These sites also experience seasonal fluctuations similar to those of the grid, making their injection-withdrawal profiles important for determining the capacity and operating system of specific plants.

Figure 11: Seasonal profile of gas stocks changing in Ukrainian underground storages



Source: https://expro.com.ua/upload/files/10_2023_EXPRO_Monthly_Magazine_ENG.pdf

Reverse injection

Reverse injection offers an alternative connection option for biomethane plants connected to low-pressure distribution networks, enabling them to supply biomethane to high-pressure transmission lines without a direct connection. This method serves as an intermediate between injection solely into the distribution network (limited by minimum consumption) and directly connecting to the transmission network (feasible only in limited zones within Ukraine). Reverse injection can facilitate the physical supply of biomethane to transmission lines and, subsequently, to end consumers in Ukraine or the EU. This approach can be implemented in network segments that have undergone or are planned for redesign. The possible network configurations for reverse injection include:

1. Conserved distribution network segments, with 20-40 bar pressure that are disconnected from end consumers but remain physically connected to the upper-level trunk pipeline.
2. Ringed clusters with configurations that allow two-way gas flow, according to consumption profiles (during specific hours/days), with two or more connections to upper-level trunk pipelines.
3. Pipelines parallel to existing pipelines, constructed during reconstruction projects for various purposes, such as reserve capacity.
4. Pipelines for gas injection facilities, equipped for reverse flow as a standard feature, such as those at gas wells, gas/condensate processing plants, storage facilities.

Although reverse injection requires pressurisation of biomethane, it provides additional connection zones for biomethane plants beyond those adjacent to transmission lines. It is estimated that each region in Ukraine could have, on average, 2 to 5 locations for reverse injection, each with a pipeline productivity of 2 to 10 mcm/year. Across Ukraine, there could potentially be 40 to 100 locations, with combined productivity of 80 to 400 mcm/year.

4.3. EXISTING EU INFRASTRUCTURE AND REQUIRED INVESTMENTS

Ukraine-EU interconnections are extensive and do not pose barriers to exports

The existing infrastructure connecting Ukraine to the EU pose no technical barriers to importing biomethane, even under the most optimistic production estimates for export. Current projections of EU demand, combined with the overcapacity of existing connections from Ukraine to the EU, indicate that infrastructure investment in expanding capacity is not required, even in the long term.

For decades, Ukrainian pipelines have served as the most important and well-developed land export route for Russian natural gas. Even if the transit of Russian gas does not cease completely after 2024 or if gas from Azerbaijan or other sources begins flowing through Ukrainian pipelines, much of the transit capacity will remain underutilised. However, the availability of this capacity will depend on the profitability of maintaining them for the Ukrainian operator (who is currently planning the optimization and likely decommissioning of part of the infrastructure).

It should be noted, that complete cessation of gas transit through Ukraine would significantly disrupt or make swap operations, such as certificate-based biomethane imports, impossible. Ukraine has gas pipeline connections with four EU Member States: Slovakia (highest capacity), Hungary, Poland and Romania, as well as with EU candidate Moldova. All connections support bidirectional flow, and some operate as virtual interconnection points (Polish and Hungarian points). Some capacities, like the Ukraine-Romanian interconnection, may not be fully available.

Table 2: Capacities of Ukraine – EU interconnection points

Interconnection point	Technical installed capacity (bcm/year)
UA-SK	80.9
UA-HU	19.3
UA-PL	5.1
UA-RO	7.5

Own calculations based on Entsog GIE System Capacity map 2024

Additionally, there are extensive internal EU pipeline connections to major potential consumers of Ukrainian biomethane, such as Germany and Italy. While north-south infrastructure connecting Central and Eastern European countries is less developed, existing capacity should be able to transport the anticipated volumes from Ukraine, at least until 2050.

Access to infrastructure & transmission of biomethane within the EU

The primary challenge for physical accession and transmission of biomethane within the EU's existing infrastructure is the variation in quality requirements for biomethane entering the network in each Member State and maintaining stable gas parameters at exit points. However, this issue does not apply to swap transactions, which are expected to represent the majority of the potential biomethane imports from Ukraine, especially at the nascent stages of the sector.

Although biomethane shares a high methane concentration (approximately 95%) with natural gas, its specifications can vary slightly and are subject to different standards across the EU. Variations may arise from the use of different feedstocks, leading to discrepancies in the properties of biomethane produced in different locations.

Regarding quality, the main challenge in injecting biomethane into the gas grid is the difference in Wobbe Index (WI) and oxygen content. Biomethane generally has a lower WI compared to natural gas (especially LNG), which can result in significant fluctuations at offtake points when both — biomethane and LNG — are injected simultaneously[55]. Additionally, biomethane requires oxygen reduction, as high oxygen levels can accelerate corrosion in some installations.

No uniform quality requirements for biomethane in the EU

The use of biomethane in the grid is complicated by the variation of quality regulations across Member States[56]. This regulations includes up to 33 parameters that vary by country, with WI and oxygen content being the most critical[57]. To integrate the biomethane market and facilitate imports from outside the EU, it is necessary to establish uniform minimum standards for biomethane applicable across all EU countries. The findings from the EU-funded European Gas Research Group (GERG) project on biomethane quality standards could act as a foundational benchmark for these standards[58].

55. K. de Wit, «The Wobbe Index in the H-gas Standard and Renewable Gases in Gas Quality Standardisation», Presentation by CEN, Madrid Forum, 14-15 October 2020, https://commission.europa.eu/system/files/2020-10/06.02_mf34_presentation-cen-gas_quality-de_wit.pdf.

56. Marcogaz, «Quality of Biomethane Required in European Countries for Injecting into Natural Gas Grid», February 2024, https://www.marcogaz.org/wp-content/uploads/2024/03/Quality-of-biomethane.pdf.

57. Additionally: GCV, relative density, water dew point, water, HC dew point, total sulfur, mercaptan sulfur, mercaptanes, HS2+COS, CO2, Hg, Cl, F, halogenures, H2, NH3, amines, CO, BTX, siloxanes, impurities, dust, methane, propane, methane number, injection temp.

58. GERG, «The European Gas Research Group», https://www.gerg.eu/.

The Biomethane Industrial Partnership (BIP Europe) has set up a subgroup of Task Force 4 to address these issues. Task Force 6 aims to identify and reduce regulatory barriers for Ukrainian gas imports and support the creation of cross-border trade, likely including the development of clear rules for access to EU gas infrastructure[59].

Facilitating biomethane access to EU gas networks and cross-border trade should be facilitated by the implementation of the 4th Gas Package[60]

5. REGULATIONS AND CERTIFICATION SCHEMES

The regulatory framework for the biomethane sector in Ukraine has been under development since 2019. Although formal legislation is in place, several bottlenecks continue to impede further development of the sector; primarily involving secondary legislation and sub-regulations, technical rules. Key issues include:

- Requirements for connection.
- Long and complicated connection procedures.
- Lack of a central authority to coordinate the biomethane sector.
- Lack of integration with the future EU biofuels database.
- Lack of an electronic system for the national registry.
- Lack of integration with the upcoming EU biofuels database.
- Issues with customs and tax procedures for export, which have hindered proper customs formalisation (partially addressed in September 2024 with the adoption of Ministry of Finance Regulation # 380)[61].

