# Indicators for biomethane market integration.

Deliverable 1.5

Presented by: DBFZ

GREENMEUP

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# Summary of the GreenMeUp project

GreenMeUp – Green Biomethane Market Uptake is a Horizon Europe project that aims at providing a basis for policy-makers and stakeholders to develop more informed renewable energy policies and country-tailored market uptake measures, in order to improve and complement existing biomethane policy in Europe.

The core activity of GreenMeUp is to reduce the gap between countries with higher rates of biomethane production and countries with lower development rates, by analyzing and comparing their framework conditions and market dynamics and promote enabling policies and measures at country level. The project aims at providing societal acceptance of the biomethane value chain through science-based evidence and tools.



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# Executive Summary

As part of the status quo and potential analysis of the biomethane market, a framework for assessing the biomethane market integration at national level has been developed. This framework consists of a set of 8 universally applicable indicators:

- Level of policy commitment
- Feedstock readiness
- Valorization of by-products
- Infrastructure performance
- Emission reduction potential
- Social perceptions
- Financial support
- Stakeholder networks

The indicators are based on the six PESTEL categories Policy, Economic, Socio-cultural, Technological, Ecological, and Legal. Qualitative and quantitative information is combined to provide a normalized score for each indicator for the status quo and for future potentials in 2030 and 2050. Each of the PESTEL categories is represented in the key indicators, emphasizing the importance of a comprehensive assessment with a multi-perspective approach.

While the primary addressees of the indicators are the GreenMeUp target countries, they can be applied to assess the market integration of further countries, such as other GreenMeUp partner countries (Germany, Italy) and other member countries of the European Biogas Association (EBA).

The content of this report is to list the 8 indicators, provide definitions and describe the scoring. Along with the Deliverable, a Word template for filling in the indicators is provided, as well as an Excel file containing supporting data and a template for results collection per country.



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# Index





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# Introduction

The GreenMeUp project aims to promote the market integration of biomethane as part of the efforts to reduce fossil fuel dependency in the EU and to contribute to the implementation of the REPowerEU plan. Projects efforts are focused in selected EU countries with high potential for biogas and biomethane production, and defined as target countries, including the Czech Republic, Estonia, Latvia, Greece, Poland, Spain and the Danube region (comprising Romania, Serbia and Hungary).

As part of the status quo and potential analysis of the biomethane market, a framework for assessing the biomethane market integration at national level has been developed. Market integration in this context is understood as the uptake and ramp-up of biomethane production as well as the transformation of value chains by enhanced biomethane production. The framework consists of a set of 8 universally applicable indicators. While the primary addressees are the GreenMeUp target countries, the indicators can be applied to assess the market integration of further countries, such as other GreenMeUp partner countries (Germany, Italy) and other member countries of the European Biogas Association (EBA).

The indicators are based on the six PESTEL categories Policy, Economic, Socio-cultural, Technological, Ecological, and Legal. Qualitative and quantitative information is combined to provide a normalized score for each indicator for the status quo and for future potentials in 2030 and 2050.

The aim of this report is to list the 8 indicators, provide definitions and describe the scoring. To assess the market integration potential, along with the Deliverable a Word template for filling in the indicators is provided, as well as an Excel file containing supporting data and a template for results collection per country.

# Methodology

An initial collection of potential market integration indicators was based on GreenMeUp Deliverable 1.1, on literature screening and on expert consultation. The indicators were clustered into PESTEL categories: Policy, Economic, Socio-cultural, Technological, Ecological, and Legal indicators. Descriptions as well as suggestions for scoring and data sources were developed for each indicator. The initial collection was further refined in two discussion rounds within the GreenMeUp team and with further biomethane experts to arrive at a list of potential indicators for market integration. From an initial longlist of 34 potential indicators (Annex 1), the prioritization was performed with all project members at the GreenMeUp project meeting in Riga, Latvia, on 14 September 2023. The indicators with highest prioritization results (score of 10 or more) were selected as key indicators. For each key indicator, a consolidated definition, a methodology for scoring, and a methodology for normalizing was elaborated in two discussion rounds within the GreenMeUp team. The final list of key indicators serves as a template for evaluating a country's biomethane market integration.

Two test runs of the framework were conducted in Q1 2024, one with Poland and one with Czech Republic as test cases. The validated framework was provided to the consortium in the form of a Word template and a supporting Excel file.



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# Results

The longlist of 34 potential indicators can be found in Annex 1, the results of the prioritization are available in Annex 2. From the longlist, 8 key indicators were selected (Table 1), with each PESTEL[1] category being represented in at least one key indicator. In the following, the description, scoring, and data sources are separately presented for each key indicator.