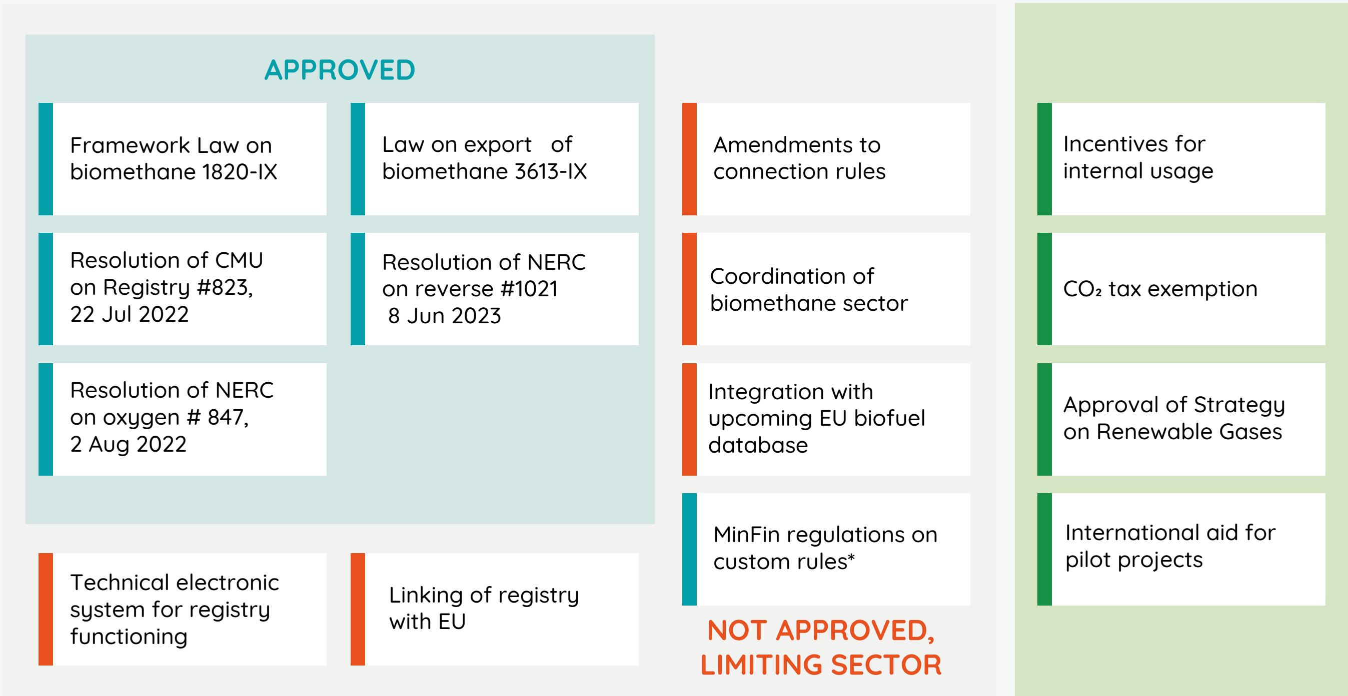
Additionally, there are broader strategic barriers such as the lack of a renewable gas strategy, lack of CO_2 tax exemption for biomethane, lack of incentives for internal use of biomethane, and limited funding to support the implementation of pilot projects.

59. Biomethane Industrial Partnership (BIP), «Task Forces», www.bip-europe.eu/task-forces.

60. European Commission, «Hydrogen and Decarbonised Gas Market», https://energy.ec.europa.eu/topics/markets-and-consumers/hydrogen-and-decarbonised-gas-market_en.

61. See detailed description of BM export procedure: A. Pastukh, Аналіз законодавчих зобов'язань для експорту біометану з України, Sustainable Agribusiness Forum, October 2024, https://saf.org.ua/news/2076/ https://saf.org.ua/news/2076/.

Figure 12: Mapping of regulations of biomethane



*Approved 8 Sept 2024 (Order # 380), technically unlocking export based on mass balance method

5.1. SUSTAINABILITY CERTIFICATION AND UDB

Export from Ukraine to the EU is possible on the basis of sustainability certificates

Currently, Ukraine lacks a formal biomethane registry, but there is an alternative: exporting biomethane based on a sustainability certificate and a Proof of Sustainability (PoS) for each batch, even without a Guarantee of Origin (GoO). This approach allows exports via pipelines or trucks as LNG/CNG.

Sustainability certification schemes were introduced in the EU under Renewable Energy Directive (RED) I, which also provided for the voluntary certification scheme[62]. These schemes allow economic operators to choose certification to demonstrate that their biomethane meets the sustainability and greenhouse gas reduction criteria outlined in RED I. Typically, private organizations set up and manage these schemes, which must be approved by the European Commission to be valid for meeting EU targets[63].

62. European Commission, «Voluntary schemes for bioenergy», https://energy.ec.europa.eu/topics/renewable-energy/bioenergy/voluntary-schemes_en#recognition-criteria.

63. The European Commission has formally recognized 15 voluntary and national certification schemes. Six of them are applicable for biomethane: ISCC, 2BSvs, Better Biomass, RSB EU RED, SURE, KZR INiG System.

Recognised sustainability certification schemes require certification at different stages of the supply chain, including:

- **First collection point**: The initial stage where business entities receive organic crops directly from farms.
- **Collection point for residues and waste**: Business entities handle collection at the point of origin and further trade that collects residues and waste.
- **Trader or storage facility**: Facilities such as elevators, warehouses, and tanks
- **Processing Facilities**: Ensuring biomethane plants comply with sustainability criteria.

Ukrainian registry and UDB

The current form of export - under certificate of sustainability - risks inconsistencies in the sector and potential physical and statistical imbalances in gas networks and reporting systems.

Existing and developed biomethane projects in Ukraine were planned under the requirements of RED II, which did not set clear deadlines for UDB implementation. However, with the new requirements of RED III, the European Commission aims to exclude automatic certification of biomethane and biomethane-based fuels if they rely on gas transported via networks outside the EU.

Therefore, the establishment of a Ukrainian biomethane registry and its connection to the Union Database (UDB) is crucial for export development. This step needs to be undertaken comprehensively and in close coordination with the EU[64]. In addition to the biomethane registry, other regulations should be adopted in Ukraine, including the mass balance method for certifying the sustainability of biomethane. The relevant provisions of RED III and the Implementing Regulation on sustainability verification, GHG savings and ILUC risks still need to be transposed and implemented.