Table 1: Eight key indicators for evaluating the biomethane market integration at national level

| PESTEL category | Indicator number | Indicator name |
|---|---|---|
| Policy | 1 | Level of policy commitment |
| Technological | 2 | Feedstock readiness |
| Economic | 3 | Valorization of by-products |
| Technological | 4 | Infrastructure performance |
| Ecological | 5 | Emission reduction potential |
| Socio-cultural | 6 | Social perceptions |
| Legal | 7 | Financial support |
| Socio-cultural | 8 | Stakeholder networks |

## Key indicator 1: Level of policy commitment

| PESTEL category | Name | Description | Measuring |
|---|---|---|---|
| Policy | Level of policy commitment | Dedicated governmental strategy, roadmap or action plan (official document) stating the present and future actions of the government to support biomethane production, distribution and consumption. Including existence of an official binding or indicative target on biomethane production or consumption. | Quantitative (5-scale scoring) plus qualitative (description) |

### Description

An adequate level of policy commitment is an important prerequisite for the market integration of biomethane. This is expressed, e.g., in a dedicated governmental strategy, roadmap or action plan (official document) stating the present and future actions of the government to support biomethane production, distribution and consumption. An official binding or indicative target on biomethane production or consumption can also give insights on the policy commitment.

[1] Policy, Economic, Socio-cultural, Technological, Ecological, and Legal indicators



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At EU level, the National Energy and Climate Plans (NECPs) outline how the EU countries intend to address the 5 dimensions of the energy union: decarbonization, energy efficiency, energy security, internal energy market, and research, innovation and competitiveness[2]. Member States were required to submit their final NECPs by 31 December 2019, as well as a progress report every two years. 24 draft updated NECPs were published in 2023, among which 12 contain a biomethane target for 2030, 6 contain a biogas target only for 2030, and 6 contain no target for biogas or biomethane. Before the 2023 draft updated NECPs, 13 countries already had a biogas target[3].

### Scoring

| **Score status quo** | **4** | **3** | **2** | **1** | **0** |
|---|---|---|---|---|---|
| **Description** | NECP with 2030 biomethane target in place | Pre-NECP 2030 biomethane target in place | Action plan in place | Study on potential without a target in place | None of the above in place |
| **Score 2030 and 2050** | **4** | **3** | **2** | **1** | **0** |
| **Description** | Binding biomethane target in place | Indicative biomethane target in place | Action plan in place | Study on potential without a target in place | None of the above in place |

### Data sources

An overview of NECPs is provided by EBA in the supporting Excel file (last update: 11/01/2024).

## Key indicator 2: Feedstock readiness

| **PESTEL category** | **Name** | **Description** | **Measuring** |
|---|---|---|---|
| Technological | Feedstock readiness | Readiness of feedstock currently used for biogas/biomethane production: Potential of residues and waste biomass streams, potential of sequential crops, as well as mobilization rate. | Quantitative (4-scale scoring) plus qualitative (description) |

### Description

The feedstock readiness is composed of feedstock potential and feedstock mobilization rate. The first step of the assessment is the evaluation of data availability on national level. If this is

[2] European Commission (2024): National energy and climate plans. Available from https://commission.europa.eu/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-energy-and-climate-plans_en

[3] European Biogas Association (2024), personal communication on 11 January 2024.



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given, in the next step the feedstock potential and mobilization rates are described and assessed. For this indicator, estimations on future feedstock potentials and mobilization rates are especially important, since the biogas and biomethane production is expected to increase in many EU countries[4].

### Scoring

| Score | 3 | 2 | 1 | 0 |
|---|---|---|---|---|
| **Description** | Feedstock available in **large** amounts, **large** percentage of feedstock is in use | Feedstock available in **large** amounts, **small** percentage of feedstock is in use. OR: Feedstock available in **small** amounts, **large** percentage of feedstock is in use | Feedstock available in **small** amounts, **small** percentage of feedstock is in use | No country-wide assessment on feedstock potential available |

### Data sources

Country-specific data for filling out this indicator can be found under:

- Gas for Climate Report 2022, especially fig. 1 and 2 on biomethane potentials and table 11 on sustainable removal rates. Available online: https://gasforclimate2050.eu/wp-content/uploads/2023/12/Guidehouse_GfC_report_design_final_v3.pdf
- Deliverable 2.1 of the GreenMeUp project, available in the Dropbox: https://www.dropbox.com/home/GreenMeUp%20-%20Horizon%20Europe%20Project/WP2/Deliverables
- In addition, the EBA Statistical Report 2023 contains detailed country analyses. It is available to EBA members here: https://www.europeanbiogas.eu/eba-statistical-report-2023/

## Key indicator 3: Valorisation of by-products

| PESTEL category | Name | Description | Measuring |
|---|---|---|---|
| Economic | Valorization of by-products | Valorisation of the by-products<br>1) energy: heat (boilers, gas engines and turbines), combined heat and power (CHP) plants, and fuel cells,<br>2) $CO_2$ (for CCU or CCS)<br>3) digestate (e.g., for fertiliser, algae and biopolymers production). | Quantitative (6-scale scoring) plus qualitative (description) |

[4] Gas for Climate Report 2022. Biomethane production potentials in the EU. Available online: https://gasforclimate2050.eu/wp-content/uploads/2023/12/Guidehouse_GfC_report_design_final_v3.pdf



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### Description

This key indicator describes the incentives for the valorization as well as the contribution to economic value generation, i.e., by generating profit, of by-products from biogas and biomethane production at national level. The by-products in focus are: (1) energy in the form of heat (boilers, gas engines and turbines), combined heat and power (CHP) plants, and fuel cells; (2) $CO_2$ (for CCU or CCS); as well as (3) digestate (e.g., for fertiliser, algae and biopolymers production). For each of the three by-product types, incentives and contribution to economic value generation are assessed in the status quo, for 2030, and for 2050.

### Scoring

| | **Existing incentives** | | **Economic value generation** | |
|---|---|---|---|---|
| **Energy** | Yes O | No O | Yes O | No O |
| **$CO_2$** | Yes O | No O | Yes O | No O |
| **Digestate** | Yes O | No O | Yes O | No O |

The number of "yes" gives the score between 0 and 6.

### Data sources

The assessment is based on literature search, combined with national experts' knowledge and judgement on whether incentives are in place and whether the by-products contribute to economic value generation.

## Key indicator 4: Infrastructure performance

| **PESTEL category** | **Name** | **Description** | **Measuring** |
|---|---|---|---|
| Technological | Infrastructure performance | Availability, quality and compatibility of supporting infrastructure: 1) gas grid (extent, accessibility and costs) and 2) filling stations (for LNG and CNG) | Quantitative (4-scale scoring) plus qualitative (description) |

### Description

The infrastructure performance is composed of the availability, quality, and compatibility of the supporting infrastructure. This key indicator focusses on the two components gas grid and filling stations. Although separate biowaste collection is a factor that is part of the infrastructure availability, it was left out of the assessment because of the mandatory requirement for all EU countries to have a separate biowaste collection in place.

### Scoring

Gas grid:

Is the regulatory framework for grid connection well established?



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| | | | |
|---|---|---|---|
| **Yes, there are clear rules in place** | O | **No, it is not well established** | O |

Is there an injection fee?

| | | | |
|---|---|---|---|
| **No** | O | **Yes** | O |

Is there a cost-sharing mechanism in place?

| | | | |
|---|---|---|---|
| **Yes** | O | **No** | O |

Filling stations:

Are there over 130 filling stations (CNG+LNG) in the country? The number 130 was chosen as the current (2024) European average.

| | | | |
|---|---|---|---|
| **Yes** | O | **No** | O |

The number of scores on the left (clear rules for regulatory framework; no injection fee, cost-sharing mechanism in place; many filling stations) gives a score between 0 and 4.

### Data sources

Country-specific data for filling out this indicator can be found under:

https://www.dropbox.com/home/GreenMeUp%20-%20Horizon%20Europe%20Project/WP1/Task%201.6%20Indicators%20for%20market%20integration/Data%20sources%20(George%2C%20Magda)

- Injection fees and grid connection cost ("*ANNEX 1 - Grid Connection Cost in Europe.xlsx*")
- Background information on biomethane grid injection ("G*reenMeUp- Variations in Nat'l... Grid Connection.pdf*")
- NGVA Europe Stations map: https://www.ngva.eu/stations-map/

## Key indicator 5: Emission reduction potential

| PESTEL category | Name | Description | Measuring |
|---|---|---|---|
| Ecological | Emission reduction potential | Potential for reduced emissions from replacing natural gas with biomethane by grid injection | Quantitative (3-scale scoring) plus qualitative (description of biogas accounting in national targets) |

### Description

The use of biomethane holds potential for avoiding, reducing and removing greenhouse gas emissions at several intervention points. The EBA Statistical Report 2023[5] provides an overview over the different routes (Fig. 1). In addition to the routes shown, indirect effects have to be

[5] Available from: https://www.europeanbiogas.eu/eba-statistical-report-2023/



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considered such as the natural gas demand for synthetic fertilizer production which decreases if synthetic fertilizer is replaced with digestate.