During the transition period for the Ukrainian biomethane registry, certificates from recognized voluntary schemes such as ISCC EU will be included in the Union's database. For Ukrainian producers, certification under such schemes will ensure that their biomethane can be listed in the UDB, provided their certificates are up to date and recognized by the EU. Ukrainian biomethane exports will be based on data from the Gas Transmission System (GTS) operator and verified for sustainability.

64. The State Agency for Energy Efficiency and Energy Saving of Ukraine (SAEE), as the authority responsible for the development of the technical electronic system for the functioning of the registry, has formally developed the IT tool and presented it in 2023. However, it is not operational because it lacks proper integration with other databases (including UDB), lacks automated registration of biomethane volumes, is not connected with other Ukrainian internal databases, does not correspond to several principles of registry functioning (e.g. log in the own cabinet of the biomethane project owner).

5.2. REGULATORY FRAMEWORK IN THE EU

REPowerEU sets the biomethane target for the EU

Work on the development of the biomethane market in the EU accelerated in 2022 after the Russia's full-scale invasion of Ukraine. To reduce the EU's dependence on Russian gas, the **REPowerEU strategy**[65], launched in March 2022, set a non-binding target of 35 bcm of biomethane production by 2030. This goal was supported by the **Biomethane Action Plan (BAP)**[66], which outlined key actions needed to achieve this goal, such as establishing industrial partnerships for biogas and biomethane production, creating national biogas and biomethane strategies, and integrating these topics into the National Energy and Climate Plans (NECPs). The **BAP also emphasizes cooperation with neighboring countries, particularly Ukraine** and the Energy Community, to increase biomethane production and trade.

The BIP emphasises EU-Ukraine cooperation

As a result of the BAP, the **Biomethane Industrial Partnership**[67] was established in September 2022 to facilitate cooperation among policymakers, industry and stakeholders. **Task Force 6**[68] was established within this partnership in September 2023 to address the challenge of unlocking the potential of biomethane production in the EU. By 2024, its key objectives included strengthening EU-Ukraine cooperation and facilitating cross-border trade.

REDs are essential for biomethane regulations in the EU

The promotion of biomethane is driven by the **EU Renewable Energy Directives (REDs). RED**[69] laid the groundwork for the EU's biofuels policy by setting sustainability criteria and environmental targets. **RED II**[70] further facilitated the development of the biogas and biomethane market by enabling their transmission through the gas grid, supporting cross-border trade, and extending the guarantee of origin (GoO) from renewable electricity to renewable gas. The GoO scheme assures end users that a certain share of the energy they consume comes from renewable sources.

65. European Commission, «REPowerEU: affordable, secure and sustainable energy for Europe», https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en.

66. European Commission, Commission Staff Working Document: Implementing the REPowerEU Action Plan: Investment Needs, Hydrogen Accelerator and Achieving the Bio-Methane Targets (SWD(2022) 230 final), 18 May 2022, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022SC0230.

67. Biomethane Industrial Partnership (BIP Europe), https://bip-europe.eu/.

68. As a result of the EU-Ukraine MoU on Strategic Partnership on Renewable Gases, see Memorandum of understanding between the European Union and Ukraine on a Strategic Partnership on Biomethane, Hydrogen and other Synthetic Gases, European Commission, https://energy.ec.europa.eu/publications/memorandum-understanding-between-european-union-and-ukraine-strategic-partnership-biomethane_en.

69. European Commission, Renewable Energy Directive, https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-directive_en.

70. European Parliament and Council, Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources, December 11, 2018, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001.

REDIII[71], which came into effect in the second half of 2023, raised the EU's 2030 renewable energy target and allowed biomethane to contribute to these targets across all gross final energy consumption, including buildings, industry, heating and cooling, and transport. EU Member States have until 2025 to transpose it into national law. This directive expands on RED II by tightening standards and introducing restrictions on specific biomass types, such as stem wood. It also mandates the creation of the Union database **(UDB)** for tracking renewable liquid and gaseous transport fuels, which is currently under development.

Despite the implementation of RED III, there remains no standardised definition of biomethane. For a gas to qualify as biomethane, it must meet the feedstock criteria, sustainability standards related to biomass origin and harvesting, and GHG emissions saving thresholds, as defined for biogas in RED II.

The Fourth EU Gas Package intends to increase biomethane's share in the EU economy

Adopted in May 2024, the **Fourth EU Gas Package**, aims to integrate renewable and low-carbon gases into the existing gas network. It promotes access to the wholesale gas market for these gases, eliminates cross-border tariffs to facilitate trade, and reduces injection costs by 75%. The regulation supports increasing the share of biomethane (and other low or zero emission gases) in EU Member State economies, particularly in industrial sectors, district heating, and energy storage. This is particularly relevant for regions still heavily reliant on coal or other high-emitting fuels.

The goal is also to coordinate cross-border cooperation, especially in setting green gas quality parameters. Establishing common EU specifications and minimum quality standards for biomethane would enhance interoperability of EU gas systems, cross-border transmission, and allow trade for larger injection volumes into the network, including at border points. The EU Agency for the Cooperation of Energy Regulators (ACER) is tasked with monitoring and removing barriers to cross-border transmission.

EU countries have until mid-2026 to transpose the new rules from the Fourth EU Gas Package into national legislation.

Regardless of EU regulations, Member States have their own regulatory constraints. For example, the German Federal Customs Office currently requires biomethane to be injected into the grid within a designated area of Germany in accordance with the Federal Emissions Control Act. However, biomethane can be transported from Ukraine to Germany via road during this period.

71. Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023, amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999, and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652, Official Journal of the European Union, 31 October 2023, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302413.

6. KEY BARRIERS TO THE DEVELOPMENT OF BIOMETHANE IN UKRAINE AND ITS EXPORTATION TO THE EU

6.1. STRATEGIC

No official government strategy

A well-crafted and widely consulted public sector strategy is essential for aligning the expectations of all stakeholders along the value chain, including domestic and international policymakers. Such strategies reduce uncertainty, enhance coordination, and minimise the risk of stranded assets.

In Ukraine, several strategic documents indirectly touch on the issue of renewable gases:

- NECP 2025-2030 (approved in June 2024)[72],
- Energy Strategy till 2050 (approved),
- National Hydrogen Strategy until 2050 (draft),
- National Renewable Energy Action Plan to 2030[73] (approved in August 2024).

The National Renewable Energy Action Plan to 2030 references the potential of exporting up to 7 bcm of biomethane by 2030, estimated to meet approximately 20% of EU demand for this fuel (using REPowerEU as a benchmark). However, the document lacks detailed guidance on coordinating industry development and remains too general to serve as an effective roadmap for sector development.

Lack of coordination at the ministerial level

In Ukraine, responsibility for biomethane-related concerns are fragmented across various ministries, including the Ministry of Energy, Ministry of Agriculture (for feedstock management), Ministry of Environment, State Agency for Energy Efficiency (SAEE) and others. This results in lack of cohesive strategic vision for the development of the sector and weakens the communication of policy and strategy between ministries, companies, and EU stakeholders. The development of biomethane policy would benefit from being consolidated under a single state agency. The lack of coordination leads to lack of certainty for all stakeholders involved, including potential investors and EU partners.

72. Ministry of Energy of Ukraine, «Проект Національного плану з енергетики та клімату України 2025-2030» (Draft National Energy and Climate Plan of Ukraine 2025-2030), Ministry of Energy of Ukraine, https://www.me.gov.ua/Documents/Detail?lang=uk-UA&id=f7088035-142e-4912-9aa0-6fe2def80c1b&title=ProektNatsionalnogoPlanuZEnergetikiTaKlimatuUkraini2025-2030&fbclid=IwZXh0bgNhZW0CMTAAAR1U4nb69MbNa_ZvH-JW5cqlmfNatqAzWaQpZ0IgI-vXPmSUYsmPuwQr60A_aem_G97PMwWkIfoqms2kIX-5HQ.

73. Cabinet of Ministers of Ukraine, «Про затвердження Національного плану дій з відновлюваної енергетики на період до 2030 року» (On the Approval of the National Renewable Energy Action Plan for the Period until 2030), Cabinet of Ministers of Ukraine, https://www.kmu.gov.ua/npas/pro-zatverdzhennia-natsionalnoho-planu-dii-z-vidnovliuvanoi-enerhetyky-na-p-a761.

6.2. ECONOMIC

State subsidies for natural gas

Subsidized natural gas prices for residential consumers and district heating companies have been maintained by various Ukrainian governments. These price distortions are likely to continue, at least throughout the course of the war, as a protective measure for the population. Consequently, the development of support schemes for renewable gases is unlikely in the near future, positioning the export market, particularly to the EU who could benefit from an ETS price premium, as the primary commercial opportunity for Ukrainian biomethane.

No focus on bio-CNG and bio-LNG

A potentially viable domestic market of Ukrainian biomethane could be its use as bio-CNG for road transport (particularly for municipal fleets) and as bio-LNG for marine transport. This approach would align with EU practices but requires the establishment of supportive legal frameworks in Ukraine. To make biomethane marketable, appropriate targets need to set in energy and environmental strategies, along with incentives for investments in infrastructure, such as refuelling stations.

CO_2 tax

Under current Ukrainian regulations **biomethane, biogas and biomass are fuels subject to a CO_2 tax**, which increases production costs and contradicts EU practices. In the EU, CO_2 taxes are paid by CO_2 emitters, such as fossil fuel users, rather than renewable energy producers, including those using biomass and renewables gases. This discrepancy places an additional financial burden on biomethane producers in Ukraine.

6.3. REGULATORY

Connection procedures

Bureaucratic and regulatory barriers at every stage of the design, development and production cycle are hindering the growth of the biomethane industry in Ukraine. The main challenge is the **llack of standardised procedures and predefined time limits for connection procedures.** Currently, **it can take a minimum of 6 months to secure permission for connection and an additional six months for the physical connection itself**.

There is also complicated way to go through — all documents by biomethane plant owners are to be submitted on local level of regional gas distribution companies (Oblgases), but then are subject to revision, verification and approval in central office of TSO.

The process is further complicated by the requirement for biomethane plant owners to submit documents to local regional gas distribution companies (Oblgases), which are then are subject to revision, verification, and approval in central office of the Transmission System Operator (TSO). Additionally, biomethane producers must obtain a license for gas production and injection into the Ukrainian system (GTS), which is complex and can take at least 6 to 12 months. Following this, producers are required to report the produced biomethane volumes on batch basis or periodically (daily, monthly, or quarterly).

A potential solution would be the adoption of a standard technical conditions form, based on past connection cases, with a set 30-day time limit for issuance and approval.

No simplified procedures

There are currently **no simplified procedures for connecting biomethane plants to local power and gas networks**, unlike those available for gas piston and gas turbine facilities under martial law. Extending these streamlined procedures to biomethane, biogas, and biomass energy production facilities could create parity with natural gas-based installations. This would be especially important for ensuring locally power generation capabilities for gas turbines and generators installed during wartime.

Quality monitoring

Once connection procedures are complete, monitoring biomethane quality remains a challenge. **Ukraine lacks established procedures for regular biomethane quality monitoring, nor an accredited national laboratory for quality analysis**, forcing producers to rely on internal TSO laboratories, which may create a conflict of interest. Establishing a national accredited laboratory aligned with EU best practices and potentially funded by international technical assistance, could address this issue.

Quality standards

An additional barrier to biomethane production in Ukraine is the **stringent quality standards**, that require biomethane to meet the high calorific value (HCV) standards as natural gas. This requirement, despite a typical 1 to 2% difference, increases production costs. A potential solution would be to set a minimum HCV standard for biomethane at 10 kWh/m^3, allowing for fluctuations above this value, but not below it.

Export procedures

The process for formalising biomethane exports from Ukraine is highly complex and time-consuming. For a biomethane plant to export, it must:

- Have a gas transportation agreement with the TSO.
- Enter into an appropriate foreign economic agreement with the buyer.
- Book the cross-border capacity and submit a trade notification to the TSO or the Gas Storage Operator.
- Prepare and submit both periodic customs and additional custom declarations.
- Prepare and submit a tax invoice.
- Report gas sales to the Regulator, and, in certain cases, to the Ministry of Energy.

Additional expenses for transporting each batch of biomethane through the transmission network, along with quality and quantity monitoring and reporting requirements, further complicate the export process[74].

74. See details: A. Pastukh, Аналіз законодавчих зобов'язань для експорту біометану з України, Sustainable Agribusiness Forum, October 2024, https://saf.org.ua/news/2076/.

RECOMMENDATIONS

FOR THE EU

- In order to promote biomethane consumption and shape its biomethane policy — both within the EU and regarding imports — the Union needs **reliable, up-to-date, and comparable data available for all Member States**. Collecting and publishing such data should be the first step in building an effective EU biomethane policy.
- Adopt strategic thinking for biomethane, ideally through the **development of an EU-wide biomethane strategy.** This strategy should not only define goals but also outline a vision and concrete framework for developing the biomethane market in Member States where it exists, and promote it in countries where it has potential, but is not yet established.
- A comprehensive strategy should harmonise and unify quality standards and requirements, address the diversity of support systems, and simplify access to cross-border networks and biomethane trade. It should also **facilitate the dissemination of know-how, best practices, and technological advancements**.
- Given the local nature of biomethane, the strategy should be based on 3 pillars: promoting **local initiative, fostering intra-EU cooperation, and encourage collaboration with accession countries, particularly Ukraine**. An essential step is launching the **UDB and granting Ukrainian producers access to it**.
- The strategy should clearly **illustrate how biomethane can contribute not only to the energy transition in the power sector and hard-to-electrify industrial sectors, but also to climate goals and transforming agriculture**. A well-designed biomethane strategy could act as a trigger for defining a new agricultural policy for an expanding EU.
- In the context of EU-Ukraine cooperation, it is essential to pursue win-win partnerships, whether through collaborations between individual producers and consumers, or the formation of cross-border clusters. This approach should aim for solutions that benefit both Ukrainian producers and EU stakeholders, encouraging sustainable development of projects and joint efforts to create a pan-European biomethane market.
- The EU needs an effective information policy that emphasises the advantages biomethane use and highlights the benefits of cooperation with Ukraine, while proactively addressing potential challenges, countering misinformation and minimising political risks.
- Clear **quantitative and qualitative requirements** for imports from third countries should be established, along with **pre-allocation of renewable gases imports from Ukraine in strategic documents** and planned on a technical level with annual allocations.