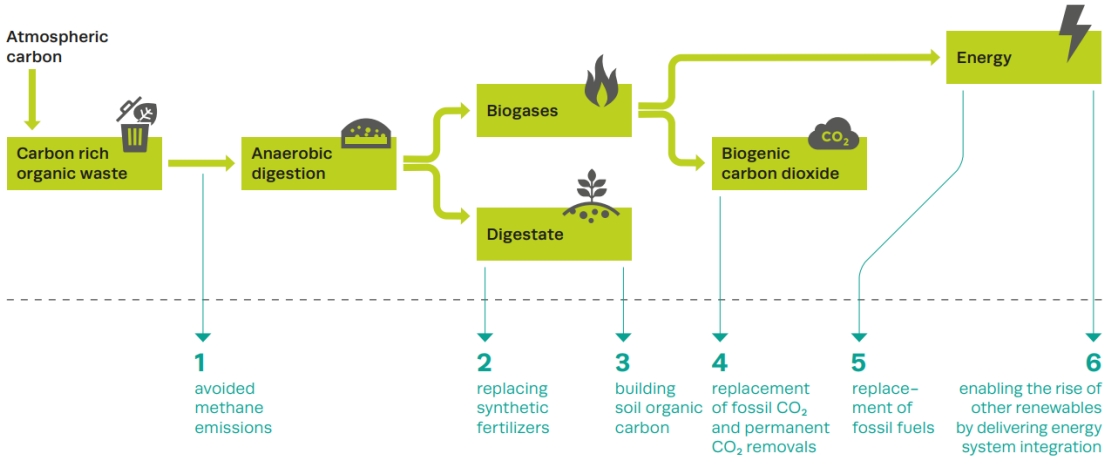


Fig. 1: Routes in which the production of biogas and biomethane contributes to the reduction of GHG emissions (source: EBA Statistical Report 2023)[6]

While the valorization of the by-products digestate and $CO_2$ are subject of key indicator 3, this indicator will focus on the replacement of fossil fuels in the energy system, i.e., route 5 in Figure 1. More precisely, natural gas replacement is projected to lead to 448.0 Mt $CO_2$eq per year of reduced emissions in the EU in 2050. This was calculated by multiplying the 2050 EU biogas/biomethane production potential of 165.1 bcm[7] with the Fossil Fuel Comparator for transport fuels (valid for compressed biomethane) of 94 g $CO_2$eq per $MJ_{fuel}$ [8] and the mean GHG savings from biomethane injected into the grid of 76% compared to natural gas[9].

Compared to the 448.0 Mt $CO_2$eq per year of reduced emissions by natural gas replacement, digestate application (route 2 in Figure 1) has the potential to reduce 57.2 Mt $CO_2$eq per year in the EU in 2050 [10]. In order to arrive at a first estimate for emission reduction potential at national level, it was decided to limit the assessment to natural gas replacement. Reasons for that include the high share of natural gas replacement in total emission reduction potential, as well as data availability issues. Emission reduction by digestate application is feedstock-dependent and therefore would have required feedstock-specific emission factors and data on production by feedstock, which is not available for all target countries.

## Scoring

The emission reduction potentials were calculated for each country as described above. They are listed in the provided Excel file "GMU_T1.6_Indicator data". If absolute values were taken

[6] Available from: https://www.europeanbiogas.eu/eba-statistical-report-2023/
[7] bcm = billion cubic meters. EBA Statistical Report 2023, available from https://www.europeanbiogas.eu/eba-statistical-report-2023/
[8] MJ = megajoule. As defined in the COM(2016) 767
[9] Joint Research Centre 2017. Solid and gaseous bioenergy pathways: input values and GHG emissions. Available from: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC104759/ld1a27215enn.pdf
[10] EBA Statistical Report 2023, available from https://www.europeanbiogas.eu/eba-statistical-report-2023/


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for the scoring, smaller countries with lower potential for biomethane production would be at a disadvantage. For that reason, the results are expressed as the share of total transport emissions. National transport emission values were taken from the Member States emission projections as reported to the European Commission[11]. For the 2050 projected values, the scenario with additional measures (WAM) was chosen to reflect maximum potentials.

| Score | 2 | 1 | 0 |
|---|---|---|---|
| **Description status quo** | Data available and potential over 4% | Data available and potential under 4% | No data available on national level |
| **Description 2050** | Data available and potential over 100% | Data available and potential under 100% | No data available on national level |

The score for the status quo constitutes an estimation below or above the European average of 4%, while the score for the 2050 potential sets the threshold at 100% of total 2050 transport emissions that can potentially be reduced by using biomethane.

### Data sources

The data sources for the calculation factors as well as the input data are described above.

## Key indicator 6: Social perceptions

| PESTEL category | Name | Description | Measuring |
|---|---|---|---|
| Socio-cultural | Social perceptions | Public opinion on the implementation of biogas and biomethane. Divided into:<br>1) market acceptance,<br>2) Sociopolitical acceptance,<br>3) Community acceptance. | Quantitative (7-scale scoring) plus qualitative (description) |

### Description

The key indicator on social perceptions measures the public opinion on the market integration of biogas and biomethane. It is based on the 3 pillars approach by Wüstenhagen et al. 2007[12]. This approach divides social acceptance into market, socio-political, and community acceptance. This division is followed for assessing this key indicator, as shown in Figure 2. In the course of the GreenMeUp project, the primary data (in red) will be the basis for assessing the components of the three pillars (in yellow), whose scores will then be averaged to arrive at a final score for the indicator.

[11] Available from: https://sdi.eea.europa.eu/webdav/datastore/public/eea_t_ghg-emission-projections_p_2023_v01_r00

[12] Wüstenhagen, Wolsink and Bürer, 2007. Social acceptance of renewable energy innovation: An introduction to the concept. Available from: https://doi.org/10.1016/j.enpol.2006.12.001



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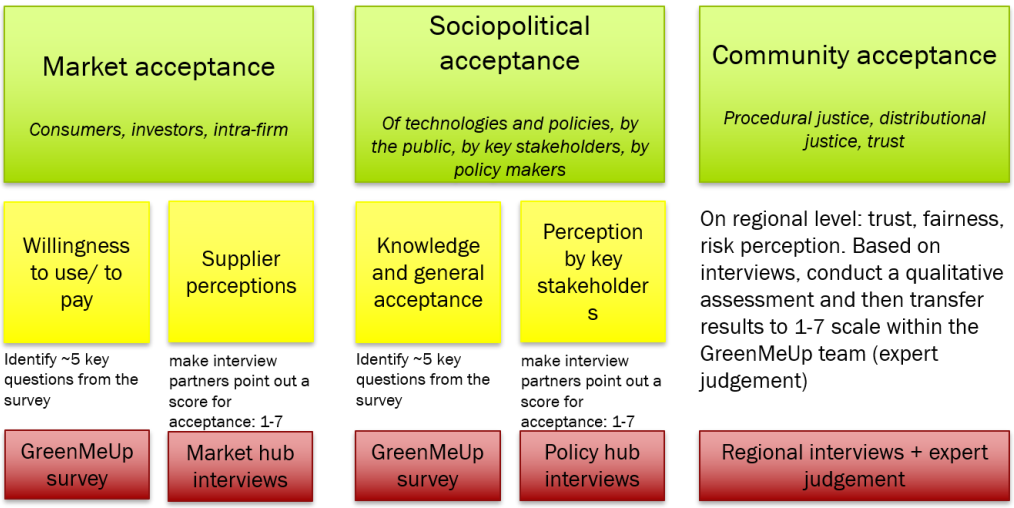


Figure 2: Framework for assessing the key indicator on social perceptions. Green: Three pillars of social acceptance, yellow: assessment components within the pillars, red: primary data from the project work.

## Scoring

The final score will have a value between 0 and 6. The survey and interview data is measured on a scale from 1 to 7. In order to stay consistent in the framework, the survey and interview results will be transferred to a scale from 0 to 6 by deducting 1.

The final score is an average of the following sub-scores:

- Market acceptance
  - Willingness to use/willingness to pay: 5 key questions from the GreenMeUp survey
  - Supplier perceptions: score for acceptance from the market hub interviews
- Sociopolitical acceptance
  - Knowledge and general acceptance: 5 key questions from the GreenMeUp survey
  - Perception by key stakeholders: score for acceptance from the policy hub interviews
- Community acceptance: Based on the regional interviews, the GreenMeUp team will conduct a qualitative assessment and give an expert judgement for a score.

## Data sources

Data source include the survey and hub interviews as well as the regional interviews conducted in GreenMeUp.



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# Key indicator 7: Financial support

| PESTEL category | Name | Description | Measuring |
|---|---|---|---|
| Legal | Financial support | Market-based mechanisms that support the production side for biogas/biomethane, like feed-in tariffs (for biomethane injection or electricity), heat recuperation bonus, connection cost principles, CAPEX support, and other incentives for construction and production | Quantitative (5-scale scoring) plus qualitative (description) |

## Description

The financial support describes the production side support for biogas and biomethane by the national government. This includes a multitude of market-based mechanisms, such as feed-in tariffs (for biomethane injection or electricity), heat recuperation bonus, connection cost principles, CAPEX support, and other incentives for construction and production. The definition of the scores is based on discussion within the GreenMeUp team.