FOR UKRAINE

Improvement of connection rules:

- To unlock production potential of Ukrainian biomethane, simplifying connection procedures is essential. Ukraine should develop a set of standard documents:
    - A standard technical specifications form for the connection of biomethane plants, with a maximum issuance period of 30 days.
    - A standard technical agreement for biomethane supply to the grid, with an option for signing post-test injection.
- Standardise the minimum calorific value requirement for biomethane at 10 kWh/nm^3 or higher and establish a national accredited laboratory for biomethane quality control in line with EU standards.
- Biomethane, biogas and biomass energy facilities should be included in the list of projects eligible for simplified connection procedures, similarly to natural gas facilities, to prevent unequal regulatory treatment.
- Create network clusters to ensure stable gas consumption.

Coordination of the biomethane sector:

- Establish a dedicated coordinating body within one of the ministries to oversee the biomethane sector in Ukraine.

Exemption from CO_2 tax:

- Ukraine should expedite the adoption of draft law No. 9597 on the register of biofuel installations, to exempt biomethane from CO_2 taxation.

Biomethane register:

- Establish a reliable Ukrainian biomethane registry, ensuring regular coordination with the European Commission on the implementation of regulation related to the accounting, reporting, monitoring, verification, and registration of biomethane in accordance with the WBI requirements.

Regulations to be adopted:

- Implement a mass-balance approach for certifying biomethane sustainability, and establish related requirements. Align regulations with the design and requirements of RED III and the Implementing Regulation for verifying sustainability, GHG savings, and risks associated with greenhouse gas emission reductions (ILUC).

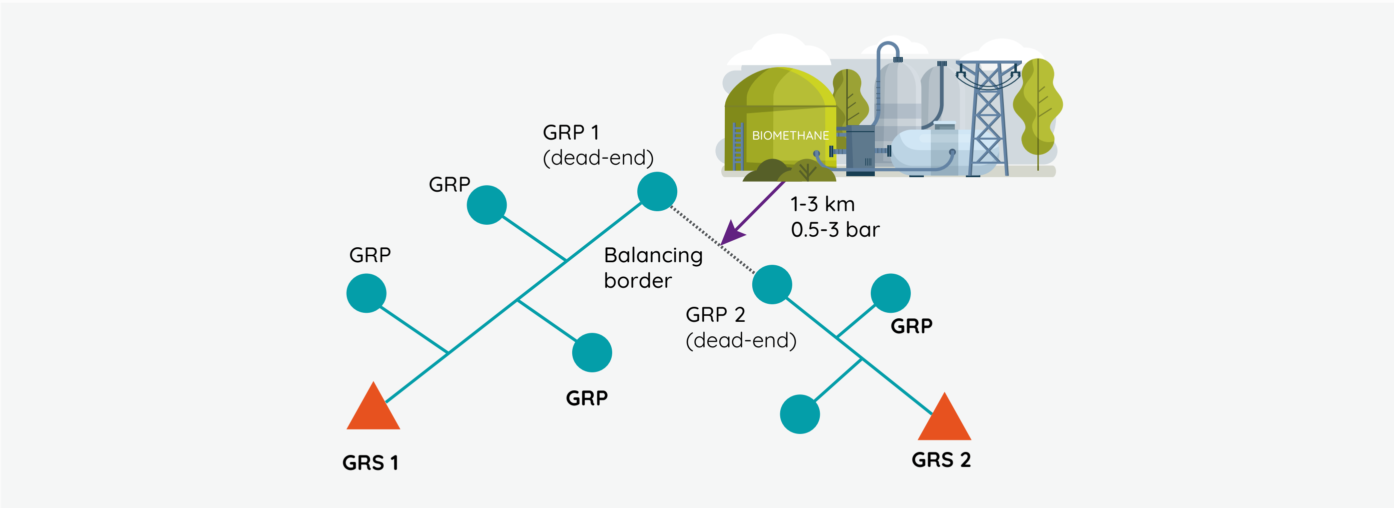
Reducing general barriers to the bioenergy sector

- Enhance the economic and legal environment to incentivise the biomethane industry in Ukraine. This includes adopting legislation to promote the cultivation and use of energy crops, establishing legislation on digestate, and developing a comprehensive Bioenergy Strategy up to 2030 or 2050 and a roadmap for renewable gases development.
- In the long term, phases out subsidies for residential natural gas prices would make methane prices more realistic, encouraging the development of domestic biomethane demand. However, given the high social impact, this may be the most challenging measure to implement.

ANNEX 1. CONNECTION SCHEMES FOR BIOMETHANE PLANTS IN UKRAINE

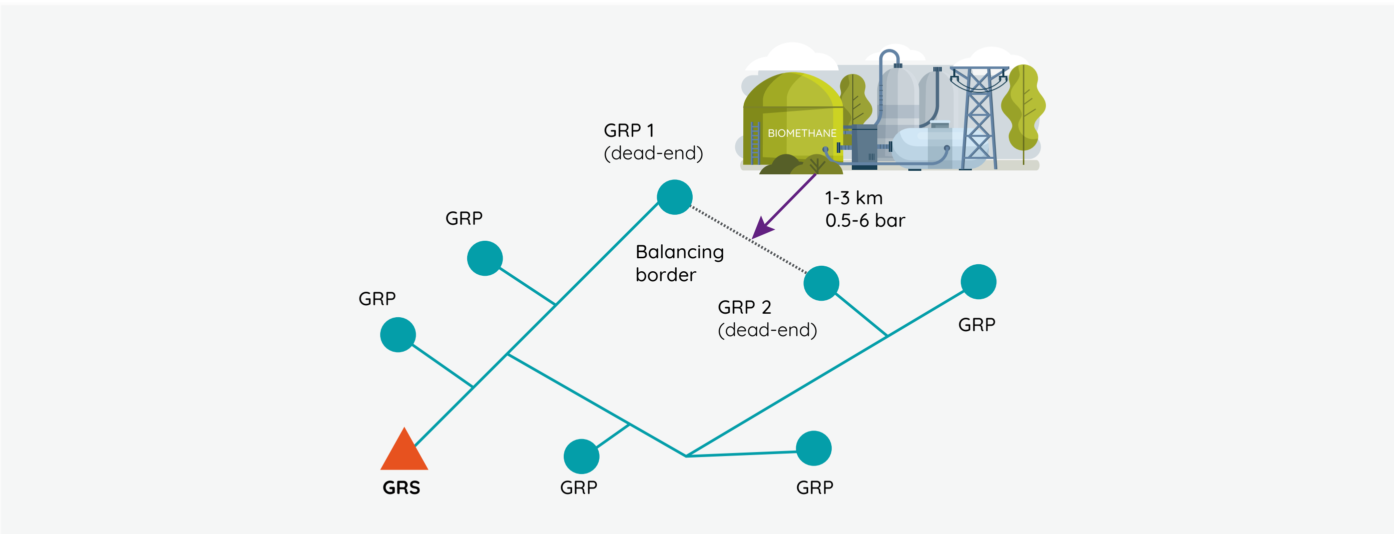
Based on practical cases from existing biomethane plants and current network layouts, the most common connection schemes in Ukraine can be categorized into five core options:

1. Connection to the Balancing Border Between Two Gas Regulation Stations (GRS)



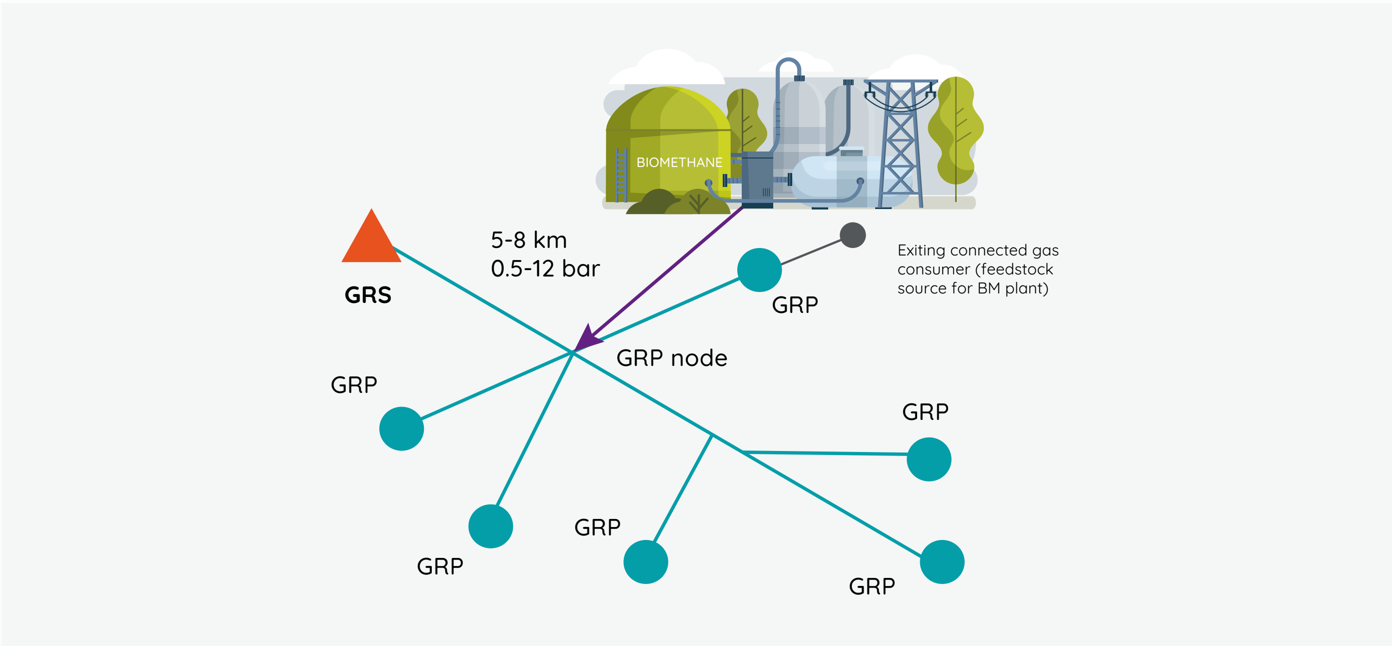
This connection scheme involves linking a biomethane plant to the balancing border between two separate GRS branches. It is applicable where the balancing points (end-line Gas Regulation Points or distribution networks running from the GRS to the end consumer) of adjacent GRSs are geographically close. Under this scheme, an additional pipeline must be designed to interconnect the two border GRP points and enable the integration of the biomethane plant at any suitable location between these points. This configuration facilitates the flow of biomethane between the two GRSs and into the broader network, ensuring balanced distribution and operational flexibility.

2. Connection to the Balancing Border Between Two Gas Regulation Points (GRPs) of a Single Gas Regulation Station (GRS)



This scheme is suitable when end-line GRPs from the same GRS are located close to each other but serve distinct consumer clusters. The network configuration comprises several branches extending from the GRS, each with its own set of GRPs, but sharing a common node immediately downstream of the GRS. The end-line GRPs may be situated 1-3 km apart, while the distance between intermediate branches or the GRS itself can be as much as 10-20 km. Connecting two adjacent end-line GRPs forms a closed-loop system within the GRS's consumer cluster. A biomethane plant can be connected at any point between these end-line GRPs, which typically operate at low pressure (approximately 0.5 bar), or at any other point within this GRS encirclement. When connected at other points in the loop, the operating pressure ranges between 6-12 bar, ensuring service for the entire GRS consumer cluster. This setup enhances distribution resilience and network stability.

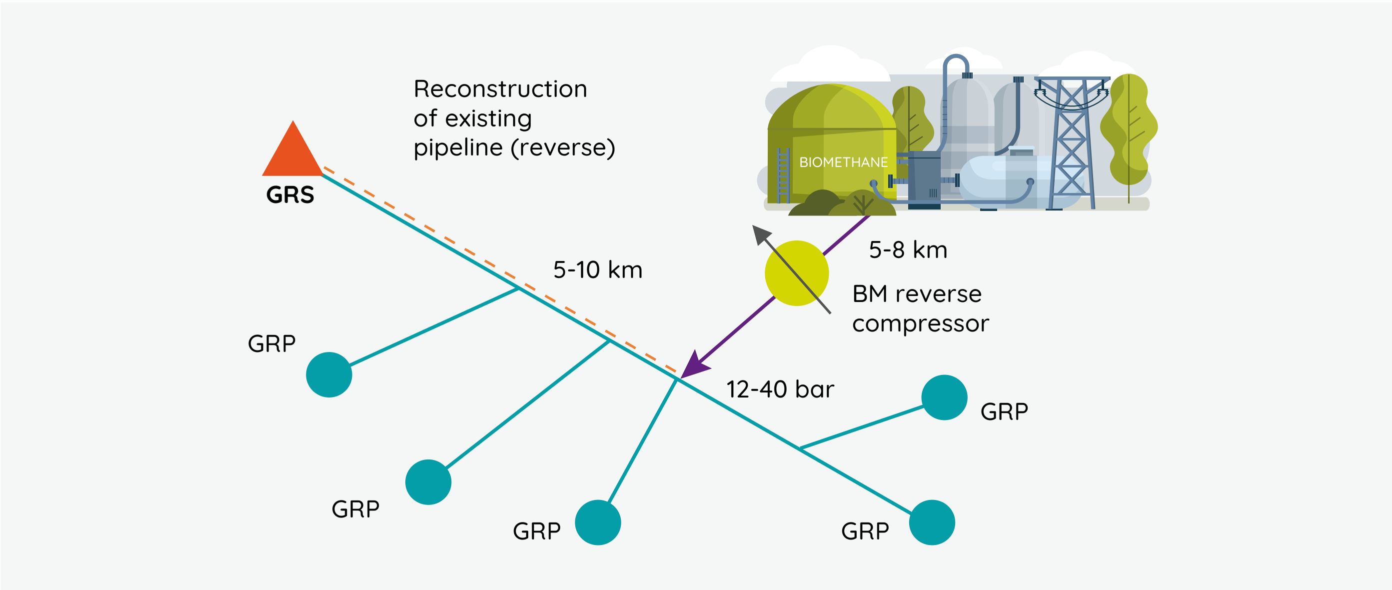
3. Connection to a Node of Several Gas Regulation Points (GRPs)