## Scoring

| Score | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|
| **Description** | Demand-driven support mechanism for specific end-uses in place, e.g., targets for transport | Subsidy operated through public tenders to maximise $CO_2$ reduction/ public expenditures | Subsidy for only biomethane (whatever the award mechanism) | Subsidy for both biogas and biomethane | Subsidy for CHP only |

## Data sources

The assessment is based on literature search, combined with national experts' knowledge and judgement on financial support mechanisms at national scale.



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# Key indicator 8: Stakeholder networks

| PESTEL category | Name | Description | Measuring |
|---|---|---|---|
| Socio-cultural | Stakeholder networks | Level of communication among key actors (government, feedstock providers, plant operators, gas grid operators, potential users) | Quantitative (7-scale scoring) plus qualitative (description) |

## Description

Stakeholder networks in the biogas and biomethane sector are an important factor for the market integration of biomethane. The strength and activity of these networks in a country is measured by this key indicator. The level of communication among key actors is described, such as government, feedstock providers, plant operators, gas grid operators, and potential users.

## Scoring

The total score for this key indicator is calculated as a sum of the scores for the three sub-questions which can be found below.

How strong is the biogas/biomethane industry representation in the country (e.g., associations representing the industry)?

| Score | 2 | 1 | 0 |
|---|---|---|---|
| Description | Very strong | Strong | Weak |

Is there a regular dialogue between the government and other key actors, such as industrial actors and civil society?

| Score | 2 | 1 | 0 |
|---|---|---|---|
| Description | Yes, very active | Yes, could be more active | No |

Are there collaboration and communication channels between biogas producers and potential partners in place (feedstock providers, gas grid operators, potential users, etc.)?

| Score | 2 | 1 | 0 |
|---|---|---|---|
| Description | Yes, very active | Yes, could be more active | No |

## Data sources

The assessment is based national experts' knowledge and judgement on stakeholder networks at national scale.



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# Visualisation and interpretation of results

The framework is aimed to be applied to target countries as well as advanced countries. The EBA national associations platform will be activated to motivate the filling out of the framework by further countries.

For country results visualization, the scores are normalized and displayed in spider plots. It is envisaged to display the scores for the status quo as well as future potentials. This will allow a quick identification of highly dynamic indicators, reflecting a high dynamic in this area at national level.

The comparison of results will happen (1) among target countries and (2) between advanced and target countries and (3) between status quo and future potentials.

In order to showcase the format of upcoming results from the country analyses, Figure 3 contains the results of an example application of the framework during the test runs. As displayed, the status quo can be mapped against future potentials to analyze which indicators are highly dynamic and which have large potentials for improvement.

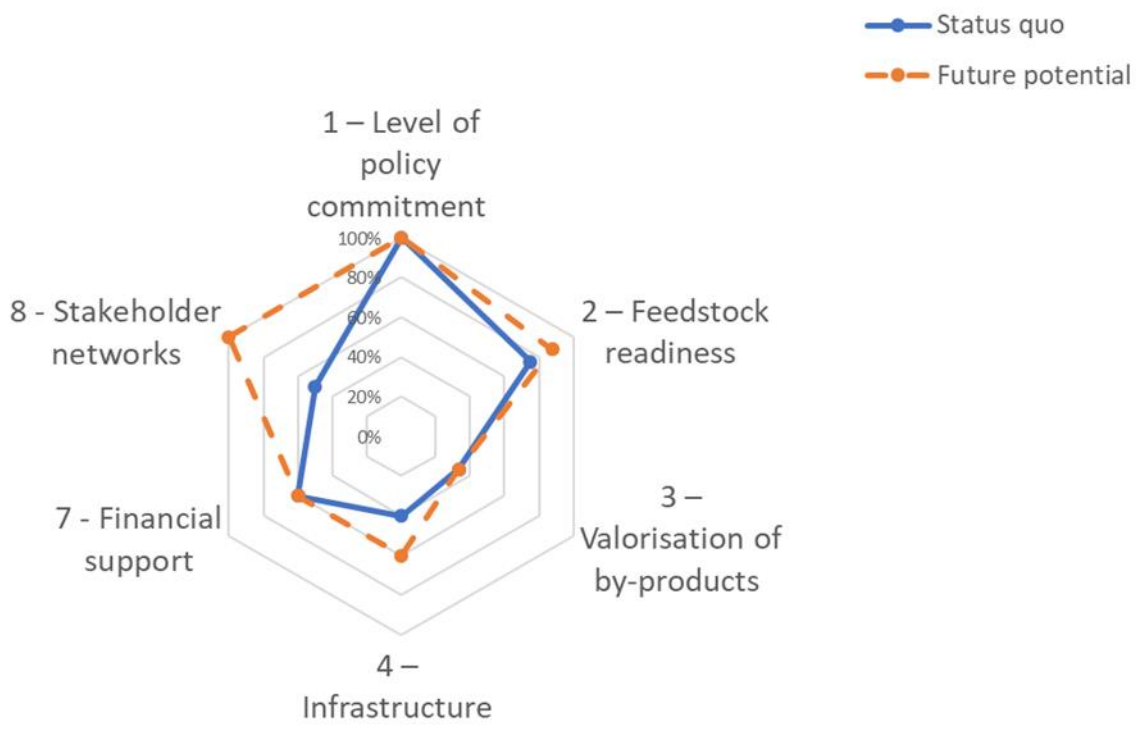


Figure 3: Example framework application to a test case.



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# Conclusions and outlook

The main findings from the development of biomethane market integration indicators are summarized as follows:

- The clear differentiation between high-scoring and lower-scoring indicators from the longlist of potential indicators shows it is possible to express the market integration with the help of few key indicators. This concentration on few key indicators was also voiced as a main advantage during the test runs of the framework. These indicators are able to capture all relevant topics for an overview over the current and potential market integration of biomethane.
- The feedback from the test runs of the indicators' scoring suggests that the framework adequately captures the main factors for the market integration of biomethane at national level and is able to describe the situation in a comprehensive way.

As an outlook, these steps will be taken following the completion of the framework development:

- The framework will be used to assess and compare the GreenMeUp target countries' market integration of biomethane, both in terms of status quo and future potentials. This will inform and support the work in WP3 and WP4 of the GreenMeUp project. For instance, the next series of hub workshops is dedicated to showing the results of the indicators to the hubs.
- The primary data on social perceptions generated during the project will be selected for the framework and fed into the framework (key indicator on social perceptions). This includes the survey, the hub interviews, and the regional interviews.
- The framework will be promoted and, if possible, applied to further countries to construct a broader database for comparisons. Here, EBA contacts will be made use of to facilitate the distribution and application of the framework.



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# Annex

## Annex 1: Longlist of potential market integration indicators

Table 2: Longlist of potential market integration indicators as of September 2023

| **PESTEL category** | **Indicator name** | **Description** |
|---|---|---|
| *policy, economic, socio-cultural, technological, ecological, legal* | | *Description or definition of the indicator* |
| Policy | **Main indicators:** | |
| Policy | National roadmap | Dedicated governmental strategy, roadmap or action plan (official document) stating the present and future actions of the Government to support biomethane production, distribution and consumption. Including existence of an official binding or indicative target on biomethane production or consumption. |
| Policy | **Optional indicators:** | |
| Policy | Monitoring | Existence of a national level assessment of biogas and biomethane potential that was mandated by the Government or endorsed by it. Presence of studies by renowned bodies relating to the potential of the sector at a national level. |
| Economic | **Main indicators:** | |
| Economic | Biomethane price | Average biomethane price. Reflects production costs, costs of biogas upgrading and economic aspects of grid injection. |
| Economic | Competition with natural gas price | Competitiveness of biomethane prices with the natural gas price. Includes price flexibility, i.e. fluctuations in biomethane and natural gas prices. |
| Economic | Valorisation of by-products | Valorisation of the by-products heat (boilers, gas engines and turbines, combined heat and power (CHP) plants and fuel cells), CO2, digestate (e.g., for fertiliser, algae and biopolymers production) |
| Economic | Economic valorisation of | Economic valorisation of GHG reductions |