This layout is the most common structural arrangement in Ukraine, where multiple GRPs converge at a single node after branching out from a single GRS. In this configuration, a biomethane plant can be connected directly to such a node without requiring significant system redesign or the creation of an encirclement. This setup provides an efficient integration point for biomethane injection into the network.

An added advantage of this scheme is that an existing natural gas consumer already connected to this GRP node can simultaneously serve as a feedstock source for the biomethane plant. This allows the connection point and the feedstock generation point to be co-located within the same biomethane complex, optimizing logistics and minimizing additional infrastructure requirements.

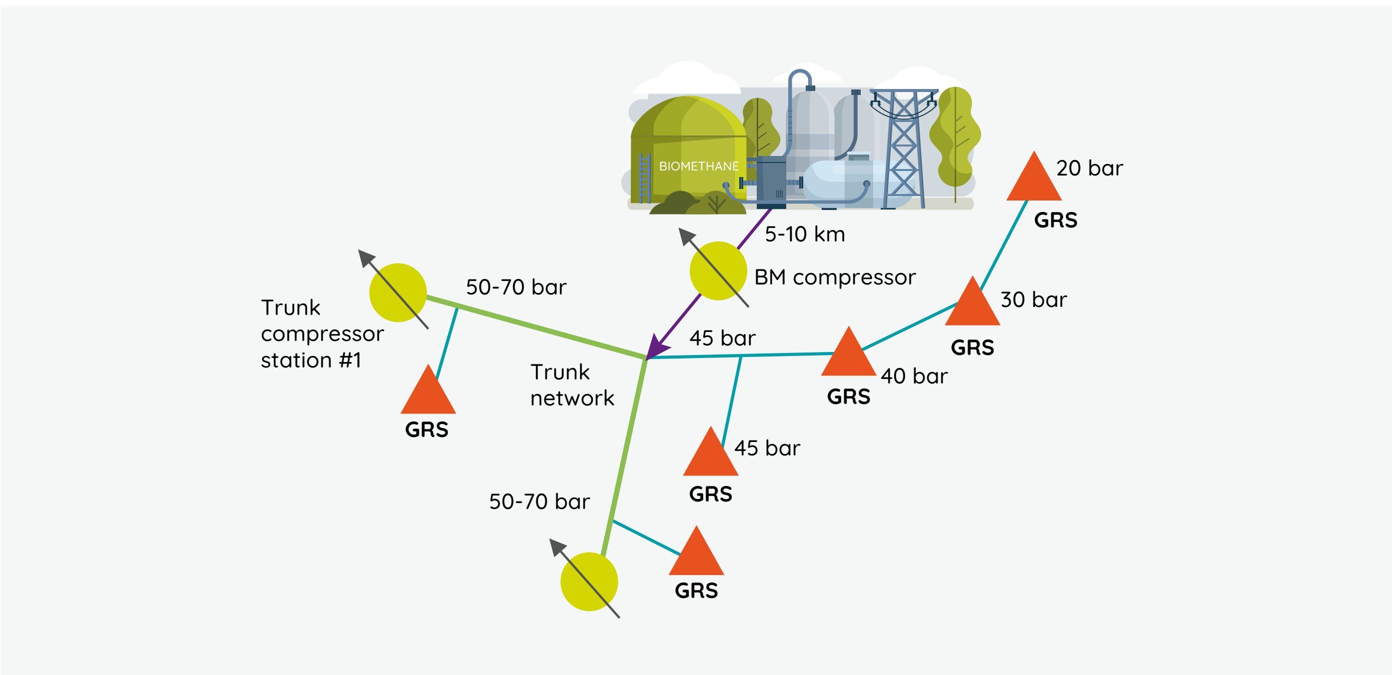
4. Connection to Lower Segment of GRS-GRP Pipeline for Reverse Injection



To ensure coverage of an entire GRS consumption cluster, a biomethane plant can be connected either at the point immediately downstream of the GRS reduction (operating at 12 bar) or at a lower segment of the GRS-GRP network (operating at pressures below 12 bar). For the latter option, reverse injection is necessary to feed biomethane back into the upper segments of the network, up to the GRS exit point but not exceeding it. This approach requires the biomethane to be pressurized sufficiently to counteract and override the existing gas flow direction.

Alternatively, an auxiliary parallel pipeline may be constructed from the biomethane plant to the upper GRS connection point (spanning 1-10 km). This option allows the injection of biomethane without disturbing the hydraulic balance of the existing gas grid, providing operational flexibility and maintaining system stability.

5. Connection Directly to the Trunk Transmission Network or Intermediary Branches Between GRS



Direct connection to transmission pipelines is necessary for large-scale biomethane plants (with capacities exceeding 20 million nm³/year) when other connection schemes are not feasible. This type of connection requires the installation of an on-site boosting compressor station, capable of pressurizing the biomethane to 45-65 bar, within the biomethane complex. Additionally, a high-pressure pipeline must be constructed to link the biomethane plant to the chosen connection point. Although this increases the overall capital expenditure (CAPEX), it ensures reliable supply and avoids operational limitations.

The trunk transmission network has the technical capacity to accommodate any volume of biomethane, as the minimum productivity of a transmission network segment is typically 300-400 million nm³/year, far exceeding the output of even the largest biomethane plants. This connection scheme bypasses the use of regional distribution infrastructure managed by Oblgases and the associated regulatory formalities, streamlining the process for large-scale operations.