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| | GHG reductions | |
| Economic | Recognition of the "renewable value" for end-consumers | Existence of a functional registries of Guarantees of origin |
| Economic | **Optional indicators:** | |
| Economic | International cross-border trade | Cross-border transfer of biomethane certificates, GO/CoO and Proofs of sustainability within the EU. National registries are a prerequisite for international trade. |
| Economic | Revenues | Average revenue of biomethane, heat recuperation, digestate, CO2 sales at country level |
| Economic | Local service companies | Number of local service companies |
| Economic | Amortisation time of a plant | Mean amortisation time of a plant ((the more byproducts with economical viability the shorter the amortisation time) |
| Socio-cultural | **Main indicators:** | |
| Socio-cultural | Know-How | Knowledge corresponding to different parts of the value chain: R&D, school and university programs (demonstration gardens with biogas and digestate production), other support mechanisms to develop know-how. Availability of programs to train direct operators of AD plants and engineers and techniciens directly involved in building plants. |
| Socio-cultural | Workforce | Number of jobs connected to biogas/ biomethane production. Incl. share of high-skilled and technical jobs. |
| Socio-cultural | Social perceptions | Any opposition from citizens regarding the construction of biogas or biomethane plants in the last x year |
| Socio-cultural | **Optional indicators:** | |
| Socio-cultural | Contribution to rural development | Development of the rural area and related economic opportunities in biogas/biomethane production. Share of jobs (of total jobs) in rural/urban areas. |
| Socio-cultural | Demonstrator projects | Living labs and lighthouses, circular economy demonstration districts and regions (initiatives) |
| Technological | **Main indicators:** | |
| Technological | Biomethane production | Amount of biomethane produced by technological pathway (anaerobic digestion, gasification) |
| Technological | Installed capacity | Number of biogas and biomethane plants, plant sizes, upgrading capacity. Also: capacity for biomethane production via gasification. |



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| Technological | Biomethane consumption | Is all biomethane produced also consumed? Biomethane share compared to natural gas consumption (Can biomethane fulfil the demand?) |
| Technological | Feedstock potential | Types, amounts and quality of feedstock currently used for biogas/biomethane production. Potential of residues and waste biomass streams. Potential of energy crops. |
| Technological | Infrastructure availability | Availability, quality and compatibility of supporting infrastructure: gas grid, biowaste sorting at source, tank trailers. Closeness to biomethane plants. |
| Technological | Share of grid connected biomethane | Share of biomethane injected into gas grids in the overall produced biomethane and biogas |
| Technological | **Optional indicators:** | |
| Technological | Optimisation potential and efficiency | Efficiency increases: Input /output of energy (electric and thermic); biogas productivity (daily produced biogas in Nm3/digester volume); high performance plant. |
| Technological | Administrative Barriers | Administrative procedures related to investment implementation, such as obtaining permits, permit processing time, eligibility for subsidies, and financing. |
| Ecological | **Main indicators:** | |
| Ecological | Emission reduction | Potential for reduced emissions (in national GHG accounting) |
| Ecological | Waste reduction | Waste reduction by mobilisation of unused residues, thereby contributing to circular economy. Utilisation of organic waste (reduction of waste going to landfill and to incineration) |
| Ecological | **Optional indicators:** | |
| Ecological | Land use and land use change | Impacts on land use and land use change through biomethane market uptake |
| Legal | **Main indicators:** | |
| Legal | Budget foreseen for biomethane production in a country (OPEX support) | Significant market design mechanisms that support the production side: feed-in tariffs (for biomethane injection or electricity), heat recuperation bonus, etc. |



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| Legal | Budget foreseen for biomethane production in a country (CAPEX support) | Significant market design mechanisms that support the production side: CAPEX support, incentives for construction and production, etc. |
| Legal | Gas injection | Legal conditions of biomethane feed-in into natural gas networks on country level, Design and operation of injection utilities, Biomethane quality adjustments. Right to inject: Legislation and regulation empowers the biomethane project developer to request a grid connection to gas grid operators with transparent criteria for feasibility. Gas quality standard for injected biomethane is clearly defined and within reach of BAU biomethane projects. |
| Legal | Demand-side support | Significant incentives to biomethane consumption: renewable green gas injection target, reduction of taxes or excise duties, recognition of GHG emission savings in end-use sectors, etc. |
| Legal | Tax reduction | Tax reduction compared to natural gas |
| Legal | **Optional indicators:** | |
| Legal | Feedstock requirements | Feedstock classification, hazardous -non hazardous, critical values of pathogen concentrations |
| Legal | Technical standards | Standards for sustainability; for network inegration of biomethane; for digestate application (carbon to soil support mechanism, national law to increase digestate percentage in economical fertiliser) |



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# Annex 2: Prioritization of potential market integration indicators

Table 3: Prioritization of potential market integration indicators

| Priority (Number of sticky dots at the project meeting) | PESTEL category | Preliminary indicator name (as of the project meeting in September 2023) |
|---|---|---|
| 13 | Policy | National roadmap |
| 13 | Technological | Feedstock potential |
| 11 | Economic | Valorisation of by-products |
| 11 | Technological | Infrastructure availability |
| 11 | Ecological | Emission reduction |
| 10 | Socio-cultural | Social perceptions |
| 10 | Legal | Budget foreseen for biomethane production in a country (OPEX support) |



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