ANNEX 2. BIOGAS/BIOMETHANE PRODUCTION POTENTIAL IN UKRAINE BY FEEDSTOCK (RAW MATERIALS) USED

Feedstock type	bcm/y
Biogas from animal waste	0.9
Biogas from harvest residues of agricultural crops	5.2
Biogas from by-products of the food processing industry	0.7
Biogas from solid household waste	0.5
Biogas from sewage sludge (municipal treatment plants)	0.1
Energy plants: biogas from corn silage (from 1 million hectares)	3.8
Biogas from cover crops (20% of arable land)	9.8
Biogas from BM obtained by thermal gasification (10%)	1.0
BIOGAS/BIOMETHANE, total, bcm of CH_4/year	21.8

Sources:
https://uabio.org/wp-content/uploads/2023/10/Kucheruk_Seminar-USAID-ERA_2023-1.pdf
https://uabio.org/wp-content/uploads/2024/08/Geletuha_Perspektyvy_vyrobnytstva_biometanu_v_Ukrayini_2.pdf
https://dixigroup.org/wp-content/uploads/2024/03/policy-brief_spivpraczya-ukrayiny-ta-yes-v-biometanovomu-sektori.pdf
https://uabio.org/wp-content/uploads/2022/09/UA-Position-paper-UABIO-29.pdf (9.7 bcm/year)

ANNEX 3. THE BIOMETHANE PROJECTS IN UKRAINE TO BE LAUNCHED IN 2024

#	Company	Location (oblast)	Unit capacity, mcm/a	Product / connection to GS network
1	Gals Agro	Chernihiv	3.0	GDN*
2	VITAGRO	Khmelnitsk	3.0	GDN
3	"Theofipol Energy Company" LLC	Khmelnitsk	56,0	GTS
4	Gals Agro	Kyivska	3.0	GDN
5	“YUM LIKVID GAS” LLC	Vinnytska	11.0	bioLNG
6	“YUM LIKVID GAS” LLC	Vinnytska	11.0	bioLNG
7	MHP	Vinnytska	24.0	bioLNG
8	MHP	Dnipropetrovska	11.0	GDN
TOTAL		x	111.0	x

* GDN – gas distribution network (local)
** GTS – gas transportation system (trunk pipeline)
Source: UABIO

ANNEX 4. ILLUSTRATION OF KEY FACTORS IN THE ECONOMICS OF A BIOMETHANE PROJECT (FOR UKRAINE)

In terms of key factors, the viability of a biomethane project would depend on the raw material mix chosen and costs of upgrading of produced biogas into biomethane. **Biogas productivity** of an average plant in Ukraine (with ~ 500 m^3/hour of biomethane output) can be illustrated by the following figures from feasibility study for Ukraine (footnote):

	Volume	DM	oDM	oDM-to-Biogas conversion ratio	Biogas output, total
	1000t/year	%	%	Cubic meters in oDM	Million cubic meters/year
Cattle slurry	30	8	85	350	0.7
Poultry manure	15	30	75	500	1.7
Biowaste	5	30	85	550	0.7
Maize stover	7	65	82	580	2.2
Catch crops	10	27	92	620	1.5
Maize/sorhum silage	15	32	93	650	2.9
Recirculation	20	5	30	-	-
TOTAL/AVERAGE	102	21	-	-	9.7

- DM is dry material, and
- oDM is a share of organic dry material in a selected raw material, and
- about 10% of input raw material transforms in digestate that could be used further as fertilizer.

The resulting biomethane output would further depend on volumes of biogas:

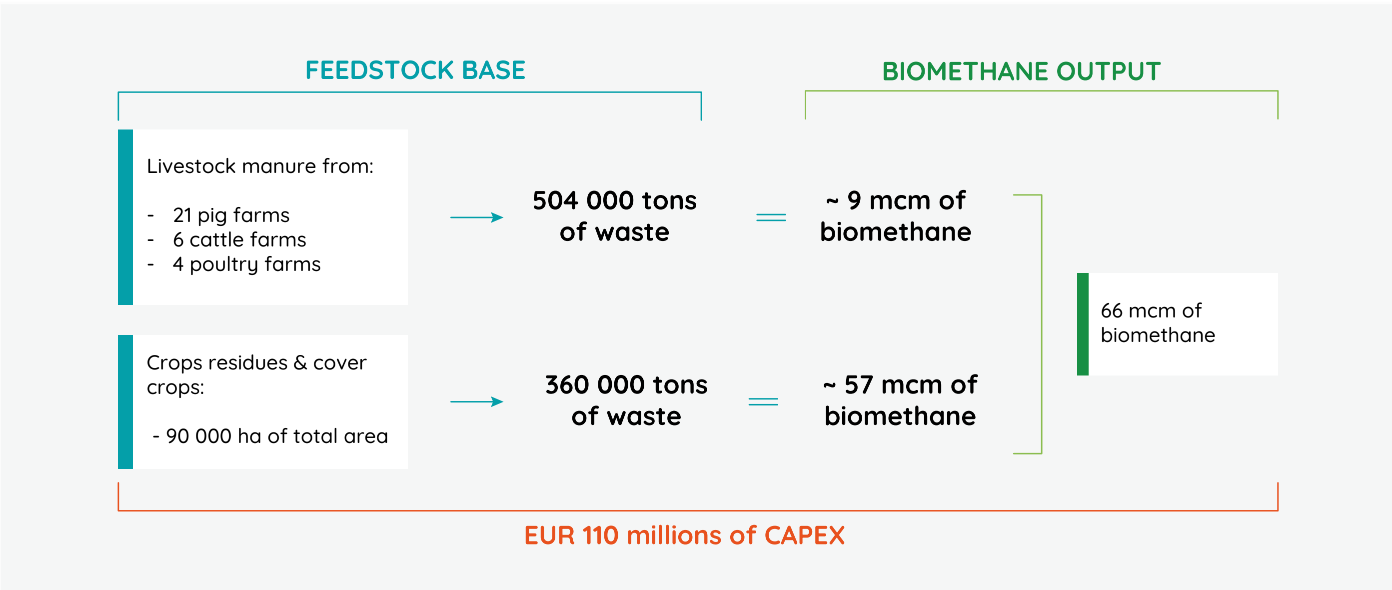
- accounted as loss in biogas production (~ 0.5% from total biogas generated volume);
- spent to CHP (for internal energy needs of specific plant, ~ 20%);
- the content of methane into processed biogas mixture (~ 53%);
- methane loss in upgrading (~ 1% out of gross methane produced).

This lead to following modelled biomethane output results:

	Million cubic meters/year	Cubic meters/hour
Gross biogas production	9.7	1 214
Biogas loss (0.5%)	0.05	6
Biogas to CHP	1.9	235
Biogas for upgrading	7.8	973
Biogas methane content	52.7%	0
Gross biomethane production	4.1	513
Biomethane loss in upgrading (1%)	0.04	5
Net biomethane production	4.0	508

Hence, about 100,000 t of feedstock are used to produce 4 mcm of biomethane and for maximizing productivity a biomethane producer should have an optimized feedstock portfolio.

The VITAGRO company data provides another illustrative example of a large-scale biomethane project with a real-life case of raw materials portfolio and CAPEX needed to launch the plant.



Source: Company data

Therefore, the **investment per unit of biomethane** produced may be considered as about **EUR 1.8 per cubic meter** including the costs of the natural gas connection of around EUR 250 thousand (though it is still a very rough estimate). About 70% of required CAPEX is attributed to construction works and machinery & equipment lines.